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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.11 NAVIGATION			For general G&C operating data, refer to operating notes, 4.6.1.
4.11.1 ORBITAL NAVIGATION			
4.11.1.1 <u>(P21) Ground Track Determination</u>			Provides crew ground track data for either CSM or LM, based on time loaded in 3.
	CMC - on (req), 4.8.1.3		
CMP 1 Key V37E 21E		2,140	
2 FL V04 N06			
	Option code 00002		
	CMC assumed option 0000X		
	(00001 = CSM,		
	00002 = LM)		
	Accept PRO		
	Reject V22E (load desired option)		
3 FL V06 N34			
	GET lat long 00XXX. HRS		Initial display will contain zeros (present time). If not changed by astronaut, P21 calculations will be based on present time.
	000XX. MIN		
	0XX.XX SEC		GET at desired position of selected vehicle.
	Accept PRO		
	Reject V25E (load desired T-lat long)		

4.11.1.1

(P21) GROUND TRACK DETERMINATION



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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 4 FL V06 N43 Lat (+N) Long (+E) Alt If desired Key N73 Alt/10 VI Gamma To increment T-lat long by 10 min Key V32E Return to 3	XXX.XX DEG XXX.XX DEG XXXX.X NM XXXXX. NM XXXXX. FPS XXX.XX DEG	2,140	Selected vehicle latitude at T-lat long. Selected vehicle longitude at T-lat long. Selected vehicle altitude above launch pad radius for earth orbit, or above lunar radius at most recently defined landing site for lunar orbit, at T-lat long. Provides altitude display with scale compatible with altitudes associated with lunar mission. For V32E, program keeps previous state vector for use in starting next iteration without, however, ensuring that subsequent integrations are precision. If times reasonably close, V32E should be used; if far apart, would be quicker to reselect P21.
5 PRO (term P21) FL V37 Key XXE			ROO.

(P21) GROUND TRACK DETERMINATION

STA/T STEP	PROCEDURE	PANEL	REMARKS
	<p>4.11.1.2 <u>(P22) Orbital Navigation</u></p>		<p>Purpose:</p> <ul style="list-style-type: none"> ● Locate, track and mark on lmk suitable for navigation. ● Calculate orbital parameter changes generated by lmk sightings marks. ● Display orbital parameter changes generated by first lmk sighting mark for crew/MSFN verification prior to state vector update. ● Update known lmk coordinates. ● Provide unknown lmk coordinates. ● Track a preloaded landing site. ● Provide coordinates of a new landing site (treated as an unknown lmk). ● Provide coordinates of an offset landing site. ● Point optics along an advanced orbit ground track to track and map a new landing site. <p>Lmks may be known or unknown.</p> <p>Known lmk - Made known to CMC by Lat, Long/2 and Alt.</p>

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4.11.1.2

(P22) ORBITAL NAVIGATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
<p>CMP</p> <p>CMC - on (req), 4.8.1.3 ISS - on & orient known (req), 4.8.1.3 & 4.14 Opt Pwr Up (req), 4.8.1.4 OPT ZERO - OFF OPT MODE - CMC SCS - on (req), 4.8.4.2</p>		<p>122</p>	<p>Unknown lmk - Identified to CMC as unknown lmk.</p> <p>There are two types of landing site mapping:</p> <ul style="list-style-type: none"> ● Landing site determination - Track and mark an unknown lmk and store coordinates in lmk ID 01. ● Landing site offset - To store offset landing site coordinates in lmk ID 01. <p>Only legitimate values of lmk ID in N70 and N71 are:</p> <p>00 - known lmk loaded by N89 01 - landing site 50-57 advanced orbit option where units digit is the number of orbits ahead. (N70 only)</p> <p>Ground Track Determination Program (P21) available to aid in selection of lmk. For orbital navigation, W-matrix should not be initialized to magnitudes >328 fps and 51,647 ft (N99 display).</p> <p>Provides monitoring and alternate control capability.</p>

(P22) ORBITAL NAVIGATION

STA/T STEP	PROCEDURE	PANEL	REMARKS
1	Sel Tot Att Disp, 4.7.2.5		
2	Sel Att Cont mode, 4.7.1		
CMP 3	Key V37E 22E	2,140	
	Poss PROG alarm (4.8.1.16)		R02.
4	FL V06 N45		
	R3 - max MGA if X-axis inplane		MGA maximum possible middle gimbal angle if CSM X-axis held in orbital plane.
CDR	If IMU align satisfactory		
	Perform ORDEAL Init, 4.8.4.8		Initial sighting attitude should position optics shaft axis inplane and $\approx 50^\circ$ ahead of local vertical.
	Mnvr to sighting att & establish orb rate		This provides optics cone of view which extends $\approx 90^\circ$ ahead of local vertical at beginning of sighting.
	Sel FDAI disp & att cont mode desired, 4.7.1 & 4.7.2		
	RHC - position Xsc axis $\approx 20^\circ$ above lcl horiz, SEF hds up; as lmk approaches, pitch slowly to $\approx 20^\circ$ below horiz (put COAS LOS on horiz or use ORDEAL FDAI)		As lmk approaches, pitch CSM down $\approx 20^\circ$ below horizon. Cone of view now extends from $\approx 50^\circ$ ahead to $\approx 30^\circ$ aft of local vertical.
	RHC or MIC - pitch to offset orb rate, roll to avoid shft axis $\approx 10^\circ$ of lmk, if known		Sighting attitude should be adjusted by small roll maneuver, if necessary, to prevent optics shaft axis from passing within 10° of target lmk. The 10° separation of lmk LOS and shaft axis ensures optics drive rates are not exceeded because of optics shaft reversal to avoid trunnion stop at -5° .

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	PRO (If E.O., go to 6)	2,140	Select IMU realignment procedure. Reselect P22 at completion of realignment procedure.
or	If realign desired Key V37E XXE		
5	FL V05 N70 (L.O. only) R2 - lmk code ABCDE A 1 (known lmk), 2 (unknown lmk) B Index of offset designator C Not used DE lmk ID		
	Reject Key V22E Load desired lmk code		
	Accept If A = 2 OPT MODE - MAN PRO Go to 8	122 2,140	
	or If A = 1 & DE = 01 or 50-57 PRO Go to 7		PROG alarm (00404) may occur at this point.
	or If A = 1 & DE = 00 PRO		
	Poss OPR ERR A = 0 or >2, B >5, or DE ≠ 00, 01 or 50-57 Recycle 5		

(P22) ORBITAL NAVIGATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 6 FL V06 N89 (lmk data) Lat (+N) Long/2 (+E) Alt Reject V25E Load desired data Accept PRO Poss OPR ERR R1 or R2 >90° Recycle 6 (R52, Auto Optics Positioning Routine) Poss FL V05 N09 00404 (TA >90°) Mnvr CSM until opt can acq lmk PRO or V34E (term prog) FL V37 Key XXE		2,140	Lmk latitude. Lmk longitude divided by 2. Lmk altitude above Fischer ellipsoid for earth orbit, or above mean lunar radius for lunar orbit. Points optics SLOS to selected lmk automatically. If in lunar orbit and a lmk code (DE) of 50 through 57 loaded in 5 (E defining desired number of orbits ahead), CMC points optics 60° ahead of CSM along advanced orbit. PROG alarm light on. PRO recomputes required optics angles. ROO.

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	If TA >50° & <90° Mnvr to reduce trun angle		If TA >50° and <90°, trunnion driven to upper limit (≈49.7754°) and held at this angle. Key V16 N92E for display of required optics angles if not presently displayed.
7	VO6 N92 (new OCDU angles) SA XXX.XX DEG TA XX.XXX DEG To mrk, OPT MODE - MAN	2,140 122	No display if OPT MODE - MAN or if R52 reselected after R53 called, see next remark. Selects R53. To regain auto optics positioning, select OPT MODE - CMC (prior to completion of R53). CSM attitude rates <u>>two-thirds</u> degree/second will result in rejection of sighting marks; indicated by PROG alarm.
	(R53, Sighting Mark Routine)		
8	FL V51 (please mrk) Center lmk in opt MARK pb - push	2,140 121 122	Known or unknown lmk in SCT. If mark made on an offset lmk (landing site), key V52E (after offset mark) or use N71 in 9 to identify offset mark. If only one mark made, it should not be identified as offset landing site. If more than one mark made, any mark may be used (and identified) as offset landing site mark. If desirable to terminate lmk tracking without making marks, key V34E or V37E XXE.
	Accept Repeat mrk proced or PRO	 2,140	If more marks desired. If sufficient marks made. At least one unrejected mark must be made before keying PRO. Otherwise, V51 reinstated. If desirable to terminate lmk tracking without making marks, key V34E or V37E XXE.

(P22) ORBITAL NAVIGATION

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Reject MARK REJ pb - push Repeat mrk proced	122	
	If 5 mrks made FL V50 N25 00016 (term mrks)	2,140	
	Accept PRO Reject MARK REJ pb - push Repeat mrk proced	122	Rejects last (5th) mark.
	OPT ZERO - ZERO (≈15 sec to zero) OPT ZERO - OFF OPT MODE - CMC Exit R53 & R52		
9	FL V05 N71 (lmk data) R2 - lmk code ABCDE	2,140	If mark was made on an offset landing site, ensure that B corresponds to mark. If no offset landing mark made, ensure B = 0.
	A 1 (known lmk), 2 (unknown lmk) B Index of offset designator C Not used DE Lmk ID		
	Reject V22E Load correct data in R2		
	Accept PRO If A is 2 (or A is 1 & DE = 01) Go to 11		
	Poss OPR ERR A = 0 or >2, B >5 or DE ≠ 00 or 01		



STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 10	FL V06 N89 (lmk coord) Lat (+N) XX.XXX DEG Long/2 (+E) XX.XXX DEG Alt XXX.XX NM Reject V25E (load desired data) Accept PRO	2,140	If auto optics positioning was performed, this data will be identical to N89 data loaded in 6.
	Poss OPR ERR R1 or R2 >90° Recycle 10		
11	FL V06 N49 ΔR XXXX.X NM ΔV XXXX.X FPS Accept PRO Reject V32E E.O. - return to 6 or L.O. - return to 5		Position vector change magnitude. Velocity vector change magnitude. If in earth orbit. If in lunar orbit.
12	FL V06 N89 Lat (+N) XX.XXX DEG Long/2 (+E) XX.XXX DEG Alt XXX.XX NM Accept PRO (L.O. only) Return to 5		If offset landing site mark made and identified to CMC, display is offset landing site coordinates. Otherwise, display is coordinates of lmk on which marks were taken. Stores coordinates in CMC memory as landing site (lmk ID 01). Previously stored landing site coordinates erased.

(P22) ORBITAL NAVIGATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Reject V32E E.O. - return to 6 or L.O. - return to 5	2,140	Does not store coordinates.
13	Key V34E (to term P22) FL V37 Key XXE		V34E at any flashing display terminates P22. R00.
14	Set opt cont OPT ZERO - ZERO OPT PWR - OFF RETCL BRT tw - DIM	 122 100 122	

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.11.1.3	<u>(P23) Cislunar Midcourse Navigation</u>		Accomplishes midcourse navigation by incorporating star/earth and star/moon optical measurements.
	CMC - on (req), 4.8.1.3 ISS - on & orient known (desired), 4.8.1.3 & 4.14		Permits auto maneuver to tracking attitude and auto optics positioning, if desired. Optics should be on for 15 minutes prior to marking.
	SCS - on (req), 4.8.4.2		Provides monitoring displays and alternate control capability.
	RCS DAP - Load & activate (desired), 4.8.2.1		Required if automatic attitude maneuver desired. For cislunar navigation, W-matrix should not be initialized to magnitudes >328 fps and 99,999 feet (N99 display).
	Opt pwr up (req), 4.8.1.4		
	1 Sel Tot Att Disp, 4.7.2.5		
	2 Sel Att Cont mode, 4.7.1		
CMP	3 Key V37E 23E (R57, Optics Calibration)	2,140	Measures effect of solar radiation on SXT trunnion angle and stores measured trunnion bias for P23.
	If IMU orient unknown RHC - mnvr to acq star in SXT FOV		Select suitable star for use by Optics Calibration Routine, R57.
	Go to 8		
	or IMU orient known Go to 4		

(P23) CISLUNAR MIDCOURSE NAVIGATION

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 4	FL V50 N25 00015 (request auto mnvr, calib star) Accept PRO Reject RHC - mnvr, acq star/lunar or earth disc in SXT FOV ENTR, go to 8	2,140	Select a suitable star/lunar or earth disc for use by Optics Calibration Routine, R57.
5	FL V01 N70 Star ID (calib) 000DE Lmk code ABCDE Horiz ID 00CDO Reject Key V21E (load desired data) R1 - 00 for planet 01-45 for star Accept Rcd data PRO		Only R1 is of significance for R57.
	Poss OPR ERR If 00 R1 51, go to 7		Target code negative of >50.
6	FL V06 N88 (planet only) X, Y, Z .XXXXX Accept PRO Reject Key V25E, load desired data		

STA/T STEP	PROCEDURE	PANEL	REMARKS
	(R60, Attitude Maneuver Routine)		Provides for maneuver (auto or manual) to attitude calculated by vecpoint routine.
CMP 7	FL V50 N18 (CMC auto request) R, P, Y XXX.XX DEG	2,140	Required gimbal angles.
CDR	Accept SC CONT - CMC CMC MODE - AUTO	1	
CMP	PRO V06 N18 R, P, Y XXX.XX DEG Mon auto mnvr on FDAI Recycle 7	2,140	Static display until completion of auto maneuver and then reverts to FL V50 N18.
	Reject V62E RHC - null FDAI err needles Recycle 7		Provides error needle reference for manual maneuver.
CDR	or SC CONT - SCS (or CMC MODE - ≠ AUTO)	1	
CMP	PRO (updates disp) Recycle 7	2,140	Recomputes desired attitude without performing auto maneuver.
	or ENTR (exit R60)		When attitude satisfactory.
8	FL V59 (perform calib mrk)		
	Accept Ctr desired calib feature or star in SXT		
	OPT ZERO - OFF	122	
	OPT SPEED - LO		
	OPT MODE - MAN		
	OPT TELTRUN - SLAVE TO SXT		
	OPT COUPLING - DIR		

(P23) CISLUNAR MIDCOURSE NAVIGATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Superimpose SLOS & LLOS MARK pb - push Go to 9	122	Trunnion bias angle is a function of angle between LLOS and sun and is a constant if sun is outside cone <u>+15</u> deg from LLOS.
	Reject If IMU orient unknown OPT MODE - MAN ENTR Go to 17 If IMU orient known OPT MODE - CMC ENTR Go to 10	2,140 122 2,140	If optics were calibrated with sun outside cone defined in preceding remark and are used outside cone during future marks, recalibration not necessary. If sun is within cone, calibration should be performed each time through P23. PROG alarm (00404) may occur at this point.
9	FL V06 N87 R2 - trun bias XX.XXX DEG		Scaling of N87 is such that small negative angle will appear as positive angle approaching 90°. (Actual angle equal to 90° minus displayed value.)
	Accept If IMU orient unknown OPT MODE - CMC PRO, go to 17 If IMU orient is unknown PRO Go to 17	122 2,140	CMC stores calibration angle.
	Reject If IMU orient known, return to 4 If IMU orient unknown, return to 8		
10	FL V05 N70 Star ID 000DE Lmk code ABCDE Horiz ID 00CDO		
	Reject Key V25E (load desired data)		Either R2 or R3 should be 00000, but not both.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	R1 - 00 for planet 01-45 for star	2,140	R1 000DE Star or planet ID
	R2 - AB not used C 1 (earth lmk), 2 (moon lmk) DE not used		R2 00100 Star/EL 00200 Star/LL
	or R2 - 00000 for horiz measurement		
	R3 - horiz ID C 1 (earth horiz), 2 (moon horiz) D 1 (near horiz), 2 (far horiz)	R3	0010 Star/ENH 00120 Star/EFH 00210 Star/LNH 00220 Star/LFH
	or R3 - 00000 for lmk measurement		
	Accept Rcd data PRO go to 11		
	or If sighting on planet/horiz, go to 12		
	or If sighting on star/horiz, go to 13		
	Poss OPR ERR R1 <0 or >45		
	or R2 (C) & R3 (CD) = 0		
or R2 (C) & R3 (CD) = 1 or 2 Either R2 or R3 must be zero (but not both)			

(P23) CISLUNAR MIDCOURSE NAVIGATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	or R2 (C) = 0 & R3 (C&D) ≠ 1 or 2	2,140	
	Recycle 10		
11	FL V06 N89		If planet or star and either earth or moon landmark sighting.
	Lat (+N)	XX.XXX DEG	
	Long/2 (+E)	XX.XXX DEG	
	Alt	XXX.XX NM	Above Fischer ellipsoid for earth orbit, or above mean lunar radius for lunar orbit.
	Accept PRO		
	If planet not specified, go to 13		
	Reject V25E (load desired data)		
	Poss OPR ERR		
	R1 or R2 >90°		
	Recycle 11		
12	FL V06 N88 (planet only)		
	X, Y, Z	.XXXXX	
	Accept PRO		
	Reject V25E (load desired data)		
13	FL V50 N25		
	00202 (request 3-axis mnvr)		Optional 3-axis maneuver or vecpoint maneuver available.
	Accept PRO (3-axis mnvr), go to 14		PRO or ENTR calls R60 to perform automatic maneuver.
	Reject ENTR (vecpoint mnvr), go to 14		

4.11.1.3

(P23) CISLUNAR MIDCOURSE NAVIGATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
	(R60, Attitude Maneuver Routine)		Provides for maneuver (auto or manual) to attitude calculated by 3-axis or vecpoint routines.
CMP 14	FL V50 N18 (CMC auto request) R, P, Y XXX.XX DEG	2,140	Required gimbal angles.
CDR	Accept SC CONT - CMC	1	
	CMC MODE - AUTO		
CMP	PRO	2,140	
	V06 N18		Static display until completion of auto maneuver and then reverts to FL V50 N18.
	R, P, Y XXX.XX DEG		
	Mon auto mnvr on FDAI		
	Recycle 14		
	Reject V62E		Provides error needle reference for manual maneuver.
	RHC - null FDAI err needles		
	Recycle 14		
CDR	or SC CONT - SCS (or CMC MODE -	1	
	≠ AUTO)		
CMP	PRO (updates disp)	2,140	Recomputes desired attitude without performing auto maneuver.
	Recycle 14		
	or ENTR (exit R60)		When attitude satisfactory.
	(R52, Automatic Optics Positioning Routine)		Points SLOS of optics at selected star.
	Poss FL V05 N09		
	00404 (TA >90°)		
	Mnvr to reduce TA		
	PRO		
	or V34E		
	FL V37		ROO.
	Key XXE		

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	If TA >50° and <90° Mnvr to reduce TA		If TA >50° and <90°, trunnion driven to upper limit (≈49.7754°) and held at this angle.
15	V06 N92 (desired opt angles) SA XXX.XX DEG TA XX.XXX DEG (R53, Sighting Mark Routine)	2,140	Optics will drive to acquire selected star or planet.
16	OPT MODE - MAN	122	
17	FL V51 (please mrk) 2,140 Check star & lmk are in SXT FOV OPT COUPLING - RSLV 122 OPT SPEED - LO RHC - position lmk near ctr of SXT FOV OHC - superimpose star & lmk images MARK pb - push	2,140	If CMC aid in reacquiring lmk/horiz desired, key V94E and place OPT MODE switch to CMC. V94 terminates R52 and R53, starts R60 going again, recalculates required optics vector, reselects R52 and positions optics. V94 usable only in P23 from R52 callup through R53 to mark accept (PRO in 18).
18	FL V50 N25 00016 (term mrks) Accept PRO Reject MARK REJ pb - push Return to 17	2,140	
19	FL V05 N71 Star ID 000DE Lmk code ABCDE Horiz ID 00CDO	2,140	Refer to 10 for codes.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Reject V25E Load desired data Accept Rcd data PRO If sighting on planet/horiz Go to 21 If sighting on star/horiz Go to 22 Poss OPR ERR R1 <0 or >45 or R2 (C) & R3 (CD) = 0 or R2 (C) & R3 (CD) = 1 or 2 Either R2 or R3 must be zero (but not both) or R2 (C) = 0 & R3 (C&D) ≠ 1 or 2 Recycle 19	2,140	
20	FL V06 N89 Lat XX.XXX DEG Long/2 XX.XXX DEG Alt XXX.XX NM Accept PRO If planet not specified, go to 22 Reject V25E Load desired data		Altitude above Fischer ellipsoid for earth orbit, or above mean lunar radius for lunar orbit.

(P23) CISLUNAR MIDCOURSE NAVIGATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Poss OPR ERR R1 or R2 >90° Recycle 20	2,140	
21	FL V06 N88 (planet only) X, Y, Z .XXXXX Accept PRO Reject V25E (load desired data)		
22	FL V06 N49 ΔR XXXX.X NM ΔV XXXX.X FPS Accept PRO Reject Reselect V37E 23E, return to 3 or V32E (go to 23)		Magnitude of position vector change. Magnitude of velocity vector change. Updates state vector. No state vector update if reject option selection.
23	FL V37 Key XXE		
24	Key V93E (if necessary)		If state vector update via P27 has not occurred. Enables W-matrix initialization.
25	Set opt cont OPT ZERO - Zero OPT PWR - OFF RETCL BRT tw - DIM	122 100 122	

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.11.1.4	<u>(P24) Rate Aided Optics</u> 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 RCS DAP - load & activate (req), 4.8.2.1 Opt pwr up (req), 4.8.1.4 Sel Tot Att disp, 4.7.2.5 Sel Att Cont mode, 4.7.1		<ul style="list-style-type: none"> ● To locate and acquire lmk via auto optics positioning. ● To track lmk using manual rate-aided optics feature of R52. ● Obtain and downlink unlimited number of sighting marks of chosen lmk.
1	Key V37E 24E	140	
2	Mnvr to sighting att		Tracking may be facilitated by initiating pitch maneuver using V79 (PTC/orb rate) procedure.
3	FL V06 N89		
	Lat (+N)	XX.XXX DEG	Lmk latitude.
	Long/2 (+E)	XX.XXX DEG	Lmk longitude divided by 2.
	Alt	XXX.XX NM	Lmk altitude above Fischer ellipsoid for earth orbit, or above mean lunar radius for lunar orbit.
	Reject V25E		
	Load desired data		
	Accept OPT MODE - CMC		
	PRO		
	Poss OPR ERR		
	R1 or R2 >90°		
	Recycle 3		

(P24) RATE AIDED OPTICS

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	(R52, Auto Optics Positioning) Poss FL V05 N09 00404 (TA >90°) Mnv CSM until opt can acq lmk PRO or V34E (term prog) FL V37 Key XXE If TA >50° & <90° Mnvr to reduce TA 4 V06 N92 (new OCDU angles) SA XXX.XX DEG TA XX.XXX DEG To mrk OPT MODE - MAN	140	<p>PROG alarm light on.</p> <p>PRO recomputes required optics angles.</p> <p>R00.</p> <p>If TA >50° and <90°, trunnion driven to upper limit (≈49.7754°) and held at this angle.</p> <p>Key V16 N92E for display of required optics angles if not presently displayed.</p> <p>No display if OPT MODE - MAN or if R52 reselected after R53 called.</p>
		122	<p>Selects R53 and enables rate-aided drive feature of R52. To regain auto optics positioning, select OPT MODE - CMC (prior to completion of R53). Having regained auto optics, FL V51 remains; rate-aided drive is disabled. However, marking process may be continued.</p>

4.11.1.4

(P24) RATE AIDED OPTICS

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STA/T STEP	PROCEDURE	PANEL	REMARKS
	(R53, Sighting Mark)		
CMP 5	FL V51 (please mrk) Ctr lmk in opt	140	Lmk is centered by using OHC augmented by rate-aided optics feature of R52.
	MARK pb - push	122	Stores mark data in downlink area.
	Accept Repeat mrk proced		Number of marks unlimited.
	Reject MARK REJ pb - push		Places complement of last mark's time register on downlink.
	Recycle 5		
	Poss OPR ERR 00110 (no mrks made)	140	
	To term mrks PRO		If sufficient marks made. At least one unrejected mark must be made before keying PRO. Otherwise, V51 reinstated. If desirable to terminate lmk tracking without making marks, key V34E or V37E XXE.
	FL V37 Key XXE		
6	Set opt cont		
	OPT ZERO - ZERO	122	
	OPT PWR - OFF	100	
	RETCL BRT tw - DIM	122	

(P24) RATE AIDED OPTICS

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.11.1.5	<u>(V82) Orbit Parameter Display (R30)</u> CMC - on (req), 4.8.1.3		Provides crew with CMC computed orbital parameters. Time from perigee/perilune (TF perigee) available via N32 if $H_p > 49.4$ NM (300,000 ft) for earth orbit or > 5.8 NM (35,000 ft) for lunar orbit. If P00 or P11 running, ΔR (miss distance) available via N50.
CMP 1	Key V82E If ave G routine on, go to 4	2,140	V82 computations based on two-body conic equations and may give erroneous results during transearth/lunar coasting. TFF display may be incorrect if return trajectory is hyperbolic.
2	FL V04 N12 Option code 00002 CMC assumed option 0000X (1 = CSM active 2 = LM active) Accept PRO Reject V22E (load desired option)		
3	FL V06 N16 GET event 00XXX. HRS 000XX. MIN 0XX.XX SEC Accept PRO Reject Key V25E Load desired time		Time for state vector integration. TFF and N32 continue to be measured from present time rather than N16 input time. CMC sets time option initially to zero, meaning present time.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 4 FL V16 N44		2,140	If average G on, display updates every 2 seconds.
	Ha Hp	XXXX.X NM XXXX.X NM	Above launch pad radius for earth orbit or above landing site radius for lunar orbit. Calculations are subject to limitations of two-body approximation and yield reasonable results if vehicle close to earth or moon.
	TFF	XXBXX MIN-SEC	Time of free fall to 49.4 NM (300,000 feet) for earth orbit, or 5.8 NM (35,000 feet) for lunar orbit. TFF reads -59B59 if Hp > 49.4/5.8 NM; under these conditions, time from perigee/perilune available by keying N32. If average G off and Hp < 49.4/5.8 NM, TFF counts down. For N32, if average G off and Hp > 49.4/5.8 NM, time from perigee/perilune counts down.
	Accept PRO Reject V32E Recycle to 3		Recalculates orbital parameters. (Valid only if average G off.)

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(V82) ORBIT PARAMETER DISPLAY (R30)

STA/T STEP	PROCEDURE	PANEL	REMARKS
4.11.2 RENDEZVOUS NAVIGATION	4.11.2.1 <u>(P20) CSM Rendezvous Navigation</u>		<p>Purpose:</p> <ul style="list-style-type: none"> Control CSM attitude and optics to acquire LM in SXT FOV and to point CSM transponder at LM or to control CSM attitude to acquire LM along CSM +X axis depending on option selected by crew. To update either LM or CSM state vector depending on crew selection. Update is based on optical tracking or VHF ranging data. <p>The uplink activity light indicates R61 requesting an automatic maneuver during rendezvous.</p> <p>For rendezvous navigation W-matrix should not be initialized to magnitudes >328 fps and 51,647 feet (N99 display).</p> <p>Provides total attitude and rate monitoring. Not required for VHF update. Not required for optical update.</p> <p>Required for control and display functions.</p> <p>If hour or more has elapsed since W-matrix initialization or if state vector has not been updated via P27.</p>
CDR	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 Opt pwr up (req), 4.8.1.4 VHF AM ranging mode sel (req), 4.5.6.6 CMC ATT - IMU (verify) LOGIC 2/3 PWR - on (up) (if no SCS) Key V93E (if necessary)	1 7 2,140	

4.11.2.1

(P20) CSM RENDEZVOUS NAVIGATION

STA/T STEP	PROCEDURE	PANEL	REMARKS
<p>1 Sel Tot Att disp, 4.7.2.5</p> <p>2 Sel Att Cont mode, 4.7.1</p> <p>CMP 3 Key V37E 20E</p>	<p>Poss PROG alarm (4.8.1.16)</p> <p>(R60, Attitude Maneuver Routine)</p> <p>(If UPLINK ACTY lt on Key V58E)</p>	<p>2,140</p>	<p>Selection of P20 automatically selects preferred tracking attitude option and LM state vector update option. Crew may exercise control of these options through use of the following extended verbs.</p> <p>V76E - Selects preferred tracking attitude. V77E - Selects +X axis tracking attitude. V80E - Selects LM state vector update. V81E - Selects CSM state vector update. V87E - Allow R22 to accept VHF range data. V88E - Inhibit acceptance of VHF range data.</p> <p>R02.</p> <p>Provides for maneuver (auto or manual) to attitude specified by option selected. R60 called only if maneuver >10° (in any axis) required. Otherwise maneuver performed by R61.</p> <p>Must key V58E in order to get R60 (V50 N18), except for initial entry to P20. R61 resets V50 N18 flag; V58E sets flag to allow R60 if subsequent auto maneuver >10° required.</p>

(P20) CSM RENDEZVOUS NAVIGATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 4	Poss FL V50 N18 (auto mnvr request) (2 sec priority) If req GMBL angle change >10° R, P, Y XXX.XX DEG	2,140	DAP will point preferred or X-axis at LM but will not constrain roll about tracking axis. If required maneuver <10°, maneuver performed by R61. Required gimbal angles.
CDR	Accept SC CONT - CMC	1	
	CMC MODE - AUTO		
CMP	PRO	2,140	This may be performed second time as attitude trim.
	VO6 N18		Priority display. At completion of maneuver, display will revert to FL V50 N18.
	R, P, Y XXX.XX DEG		
	Mon auto mnvr on FDAI		
	Reject Key V62E		Provides reference for manual maneuver.
	RHC - null FDAI err needles		
	Recycle 4		
CDR	or SC CONT - SCS (or CMC mode ≠ auto)	1	To update display without performing maneuver.
CMP	PRO	2,140	
	Recycle 4		
	When att satisfactory		
	ENTR		Terminates Attitude Maneuver Routine, R60. (Routine R61 will continue to compute and maintain selected attitude (option) as long as SC control CMC AUTO and RHC not moved out of detent.) UPLINK ACTY light will be lit if V50 N18 flag not set and tracking angles >10 degrees.

4.11.2.1

(P20) CSM RENDEZVOUS NAVIGATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	a. If opt sighting mrks desired, go to 5 or b. If BU opt (COAS) sighting mrks desired, go to 8 or c. If VHF ranging data update desired, Key V87E Go to 11	2,140	
	(R52, Automatic Optics Positioning)		
5	OPT ZERO - OFF OPT MODE - CMC If TA >50°	122	If TA >50°, trunnion driven to upper limit ($\approx 49.7754^\circ$) and held at this angle.
	a. RHC - man mnvr to selected tracking att		Key V16 N22 for desired gimbal angles. Key V16 N92 for desired optics angles.
CDR	or b. SC CONT - CMC CMC MODE - AUTO Key V58E if RHC moved from detent	1 2,140	To perform sighting marks on LM.
	(R21, Rendezvous Tracking Sighting Mark Routine)		
6	Key V57E		

(P20) CSM RENDEZVOUS NAVIGATION

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 7	FL V51 N45 (please mrk) Mrks (VHF/opt)	2,140	Number of marks processed by R22. Two most significant digits display VHF ranging marks. Two least significant digits display optics marks [either SXT or backup optics (COAS) marks]. Optics mark counter does not distinguish between backup and primary marks.
	TF GETI (next burn)	XXBXX MIN-SEC	Constraint - R2 cannot be >59B59 at this point. If TF GETI >59 min 59 sec, display is limited. N35 may be used to get full time to ignition.
	MGA (next burn)	XXX.XX DEG	MGA displayed as -00002 at this point if IMU not on and orientation known (REFSMMAT flag reset). Otherwise, MGA at GETI displayed if CSM +X axis aligned with initial thrust direction.
	OPT MODE - MAN OHC - ctr LM in SXT MARK pb - push	122	
	Accept Repeat mrk proced		If more marks desired.
	or PRO OPT MODE - CMC Go to 11	2,140 122	If sufficient marks have been made. To ensure processing of last mark, wait 15 seconds before proceeding. This allows for previous mark to be processed. If PRO done too soon, one of last two marks may be ignored.
	Reject MARK REJ pb - push Repeat mrk proced		

STA/T STEP	PROCEDURE	PANEL	REMARKS
(R23, Backup Rendezvous Tracking Sighting Mark Routine)			To perform sighting marks on LM using backup optics (COAS).
CMP 8	Key V54E	2,140	
9	FL V06 N94 SA XXX.XX DEG TA XX.XXX DEG		SA - Shaft angle (nominal = 00000). TA - Trunnion angle (nominal = 57470).
	Accept PRO Reject Key V24E Load desired data		
10	FL V53 N45 (request alt LOS mrk) Mrks (VHF/opt) XXBXX MKS		Number of marks processed by R22. Two most significant digits display VHF ranging marks. Two least significant digits display optics marks [either SXT or backup optics (COAS) marks]. Optics mark counter does not distinguish between backup and primary marks.
	TF GETI (next burn) XXBXX MIN-SEC		Constraint - R2 cannot be >59B59 at this point. If TF GETI >59 min 59 sec, display is limited. N35 may be used to get full time to ignition.
	MGA (next burn) XXX.XX DEG		MGA displayed as -00002 at this point if IMU not on and orientation known (REFSMMAT flag reset). Otherwise, MGA at GETI displayed if CSM +X axis aligned with initial thrust direction.
	RHC - Align LM in COAS ENTR		Alternate LOS mark.

(P20) CSM RENDEAVOUS NAVIGATION

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Accept Repeat mrk proced or PRO	2,140	If more marks desired. If sufficient marks have been made. To ensure processing of last mark, wait 15 seconds before proceeding. This allows for previous marks to be processed. If PRO done too soon, one of the last two marks may be ignored.
	Reject V86E Repeat mrk proced		Rejects previous mark.
	(R22, Rendezvous Tracking Data Processing Routine)		
11	Poss FL V06 N49 (2 sec priority)		Excessive update parameters. To change ΔR and ΔV threshold values, refer to 4.8.1.10.
	ΔR XXXX.X NM		
	ΔV XXXX.X FPS		
	Source code 0000X.		00001 = Optics (CMC does not differentiate between SXT and COAS marks). 00002 = VHF ranging.
	Wait 2 sec		Priority display. Will not respond to DSKY input until after 2 seconds.
	Accept PRO		Incorporates update data.
	Reject Key V32E		Does not incorporate update data. (V32E will erase mark data from positions 1, 2, and 3 if R3 = 00001.)

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 12	To term P20 & all other prog running Key V37E 00E	2,140	If V56 keyed in during computation in P34/P35, these computations will be restarted from beginning. FL V37 only if no other program active.
or	To term P20 only Key V56E		
	Poss FL V37 Key XXE		
13	Set opt cont OPT ZERO - ZERO OPT PWR - OFF RETCL BRT tw - DIM	122 100 122	

(P20) CSM RENDEZVOUS NAVIGATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.11.2.2	<u>(V83) Rendezvous Parameter Display #1 (R31)</u>		Displays CMC calculated rendezvous parameters (range, range rate, and theta).
	CMC - on (req), 4.8.1.3 ISS - on & orient known (req), 4.8.1.3 & 4.14		Required for meaningful display of theta.
CMP	1 Key V83E	2,140	
	Poss OPR ERR		If another extended verb active.
	2 FL V16 N54		Display updated at 2-second intervals.
	Range XXX.XX NM		Range and range rate based on stored state vectors. Range and range rate displays may degrade considerably at ranges below ≈0.3 to 0.5 NM depending on marking schedules and resultant CMC navigation accuracy. Once this routine has started, changes to state vector caused by optics mark or VHF sample will not be reflected in displayed parameters.
	Range rate XXXX.X FPS		(-) range rate indicates closing. This calculation not sufficiently accurate for reliable terminal closing values. It should not be utilized without good visual cues.
	Theta (lcl horiz/ CSM +X) XXX.XX DEG		Theta - Angle included between +Xsc axis and local horizontal. Angle in range 0° to 180° indicates +Xsc axis is above local horizontal plane. Total range: 0° to 360°.
	PRO Return to prog in progress		

4.11.2.2

(V83) RENDEZVOUS PARAMETER DISPLAY #1 (R31)

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.11.2.3	<u>(V85) Rendezvous Parameter Display #2 (R34)</u>	2,140	Displays CMC calculated rendezvous parameters (range, range rate, and phi).
	CM - on (req), 4.8.1.3 ISS - on & orient known (req), 4.8.1.3 & 4.14 Opt pwr up (req), 4.8.1.4		Required for meaningful display of phi. Required for meaningful display of phi.
CMP	1 Key V85E		If another extended verb active.
	Poss OPR ERR		Display updated at 2-second intervals.
	2 FL V16 N53		Range and range rate computed based on stored LM and CSM state vectors. (-) range rate indicates closing. Range and range rate displays may degrade considerably at ranges below ≈0.3 to 0.5 NM depending on marking schedules and resultant CMC navigation accuracy. Once this routine has started, changes to state vector caused by optics mark or VHF sample will not be reflected in displayed parameters.
	Range XXX.XX NM Range rate XXXX.X FPS		Phi - Angle included between optics starline of sight and a local horizontal. Angle in range 0° to 180° indicates SLOS is above local horizontal plane. Total range: 0° to 360°.
	Phi (lcl horiz/ SLOS) XXX.XX DEG		
	PRO Return to prog in progress		

(V85) RENDEZVOUS PARAMETER DISPLAY #2 (R34)

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STA/T STEP	PROCEDURE	PANEL	REMARKS
<p>4.11.2.4</p> <p>CMP 1</p> <p>2</p> <p>3</p>	<p><u>(V90) Rendezvous Out of Plane Display</u> <u>(R36)</u></p> <p>CMC - on (req), 4.8.1.3</p> <p>Key V90E</p> <p>Poss OPR ERR</p> <p>FL V04 N12 Option code 00002. CMC assumed option 0000X. (1 = CSM active; 2 = IM active)</p> <p>Accept PRO Reject V22E (load desired option)</p> <p>FL V06 N16 GET event 00XXX. HRS 000XX. MIN 0XX.XX SEC</p> <p>Accept PRO Reject Key V25E Load desired GET event</p>	<p>2,140</p>	<p>Displays CMC calculated rendezvous out-of-plane parameters (Y, Ydot, Psi) for vehicles selected in 2.</p> <p>If another extended verb active.</p> <p>GET for which out-of-plane parameters desired. N16 initialized to TIG(N33) before this display, and after recycle. (Present time indicated by all zeros.)</p>

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 4	FL V06 N90 (rndz out of plane param) Y XXX.XX NM	2,140	Y - Distance along <u>V</u> x <u>R</u> of passive vehicle.
	Ydot XXXX.X FPS		Ydot = Rate of change of Y. +, increasing; -, decreasing.
	Psi XXX.XX DEG		Psi - Angle between active vehicle orbital plane and LOS to passive vehicle projected into horizontal plane. Range: 0° to 360°.
	Accept PRO Exit R36 Reject Key V32E Return to 3 (adjust GET event)		To obtain additional data point.

(V90) RENDEZVOUS OUT OF PLANE DISPLAY (R36)

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.11.2.5	<u>(V89) Rendezvous Final Attitude (R63)</u>		Calculates final gimbal angles required to point either CSM +X axis or preferred tracking axis at LM. Provides auto maneuver to selected attitude by calling R60.
	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		
CMP 1	Key V37E OOE	2,140	R63 may be selected from P00 only.
2	Sel ISS Tot Att Disp, 4.7.2.5		Both FDAIs recommended so that either reference system (IMU or GDC) may be monitored. (CMC attitude error and rate display available.)
3	Key V89E Poss PROG alarm (4.8.1.16)		R02.
4	FL V04 N06 Option code 00003 CMC assumed option 0000X (00001 - Pref; 00002 - +X axis) Accept PRO Reject Key V22E Load desired option		
5	FL V06 N18 (computed GMBL angles) R, P, Y XXX.XX DEG Accept PRO Reject Key V32E (to update disp) or Key V34E (to term routine)		Computed required gimbal angles at selected tracking attitude (preferred or +X axis) if present IMU orientation maintained.

4.11.2.5

(V89) RENDEZVOUS FINAL ATTITUDE (R63)

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STA/T STEP	PROCEDURE	PANEL	REMARKS
	(R60, Attitude Maneuver Routine)		
CMP 6	FL V50 N18 (CMC auto request) R, P, Y XXX.XX DEG	2,140	Provides maneuver (automatic or manual) to attitude selected in 4. Required gimbal angles.
CDR	Accept SC CONT - CMC	1	
CMP	CMC MODE - AUTO PRO	2,140	
	Go to 7		
	Reject Key V62E RHC - null FDAI err needles		Provides reference for manual maneuver.
CDR	or SC CONT - SCS	1	Recomputes desired attitude without performing auto maneuver.
CMP	(or CMC MODE ≠ AUTO) PRO (to update disp) Recycle 6	2,140	
	or ENTR Exit R60		Terminates R60.
7	V06 N18 (auto mnvr) R, P, Y XXX.XX DEG		
	Mon auto mnvr on FDAI Return to 6		

(V89) RENDEZVOUS FINAL ATTITUDE (R63)

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.11.2.6	(P76) TARGET DELTA V		Provides LM maneuver parameters to CMC for updating CMC knowledge of LM state vector.
	CMC - on (req), 4.8.1.3		P76 may be performed concurrently with P20. If P20 operating, discontinue marking and ensure data incorporation complete in P20 by reviewing N45 mark counters prior to P76 state vector changes. If P76 completed prior to IM burn, delay P20 state vector updates until after LM maneuver executed.
CMP 1	Key V37E 76E	2,140	
2	FL V06 N33 GETI	OOXXX. HRS OOOXX. MIN OXX.XX SEC	
	Accept PRO Reject Key V25E Load desired GETI		
3	FL V06 N84 ΔVX, Y, Z (LM 1c1 vert)	XXXX.X FPS	
	Accept PRO Reject Key V25E Load desired data		CMC updates LM state vector and zeros mark counters.
4	FL V37 Key XXE		ROO.

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4.11.2.6

(P76) TARGET DELTA V

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NORMAL BACKUP

STA/T STEP	PROCEDURE	PANEL	REMARKS
4.12	PRETHRUSTING		
4.12.1	ORBIT CHANGE PRETHRUSTING		If P37 Return to Earth Program desired, go to 4.12.1.2.
4.12.1.1	<u>(P30) External Delta V Prethrusting</u>		Accepts targeting parameters from sources external to CMC and computes, therefrom, required velocity and other initial conditions required by CMC for execution of ΔV maneuver. Targeting parameters include time of ignition (TIG) and impulsive ΔV along CSM local vertical axes at TIG. P30 displays, to flight crew and MSFN, certain specific dependent variables associated with desired maneuver for approval by flight crew/MSFN.
	CMC - on (req), 4.8.1.3 ISS - on & orient known (desired), 4.8.1.3 & 4.14		ISS must be on and its orientation known to obtain middle gimbal display (step 5).
CMP 1	Key V37E 30E	2,140	At this point, P30 sets TRACK and UPDATE flags.
2	FL V06 N33 GETI, stored	OOXX. HRS OOXX. MIN OXX.XX SEC	
	Accept Rcd GETI PRO Reject V25E, load desired GETI		
3	FL V06 N81 (ΔV compnts) $\Delta V_X, Y, Z$ (1cl vert at GETI)	XXXX.X FPS	Stored ΔV components along local vertical axes at GETI. If P30 for estimating perilune, load N81: +00000 +00010 +00000

4.12.1.1

(P30) EXTERNAL DELTA V PRETHRUSTING

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Accept PRO Reject V25E, load desired data	2,140	PRO option resets UPDATE flag and sets external ΔV flag.
4	FL V06 N42 (calculated thrust parameters) Ha XXXX.X NM Hp XXXX.X NM ΔV (req) XXXX.X FPS Coord parameters with MSFN (if available) Accept PRO Reject Reselect P30 or P27 Load new parameters		Altitudes above launch pad radius if earth orbit or above lunar radius at most recently defined landing site. Measurements limited to 9999.9 NM. Calculated Ha and Hp in P30 considerably in error for long burns and should be ignored because parameters computed (assuming an impulsive ΔV) at time of ignition along CSM local vertical axis. ΔV magnitude of impulsive ΔV vector at GETI.
5	FL V16 N45 Mrks (VHF/opt) XXBXX MKS		Number of marks processed by R22. Two most significant digits display VHF ranging marks. Two least significant digits display optics marks [either SXT or backup optics (COAS) marks]. Optics mark counter does not distinguish between backup and primary marks.
-59:59	TF GETI (next burn) XXBXX MIN-SEC		Constraint: R2 cannot be >59B59 at this point. If TF GETI >59 min 59 sec, display limited. For full time to ignition display, use N35.
	MGA (next burn) XXX.XX DEG		MGA displayed as -00002 at this point if IMU not on and orientation known (REFSMMAT flag reset). Otherwise, MGA at GETI displayed if CSM +X axis aligned with initial thrust direction.

(P30) EXTERNAL DELTA V PRETHRUSTING

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Rcd values PRO Align GDC to IMU, 4.8.4.6	2,140	If average G on, ROO turns off average G, and zeros rendezvous mark and VHF ranging mark counters. Otherwise, counters not zeroed. ROO also sets or resets RNDZ, TRACK, and UPDATE flags, depending on which programs in progress or called. ROO may recycle into P20 under certain conditions.
6 FL V37	Key XXE		
	Go to (P40) G&N/SPS Thrusting, 4.13.2.1 or (P41) G&N/SM RCS Thrusting, 4.13.2.2 or SCS Thrusting, 4.13.3 or (P52) IMU Realign, 4.14.1.2		IMU realign should be selected if MGA unsatisfactory in step 5.

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4.12.1.1

(P30) EXTERNAL DELTA V PRETHRUSTING



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STA/T STEP	PROCEDURE	PANEL	REMARKS
	<p>4.12.1.2 <u>(P37) Return to Earth Program</u></p> <p>CMC - on (req), 4.8.1.3 ISS - on & orient known (desired), 4.8.1.3 & 4.14 SCS - on (desired), 4.8.4.2 DAP Data Load - complete (req), 4.8.2.1 (P30) External ΔV Prethrusting (if desired), 4.12.1.1</p> <p>CMP 1 Key V37E 37E 2 FL V06 N33 (GETI)</p> <p>OOXXX. HRS OOOXX. MIN OXX.XX SEC</p> <p>Accept Rcd GETI PRO Reject V25E, load desired values</p>	<p>2</p>	<p>Computes return-to-earth trajectory for CSM from outside lunar sphere of influence at TIG. P37 computes and displays preliminary series of parameters based on conic trajectory and crew-specified time of ignition, maximum change in velocity, and entry angle. Upon acceptance, P37 computes and stores target parameters for use by P40 or P41. P37 not restart protected and must be reselected if a restart occurs. P37 assumes no MSFN contact required.</p> <p>Provides two modes of operation: fuel critical and nonfuel critical. Nonfuel critical mode can be used to move landing site by adjusting maximum change in velocity.</p> <p>Desired to provide MGA display (step 10).</p> <p>Ground elapsed time of ignition.</p>

(P37) RETURN TO EARTH PROGRAM

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 3 FL V06 N60 Blank V Pred Gamma EI Accept Rcd R2 value PRO Reject V22E, V23E, or V25E Load desired values Poss PROG alarm (comp problem) FL V05 N09 00605 (solution does not converge; excessive iterations) 00612 (state vector in wrong sphere of influence) V32E RSET, return to 2	XXXXX. FPS XXX.XX DEG	2	R2 and R3 initially 00000. Maximum allowable change in velocity. To compute fuel critical trajectory, zeros should be loaded in R2. If slowdown desired, load negative value. Flight path angle between inertial velocity vector and local horizontal at entry interface altitude, 65.8 NM (400,000 feet). Minus indicates flight path below horizontal plane. If zero-loaded in R3, computation solved to hit center of entry corridor. Otherwise, computation solved to hit angle entered. Record R2 for subsequent use. Both input scaler (desired ΔV) and output scaler (entry velocity) use VPRED register of N60. Therefore, original ΔV input no longer in N60. R2 of N56 contains magnitude of original input.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	or FL V37 Key V05 N09E (to verify alarm) 20607 (no solution from time theta or time radius routine) 20610 (state vector at TIG <400K feet) KEY REL 37E, return to 2	2	Time required for transfer from GETI to time of entry at 65.8 NM (400,000 ft) above Fischer ellipsoid.
4	FL V06 N61 (entry data) Impact Lat (+N) XXX.XX DEG Impact Long (+E) XXX.XX DEG Blank Accept Rcd values PRO Reject V32E, return to 2		
5	FL V06 N39 ΔT Trans 00XXX. HRS 000XX. MIN 0XX.XX SEC Accept Rcd values PRO Reject V32E, return to 2		
6	FL V06 N60 Blank V Pred XXXXX. FPS Gamma EI XXX.XX DEG		

(P37) RETURN TO EARTH PROGRAM

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Accept Rcd values PRO Reject V32E, return to 2	2	
7	FL V06 N81 (ΔV compnts) $\Delta V_X, Y, Z$ (lcl vert at GETI) XXXX.X FPS Crew option Key N40E TF GETI XXBXX MIN-SEC VG XXXX.X FPS ΔV (accum) XXXX.X FPS		
	Rcd VG (lcl vert vel to be gained) KEY REL		
	Accept Rcd N81 values PRO If first pass, recycle to 4		
	Poss PROG alarm (comp problem) FL V05 N09 00605 (solution does not converge; excessive iterations) 00613 (re-entry angle out of limits)		
	Key V32E, return to 2		

4.12.1.2

(P37) RETURN TO EARTH PROGRAM



STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 8	FL V04 N06 (propul code) 00007 (option code) 0000X (CMC assumed option) Blank Accept PRO Go to 9 Reject V22E, load desired option Recycle 8	2	CMC initially sets 00001 in R2 to indicate data intended for SPS thrust (P40). 00002 indicates RCS (P41). DAP Data Load should be complete before PRO.
9	FL V06 N33 GETI Rcd data PRO	00XXX. HRS 000XX. MIN 0XX.XX SEC	External ΔV flag reset at this point.
N 10	FL V16 N45 (mnvr data) Mrks (VHF/opt) TF GETI MGA If IMU not aligned R3 -00002 PRO	XXBXX MKS XXBXX MIN-SEC XXX.XX DEG	Marks (VHF/optics) not meaningful to this program. MGA (+) at TIG if CSM +X axis aligned with initial thrust direction.
11	FL V37 Key XXE Go to Thrusting, 4.13		If average G on, R00 turns off average G and zeros rendezvous mark and VHF ranging mark counters. Otherwise, counters not zeroed. R00 also sets or resets RNDZ, TRACK and UPDATE flags, depending on which programs in progress or called. R00 may recycle into P20 under certain conditions.

(P37) RETURN TO EARTH PROGRAM

STA/T STEP	PROCEDURE	PANEL	REMARKS
4.12.2	RENDEZVOUS PRETHRUSTING		<p>P32 Co-elliptic Sequence Initiation (CSM active) or P72 Co-elliptic Sequence Initiation Targeting (LM active) calculates parameters associated with CSI and with either P33 or P73 Constant Delta Altitude (CDH) ΔV Maneuvers.</p> <p>Successful completion dependent upon assumptions:</p> <ol style="list-style-type: none"> Prescribed angle (E) exists at selected GETI (TPI). GETI (CDH) -GETI (CSI), and GETI (TPI) -GETI (CDH), each >10 minutes. CSI burn parallel to passive vehicle orbital plane (crew may modify), impulsive, and in active vehicle horizontal plane. CDH maneuver minimizes ΔH variations and resulting Hp >85 for EO or >5.8 NM for LO. Computed variables may be stored for later MSFN verification. <p>P32 or P72 may be performed concurrently with P20. If P20 operating, optic sighting marks on LM may be initiated by keying V57E (R21) or V54E (R23) and referring to 4.11.2.1, steps 5-7 or 8-10, respectively. Also if P20 operating, VHF ranging data state vector update may be initiated by configuring for VHF AM Ranging Mode, 4.5.6.6, and keying V87E.</p> <p>Keying V34E terminates P32 or P72 at any flashing display.</p>

4.12.2.1

(P32/P72) CO-ELLIPTIC SEQUENCE INITIATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
	CMC - on (req), 4.8.1.3 ISS - on & orient known (desired), 4.8.1.3 & 4.1		Required if P20 running and automatic state vector update desired and, if P32, for meaningful MGA display during final N45 display (step 8).
CMP 1	Key V37E 32E/72E	2,140	
2	FL V06 N11 GETI (CSI) 00XXX. HRS 000XX. MIN OXX.XX SEC		
	Accept Rcd GETI (CSI) PRO Reject Key V25E Load desired GETI (CSI)		
3	FL V06 N55 N 0000X		Future active vehicle apsidal crossing (perilune or apolune). Should load to define future crossing at which CDH maneuver should occur; e.g., 00001 = first, 00002 = second, etc.
	E XXX.XX DEG		Elevation angle at GETI (TPI).
	CENTANG 00000		Initially 00000 (except for recycle from step 5) and used by CMC as an option code. If any nonzero value loaded in R3, CMC calculates CDH parameters for GETI (CDH) at N (180°) from CSI maneuver where N specified by value set in R1.

(P32/P72) CO-ELLIPTIC SEQUENCE INITIATION

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Accept Rcd data PRO	2,140	
	Reject Key V25E Load desired data		
4	FL V06 N37 GETI (TPI)		
		OOXXX. HRS OOOXX. MIN OXX.XX SEC	
	Accept Rcd GETI (TPI) PRO		
	Go to 8		
	Reject Key V25E Load desired GETI (TPI)		
5	CMC Computes CSI & CDH parameters		
	Poss FL V05 N09		
	00600 no solution of LOS at TPI		
	00601 post CSI Hp <5.8 NM (<85 NM for EO)		
	00602 post CDH Hp <5.8 NM (<85 NM for EO)		
	00603 CDH -CSI <10 min		
	00604 TPI -CDH <10 min		
	or Computed GETI (CDH) >input GETI (TPI) in step 4		
	00605 no solution & CMC iterations >15		

4.12.2.1

(P32/P72) CO-ELLIPTIC SEQUENCE INITIATION

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	00606 CSI ΔV >1000 fps (for two consecutive iterations) Key V32E Return to 2 FL V06 N75 Δ Alt (CDH) XXXX.X NM ΔT (CDH -CSI) XXBXX MIN-SEC ΔT (TPI -CDH) XXBXX MIN-SEC Rcd values PRO	2,140	To adjust input parameters. Maximum reading (displayed) in R2 and R3 is 59B59. Only minutes and seconds displayed although time computation done in hours, minutes, and seconds. Computed CDH and TPI times can be determined by calling N13 and N37, respectively.
6	FL V06 N81 ΔVX, Y, Z (lcl vert) XXXX.X FPS Accept Rcd values PRO Reject Key V25E Load desired values		CMC calculated components of ΔV (in local vertical coordinates) for CSI. To modify ΔV (local vertical) to correct for out of planeness, key V90E (R36). Use data obtained from R36 to determine desired ΔV (local vertical). Modification will not impact N82 of step 7.
7	FL V06 N82 ΔVX, Y, Z (lcl vert) XXXX.X FPS Rcd values PRO		CDH velocity components based on original CSI values of step 6, and cannot be written over.
8	FL V16 N45 Mrks XXBXX MKS		Number of marks processed by R22. Two most significant digits display VHF ranging marks. Two least significant digits display optics marks [either SXT or backup optics (COAS) marks].

(P32/P72) CO-ELLIPTIC SEQUENCE INITIATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	TF GETI (CSI)	XXBXX MIN-SEC 2,140	Time from CSI ignition. Maximum reading is 59B59. -, before; +, after.
	MGA	-0000X	-00001 for other than final pass. -00002 for final pass (and IMU not aligned if P32).
	Or IMU ALIGNED & P32	+XXX.XX DEG	Middle gimbal angle (yaw): +XXX.XX DEG for final pass and IMU aligned (if +X axis aligned to initial thrust direction).
	To continue mrk process Key V32E Return to 5		
	or To term mrk process & do fnl pass thru prog PRO Return to 5		
	or After fnl pass thru prog PRO		
9	FL V37 Key XXE		ROO.

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4.12.2.1

(P32/P72) CO-ELLIPTIC SEQUENCE INITIATION

STA/T STEP	PROCEDURE	PANEL	REMARKS
4.12.2.2	<u>(P33/P73) Constant Delta Altitude</u>		<p>P33 Constant Delta Altitude (CSM active) or P73 LM Constant Delta Altitude Targeting (LM active) computes parameters associated with CDH maneuver. Successful completion dependent upon prior completion of P32 for P33, or P72 for P73.</p> <p>P33 or P73 may be performed concurrently with P20. If P20 operating, optic sighting marks on LM may be initiated by keying V57E (R21) or V54E (R23) and referring to 4.11.2.1, steps 5-7 or 8-10, respectively. Also if P20 operating, VHF ranging data state vector update may be initiated by configuring for VHF AM Ranging Mode, 4.5.6.6, and keying V87E.</p> <p>Keying V34E terminates P33 or P73 at any flashing display.</p> <p>Required if P20 running and automatic state vector desired and, if P33, for meaningful MGA display during final N45 display in step 5.</p> <p>P33 or P73 computations based upon GETI (TPI), and elevation angle (E) defined in P32 or P72.</p>
	<p>CMC - on (req), 4.8.1.3 ISS - on & orient known (desired), 4.8.1.3 & 4.14</p> <p>If P33 - P32 (complete), 4.12.2.1 If P73 - P72 (complete), 4.12.2.1</p>		
CMP	<p>1 Key V37E 33E/73E</p> <p>2 FL V06 N13 GETI (CDH)</p> <p>OOXX. HRS OOXX. MIN OXX.XX SEC</p>	2,140	

(P33/P73) CONSTANT DELTA ALTITUDE

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Accept Rcd GETI (CDH)	2,140	
	PRO		
	Go to 5		
	Reject Key V25E		
	Load desired GETI (CDH)		
	3 CMC computes CDH parameters		
	Poss FL V05 N09		
	00611 (No GETI for given E)		
	PRO, go to FL V06 N75		
	or Key V32E, return to 2		
FL V06 N75			
Δ Alt (CDH)	XXXX.X NM		
ΔT (TPI -CDH)	XXBXX MIN-SEC		
ΔT (TPI -TPI)	XXBXX MIN-SEC		
Rcd values			
PRO			
4 FL V06 N81			
ΔVX, Y, Z (lcl vert)	XXXX.X FPS		
Accept Rcd values			
PRO			
Reject Key V25E			
Load desired values			

To force GETI (CDH) solution.

To adjust input parameters.

Maximum reading (displayed) in R2 and R3 is 59B59. Only minutes and seconds displayed although time computation done in hours, minutes, and seconds.

TPI computed minus TPI computed in P32 or P72. TPI time, computed in P33 or P73, can be determined by calling N37.

CMC calculated components of ΔV (in local vertical coordinates) for CDH.

To modify ΔV (local vertical) to correct for out of planeness, key V90E (R36). Use data obtained from R36 to determine desired ΔV (local vertical).

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 5	FL V16 N45 Mrks	2,140	Number of marks processed by R22. Two most significant digits display VHF ranging marks. Two least significant digits display optics marks [either SXT or backup optics (COAS) marks].
	XXBXX MKS		
	TF GETI (CDH)	XXBXX MIN-SEC	Time from CDH ignition. Maximum reading is 59B59. -, before; +, after.
	MGA	-0000X	-00001 for other than final pass. -00002 for final pass (and IMU not aligned if P33).
	Or IMU ALIGNED & P33	+XXX.XX DEG	Middle gimbal angle (yaw): +XXX.XX DEG for final pass and IMU aligned (if +X axis aligned to initial thrust direction).
	To continue mrk process Key V32E Return to 3		
	or To term mrk process & do fnl pass thru prog PRO Return to 3		
	or After fnl pass thru prog PRO		
6	FL V37 Key XXE	ROO.	

(P33/P73) CONSTANT DELTA ALTITUDE

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STA/T STEP	PROCEDURE	PANEL	REMARKS
<p>4.12.2.3</p> <p>CMC - on (req), 4.8.1.3 ISS - on & orient known (desired), 4.8.1.3 & 4.14</p> <p>CMP 1 Key V37E 34E/74E</p> <p>2 FL V06 N37 GETI (TPI)</p>	<p><u>(P34/P74) Transfer Phase Initiation</u></p> <p>OOXX. HRS OOXX. MIN OXX.XX SEC</p>	<p>2,140</p>	<p>P34 Transfer Phase Initiation (CSM active) or P74 LM TPI Targeting (LM active) calculates required ΔV and other initial conditions required by CMC for CSM execution (P34), or by LGC for LM execution (P37), of TPI maneuver, given:</p> <ol style="list-style-type: none"> a. Time of ignition, GETI (TPI), or elevation angle (E) of active-to-passive LOS at GETI (TPI). b. Central angle of transfer (CENTANG) of passive vehicle from GETI (TPI) to time of intercept. c. Calculates GETI (TPI) given E, or E given GETI (TPI). <p>P34 or P74 may be performed concurrently with P20. If P20 operating, sighting marks on LM may be initiated by keying V57E (R21) or V54E (R23) and referring to 4.11.2.1, steps 5-7 or 8-10, respectively. Also if P20 operating, VHF ranging data state vector update may be initiated by configuring for VHF Ranging Mode, 4.5.6.6, and keying V87E.</p> <p>Required if P20 running and automatic state vector desired and, if P34, for meaningful MGA display during final N45 display (step 8).</p>

4.12.2.3

(P34/P74) TRANSFER PHASE INITIATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Key V25E Load desired GETI (TPI) Rcd GETI (TPI) PRO	2,140	Load desired GETI (TPI) if CMC computation of E desired. For a specified value of E and CMC computation of GETI (TPI), load an initial value of GETI (TPI). Loaded value should be within 30 minutes of actual.
3	FL V06 N55 NN E CENTANG Accept Rcd CENTANG & E PRO Go to 8 Reject Key V25E Load desired data	0000X. XXX.XX DEG XXX.XX DEG	Integration method and number of precision offset computations desired. NN initially 0. Elevation angle. Central angle of passive vehicle from GETI (TPI) to time of intercept.
4	If E specified (CMC computes GETI) Poss FL V05 N09 00611 (no GETI for given E) PRO Return to 2 (adj input parameters)		Load desired NN in R1: 0, conic integration; X, precision integration with (X) target offsets. Desired E in R2, CMC computes GETI (TPI). +00000 in R2, CMC computes E.

(P34/P74) TRANSFER PHASE INITIATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	FL V06 N37 GETI (TPI)	2,140	
		00XXX. HRS 000XX. MIN OXX.XX SEC	
	Rcd GETI (TPI) PRO Go to 5		
	or If +00000 specified for E (CMC computes E) FL V06 N55 NN	0000X.	Integration method and number of precision offset computations desired.
	E CENTANG	XXX.XX DEG XXX.XX DEG	CMC computed E.
	Rcd E PRO		
5	FL V06 N58 Hp	XXXX.X NM	Perigee altitude above launch pad radius for earth orbit, or perilune altitude above landing site radius for lunar orbit, after TPI maneuvers. Display meaningless if Hp >9999.9 NM.
	ΔV (TPI)	XXXX.X FPS	Required impulsive ΔV to accomplish TPI maneuver at GETI (TPI).

4.12.2.3

(P34/P74) TRANSFER PHASE INITIATION

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	AV (TPF) XXXX.X FPS Rcd data PRO If not fnl pass, go to 7	2,140	Required impulsive AV to accomplish intercept maneuver (TPF) at calculated time of intercept. To obtain central angle of active vehicle, key V06 N52.
6	FL V06 N81 (fnl pass only) AVX, Y, Z (lcl vert) XXXX.X FPS Accept Rcd AV (lcl vert) PRO Reject Key V25E Load desired AV (lcl vert)		Required impulsive AV components in active vehicle local vertical coordinates. To modify AV (lcl vert) to correct for out of planeness, key V90E (R36). Use data obtained from R36 to determine desired AV (local vertical).
7	FL V06 N59 AV 1, 2, 3 (LOS) XXXX.X FPS Rcd AV (LOS) PRO		Required impulsive AV components in an orthogonal coordinate system oriented along CSM to LM LOS in P34, or along LM to CSM LOS for P74. (For complete definition, refer to GSOP section 5.4.2.2 of R577.)
8	FL V16 N45 Mrks TF GETI (TPI) MGA	XXBXX MKS XXBXX MIN-SEC -0000X	Number of marks processed by Rendezvous Data Processing Routine, R22. Two most significant digits display VHF ranging marks. Two least significant digits display optics marks [either SXT or backup optics (COAS) marks]. Time from ignition. Max reading is 59B59. -, before; +, after. -00001 for other than final pass. -00002 for final pass (and IMU not aligned in P34).

(P34/P74) TRANSFER PHASE INITIATION

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	<p>Or IMU ALIGNED & P34 +XXX.XX DEG</p> <p>To continue mrk process Key V32E Return to 4</p> <p>or To term mrk process & do fnl pass thru prog PRO Return to 4</p> <p>or After fnl pass thru prog PRO If P74, xmit all mnvr parameters to LM</p> <p>9 FL V37 Key XXE</p>	2,140	<p>Middle gimbal angle (yaw): +XXX.XX DEG for final pass and IMU aligned (if +X axis aligned to initial thrust direction).</p> <p>ROO.</p>

STA/T STEP	PROCEDURE	PANEL	REMARKS
4.12.2.4	<u>(P35/P75) Transfer Phase Midcourse</u>		P35 Transfer Phase Midcourse (CSM active) or P75 TPM Targeting (LM active) calculates required ΔV and other initial conditions required by CMC for CSM (P35), or by LGC for LM (P75), execution of next midcourse correction of transfer phase.
	CMC - on (req), 4.8.1.3 If P35 - P34 (complete), 4.12.2.4 If P75 - P74 (complete), 4.12.2.4		P35 or P75 may be performed concurrently with P20. If P20 operating, sighting marks on LM may be initiated by keying V57E (R21) or V54E (R23) and referring to 4.11.2.1, steps 5-7 or 8-10, respectively. Also if P20 operating, VHF ranging data state vector update may be initiated by configuring for VHF Ranging Mode, 4.5.6.6, and keying V87E.
	ISS - on & orient known (desired), 4.8.1.3 & 4.14		Time of intercept computed and stored by P34 (P74) required for P35 (P75) computations. Type of integration (conic or precision) and number of offsets determined by P34 (P74) computations.
CMP 1	Key V37E 35E/75E Go to 4	2,140	Required if P20 running and automatic state vector desired and, if P35, for meaningful MGA display during final N45 display (step 4).
2	FL V06 N81 (fml pass only) ΔV X, Y, Z (lcl vert) XXXX.X FPS Accept Rcd ΔV (lcl vert) PRO Reject Key V25E Load desired ΔV (lcl vert)		Required ΔV components in active vehicle local vertical coordinates. To modify ΔV (local vertical) to correct for out of planeness, key V90E (R36). Use data obtained from R36 to determine desired ΔV (local vertical).

(P35/P75) TRANSFER PHASE MIDCOURSE

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 3	FL V06 N59 ΔV 1, 2, 3 (LOS)	XXXX.X FPS	2,140
	Rcd ΔV (LOS PRO		Required impulse ΔV components in an orthogonal coordinate system oriented along CSM to LM LOS (P35) or along LM to CSM LOS (P75). (For complete definition refer to GSOP section 5.4.2.3 of R577.) To obtain active vehicle central angle, key V06 N52.
4	FL V16 N45 Mrks	XXBXX MKS	Number of marks processed by R22. Two most significant digits display VHF ranging marks. Two least significant digits display optics marks [either SXT or backup optics (COAS) marks].
	TF GETI (TPM)	XXBXX MIN-SEC	Time from ignition (update at 1-second intervals). Max reading is 59B59; -, before; +, after. GETI (TPM) recomputed as Tnow +A (+B for P75) for each recycle and again when final pass selected (PRO). Value of A (B for P75), stored in erasable memory, may be changed by using procedure 4.8.1.11, by P27 update, or by prelaunch erasable load.
	MGA	-0000X	-00001 for other than final pass. -00002 for final pass (and IMU not aligned in P35).
	Or IMU ALIGNED & P35	+XXX.XX DEG	Middle gimbal angle (yaw): +XXX.XX DEG for final pass and IMU aligned (if +X axis aligned to initial thrust direction)
	To continue mrk process Key V32E Return to 3		

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP or To term mrk proced & do fnl pass thru prog PRO Return to 2		2,140	
or After fnl pass thru prog PRO If P75, xmit all mnvr parameters to LM			
5 FL V37 Key XXE			ROO. [Faint, illegible text in the Remarks column]

(P35/P75) TRANSFER PHASE MIDCOURSE

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.13 THRUSTING	4.13.1 VEHICLE PREPARATION		For general G&C operating data, refer to operating notes 4.6.1.
	(Proced not designated "req" are optional)		
	1 For orb change		
	Obtain update from MSFN		
	Gas Separator Cartridge Prep (req)		
	Remove separator from water pistol & stow temporarily in LEB stowage bag		
	Assure separator on food prep unit secured with bayonet locks		
	Install outlet cap on food prep unit separator		
	SPS & SM RCS Checks, 4.5.2.1 & 4.5.2.2		
	EPS DC & AC Checks, 4.5.3.3 & 4.5.3.4		
	Press Suit Ckt & PGA Check at 5.0 psia, 4.5.4.9 (if req)		
	C&WS Oper Check, 4.5.5.1		
	CMC Self Check, 4.8.1.7		
	DSKY Condition Lt Check, 4.8.3.1		
	If undocked from LM		
	Dry tunnel		If necessary, absorb water with towel. Condensed moisture in tunnel rains on crew during thrusting.
	ΔV Test & Null Bias Check, 4.7.6.1		In-flight verification of X-axis accelerometer output, ΔV indicator, SPS THRUST light, and thrust cutoff relay in EMS.
	2 For deorbit or lunar ret		
	Deorbit or Lunar Ret Veh		
	Prep, 4.15.1 (req)		

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THRUSTING



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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.13.2	<p>G&N THRUSTING</p> <p>4.13.2.1 <u>(P40) G&N SPS Thrusting</u></p> <p>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</p> <p>Test C/W lamps DAP - load & activate, including ull sel, 4.8.2.1</p>		<p>Computes preferred CSM attitude and IMU orientation for SPS thrust.</p> <p>Calculates and displays gimbal angles which would result if present IMU orientation used for thrust in preferred vehicle attitude (function of R60 computations). Crew then decides whether to thrust at present IMU orientation or to reorient IMU using P52/P54.</p> <p>Maneuvers CSM to thrust attitude (R60); controls GNCS during SPS thrust countdown, ignition, thrust, and thrust termination; and allows residual steering error trimming.</p> <p>G&C circuit breakers on all panels should be closed except as defined in Limited Use Controls, 4.6.4.</p> <p>SPS trim values should be reviewed now for use at beginning of P40 in computing preferred IMU orientation and final vehicle attitude. SPS trim values are updated during CMC-controlled burn. If a roll jet fails on during SPS thrust, an appreciable roll excursion ($\approx 30^\circ$) may occur. PITCH-YAW DAP will continue to function properly.</p>

(P40) G&N SPS THRUSTING

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STA/T STEP	PROCEDURE	PANEL	REMARKS
	<u>WARNING</u>		
	Experiments must be retracted prior to SPS thrust. Prevents poss boom or track structural failure.		
	Gamma ray & mass spectrometer booms, & map camr tracks - retracted (req), 4.18.3.2, 4.18.3.4, & 4.18.3.6		
	If experiments S163 & S166 not complete		
	Pan camr boost mode - on (req), 4.18.9.1, step 1		
	Map camr stby mode - on (req), 4.18.12.2, step 1		
	Prethrust prog (req), 4.12		
	Veh prep (req), 4.13.1		
CMP	1 AV Setup, 4.7.6.2 OPT ZERO - ZERO (verify)	122	Prevents optics drift during TVC use of OCDUs.
	2 Key V37E 00E	2	POO updates state vector periodically.
	3 Key V37E 40E		TFI available (prior to step 10) by keying V16 N35E or V16 N40E.
	Poss PROG alarm (4.8.1.16)		R02. If no alarms at this point (after R02 exited), CMC computes initial thrust direction and initial value of VG (local vertical), computes preferred IMU orientation, and sets PFRATFLG (preferred attitude flag) and stores desired attitude for use in R60. Final attitude computed in R60, gimbals trimmed for initial thrust, and 0.5-degree deadband set in RCS DAP.

4.13.2.1

(P40) G&N SPS THRUSTING

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	4 If VG disp desired Key V06 N81E VGX, Y & Z XXXX.X FPS (1cl vert at GETI) (R60, Attitude Maneuver)	2	Display available until average G turned on (GETI minus 30 seconds). Maneuvers CSM to attitude stored in P40. Maneuver performed automatically by G&N, or manually with an optional final automatic G&N-controlled trim maneuver.
	5 FL V50 N18 (sel CMC - auto) R, P, Y XXX.XX DEG Establish tot att disp, 4.7.2.5		Desired final gimbal angles. Both FDAIs should be selected to provide redundant displays.
CDR	Accept BMAG MODE (3) - RATE 2 CMC Att Cont - auto, 4.7.1.6	1	Prevents BMAGs from hitting stops during maneuvers.
CMP	PRO Reject Sel desired Att Cont, 4.7.1 Mnvr to thrust att ENTR - Go to 7	2	PRO initiates auto maneuver without reviewing final gimbal angles. If review desired prior to auto maneuver, reject option should be selected. If desired, attitude set control panel can then be set to final gimbal angles to provide attitude error information for completion of maneuver manually if G&N fails.
	6 Auto mnvr V06 N18 (fnl att) R, P, Y XXX.XX DEG		Angles obtained from a VECPOINT calculation. Maneuver rate is as last defined by DAP load.
CDR,CMP	Mon FDAIs If RHC used or SCS sel, go to 7	1,2	CSM began maneuver to final attitude when PRO keyed in step 5. Refer to 4.6.1.3, note 1b.

(P40) G&N SPS THRUSTING

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 7	FL V50 N18 (att trim enbl) R, P, Y XXX.XX DEG	2	Final trim maneuver should be considered essential to SPS ΔV attitudes. Display of final gimbal angles remains in registers. Final attitude trim maneuver performed after gimbal drive and trim check.
8	Ign prep		Sets up nontime-critical switching required for thrust. If necessary for deorbit, MSFN dumps and rewinds tape recorder, and changes to HBR.
	<u>CAUTION</u>		
	If either bat bus A(B) current fails to incr after cycling MN BUS TIE sws, configure bats to mn buses using cb BAT C TO BAT BUS A(B) & cb MNA(B) BAT C as necessary.	250	Assumes reconfiguration BAT C to MNA(B) for orbit change; BAT A(B) and BAT C to MNA(B) for deorbit.
LMP -10:00	MN BUS TIE BAT A/C - on (up) Verify bat bus A current incr &/or bat volt decr	5 3	Verification of current increase for appropriate battery bus via DC AMPS indicator (panel 3) confirms successful operation of main bus tie motor switches. MN BUS TIE BAT A/C and B/C switches at on provide two batteries on line for orbit change if cb MNA & B BAT C (2) - open, or three batteries on line for deorbit and entry if circuit breakers closed (panel 275).
	MN BUS TIE BAT B/C - on (up) Verify bat bus B current incr &/or bat volt decr	5 3	
	SPS He VLV tb (both) - bp SPS He VLV (both) - AUTO	3	Barber pole indicates helium isolation valves closed.
CDR	RHC PWR DIR (both) - OFF SC CONT - CMC CMC MODE - AUTO	1	

STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	SCS TVC (2) - RATE CMD	1	Provides rate damped manual TVC as backup to G&N, if THC - CW. SCS auto or MTVC acceleration command optional, but less desirable backup modes.
	BMAG MODE (3) - ATT 1/RATE 2 RATE - LO ATT DBD - MIN TVC GMBL DR (2) - AUTO		
9	Gmb1 drive & trim check		PITCH and YAW GMBL caution/warning lights (panel 2) indicate overcurrent to actuator motors.
	cb SPS PITCH 1 BAT A - close (verify)	8	Remain closed from launch through first SPS thrust and closed again for each subsequent SPS thrusting.
	cb SPS YAW 1 BAT A - close (verify)		
	TVC SERVO PWR 1 - AC1/MNA	7	
	TVC SERVO PWR 2 - AC2/MNB		
	THC PWR - on (up)	1	Opens RHC 2 (commander's) breakout switch (dc circuits) to prevent attitude maneuvers through CMC during MTVC checks. During burn, RCS DAP disabled at SPS engine ignition (TFI = 0).
	RHC PWR NORM 2 - AC		
	RHC 2 - ARMED		
-05:00	GMBL MOT P1 & Y1 - START		START position is momentary. Also refer to 4.6.1.1, note 11.
	Auto switchover check		
	THC - CW		Enables MTVC and switches TVC to channel 2.
	RHC - verify no MTVC cont		
	GMBL POS ind (4) - no motion		Verifies TVC switches from channel 1 to channel 2 (which is off) when THC CW selected.
	Sec TVC check		
	GMBL MOT P2 & Y2 - START		START position is momentary.
	Confirm & set trim cont		Verifies secondary gimbal trim control.
	SPS GMBL tw (2) - + & -		
	Set to c.g. trim values		Trim values obtained from DAP Data Load (4.8.2.1) or MSFN.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	RHC 2 - Verify MTVC		Gimbals drive in response to RHC movement and return to set-in values when RHC neutral. Verifies control of secondary MTVC loops through RHC. Gimbals move proportional to RHC deflection since MTVC integrator not enabled until engine ignition.
	THC - neut RHC PWR NORM 2 - AC/DC	1	
	Accept Complete auto att trim		Accept and reject options refer to attitude trim enable flash N50 N18 in step 7.
	BMAG MODE (3) - RATE 2 Align CSM in roll CMC Att Cont - Auto, 4.7.1.6 PRO	2	
CMP	Returns to V06 N18 disp of 6		Does not imply that any previous checks need be repeated for each trim enable.
	Reject Sel desired Att Cont, 4.7.1 Verify/mnvr to thrust att (V62E for tot att err disp)		
CDR	RHC PWR DIR (both) - MNA/MNB	1	Enables manual direct RCS for overriding an auto RCS roll failure during thrusting.
	MAN ATT (3) - RATE CMD RATE - HI		If MTVC required, RATE - HI bypasses noise problem in SCS gyro assemblies because of thrusting vibration levels, which can cause spurious RCS roll jet firings.
	BMAG MODE (3) - ATT 1/RATE 2		
	or If RATE 1 ΔV planned BMAG MODE PITCH - RATE 1 BMAG MODE YAW - RATE 1		RATE 1 ΔV should be used for burns where angular change >15° or if gyro assembly 2 failed.
	or BMAG MODE (in axis) - RATE 1		

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	Align GDC to IMU if necessary, 4.8.4.6	2	DSKY display option recommended because of its availability - only need to set ATT SET thumbwheels to DSKY values and defer alignment until just prior to thrust.
CMP	Check boresight star ENTR (exit R60)		
10 FL V50 N25	00204 (CMC GMBL drive test)		Manual drive, trim and MTVC check accomplished before CMC gimbal drive test enabled (PRO keyed).
	Accept PRO Mon GMBL drive seq		
	Reject ENTR GMBLs drive to trim position (after 4 sec)		If gimbal test sequence not desired, gimbals drive to trim 4 seconds after ENTR keyed.
11 V06 N40	TF GETI XXBXX MIN-SEC VG XXXX.X FPS ΔV (accum) XXXX.X FPS		TF GETI max reading is 59B59. Sign minus before nominal GETI, plus after. Event Timer will not agree with R1 if GETI was slipped.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR 12 -02:00	2-min countdown Report TF GETI = 2 min FDAI SCALE - 5/5 ΔV THRUST A(B) - NORM THC - ARMED	1	Guarded.
CDR,CMP -00:40 CMP	RHC (both) - ARMED (R41, State Vector Integration) If PROG lt - on, CMC slipped TIG DSKY R1 continues count to former TIG DSKY clears at new TIG -35 sec COMP ACTY lt - out (exit R41)	2	May illuminate between TIG -42.5 and -35 seconds. TIG slipped delta amount as required by CMC to complete state vector integration.
-00:35	DSKY clears		
-00:30	VO6 N40 (ave G on) Check ΔV (accum) for PIPA bias R3 ≤0002.0 FPS		Static display, with COMP ACTY lt flash every 2 seconds. G&N controlled burns unreliable if R3 >0002.0 FPS.
LMP	If orb change UP TLM CMD - RSET then NORM PCM BIT RATE - HI	3	
CDR	TAPE RCDR FWD - FWD EMS MODE - NORM	1	4.6.1.1, note 9.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR -00:29 to -00:06	Perform ull if req		No ullage required if sump tanks full. CSM/LM or CSM 2 or 4 jet ullage times defined in SNA-8-D-027 CSM Data Book, Vol I. Retain ullage for ≈1 second after ignition. Exact velocity change not critical - only a steady ullage to settle SPS propellants.
	XXXXXXXXXXXXXXXXXXXXXXXXXXXXX X		
	No ull DIR ULL pb - push, hold RHC - cont att	1	Direct ullage inhibits pitch and yaw auto RCS. Maintain attitude within deadband limits.
	XXXXXXXXXXXXXXXXXXXXXXXXXXXXX X		
-00:05 CMP 13	FL V99 N40 (eng enbl) TF GETI XXBXX MIN-SEC VG XXXX.X FPS ΔV (accum) XXXX.X FPS	2	CMC changes V06 to V99, but retains previous display in registers. Do not exercise extended verb or monitor displays for extended periods during TVC; these displays can override a FL V97 N40 (low thrust) display. Override indicates CMC thinks engine off, steering stopped (including cutoff computations), and attitude hold established.
	Accept PRO Go to 14 Reject ENTR, go to 16 as req & 17 Man trim with RCS		If ENTR option selected, post SPS burn switching in step 16 must be accomplished.
	or V34E FL V37 Key XKE		If average G on, ROO turns off average G, zeros rendezvous mark and VHF ranging mark counters. Otherwise counters not zeroed. ROO also sets or resets RNDZ, TRACK, and UPDATE flags, depending on which programs in progress or called.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR 14 00:00	Ign SPS THRUST lt - on	1	If LM off, CMC will not accept V46 or V48 during TVC. If LM on, CMC will accept V46 as cue for low bandwidth mode (decreases control required response because of off-nominal bending moments).
CMP	VO6 N40 TFC VG (decr) ΔV accum (incr)	2	Time from engine cutoff. Sign (-) before cutoff, (+) thereafter. TFC display discontinuous for 4 to 5 seconds after ignition.
CDR	ΔV ind - decr	1	
CMP	Poss PROG alarm Key V05 NO9E (to verify alarm) 01407 (VG incr)	2	
IGN+1 sec CDR	Discontinue ull		RCS X-axis translation discontinued by program 2 seconds after engine-on command. RCS DAP disabled at ignition.
IGN+2 to 5 sec	ΔV THRUST (2) - NORM (if desired)	1	Guarded. For dual bank operation.
	XXX If no ign or premature shutdown		Engine restart should not be attempted within 5 seconds from initial ignition - avoids undesirable helium pressure excursions.
	Continue ull ΔV THRUST (2) - NORM Recycle 14		Guarded.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
LMP	<p>OXID FLOW VLV INCR - as req SPS OXID VLV tb - verify</p> <p>XXX X No SPS OXID VLV tb response during flow adj OXID FLOW VLV INCR - NORM Wait 6 sec OXID FLOW VLV PRIM - SEC OXID FLOW VLV INCR - as req OXID FLOW VLV tb - verify</p> <p>No SPS OXID VLV tb response during flow adj in prim & sec modes</p> <p><u>CAUTION</u></p> <p>Do not use sec oxid flow vlv with prim vlv functioning properly. Failure of sec vlv could result in loss of prplnt mgmt capability.</p> <p>OXID FLOW VLV INCR - NORM Wait 6 sec OXID FLOW VLV PRIM - PRIM OXID FLOW VLV INCR - as req</p> <p>X XXX X</p>	3	<p>Switch position determined by SPS oxidizer unbalance. Continue monitoring SPS OXID UNBAL indicator.</p> <p>Continue monitoring SPS OXID UNBAL indicator and control oxidizer flow with OXID FLOW VLV PRIM switch in SEC position until thrusting completed.</p> <p>Probable SPS OXID VLV talkback failure.</p> <p>SPS OXID UNBAL indicator trend may be used to confirm valve position.</p>

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STA/T STEP	PROCEDURE	PANEL	REMARKS
	<u>CAUTION</u>		
CDR	If noncritical burn & $\Delta P > 20$ psi AV THRUST (2) - OFF	1	ΔP between fuel and oxidizer should not exceed 20 psi during burn or degraded performance, rough combustion, and/or engine failure may result.
16	Deorbit SPS mon		SPS OXID unbalance indicator erratic for about 25 seconds after ignition.
	Pc ind - 95-105 psia		65 to 125 percent green range on indicator corresponds to psia. Normal Pc range 95-105 psia.
LMP	SPS INJ VLV ind (4) - OPEN SPS He VLV tb (both) - gray SPS FUEL & OXID PRESS ind (2) - 170-195 psia	3	All four injector valves open for dual-bank operation. Gray indicates helium isolation valves open.
CDR or CMP 17	FDAI - mon err & rates	1,2	Monitoring for possible required MTVC takeover.
CDR	XXX X MTVC takeover THC - CW Maintain att cont man		
	or AV THRUST (2) - OFF Damp rates to IMU ball or out window Reorient & hold thrust att THC - CW AV THRUST A(B) - NORM	1	Guarded. Guarded.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	FL V16 N40 (eng cutoff) TFC (static at 2.5 sec from cutoff) VG ΔV (accum)	2	Time from cutoff. At cutoff +2.5 seconds, CMC sets wide deadband in RCS DAP. Then CMC switches from TVC DAP to RCS DAP at cutoff +3.1 seconds.
CDR C/O+1 sec	EVNT TMR ind - 59:59 (-) thrust duration ΔV THRUST (2) - OFF SPS THRUST - NORM (verify) Report eng off Pc = 0	1	Timer normally counts down from 59:59. Guarded. Lever lock.
LMP C/O +2.5 sec	SPS INJ VLV ind (4) - CLOSE SPS He VLV tb (both) - bp	3	Barber pole indicates helium isolation valves closed.
CDR	GMBL POS ind (4) - servo null For postorbit change free drift BMAG MODE (3) - RATE 2 CMC MODE - FREE GMBL MOT P2 & Y2 - OFF GMBL MOT P1 & Y1 - OFF If MTVC THC - neut TVC SERVO PWR (both) - OFF If orb change cb SPS PITCH 1 BAT A - open cb SPS YAW 1 BAT A - open	1 7 8	CMC removes TVC enable discrete (C/O indicated by TFC sign change and VG → 0). 4.6.1.1, note 11. To prevent possible reignition (if G&N thrust-on command still present), ΔV THRUST switches must be OFF prior to THC - neutral.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	If deorbit cb SPS PITCH (both) - open cb SPS YAW (both) - open	8	
	EMS MODE - STBY	1	4.6.1.1, note 9.
LMP	If orb change PCM BIT RATE - LO	3	
CDR	Rcd ΔV ind	1	
CMP	PRO	2	CMC sets minimum deadband in RCS DAP.
19	FL V16 N85 (VG vctr compnt) VGX, Y, Z (cont) XXXX.X FPS		Velocity to be gained resolved along CSM X, Y, and Z control axes (updated each computation cycle).
CDR	If VG compnt to be nulled CMC MODE - AUTO or HOLD RHC/THC - null out VG compnt THC - neut, LOCKED If orb change RHC - LOCKED	1	Optional. All AUTO RCS switches must be on for nulling residuals in 3 axis.
LMP	If deorbit TAPE RCDR FWD - off (ctr)	3	
CMP	If R30 desired Key V82E Go to 20	2	
	To term P40 PRO Go to 21		CMC sets last specified R03 deadband in RCS DAP.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 20 FL V16 N44 Ha Hp TFF If Hp > 49.4 NM/5.8 NM R3 = -59B59 PRO (exit R30) Return to 19	(R30, Orbital Parameter Display) XXXX.X NM XXXX.X NM XXBXX MIN-SEC	2	Altitudes above launch pad radius (earth orbit) or lunar radius at most recently defined lunar landing site (lunar orbit). Parameter calculations yield reasonable results if vehicle close to earth or moon. Time of free fall to 49.4 NM (300,000 feet) above launch pad radius (earth orbit) or 5.8 NM (35,000 feet) above lunar radius at most recently defined lunar landing site (lunar orbit). If TFF = -59B59, time from perigee or perilune available via N32E.
21 FL V37 If orb change Key XXE Set conts after tailoff LMP MN BUS TIE (2) - OFF		5	If average G on, ROO turns off average G, and zeros rendezvous and VHF ranging mark counters. Otherwise counters not zeroed. ROO also sets or resets RNDZ, TRACK, and UPDATE flags, depending on which programs in progress or called. Under certain conditions, ROO may recycle into P20. Monitor main bus voltage for maximum allowable (31 vdc) during power down sequence.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
LMP	<p>XXX X If MN BUS TIE fail prior to thrust Leave MN BUS TIE BAT B/C(A/C) - on (up) Go to EPS SSR-2, BAT BUS A(B) reconfig for subsequent mn bus ties XXX X</p>	5	<p>Circuit breakers used to reconfigure for subsequent bat bus operation and battery charging procedures in place of opening (known) good main bus tie motor switches.</p>
CMP	Rcd burn data		<p>Recorded burn data should include ΔV accomplished and SPS propellant quantity remaining.</p>
CDR	<p>EMS FUNC - OFF THC PWR - OFF RHC PWR DIR (both) - OFF</p>	1	
LMP	<p>If pan & map camr in stby mode PAN CAMR PWR - OFF MAP CAMR ON - OFF</p>	230	
CMP	<p>SM/AC PWR - OFF Chg bats, 4.5.3.5 If last MCC & lunar return, or TLI abort Go to Deorbit or Lunar Return Veh Prep, 4.15.1, prior to entry</p>	181	
	<p>or If deorbit Rcd burn data Key 61E Go to CM/SM Sep, 4.15.2</p>	2	<p>Recorded burn data should include ΔV accomplished.</p>

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.13.2.2	<u>(P41) G&N SM-RCS Thrusting</u>		Computes preferred CSM attitude and preferred IMU orientation for RCS thrust, and maneuvers CSM to thrust attitude (R60).
	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		G&C circuit breakers on all panels should be closed except as defined in Limited Use Controls, 4.6.4.
	Test C/W lamps Prethrust prog (req), 4.12 Veh Prep (req), 4.13.1 DAP - Load & Activate, 4.8.2.1		
CDR 1	Set EVNT TMR to read 00:00 at GETI	1	
CMP 2	Key V37E 00E	2	P00 updates state vector periodically.
3	Key V37E 41E		TFI available (prior to step 12) by keying V16 N35E or V16 N40E.
	Poss PROG alarm (4.8.1.16)		R02. If no alarms at this point (after R02 exited), CMC computes initial thrust direction and initial value of VG (local vertical), computes preferred IMU orientation, sets PFRATFLG (preferred attitude flag) and stores desired attitude for use in R60. Final attitude computed in R60 and 0.5-degree deadband set in RCS DAP.
4	If VG disp desired Key V06 N81E VGX, Y, Z XXXX.X FPS (Lcl vert at GETI)		Display available until average G turned on (GETI minus 30 seconds).

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STA/T STEP	PROCEDURE	PANEL	REMARKS
	(R60, Attitude Maneuver)		Maneuvers CSM to attitude stored in P41. Maneuver performed automatically by G&N, or manually with optional final automatic G&N controlled trim maneuver.
CMP 5	FL V50 N18 (sel CMC - auto) R, P, Y XXX.XX DEG Establish Tot Att disp, 4.7.2.5	2	Desired final gimbal angles. Both FDAIs should be selected to provide redundant displays.
CDR	Accept BMAG MODE (3) - RATE 2 CMC Att Cont - auto, 4.7.1.6	1	Prevents BMAGs from hitting stops during maneuvers.
CMP	PRO	2	Initiates auto maneuver without a review of final gimbal angles.
CDR	Reject Sel desired Att Cont, 4.7.1 Mnvr to thrust att		
CMP	ENTR, go to 8		
	6 Auto mnvr V06 N18 (fnl att) R, P, Y XXX.XX DEG		
CDR, CMP	Mon FDAIs If RHC used or SCS sel, go to 7	1,2	CSM began maneuver to final attitude when PRO keyed in step 5. ICDU drives to achieve final gimbal angles. Refer to 4.6.1.3, note 1b.
CMP 7	FL V50 N18 (att trim enbl) R, P, Y XXX.XX DEG	2	Step should be completed prior to TIG -2 minutes. Display of final gimbal angles in registers.
CDR	Accept BMAG MODE (3) - RATE 2 CMC Att Cont - auto, 4.7.1.6	1	

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	PRO Returns to VO6 N18 disp of 6	2	Does not imply that any previous checks need be repeated for each trim enable.
CDR	Reject Sel desired Att Cont, 4.7.1 Verify/mnvr to thrust att (V62E for tot att err disp)		All RCS channels required for 3-axis translation.
CMP CDR	MAN ATT (3) - RATE CMD BMAG MODE (3) - ATT 1/RATE 2 Align GDC to IMU if necessary, 4.8.4.6	1	DSKY display option recommended because of its availability - only need to set ATT SET thumbwheels to DSKY values and defer alignment until just prior to thrust.
CMP	ENTR (exit R60)	2	
8	Mon VG disp VO6 N85 (VG vctr compnts) VGX, Y, Z (cont) XXXX.X FPS		Components resolved along CSM axes, and updated at 1-second intervals.
-05:00	9 Ign prep		Sets up nontime-critical switching required for thrust.
CDR	Check boresight star For X axis thrust THC PWR - on (up) If orb change AV Test & Null Bias Check, 4.7.6.1 AV Setup, 4.7.6.2	1	For deorbit thrust, check accomplished during EMS Entry Test, 4.15.1.3, if desired. Set to AV obtained from charts, P30, and/or MSFN.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
(R41, State Vector Integration)			
-00:40 CMP 10	If PROG lt - on, CMC slipped TIG DSKY R1 continues count to former TIG DSKY clears at new TIG -35 sec COMP ACTY lt - out (exit R41)	2	May illuminate between TIG -42.5 and -35 seconds. TIG slipped delta amount as required by CMC to complete state vector integration.
-00:35	DSKY clears		
-00:30 11	V16 N85 (ave G on)		Static display with COMP ACTY light flash every 2 seconds.
-00:25 CDR	THC - ARMED		
CDR, CMP	RHC (both) - ARMED		
CDR	LIM CYCLE - OFF If deorbit	1	For SCS translations.
LMP	TAPE RCDR FWD - FWD	3	
CDR	EMS MODE - NORM	1	4.6.1.1, note 9.
00:00 12	RCS thrust		
CMP	FL V16 N85 (requests null VG) VGX, Y, Z (cont) XXXX.X FPS	2	Event Timer not valid if GETI slipped.
CDR	Man null VG		Command manual translations and rotations to null VG components.
CMP	If R30 desired Key V82E Go to 13		
	To term P41 PRO Go to 14		CMC sets last specified R03 deadband in RCS DAP.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	If orb change Key XXE If last MCC & lunar return, or TLI abort Go to Deorbit or Lunar Return Veh Prep, 4.15.1, prior to entry or If deorbit Key 6LE (if desired) Go to CM/SM Sep, 4.15.2	2	P61 may be bypassed if hybrid or SCS deorbit.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.13.2.3	<u>G&N Hybrid Deorbit Thrusting</u>		Computes preferred CSM attitude and preferred IMU orientation for RCS thrusting maneuver. Maneuvers CSM to thrusting attitude (R60), and provides sufficient displays for cutoff of both SM RCS burn followed by CM RCS deorbit burn.
	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 Test C/W lts Prethrust prog (req), 4.12 Veh Prep (req), 4.13.1 DAP - Load & Activate, 4.8.2.1		G&C circuit breakers on all panels should be closed except as defined in Limited Use Controls, 4.6.4.
CDR 1	Set EVNT TMR to read 00:00 at GETI	1	
CMP 2	Key V37E 41E	2	
	Poss PROG alarm (4.8.1.16)		R02. If no alarms at this point (after R02 exited), CMC computes initial thrust direction and initial value of VG (local vertical), computes preferred IMU orientation, sets PFRATFLG (preferred attitude flag), and stores desired attitude for use in R60. Final attitude computed in R60 and 0.5-degree deadband set in RCS DAP.
3	If VG disp desired Key V06 N81E VGX, Y, Z XXXX.X FPS (lcl vert at GETI)		Display available until average G turned on (GETI minus 30 seconds).

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Reject Sel desired Att Cont, 4.7.1 Verify/mnvr to thrust att (V62E for tot att err disp)		
CDR	MAN ATT (3) - RATE CMD BMAG MODE (3) - ATT 1/RATE 2	1	DSKY display option recommended because of its availability - only need to set ATT SET thumbwheels to DSKY values and defer alignment until just prior to thrust.
CMP	ENTR (exit R60)	2	
7	Mon VG disp VO6 N85 (VG vctr compnts) VGX, Y, Z (cont) XXXX.X FPS		Components resolved along CSM axes and updated at 1-second intervals.
LMP 8	Configure & preload bats		Prepares for battery preloading prior to CM/SM separation and verifies batteries transferred to main buses.
	<u>CAUTION</u> If either bat bus A(B) current fails to incr after cycling MN BUS TIE sws, configure bats to mn buses using cb BAT C TO BAT BUS A(B).	250	Assumes reconfiguration BAT A(B) and BAT C to MNA(B).
-10:00	MN BUS TIE BAT A/C - on (up) Verify bat bus A current incr &/or bat volt decr MN BUS TIE BAT B/C - on (up) Verify bat bus B current incr &/or bat volt decr	5 3 5 3	Verification of current increase for appropriate battery bus via DC AMPS indicator (panel 3) confirms successful operation of main bus tie motor switches. MN BUS TIE BAT A/C and B/C switches at on provide two batteries on line if circuit breaker MNA & B BAT C (2) - open, or three batteries on line for deorbit and entry if circuit breakers closed (panel 275).

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STA/T STEP	PROCEDURE	PANEL	REMARKS
-05:00 CDR 9	Ign prep THC PWR - on (up) ΔV Setup, 4.7.6.2 (R41, State Vector Integration)	1	Sets up nontime-critical switching required for thrusting. Set to ΔV obtained from charts, P30, and/or MSFN.
-00:40 CMP 10	If PROG lt - on, CMC slipped TIG DSKY R1 continues counting to former TIG DSKY clears at new TIG -35 sec COMP ACTY lt - out (exit R41)	2	May illuminate between TIG -42.5 and -35 seconds. TIG slipped delta amount as required by CMC to complete state vector integration.
-00:35	DSKY clears		
-00:30 11	V16 N85 (ave G on)		Static display with COMP ACTY light flashing every 2 seconds.
-00:25 CDR, CMP CDR	RHC (both) - ARMED THC - ARMED LIM CYCLE - OFF	1 3 1	For SCS translations. 4.6.1.1, note 9.
LMP CDR	TAPE RCDR FWD - FWD EMS MODE - NORM		
00:00 CMP 12	SM RCS thrust FL V16 N85 (request null VG) VGX, Y, Z (cont) XXXX.X FPS	2	Event Timer not valid if GETI slipped.
CDR	Man null VG Mon DSKY, ΔV ind, & EVNT TMR	1,2	Command manual translation and rotation to null VG components.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Crew options V83 - R, R dot, 0 V82 - Ha, Hp, TFF	2	
13 CDR CMP CDR	SM RCS thrust complete EMS MODE - STBY Rcd DSKY, ΔV ind, & EVNT TMR values Reset EVNT TMR THC - neut, LOCKED	1 1,2 1	4.6.1.1, note 9.
14	Sel SCS Att Cont mode, 4.7.1		Separation follows immediately, preventing proper G&N DAP operation until entry DAP selected in P62.
15	Perform Sep proced, 4.15.2		Separation at SM deorbit attitude saves time. Only one minute allowed between burns.
16 CDR,CMP CDR	Verify/mnvr to CM RCS deorbit att R ___°, P ___°, Y ___° MAN ATT YAW, ROLL - RATE CMD MAN ATT PITCH - ACCEL CMD RATE - HI ATT DBD - MIN RHC (both) - ARMED FDAI SCALE - 5/5		Both CM RCS systems should be enabled. CM RCS deorbit portion completed with +X axis ≈70° below velocity vector (apex down and forward); ≈110° +pitch maneuver from heads down, BEF, SM RCS portion of deorbit.
CMP 17	Key V82E FL V16 N44 Ha Hp TFF XXXX.X NM XXXX.X NM XXBXX MIN-SEC	2	Altitudes above launch pad radius. Time of free fall to 49.4 NM (300,000 feet) above launch pad radius.

4.13.2.3

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR 18	EVNT TMR ind - SM RCS C/O +1 min EMS MODE - NORM	1	One minute after SM RCS cutoff, start CM RCS burn. 4.6.1.1, note 9.
CMP CDR	RHC 1 - contin -pitch RHC 2 - pulse to maintain att in pitch axis Mon FDAI XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX X If only 1 RHC Pulse RHC + & - $\approx 5^\circ$ pitch from pitch retro att, maintaining rates $< 3^\circ/\text{sec}$ X XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX X		Negative pitch jets have ≈ 25 to 30 percent less authority than positive jets because of jet location and thrust direction relative to CM c.g.
CMP 19	Mon Hp & TFF on DSKY	2	Monitor Event Timer for duration of thrust no greater than 02:10 for either single or dual system. Conserve CM RCS propellant reserves, 30 pounds each system for entry. ΔV indicator cutoff cue must be adjusted to account for EMS sensing axis (along X) being reversed from SM RCS burn and biased off $\approx 70^\circ$ from CM RCS velocity vector. ($\Delta V_{\text{ems}} = \Delta V_{\text{cm}} \cos 70^\circ$).
20	PRO FL V16 N85 VGX, Y, Z (cont) XXXX.X FPS		
21	Thrust complete, ΔV ind = _____ or EVNT TMR = _____	1	
	PRO	2	
CDR	MAN ATT (3) - RATE CMD	1	
	Rcd ΔV ind, DSKY, EVNT TMR	1,2	

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STA/T STEP	PROCEDURE	PANEL	REMARKS
LMP CDR	TAPE RCDR FWD - off (ctr) ATT DBD - MAX	3 1	
CMP 22 CDR CDR,CMP	FL V37 EMS MODE - STBY RHC (both) - LOCKED	2 1	4.6.1.1, note 9.
23	Sel Att Cont mode, 4.7.1 Mnvr to entry att R ___°, P ___°, Y ___°		
CDR 24	Set up for CM RCS sys 1 AUTO RCS A/C ROLL (4) - OFF AUTO RCS CM 1 (6) - MNA or MNB AUTO RCS CM 2 (6) - OFF	8	Electrically isolates system 2 for entry. If problem develops in system 1, disable affected channel and use direct RCS control.
25	Go to G&N Entry, 4.15.3		

4.13.2.3

G&N HYBRID DEORBIT THRUSTING

STA/T STEP	PROCEDURE	PANEL	REMARKS
4.13.3	SCS THRUSTING		
4.13.3.1	<u>SCS SPS Thrusting</u>		
	CMC - on (desired), 4.8.1.3 ISS - on & orient known (desired), 4.8.1.3 & 4.14 SCS - on (req), 4.8.4.2		CMC and ISS on, and orientation known, necessary for P47 monitor. G&C circuit breakers on all panels should be closed except as defined in Limited Use Controls, 4.6.4.
	<u>WARNING</u>		
	Experiments must be retracted prior to SPS thrust. Prevents poss boom or track structural failure.		
	Gamma ray & mass spectrometer booms, & map camr tracks - retracted (req), 4.18.3.2, 4.18.3.4, & 4.18.3.6 If experiments S163 & S166 not complete Pan camr boost mode - on (req), 4.18.9.1, step 1 Map camr stby mode - on (req), 4.18.12.2, step 1 Veh Prep (req), 4.13.1		
	1 ΔV Setup, 4.7.6.2		
CMP	2 Key V37E 00E	2	P00 updates state vector periodically.
	3 Establish Tot Att disp, 4.7.2.5		To obtain telemetry on BMAG attitude error, FDAI SEL switch must be in 1 or 2 position (with SCS displays).
	4 SCS Att Mnvr to thrust att, 4.8.4.5		

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	5 Establish SCS Att Hold, 4.7.1.4 Check boresight star	2	Limit cycle, maximum deadband and low rate should be selected for propellant conservation.
	6 Ign prep		Sets up nontime-critical switching required for thrusting.
LMP	SPS He VLV tb (both) - bp SPS He VLV (both) - AUTO	3	Barber pole indicates helium isolation valves closed.
	<u>CAUTION</u> If either bat bus A(B) current fails to incr after cycling MN BUS TIE sws, configure bats to mn buses using cb BAT C TO BAT BUS A(B) & cb MNA(B) BAT C as necessary.	250	Assumes reconfiguration BAT C to MNA(B) for orbit change; BAT A(B) and BAT C to MNA(B) for deorbit.
LMP	-10:00 MN BUS TIE BAT A/C - on (up) Verify bat bus A current incr &/or bat voltage decr	5 3	Verification of current increase for appropriate battery bus via DC AMPS indicator (panel 3) confirms successful operation of main bus tie motor switches.
	MN BUS TIE BAT B/C - on (up) Verify bat bus B current incr &/or bat voltage decr	5 3	
CDR	RHC PWR DIR (both) - OFF SCS TVC (2) - AUTO TVC GMBL DR (2) - AUTO ΔV CG - LM/CSM or CSM Establish Ull Sel, 4.6.1	1	MN BUS TIE BAT A/C and B/C switches at on provide two batteries on line for orbit change if circuit breakers MNA & B BAT C (2) - open, or three batteries on line for deorbit and entry if circuit breakers closed (panel 275).
CMP	7 If P47 for thrust mon Key V37E 47E Poss PROG alarm (4.8.1.16)	2	G&N monitoring highly desirable but not required. Refer to 4.8.1.6 for P47 description. R02.

4.13.3.1

SCS SPS THRUSTING

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NORMAL / BACKUP

APOLLO OPERATIONS HANDBOOK

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	FL V16 N83 AVX, Y, Z (cont) XXXX.X FPS	2	
	If desired Key N62E VI XXXXX. FPS H dot XXXXX. FPS H pad XXXX.X NM		Inertial velocity. Altitude rate. Altitude above pad radius (earth orbit) or landing site radius (lunar orbit).
	KEY REL (to return to N83)		
	8 Gmbl drive & trim check		PITCH and YAW GMBL caution/warning lights indicate overcurrent to actuator motors.
CDR	TVC SERVO PWR 1 - AC1/MNA	7	
	TVC SERVO PWR 2 - AC2/MNB		
	cb SPS PITCH 1 BAT A - close (verify)	8	Remain closed from launch through first SPS thrust and closed again for each subsequent SPS thrusting.
	cb SPS YAW 1 BAT A - close (verify)		
	THC PWR - on (up)	1	
	RHC PWR NORM 2 - AC		Opens RHC 2 (commander's) breakout switch dc circuits to prevent loss of attitude reference. Prevents RCS jets from firing when RHC is used for MTVC check. Normally, IGN 1 signal disables RCS pitch and yaw channels 1 second after SPS engine ignition.
	RHC 2 - ARMED		
	Prim TVC check		4.6.1.1, note 11.
-05:00	GMBL MOT P1 & Y1 - START		START position is momentary.
	Verify trim cont on ind		Gimbals drive in response to thumbwheel movement. Verifies primary gimbal trim control.
	Auto switchover check		
	THC - CW		
	RHC 2 - verify no MTVC		
	GMBL POS ind (4) - no motion		Verifies TVC control switches from channel 1 to channel 2 (which is off) when THC - CW selected.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	Sec TVC check GMBL MOT P2 & Y2 - START Verify trim cont	1	START position is momentary. Verifies secondary gimbal trim control.
	Verify MTVC THC - neut		Gimbals drive in response to RHC movement, and return to set-in values when RHC neutral. Verifies control of secondary MTVC loops through RHC.
	SPS GMBL tw (2) - set & confirm fnl desired gmb1 position		Gimbals trimmed in primary channel to thrusting values (SCS modes).
9	RHC PWR DIR (both) - MNA/MNB		Enables manual direct RCS for overriding a roll automatic RCS failure during thrusting.
	RHC 2 - null att err		Needles can be used as error null reference during MTVC contingency takeover from automatic ΔV mode.
	ATT DBD - MIN RHC PWR NORM (both) - AC/DC Check boresight star		Set to MIN as errors nulled.
CMP 10	2-min countdown		
-02:00	Report TF GETI = 2 min	2	
CDR	FDAI SCALE - 5/5 ΔV THRUST A(B) - NORM THC - ARMED LIM CYCLE - OFF If orb change	1	Guarded.
LMP	UP TLM CMD - RSET, then NORM PCM BIT RATE - HI	3	
-00:30	TAPE RCDR FWD - FWD		
CDR	EMS MODE - NORM	1	4.6.1.1, note 9.

4.13.3.1

SCS SPS THRUSTING

STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR -00:29 to -00:06	Perform ull (if req)		No ullage required if SPS sump tanks full. CSM/LM or CSM 2 or 4 jet ullage times defined in SNA-8-D-027 CSM Data Book, Vol I. Exact velocity change not critical - only steady ullage to settle SPS propellants.
	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX X No ull DIR ULL pb - push, hold RHC 2 - cont att X XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	1	Direct ullage inhibits pitch and yaw auto RCS control. Attitude should be maintained manually.
11 00:00	Orb change ign If ull present THRUST ON pb - push If no ull present THC - +X, hold THRUST ON pb - push SPS THRUST lt - on IGN+1 sec RATE - HI		Engine restart should not be attempted within 5 seconds from initial ignition - avoids undesirable He pressure excursions. Provides ullage discrete to SCS.
	Discontinue ull		Bypasses noise problem in SCS gyro assemblies because of thrusting vibration levels and provides backup to auto selection of high rate in pitch and yaw TVC.
IGN +2 to 5 sec	AV THRUST (2) - NORM (if desired) Init ull THRUST ON pb - push		For dual bank operation. Ullage and THRUST ON pushbutton required to satisfy SCS logic for second bank operation.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	<p style="text-align: center;">XXX X</p> <p>If no ign, or premature shutdown ΔV THRUST (2) - NORM Recycle 11</p> <p>or SPS THRUST - DIR ON Recycle 11</p> <p>or Term mnvr</p> <p style="text-align: center;">XXX X</p>	1	Lever lock.
00:00	<p>12 Deorbit ign SPS THRUST - DIR ON</p> <p>SPS THRUST lt - on IGN+1 sec RATE - HI</p>		<p>Engine restart should not be attempted within 5 seconds from initial ignition to avoid undesirable He pressure excursions.</p> <p>Bypasses noise problem in SCS gyro assemblies because of thrusting vibration levels and provides backup to automatic selection of high rate in pitch and yaw TVC.</p>
	<p style="text-align: center;">XXX X</p> <p>If no ign ΔV THRUST (2) - NORM Recycle 12</p> <p>or Term mnvr</p> <p style="text-align: center;">XXX X</p>		Guarded.
IGN +2 to 5 sec	<p>Discontinue ull</p> <p>ΔV THRUST (2) - NORM</p>		Guarded.

4.13.3.1

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STA/T STEP	PROCEDURE	PANEL	REMARKS
13 CDR	Orb change SPS mon Pc ind - 95-105 psia	1	65 to 125 percent green range on indicator corresponds to psia. Normal range 95-105 psia.
LMP	SPS INJ VLV ind (2 or 4) - OPEN SPS He VLV tb (both) - gray SPS FUEL & OXID PRESS ind (2) - 170-195 psia SPS OXID UNBAL ind - mon	3	All four injector valves open for dual-bank operation. Gray indicates helium isolation valves open. Prior to crossover, maintain unbalance near value at which indicator first stabilizes after burn initiation. After crossover, maintain unbalance near zero.
	XXX		
	SPS OXID UNBAL ind erratic, pegged or failed stationary PUG MODE - AUX		Selects auxiliary PUGS for SPS OXID UNBAL indication.
	SPS OXID UNBAL ind erratic, pegged or failed stationary in prim & aux modes PUG MODE - NORM		
	SPS FUEL & OXID QTY ind (2) - mon		OXID FLOW VLV INCR switch controls oxid/fuel mixture ratio to maintain SPS OXID QTY indicator within <u>+0.4</u> percent of SPS FUEL QTY indicator.
	SPS FUEL or OXID QTY ind erratic, pegged or failed stationary PUG MODE - AUX		
	SPS FUEL or OXID QTY ind erratic, pegged or failed stationary in prim & aux modes PUG MODE - NORM		Probable loss of PUGS data.
	XXX		

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STA/T STEP	PROCEDURE	PANEL	REMARKS
LMP	<p>OXID FLOW VLV INCR - as req SPS OXID VLV tb - verify</p> <p>XXX X</p> <p>No SPS OXID VLV tb response during flow adj OXID FLOW VLV INCR - NORM Wait 6 sec OXID FLOW VLV PRIM - SEC OXID FLOW VLV INCR - as req OXID FLOW VLV tb - verify</p> <p>No SPS OXID VLV tb response during flow adj in prim & sec modes</p> <p><u>CAUTION</u></p> <p>Do not use sec oxid flow vlv with prim vlv functioning properly. Failure of sec vlv could result in loss of prplnt management capability.</p> <p>OXID FLOW VLV INCR - NORM Wait 6 sec OXID FLOW VLV PRIM - PRIM OXID FLOW VLV INCR - as req</p> <p>X XX X</p>	3	<p>Switch position determined by SPS oxidizer unbalance. Continue monitoring SPS OXID UNBAL indicator.</p> <p>Continue monitoring SPS OXID UNBAL indicator and control oxidizer flow with OXID FLOW VLV PRIM switch in SEC position until thrusting completed.</p> <p>Probable SPS OXID VLV talkback failure.</p> <p>SPS OXID UNBAL indicator trend may be used to confirm valve position.</p>

4.13.3.1

SCS SPS THRUSTING

STA/T STEP	PROCEDURE	PANEL	REMARKS
	<u>CAUTION</u>		
	If noncritical burn & $\Delta P > 20$ psi,		ΔP between fuel and oxidizer should not exceed 20 psi during burn or degraded performance, rough combustion and/or engine failure may result.
CDR	AV THRUST (2) - OFF	1	Guarded.
14	Deorbit SPS mon		SPS OXID UNBAL indicator erratic for about 25 seconds after ignition.
LMP	Pc ind - 95-105 psia SPS INJ VLV ind (4) - OPEN SPS He VLV tb (both) - gray SPS FUEL & OXID PRESS ind (2) - 170-195 psia	3	Gray indicates helium isolation valves open.
CDR or LMP 15	FDAI - mon att err & rates	1,2	
	XX		
CDR	Orb change MIVC takeover Pitch & yaw err & rates abnormal AV THRUST (2) - OFF Damp rates to IMU ball or out window with RHC	1	Backup procedure bypasses maximum possible failure modes, thereby providing alternate means of completing burn without troubleshooting.
	If no response Use dir RCS & disable affected chan		Since a failure causing abnormal TVC and RCS attitude control is not a failed-on jet, RCS disabling should be done with MAN ATT switch to ACCEL CMD rather than AUTO RCS switches OFF, thereby providing automatic RCS control for reorientation.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	If rate needle(s) abnormal BMAG MODE - RATE 1 Reorient to thrust att THC - CW ΔV THRUST A(B) - NORM Init ull THRUST ON pb - push or SPS THRUST - DIR ON Fly MTVC (rate cmd) IGN+2 to 5 sec ΔV THRUST B(A) - NORM (if desired) Init ull THRUST ON pb - push or SPS THRUST - DIR ON or Term mnvr XX XX	1	Guarded. Lever lock. For dual bank operation. Ullage and THRUST ON pushbutton required to satisfy SCS logic for second bank operation if SPS THRUST switch not at DIR ON. Lever lock.
	Orb change roll err & rates abnormal & no roll att cont MAN ATT ROLL - ACCEL CMD RHC - cont roll rates or AUTO RCS (16) - OFF Cont roll using dir RCS XX	8	

4.13.3.1

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	<p>XXX</p> <p>Deorbit MTVC takeover If err & rates abnormal ΔV THRUST (2) - OFF Damp rates to IMU ball or out window with RHC SPS THRUST - NORM</p> <p>If no response Use dir RCS & disable affected chan</p> <p>If rate needle(s) abnormal BMAG MODE - RATE 1</p> <p>Reorient to thrust att THC - CW ΔV THRUST A(B) - NORM Init ull SPS THRUST - DIR ON Fly MTVC (rate cmd)</p> <p>IGN+2 to 5 sec ΔV THRUST (2) - NORM</p> <p>or Term mnvr</p> <p>XXX</p>	1	<p>Backup procedure bypasses maximum possible failure modes, thereby providing an alternate means of completing burn without troubleshooting.</p> <p>Lever lock.</p> <p>Since a failure causing abnormal TVC and RCS attitude control is not a failed-on jet, RCS disabling should be done with MAN ATT switch to ACCEL CMD rather than AUTO RCS switches - OFF, thereby providing automatic RCS control for reorientation.</p> <p>Guarded.</p> <p>Lever lock.</p> <p>Guarded.</p>

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STA/T STEP	PROCEDURE	PANEL	REMARKS
	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX X		
CDR	Deorbit no roll att cont MAN ATT ROLL - ACCEL CMD RHC - cont roll rates	1	
	or AUTO RCS (16) - OFF Cont roll using dir RCS	8	
	X XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX X		
16	Mon for SPS eng cutoff cue ΔV ind - goes thru -0.1 &/or EVNT TMR ind - 59:59 (-) thrust duration	1	For suspected ΔV indicator failures, utilize Event Timer to terminate SPS thrust manually. Timer normally counts down from 59:59.
	ΔV THRUST (2) - OFF SPS THRUST - NORM SPS THRUST lt - out For postorbit change free drift MAN ATT (3) - ACCEL CMD Report eng cutoff Pc = 0		Guarded. Lever lock.
LMP	SPS INJ VLV ind (4) - CLOSE SPS He VLV tb (both) - bp	3	Barber pole indicates helium isolation valves closed.
17	Set cont after tailoff		
CDR	GMBL MOT P2 & Y2 - OFF GMBL MOT P1 & Y1 - OFF EMS MODE - STBY	1	4.6.1.1, note 11. 4.6.1.1, note 9.
LMP	If orb change PCM BIT RATE - LO	3	
CMP	Red ΔV ind	1	
CDR	TVC SERVO PWR (both) - OFF	7	

4.13.3.1

SCS SPS THRUSTING

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	If orb change cb SPS PITCH 1 BAT A - open cb SPS YAW 1 BAT A - open	8	
	If deorbit cb SPS PITCH (both) - open cb SPS YAW (both) - open		
	ATT DBD - MAX	1	
	THC - LOCKED		
	If deorbit		
LMP	TAPE RCDR FWD - off (ctr)	3	
	If orb change		
CDR,CMP	RHC (both) - LOCKED		
CDR	RHC PWR DIR (both) - OFF	1	
CMP	(To re-zero registers, V32E)	2	Provides capability to monitor another burn without going through ROO.
18	PRO (exit P47)		When P47 termination desired.
19	FL V37 Key XXE If deorbit Go to CM/SM Sep, 4.15.2		
	If orb change		
LMP	MN BUS TIE (2) - OFF	5	
	XX If MN BUS TIE fail prior to thrust Leave MN BUS TIE BAT B/C(A/C) - on (up) Go to EPS SSR-2 BAT BUS A(B) reconfig for subsequent mn bus ties		Circuit breakers used to reconfigure for subsequent bat bus operation and battery charging procedures in place of opening (known) good main bus tie motor switches.
	XX		

SCS SPS THRUSTING

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	EMS FUNC - OFF	1	
LMP	If pan & map camr in stby mode PAN CAMR PWR - OFF	230	
CMP	MAP CAMR ON - OFF	181	
	SM/AC PWR - OFF		
	Charge bats, 4.5.3.5		
	If last MCC & lunar return, or		
	TLI abort		
	Go to Deorbit or Lunar Return		
	Veh Prep, 4.15.1, prior to		
	entry		

4.13.3.1

SCS SPS THRUSTING



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STA/T STEP	PROCEDURE	PANEL	REMARKS
	4.13.3.2 <u>SCS SM RCS Thrusting</u> CMC - on (desired), 4.8.1.3 ISS - on & orient known (desired), 4.8.1.3 & 4.14 SCS - on (req), 4.8.4.2 Veh Prep (req), 4.13.1		CMC and ISS on, and orientation known, necessary for P47 monitor.
CMP	1 Key V37E 00E 2 Establish Tot Att disp, 4.7.2.5 3 Sel desired Att Cont, 4.7.1 Mnvr to thrust att 4 Establish SCS Att Hold, 4.7.1.4	2	POO updates state vector periodically. All RCS channels required for 3-axis thrusting. Limit cycle, maximum deadband and low rate should be selected for propellant conservation until prior to thrusting.
	-05:00 5 Check boresight star 6 For X-axis thrust If orb change AV Test & Null Bias Check, 4.7.6.1 AV Setup, 4.7.6.2		EMS can monitor only X-axis thrusting. For deorbit thrust, AV Test & Null Bias Check previously accomplished during Deorbit or Lunar Return Vehicle Preparation, 4.15.1, if desired.
	7 If P47 for thrust mon Key V37E 47E		G&N monitoring highly desirable, but not required. Refer to 4.8.1.6 for P47 description.

SCS SM RCS THRUSTING

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Poss PROG alarm (4.8.1.16)	2	R02.
	FL V16 N83		
	ΔVX, Y, Z (cont) XXXX.X FPS		
	If desired		
	Key N62E		
	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).
	KEY REL (to return to N83)		
-00:30			
CDR,			
CMP 8	RHC (both) - ARMED		
CDR	THC - ARMED		
	ATT DBD - MIN	1	
	LIM CYCLE - OFF		
LMP	If deorbit		
	TAPE RCDR FWD - FWD	3	
CDR	EMS MODE - NORM	1	4.6.1.1, note 9.
00:00			
9	Perform thrust by manually nulling ΔV ind		
10	EMS MODE - STBY		4.6.1.1, note 9.
	Rcd ΔV compnts		
	If orb change		
	EMS FUNC - OFF		
CDR,LMP	RHC (both) - LOCKED		

4.13.3.2

SCS SM RCS THRUSTING

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	THC - neut, LOCKED		
LMP	If deorbit		
	TAPE RCDR FWD - off (ctr)	3	
CMP	(To re-zero registers, V32E)	2	Provides capability to monitor another burn without going through R00.
11	PRO (exit P47)		
12	FL V37 Key XXE		R00 turns off average G.
13	If deorbit Go to CM/SM Sep, 4.15.2		
14	If last MCC & lunar return, or TLI abort Go to Deorbit or Lunar Return Veh Prep, 4.15.1, prior to entry		

SCS SM RCS THRUSTING

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STA/T STEP	PROCEDURE	PANEL	REMARKS
	<p>4.13.3.3 <u>SCS Hybrid Deorbit Thrusting</u></p> <p>CMC - on (desired), 4.8.1.3 ISS - on & orient known (desired), 4.8.1.3 & 4.14 SCS - on (req), 4.8.4.2 Veh Prep (req), 4.13.1</p>		<p>This procedure can be utilized for a pure CM RCS deorbit by omitting steps 10 and 11.</p> <p>CMC and ISS on, and orientation known, necessary for P47 monitor.</p>
CMP 1	Key V37E 00E	2	P00 updates state vector periodically.
2	Establish Tot Att disp, 4.7.2.5		
3	Sel desired Att Cont, 4.7.1 Mnvr to thrust att R ____°, P ____°, Y ____°		Thrusting attitude for SM RCS portion of hybrid burn is nominally a retrograde +X translation with heads down and BEF.
4	Establish SCS Att Hold, 4.7.1.4		Limit cycle, maximum deadband, and low rate should be selected for propellant conservation until prior to thrusting.
LMP 5	Configure & preload bats		Prepares for battery preloading prior to CM/SM separation and verifies batteries transferred to main buses.
	<p style="text-align: center;"><u>CAUTION</u></p> <p>If either bat bus A(B) current fails to incr after cycling MN BUS TIE sws, configure bats to mn buses using cb BAT C TO BAT BUS A(B).</p>	250	Assumes reconfiguration BAT A(B) and BAT C to MNA(B).

4.13.3.3

SCS HYBRID DEORBIT THRUSTING

STA/T STEP	PROCEDURE	PANEL	REMARKS
LMP -10:00	MN BUS TIE BAT A/C - on (up) Verify bat bus A current incr &/or bat voltage decr MN BUS TIE BAT B/C - on (up) Verify bat bus B current incr &/or bat voltage decr	5 3 5 3	Verification of current increase for appropriate battery bus via DC AMPS indicator (panel 3) confirms successful operation of main bus tie motor switches. MN BUS TIE BAT A/C and B/C switches at on provide two batteries on line if circuit breakers MNA & B BAT C (2) - open, or three batteries on line for deorbit and entry if circuit breakers closed (panel 275).
-05:00 CMP 6	Check boresight star		
7	For X-axis thrust ΔV Setup, 4.7.6.2		If G&N inoperative, X axis only direction ΔV can be measured.
8	If P47 for thrust mon Key V37E 47E	2	G&N monitoring desirable but not required. Refer to 4.8.1.6 for P47 description.
	Poss PROG alarm (4.8.1.16)		R02.
	FL V16 N83 AVX, Y, Z (cont) XXXX.X FPS		
	If desired Key N62E		
	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).
	KEY REL (to return to N83)		

SCS HYBRID DEORBIT THRUSTING

STA/T STEP	PROCEDURE	PANEL	REMARKS
-00:30			
CDR,			
CMP 9	RHC (both) - ARMED		
CDR	THC - ARMED	1	
	ATT DBD - MIN		
	LIM CYCLE - OFF		
LMP	TAPE RCDR FWD - FWD	3	
CDR	EMS MODE - NORM	1	4.6.1.1, note 9.
00:00			
10	Perform SM RCS thrust Mon AV ind or EVNT TMR ind		
11	SM RCS thrust complete EMS MODE - STBY Rcd AV ind, EVNT TMR ind		4.6.1.1, note 9.
12	Sel SCS Att Cont mode, 4.7.1		
13	Perform Sep proced, 4.15.2		Separation at SM deorbit attitude saves time. Only one minute allowed between burns.
14	Mnvr to CM RCS deorbit att R <u> </u> °, P <u> </u> °, Y <u> </u> ° Verify using external visual cues MAN ATT ROLL, YAW - RATE CMD MAN ATT PITCH - ACCEL CMD RATE - HI FDAI SCALE - 5/5	2 1	Both CM RCS systems should be enabled. CM RCS portion completed with +X axis $\approx 70^\circ$ below velocity vector (apex down and forward); $\approx 110^\circ$ +pitch maneuver from heads down, BEF, SM RCS portion of deorbit.
15	EVNT TMR ind - SM RCS C/O +1 min EMS MODE - NORM		One minute after SM RCS cutoff, start CM RCS burn. 4.6.1.1, note 9.

4.13.3.3

SCS HYBRID DEORBIT THRUSTING

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	RHC 1 - contin -pitch	2	Negative pitch jets have ≈25 to 30 percent less authority than positive jets because of jet location and thrust direction relative to CM c.g.
CDR	RHC 2 - pulse +pitch to maintain att in 3 axes	1	
	XXX X If only 1 RHC Pulse RHC + & - ≈5° pitch from pitch retro att, maintaining rates <3°/sec XXX X		
16	Mon ΔV ind or EVNT TMR ind for req value		ΔV ind cutoff cue must be adjusted to account for EMS sensing axis (along X) being reversed from SM RCS burn and biased off ≈70° from CM RCS velocity vector. (ΔVems = ΔVcm Cos 70°).
17	Term CM RCS deorbit burn MAN ATT (3) - RATE CMD or ACCEL CMD EMS MODE - STBY Rcd ΔV ind THC - LOCKED		4.6.1.1, note 9.
18	Set up for CM RCS Sys 1 AUTO RCS A/C ROLL (4) - OFF AUTO RCS CM 1 (6) - MNA or MNB AUTO RCS CM 2 (6) - OFF	8	Electrically isolates system 2 for entry. If a problem develops in system 1, disable affected channel and use direct RCS control.
CMP 19	PRO (exit P47)	2	
20	FL V37 Key XXE Go to SCS Entry, 4.15.4		

SCS HYBRID DEORBIT THRUSTING

SM2A-03-BLOCK II-J-(2)
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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.14	ALIGNMENTS		For general G&C operating data, refer to operating notes, 4.6.1.
4.14.1	G&N ALIGNMENTS		
4.14.1.1	<u>(P51/P53) IMU Orientation Determination</u>		(P51) IMU Orientation Determination defines inertial orientation of IMU using optics. (P53) Alternate LOS IMU Orientation Determination defines inertial orientation of IMU using backup optical device (COAS). P53 may also be used with failed optics or MARK pb.
	CMC - on (req), 4.8.1.3 ISS - on (req), 4.8.1.3 SCS - on (desired), 4.8.4.2		Provides total attitude monitoring and attitude control capability. Minimum impulse control using RHC available (SCS & G&N) for sighting mark target alignment.
CDR	LOGIC 2/3 PWR - on (up) (req if no SCS) Opt - on (req, P51), 4.8.1.4 COAS - calib (req, P53), 4.14.1.6 Att Cont (req), 4.7.1 Total Att Disp (req), 4.7.2.5	7	Required for control and display functions. Optics required for P51; COAS used for P53. Allows maneuvering, and provides inertial stability of CSM to ensure accuracy of alignments. Both ISS and GDC attitude displays recommended for monitoring of IMU coarse align and SC motion.
CMP	1 Key V37E 51E/53E Poss PROG alarm (4.8.1.16)	2,140	R02.
	2 FL V50 N25 00015 (trgt acq)		Targets (celestial bodies).

APOLLO OPERATIONS HANDBOOK

SM2A-03-BLOCK II-J-(2)

4.14.1.1

(P51/P53) IMU ORIENTATION DETERMINATION

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	a. Desired att cont mode, 4.7.1 Mnvr to acq tgts, if necessary PRO If P51 go to 3 If P53 go to 4	2,140	V16 N20 may be keyed in to monitor for impending gimbal lock if operating from LEB where no FDAI available.
	or b. To coarse align IMU to SC axes ENTR (when att acpt) V41 N22 (coarse align) R, P, Y 000.00 DEG NO ATT lt - on, then out Recycle 2 (R53, Sighting Mark Routine)		Time and RCS fuel may be saved and subsequent IMU alignment decisions greatly simplified if IMU left inertially stabilized as close as possible to orientation required for future CMC programs.
3	FL V51 (please mrk) OPT ZERO - OFF OPT MODE - MAN Ctr trgt in SXT MARK (on trgt), go to 6 (R56, Alternate LOS Sighting Mark Routine)	122	SCT may be used if reduced accuracy acceptable.
4	FL V06 N94 SA XXX.XX DEG TA XX.XXX DEG	2,140	To perform sighting marks using COAS.

(P51/P53) IMU ORIENTATION DETERMINATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP Accept PRO Reject Key V24E	Load desired SA & TA	2,140	Values obtained from COAS Calibration, 4.14.1.6. Nominal SA and TA for COAS sightings are: SA - 000.00 DEG TA - 57.470 DEG
5 FL V53 (please mrk) RHC - ctr trgt in COAS reticle ENTR, go to 6			SCS minimum impulse mode is recommended. CMC interprets ENTR as a mark. An inadvertent PRO instead of ENTR will recycle FL V53.
6 FL V50 N25 00016 (term mrks) Accept PRO Reject If P51, MARK REJ pb - push Return to 3		122	An unsatisfactory mark may be rejected by pressing MARK REJ pushbutton (P51) or ENTR (P53) anytime prior to terminating marking sequence. In P51, possible program alarms if marks rejected without prior marks or if surplus marks made.
	If P53, ENTR, return to 5	2,140	CMC interprets ENTR as a mark reject.
7 FL V01 N71 Trgt code Accept PRO	000XX		Target (celestial body) codes: 00 - Planet (any planet except Earth) 01 to 45 - Star 46 - Sun 47 - Earth 50 - Moon
	Poss OPR ERR Recycles disp		Target code negative or >50.

4.14.1.1

(P51/P53) IMU ORIENTATION DETERMINATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Reject Key V21E Load trgt code	2,140	This flash will occur only if marks were made on a planet. X, Y, Z - components of planet unit position vector at present time.
	For trgt 2 (trgt code ≠ 00) P51, return to 3 P53, return to 4		Use on-board tables to determine planet position vector at present time.
8	FL V06 N88 (planet only) X, Y, Z .XXXXX		Tests accuracy of pair of target sightings.
	Accept PRO Reject Key V25E Load desired data		
	For trgt 2 P51, return to 3 P53, return to 4		
	(R54, Sighting Data Display Routine)		
9	FL V06 N05 Sighting angle diff XXX.XX DEG		CMC calculates and stores IMU orientation as REFSMMAT.
	Accept PRO Reject Key V32E, return to 2		
10	FL V37 Key XXE		ROO.
11	If P51 and no P52 Opt Pwr Down, 4.8.1.4		

(P51/P53) IMU ORIENTATION DETERMINATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.14.1.2	<u>(P52/P54) IMU Realign</u>		<p>(P52) IMU Realign, and (P54) Alternate LOS IMU Realign, aligns IMU from known orientation to one of four orientations selected by crew. Sightings made on two targets (celestial bodies) with optics in P52, or with COAS in P54.</p> <p>Orientation options available are:</p> <ul style="list-style-type: none"> ● Preferred ● Nominal ● REFSMMAT ● Landing site <p>Provides total attitude monitoring and attitude control capability. Minimum impulse control using RHC available (SCS & G&N) for sighting mark target alignment.</p>
	<p>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</p>		
CDR	<p>LOGIC 2/3 PWR - on (up) (req if no SCS) Optics - on (req, P52), 4.8.1.4 COAS - calib (req, P54), 4.14.1.6 Att Cont (req), 4.7.1</p> <p>Tot Att Disp (req), 4.7.2.5</p>	7	<p>Required for control and display functions. Optics required for P52; COAS used for P54.</p> <p>Allows maneuvering, and provides inertial stability of CSM to ensure accuracy of alignments.</p> <p>Both ISS and GDC attitude displays recommended for monitoring of IMU coarse align and SC motion.</p>
CMP	1 Key V37E 52E/54E	2,140	
	Poss PROG alarm (4.8.1.16)		R02.

4.14.1.2

(P52/P54) IMU REALIGN

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 2 FL V04 N06		2,140	If preferred orientation defined, R2 = 00001. Otherwise R2 = 00003 (REFSMAT alignment).
	Option code 00001 Option 0000X		Options available are: 00001 - Preferred (operator ensures preferred orientation defined) 00002 - Nominal 00003 - REFSMAT 00004 - Landing site
	Accept PRO Reject Key V22E Load desired option		
	a. If 00001 sel, go to 5		
	or b. If 00002 or 0004 sel, go to 3		
	or c. If 00003 sel, go to 8		
3 FL V06 N34			GET align - Time at which nominal orientation defined. Display initially 0, 0, 0. If this value accepted, nominal orientation will be defined for GET align automatically selected as present time.
	GET align 00XXX. HRS 000XX. MIN 0XX.XX SEC		
	Accept PRO If option 2, go to 5 Reject Key V25E Load desired GET align		
4 FL V06 N89			Stored landing site coordinates.
	Lat (+N) XX.XXX DEG Long/2 (+E) XX.XXX DEG Alt XXX.XX NM		
	Accept PRO Reject Key V25E Load correct coordinates		

(P52/P54) IMU REALIGN

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 5 FL V06 N22 R, P, Y	XXX.XX DEG	2,140	To obtain acceptable MGA. V32E recycles to update gimbal angle display.
	Accept PRO Reject Desired att cont mode, 4.7.1 Mnvr SC Key V32E		
	or Key V37E XXE Exit P52/P54		
6 FL V50 N25	00013 (coarse align or pulse torque)		
	Coarse align PRO, go to 7		Selects coarse align R50 and allows auto optics positioning.
	Pulse torque ENTR		To pulse torque gyros. Bypasses R50 and auto optics positioning.
	V16 N20 (present gmb1 angles) R, P, Y XXX.XX DEG		If it appears that IMU will be torqued into gimbal lock, maneuver should be performed to avoid condition. If SC CONT at CMC and CMC MODE at AUTO or HOLD, the DAP will maneuver vehicle to follow platform as it moves. If N93 used for display, scaling of N93 will not remain XX.XXX. Initially, N93 will display proper values; thereafter, R2, then R3, and finally R1 will diminish to zero as each gyro axis is torqued.
	Go to 20		

4.14.1.2

(P52/P54) IMU REALIGN



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STA/T STEP	PROCEDURE	PANEL	REMARKS
	(R50, Coarse Align Routine)		
CMP 7	Verify coarse align complete NO ATT lit - on, then out Mon ball motion	2,140	If required gimbal angle change <1 degree, IMU will not be coarse-aligned.
8	FL V50 N25 00015 (trgt acq)		
	a. For CMC assist in sel Desired att cont mode, 4.7.1 Mnvr to acq trgt		After target acquisition, SCS minimum impulse operation desirable for minimum fuel consumption and reduction of vehicle rates to minimum.
	PRO		CMC performs target selection routine. However, for P54, since primary optics are not being used, selected stars may not be acceptable for backup optics sightings.
	Poss FL V05 N09 00405 (accept pair not avail) Mnvr until suitable trgt acq PRO, go to 9		
	or Key V32E, recycle 8		
or	b. To bypass CMC sel ENTR		Crew manually acquires target.

(P52/P54) IMU REALIGN

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 9 FL V01 N70	Trgt code 000XX	2,140	Target (celestial body) codes: 00 - Planet (any planet except Earth) 01 to 45 - Star 46 - Sun 47 - Earth 50 - Moon Target code negative or >50.
Accept	If P52 OPT ZERO - OFF OPT MODE - as desired PRO	122 2,140	
	If P54 PRO		
	Poss OPR ERR Recycles disp		
Reject	Key V21E Load desired code		
For P52	If trgt code ≠ 00 & OPT MODE - CMC, go to 11	122	
	or OPT MODE - MAN, go to 12		
For P54	If trgt code ≠ 00, go to 13		
10 FL V06 N88 (planet only)	X, Y, Z .XXXXX	2,140	
Accept	If P52 PRO		
	If OPT MODE - MAN, go to 12	122	X, Y, Z - Components of planet unit position vector at present time.

4.14.1.2

(P52/P54) IMU REALIGN

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	If P54 PRO, go to 13 Reject Key V25E Load desired data (R52, Auto Optics Positioning Routine)	2,140	Use on-board tables to determine planet position at present time.
11	V06 N92 (desired opt angles) SA XXX.XX DEG TA XX.XXX DEG Poss FL V05 N09 (2 sec priority) 00404 (TA >90°)		Points SLOS of optics at selected target. Optics will drive to acquire selected target. No display if R52 reselected after R53 called.
	a. Desired att cont mode, 4.7.1 Mnvr to reduce TA		If required optics angles not being displayed, key V16 N92E to obtain display.
	PRO		
	or b. Key V34E FL V37 Key XXE		ROO.
	If TA >50° & <90° Desired att cont mode, 4.7.1		If TA >50° and <90°, trunnion driven to upper limit (≈49.7754°) and held at this angle.
	Mnvr to reduce TA		If required optics angles not being displayed, key V16 N92E to obtain display.
	When sighting mrks are desired OPT MODE - MAN	122	Calls R53. To regain auto optics positioning, select OPT MODE - CMC (prior to completion of R53).

(P52/P54) IMU REALIGN

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STA/T STEP	PROCEDURE	PANEL	REMARKS
	(R53, Sighting Mark Routine)		
CMP 12	FL V51 (please mrk) Ctr trgt in SXT MARK (on trgt), go to 15	2,140 122	SCT may be used if reduced accuracy acceptable.
	(R56, Alternate LOS Sighting Mark Routine)		To perform sighting marks using COAS.
13	FL V06 N94 SA XXX.XX DEG TA XX.XXX DEG Accept PRO Reject Key V24E Load desired SA & TA	2,140	Values obtained from COAS Calibration, 4.14.1.6. Nominal SA and TA for COAS sightings are: SA - 000.00 DEG TA - 57.470 DEG
14	FL V53 (please mrk) RHC - ctr trgt in COAS reticle ENTR		SCS minimum impulse mode recommended. CMC interprets ENTR as a mark. An inadvertent PRO instead of ENTR will recycle FL V53.
15	FL V50 N25 00016 (term mrks) Accept PRO Reject If P52, MARK REJ pb - push Return to 12	122	An unsatisfactory mark may be rejected by pressing MARK REJ pushbutton (P52) or ENTR (P54) anytime prior to terminating marking sequence. In P52, possible program alarms if marks rejected without prior marks or if surplus marks made.

4.14.1.2

(P52/P54) IMU REALIGN

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	If P54, ENTR Return to 14	2,140	CMC interprets ENTR as a mark reject.
16 FL V01 N71	Trgt code 000XX		Target (celestial body) codes: 00 - Planet (any planet except Earth) 01 to 45 - Star 46 - Sun 47 - Earth 50 - Moon
	Accept PRO		
	Poss OPR ERR Recycles disp		Target code negative or >50.
	Reject Key V21E Load trgt code		
	If trgt code \neq 00 Return to 9 for trgt 2		
17 FL V06 N88 (planet only)	X, Y, Z .XXXXX		This flash will occur only if marks were made on a planet. X, Y, Z - Components of planet unit position vector at present time.
	Accept PRO		
	Reject Key V25E Load desired data		Use on-board tables to determine planet position vector at present time.
	Return to 9 for trgt 2		

(P52/P54) IMU REALIGN

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STA/T STEP	PROCEDURE	PANEL	REMARKS
	(R54, Sighting Data Display Routine)		
CMP 18	FL V06 N05 Sighting angle diff XXX.XX DEG	2,140	Tests accuracy of pair of target sightings.
	Accept PRO Reject Key V32E, go to 20		
	(R55, Gyro Torquing Routine)		
19	FL V06 N93 (Δ gyro angles) X, Y, Z XX.XXX DEG		Calculates and displays gyro torquing angles for final (fine) alignment of inertial platform and to torque gyros. X, Y, Z Gyro - Angle through which each gyro must be torqued to complete fine alignment. Once this step is complete, CMC will reset preferred orientation flag. If CMC MODE switch is at AUTO or HOLD during R55, the DAP will maneuver CSM to follow platform as it moves.
	Accept PRO (gyros torqued) Reject Key V32E, go to 20 or Key V37E 00E, go to 22		Pulse IRIGs through desired angle. Do not torque gyros.
20	FL V50 N25 00014 (fine align check)		
	Accept PRO, return to 8 Reject ENTR		PRO repeats target sightings (R52 & R53) for P52; (R56) for P54 sighting data test (R54), and gyro torquing (R55) to verify accuracy of alignment.

4.14.1.2

(P52/P54) IMU REALIGN

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 21 FL V37 Key XXE		2,140	R00.
22 If P52 Opt Pwr Down, 4.8.1.4			

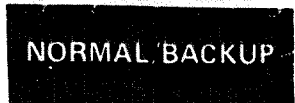
(P52/P54) IMU REALIGN

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.14.1.3 <u>(V40 N20) Zero ICDU Extended Verb</u>	CMC - on (req), 4.8.1.3 ISS - on (req), 4.8.1.3	2,140	<ul style="list-style-type: none"> • Ensures synchronization between ISS CDU counters and CDU counters in CMC. • Terminates IMU coarse align mode and enters fine align mode (inertial IMU).
CMP 1	Key V40 N20E NO ATT lt - OFF Wait 15 sec		If IMU stall routine in use. If ISS in coarse align mode with gimbal lock.
	Poss OPR ERR Poss PROG alarm Exit routine Key V05 N09E (to verify alarm) 00206 (zero encode not allowed) Key V41 N20E, 4.14.1.4		

4.14.1.3

(V40 N20) ZERO ICDU EXTENDED VERB



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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.14.1.4	<u>(V41 N20) Coarse Align ICDU</u> <u>Extended Verb</u>		Coarse aligns IMU to gimbal angles specified by crew.
	CMC - on (req), 4.8.1.3 ISS - on (req), 4.8.1.3		
CMP	1 Key V41 N20E	2,140	
	Poss OPR ERR Exit coarse align		Occurs if another extended verb active, or if IMU stall routine in use.
	2 FL V21 N22 (load CDU angles) R, P, Y XXX.XX DEG		Registers initially blank.
	Accept Load desired angles Reject V33E		4.6.1.3, note 3m.
	DSKY - V41 NO ATT lt - on		NO ATT lt will remain on even after gimbals have been driven to specified angles.
	Poss PROG alarm Key V05 N09E (to verify alarm) 00211 (error >2°)		Present and specified gimbal angles may be compared by keying V16 N20E and V16 N22E. Alternate method is to key V62E (Mode 2) to display difference between N20 and N22 on FDAI error needles.
	To repeat coarse align Key V41 N20E		
	3 To extinguish NO ATT lt & term coarse align Key V40 N20E Wait 15 sec		Zero ICPU extended verb, 4.14.1.3.
	or V42E		Torque gyros extended verb, 4.8.3.2.

(V41 N20) COARSE ALIGN ICPU EXTENDED VERB

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.14.1.5	<u>(V41 N91) Coarse Align OCDU</u> <u>Extended Verb</u>		Drive optics to shaft and trunnion angles specified by crew. Not permitted from start of drive test until end of burn. (Ref note opposite 00117 alarm, step 3.)
	CMC - on (req), 4.8.1.3 Opt Pwr Up (req), 4.8.1.4		
CMP 1	Key V37E OOE	2,140	V41 N91 from P00 only.
2	OPT ZERO - OFF OPT MODE - CMC	122	
3	Key V41 N91E	2,140	
	Poss OPR ERR Exit coarse align OCDUs		Occurs if another extended verb active.
	Poss PROG alarm Key V05 N09E (to verify alarm) 00115 (OPT MODE not CMC) OPT MODE - CMC	122	OPR ERR lt on.
	or 00117 (OPT not avail) Exit coarse align	2,140	This alarm code indicates that OCDUs are being used by TVC DAP or gimbal drive test and that this procedure cannot be performed. May occur from start of drive test until end of burn.
4	FL V21 N92 (Load OCDUs) SA XXX.XX DEG TA XX.XXX DEG		Registers initially blank.
	Accept Load desired SA & TA Reject V33E		
5	DSKY - V41		4.6.1.3, note 3m. Key V16 N91E to monitor optics angles.
6	Opt Pwr Down, 4.8.1.4		

4.14.1.5

(V41 N91) COARSE ALIGN OCDU EXTENDED VERB

STA/T STEP	PROCEDURE	PANEL	REMARKS
4.14.1.6	<u>Inflight COAS Calibration</u>		
	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 COAS filter installed (req)		Provides method for in-flight calibration of COAS (i.e., equivalent shaft and trunnion angles). Spare COAS light bulbs (2) are stowed in volume U3. When installing COAS on window mount, align (rotate COAS barrel to detent) as indicated by arrow on decal. Filter used to reduce glare of reticle image when sighting on low intensity targets.
1	Opt Pwr Up, 4.8.1.4		
2	Sel Tot Att Disp, 4.7.2.5		
CMP	3 Key V37E 52E	2,140	
	Poss PROG alarm (4.8.1.16)		R02.
4	FL VO4 NO6		
	Option code 00001		If preferred alignment flag is set, R2 will display 00001. Otherwise, R2 will display 00003 (REFSMMAT alignment).
	Option 0000X		Options available are: 00001 - Preferred (operator ensures preferred orientation defined) 00002 - Nominal 00003 - REFSMMAT 00004 - Landing site
	Sel REFSMMAT orient (V22E, 3E) PRO		

INFLIGHT COAS CALIBRATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 5	FL V50 N25 00015 (trgt acq) Att Cont Mode, 4.7.1 Mnvr to acq trgt in COAS ENTR	2,140	Target (celestial bodies).
6	FL V01 N70 Trgt code 000XX OPT ZERO - OFF OPT MODE - CMC	122	Target codes: 00 - Planet (any planet except Earth) 01 to 45 - Star 46 - Sun 47 - Earth 50 - Moon
	Reject Key V21E Load trgt code of trgt centered in COAS Accept PRO Poss OPR ERR Recycles display If trgt not a planet, go to 8	2,140	Target code negative or >50.
7	FL V06 N88 (planet only) X, Y, Z .XXXXX		X, Y, Z - Components of planet unit position vector at present time.
	Accept PRO Reject Key V25E Load desired data		

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4.14.1.6

INFLIGHT COAS CALIBRATION



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STA/T STEP	PROCEDURE	PANEL	REMARKS
	(R52, Auto Optics Positioning Routine)		
CMP 8	V06 N92 SA XXX.XX DEG TA XX.XXX DEG When trgt centered in COAS & SA & TA relatively constant Key VERB (to freeze disp) Accept Rcd SA & TA for use in P53/P54 Reject KEY REL Repeat 8	2,140	Display will be updated every ≈0.5 second.
9	Opt Pwr Down, 4.8.1.4		
10	Sel new prog		

INFLIGHT COAS CALIBRATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.14.2	SCS ALIGNMENTS		
4.14.2.1	<u>Alternate SC Inertial Attitude Determination and GDC Alignment</u>		
	SCS - on (req), 4.8.4.2		
	1 Opt Pwr Up, 4.8.1.4		
	2 Sel Tot Att, Att Err & Rate Disp for SCS, 4.7.2		If IMU off, only FDAI 1 need be powered or selected.
	3 Sel SCS Att Hold/Rate Cmd, 4.7.1.4		For fuel conservation, max deadband preferred until stars obtained.
CMP	4 Obtain 2 stars in SCT Sel Opt Cont, 4.7.5.2 OHC - ctr star on R-line OHC - ctr star in FOV Hold star 1 in ctr of FOV Hold star 2 on R line	121	OHC - Optics hand control. Final adjustment required OPT COUPLING - DIRECT. Minimum impulse control can be used to allow positioning of stars on R line.
CDR	5 BMAG MODE (3) - RATE 2 ATT DBD - MIN BMAG MODE (3) - ATT 1/RATE 2	1	Stars must be kept aligned while BMAGs caged.

4.14.2.1 ALTERNATE SC INERTIAL ATTITUDE DETERMINATION AND GDC ALIGNMENT



STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 6	Read & rcd angles on trun & shft ind(s) & xmit with star data to MSFN	121	
7	Obtain inertial att values for ATT SET tw from MSFN		
8	Align GDC to MSFN values, 4.7.3		
9	Opt Pwr Down, 4.8.1.4		

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ALTERNATE SC INERTIAL ATTITUDE DETERMINATION AND GDC ALIGNMENT

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.14.2.2	<u>Inplane GDC Alignment</u>		Provides method for aligning SCS attitude reference system in orbital plane (+Y axis of reference along $\underline{V} \times \underline{R}$). This allows use of ORDEAL on FDAI 2 with IMU out of plane.
	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		
CDR	1 Sel Tot Att Disp, 4.7.2.5 FDAI SEL - 1/2	1	
CMP	2 Key V37E 52E	2,140	
	Poss PROG alarm (4.8.1.16)		R02.
	3 FL V04 N06		Options available are:
	Option code 00001		00001 - Preferred (operator ensures preferred orientation defined)
	Option 0000X		00002 - Nominal
			00003 - REFSMMAT
			00004 - Landing site
	Select nom option Key V22E 2E		
	PRO		
	4 FL V06 N34		GET align - Time at which vehicle position and velocity vectors selected to define IMU local vertical orientation.
	GET align	00XXX. HRS 000XX. MIN 0XX.XX SEC	

4.14.2.2

INPLANE GDC ALIGNMENT

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Key V25E Load present time plus 10 min	2,140	
5	Establish Att Cont, 4.7.1 Damp veh rates PRO	1	Selected to prevent drift between gimbal angle calculation and GDC alignment.
6	FL V06 N22 R, P, Y XXX.XX DEG	1	IMU gimbal angles for desired IMU orientation at present SC attitude.
CDR	7 ATT SET tw - adj to Euler angles disp on DSKY	1	
8	Align GDC, 4.7.3	1	
9	Sel new program	1	

INPLANE GDC ALIGNMENT

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.14.2.3	<u>Backup GDC Alignment With COAS</u>		Aligns GDC without IMU, CMC or optics.
	SCS - on (req), 4.8.4.2 CMC - off or STBY (req)		A more accurate alignment can be performed if COAS calibration procedure, 4.14.1.6, has been performed earlier and calibration information provided to MSFN for use in computation of R, P and Y ALIGN.
CMP	1 Rcd following data from MSFN GDC Align Values (step 2) R ALIGN _____, P ALIGN _____ Y ALIGN _____ Boresight star data (step 13) Boresight star SPA _____° SXP _____° Nav stars Prim star _____ (step 5) Sec star _____ (step 8) Star diff angle _____° (step 7)		SPA - Sight pitch angle SXP - Star X position
CDR	2 SCS att set for FDAI 1, 4.7.2.4 ATT SET tw - set R, P, Y ALIGN 3 Install COAS & set reticle to 0° pitch 4 Sel SCS att cont mode, 4.7.1 5 Mvvr to position prim star on crosshairs of COAS reticle	1	Star difference angle cannot exceed 35° since this is maximum COAS field of view in pitch.

4.14.2.3

BACKUP GDC ALIGNMENT WITH COAS



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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR 6	Establish att hold with min P & Y dbd		
7	Pitch COAS reticle up Star Angle Diff value		
8	Roll SC to place sec star on pitch axis of COAS reticle		
9	Establish att hold with min roll dbd		
10	Repeat 3 through 9 as necessary		
11	Align GDC, 4.7.3 GDC ALIGN pb - push, when stars positioned, until err null on FDAI 1	1	
12	Mnvr to ΔV att ATT SET tw - set to ΔV att Mnvr Null errors on FDAI		
13	Perform Boresight Star ck		

BACKUP GDC ALIGNMENT WITH COAS

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.14.3	BACKUP GDC AND/OR IMU ALIGNMENT		Aligns GDC and/or IMU without CMC.
	SCS - on (req), 4.8.4.2 CMC - off or STBY (for step 3a)		
CMP	1 Rcd following data from MSFN GDC Align Values (step 8) R ALIGN _____, P ALIGN _____, Y ALIGN _____		
	SXTS data (step 10) SXTS _____ SHAFT _____ ° TRUN _____ °		SXTS - Sextant star.
	Boresight star data (step 4) Boresight star _____ SPA _____ ° SXP _____ °		SPA - Sight pitch angle. SXP - Star X position.
	Nav stars (step 7) Prim star _____ (0° mark on R line of SCT reticle) Sec star _____ (R line)		0° and 0° allows SC to be rolled about boresight star in 7.
	2 ISS att set for FDAI 1, 4.7.2.4		

4.14.3

BACKUP GDC AND/OR IMU ALIGNMENT

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 3	Cage IMU If IMU in stby IMU PWR - on (up) (IMU automatically cages) If IMU powered up a. IMU PWR - OFF Wait 5 min for gyros to run down IMU PWR - on (up)	100	This step is bypassed, if only GDC aligned. Guarded. Occurs only if CMC off, or in STBY. Guarded. Guarded.
CDR or	b. ATT SET tw - set to 0°, 0°, 0° Mnvr SC to 0°, 0°, 0° & null FDAI 1 errors IMU CAGE - on (up) & hold until 11	1	IMU gimbal angles should be 0+5° before caging to avoid damaging gyros. Guarded.
	4 Sel desired SCS Att Cont Mode, 4.7.1, & mnvr to position boresight star in COAS		
	5 Opt Pwr Up, 4.8.1.4		
CMP 6	Set opt to 0° shift & 352.5° trun, 4.7.5 OPT PWR - OFF	100	0° shaft and 352.5° trunnion places 0° mark of SCT reticle along +Zsc axis. Eliminates optics drift.
	7 Mnvr to position stars in SCT		Roll SC around boresight star to acquire navigation stars. After positioning primary star on 0° mark, SC may be yawed about this star to place secondary star on R line.

BACKUP GDC AND/OR IMU ALIGNMENT

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR 8	Align GDC ATT SET tw - set to R, P, Y ALIGN ATT SET - GDC GDC ALIGN pb - push when stars positioned, until err null on FDAI 1	1	ELEC PWR - GDC/ECA (required for GDC ALIGN) satisfied by SCS Power Up, 4.8.4.2.
9	Mnvr to ΔV att ATT SET tw - set to ΔV att Mnvr Null err on FDAI 1		
10	Perform SXTS ck & adj SC att if necessary		With optics set to proper shaft and trunnion angles, and SC at ΔV attitude, specified star should appear in SXT.
11	Uncage IMU IMU CAGE - on (up) and rel If 3b was used IMU CAGE - rel		This frees IMU at 0°, 0°, 0°. (For deorbit, GDC will be at 180°, 180°, 0°.)
12	Opt Pwr Down, 4.8.1.4		

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4.14.3

BACKUP GDC AND/OR IMU ALIGNMENT

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.15 ENTRY 4.15.1 DEORBIT OR LUNAR RETURN VEHICLE PREPARATION (Proced in 4.15.1.1 thru 4.15.1.4 not designated as "req" are optional) 4.15.1.1 <u>General System Management</u> Cab Cold Soak Oper (GETI or EI minus 8 to 12 hrs), 4.5.4.13 or If no cold-soak CMP SEC EVAP H2O CONT - AUTO (req)	382 If lunar return CMC - on, 4.8.1.3 ISS - on & orient known, 4.8.1.3 & 4.14 SCS - on (req), 4.8.4.2 DAP Data Load - complete, 4.8.2.1 1 Obtain update & entry data from MSFN		Deorbit preparation applies to any deorbit (SPS or RCS, pure or hybrid, whether G&N, SCS or manually controlled) and should be done prior to deorbit thrust to minimize crew workload between deorbit and entry. For lunar return, preparation accomplished after final MCC and during coast period prior to SM separation from CM. Provides cabin heat-sink during entry. EI (entry interface) ≈400,000 feet.

4.15.1.1 DEORBIT OR LUNAR RETURN VEHICLE PREPARATION



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STA/T STEP	PROCEDURE	PANEL	REMARKS
LMP 2	If deorbit Configure TLM (req) TAPE RCDR FWD - off (ctr) PCM BIT RATE - HI UP TLM CMD - RSET, then NORM Propul Sys Checks, 4.5.2.1 thru 4.5.2.3	3	After MSFN dumps and rewinds tape recorder and returns DSE control to crew at last contact prior to deorbit, TAPE RCDR FWD switch placed to off (center) and PCM BIT RATE switch to HI.
3	If lunar return Configure telcom (req) VHF AM A - SIMPLEX Propul Sys Checks, 4.5.2.2 & 4.5.2.3		
4	EPS DC & AC checks, 4.5.3.3 & 4.5.3.4 PYRO BAT A & B >35 vdc (verify)		
	XX X If PYRO BAT A(B) <35 vdc cb PYRO A(B)/SEQ A(B) - open cb BAT BUS A(B) TO PYRO BUS - close	250	
	X XX X		
5	ECS Mon Check, 4.5.4.1		
CMP 6	Stow gas separator cartridges (req) Remove separator bags from stowage Disconnect separators from water pistol & food prep unit Place separators in stowage bags Stow separators	352	

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 7	Stow loose gear (req)		
8	Dry tunl		If necessary, absorb water with towel. Condensed moisture rains on crew.
9	CMC Self-Check Proced, 4.8.1.7		
10	DSKY Condition Lt Check, 4.8.3.1		
11	C&WS Oper Check, 4.5.5.1		
12	P52 IMU Align, 4.14.1.2		
	<u>4.15.1.2 RSI Test and Alignment</u>		Permits testing EMS roll stability indicator (RSI) and positioning to desired orientation for entry.
CDR	ELEC PWR - GDC/ECA ATT SET - GDC	7 1	
1	EMS ROLL - on (up) GDC ALIGN pb - push, hold ATT SET YAW tw - adj thru 45° angle, observe RSI tracks ≈45°, then position RSI GDC ALIGN pb - rel EMS ROLL - OFF		Avoid FDAI gimbal lock region.
2	ATT SET YAW tw - reset GDC ALIGN pb - push (32 sec max)		This step required only if GDC was aligned and realignment required.
	<u>4.15.1.3 EMS Entry Test</u>		Light illumination other than those listed indicates a malfunction. Lift vector up (G >0.2) and down (G <0.2) lights for entry from lunar mission only. ΔV/EMS SET switch slews G-V scroll and sets RNG indicator.

4.15.1.3

DEORBIT OR LUNAR RETURN VEHICLE PREPARATION

STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR 1	Init EMS prep EMS FUNC - OFF (verify) cb EMS (2) - close EMS MODE - STBY	1 8 1	
2	EMS FUNC - EMS TEST 1 (CCW) Wait 5 sec Adj alphanumeric brightness (option) EMS MODE - NORM Wait 10 sec min All ind lts - out RNG ind - 0.0 Slew scroll until hairline superimposed on notch in next self-test pattern		Test 1 checks .05 G comparator lower trip-point. Ten seconds should be allowed to verify no malfunctions. No light on before or after 10 seconds. EMS scroll can be slewed only one inch in reverse.
3	EMS FUNC - EMS TEST 2 Wait 10 sec .05 G lt - on (all others out)		Test 2 checks .05 G comparator upper trip-point. No other light on before or after 10 seconds.
4	EMS FUNC - EMS TEST 3 .05 G lt - on Lift vector dn lt - on (10 sec after .05 G lt) Set RNG ind to 58.0+0.0 NM		Test 3 checks corridor verification circuitry associated with lift vector down light. G < 0.2. RNG indicator displays minus sign for negative numbers or no sign for positive numbers in most significant digit.
5	EMS FUNC - EMS TEST 4 .05 G lt - on (all others out) G-V trace (during 10 sec period) within test pattern		Test 4 checks range-to-go integrator circuits, range-to-go indicator, G-V servo circuits, and G-V plotter.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	<p>After 10 sec, G-V trace stops at lower right corner of test pattern at ≈ 9 G RNG ind (during 10 sec period) counts toward zero. After 10 sec, stops at $\approx 0.0 \pm 0.2$ G</p>	1	<p>Test 5 checks corridor verification circuitry associated with lift vector up light and enables scroll slewing to start of entry pattern. After scroll set to less than 37K fps, reselecting EMS TEST 5 switch position not permitted; range integrator and scroll synchronization would be lost.</p>
6	<p>EMS FUNC - EMS TEST 5 .05 G lt - on Lift vector up lt - on (10 sec after .05 G lt) RNG ind - 0.0 Scribe traces vert line ≈ 9 G to 0.28 ± 0.1 G & stops (trace within test pattern) Align G-V scroll to entry pattern (hairline on 37K fps line)</p>		
7	<p>EMS FUNC - RNG SET G-V traces vert line ≈ 0.28 G to 0.0 ± 0.1 G & stops If lunar return Slew RNG ind to pred RTOGO from .05 G</p>		
8	<p>EMS FUNC - Vo SET</p> <p style="text-align: center;"><u>CAUTION</u></p> <p>Never slew scroll in incr direction more than 1500 fps. Ensures range integrator remains slaved to scroll velocity.</p>		

4.15.1.3

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	Slew scroll until display index (arrow) aligned to pred entry velocity	1	Scroll can be slewed only one inch in reverse. In Vo SET position, both initial velocity in range integrator and scroll velocity change simultaneously.
	9 ΔV Test & Null Bias Check, 4.7.6.1		
	4.15.1.4 <u>Systems Preparation</u>		
	If suited Press Suit Circuit & PGA Check at 5.0 psia, 4.5.4.9		
ALL CMP	Mae Wests - donned EMER CAB PRESS sel - OFF	351	
EI or GETI -1:00:00	1 CM RCS temp check SYS TEST (2) - 5C, 5D, 6A, 6B, 6C, 6D	101	Checks CM RCS 12, 14, 16, 21, 24, and 25 jet injector temperatures, respectively.
CDR	If lowest reading <3.9 vdc (28°F) cb CM RCS HTRS (both) - close cb RCS LOGIC (2) - close CM RCS LOGIC - on (up)	8 1	
CMP	CM RCS HTRS - on (up) for 20 min	101	Jet injector valve direct coils utilized for preheating all jets.
	2 URINE DUMP - OFF		
	3 WASTE H2O DUMP - OFF		
	4 Align RSI & GDC, 4.15.1.2		
	5 If deorbit Set FDAI 2 on ORB RATE & restow, 4.8.4.8		

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 6 -40:00	CM RCS heating completion (if accomplished) CM RCS HTRS - OFF	101	
LMP 7	Configure entry bats (req) cb MNA BAT C - close cb MNB BAT C - close	275	
8	If SPS deorbit Cryo 02 & H2 Man Fan Opera, 4.5.3.10		
CDR 9	Panel 8 - all cb closed except (req) cb PL VENT FLT/PL - open cb FLOAT BAG (all) - open cb EDS (all) - open cb CM RCS HTR (both) - open If lunar return cb SPS PITCH (both) - open cb SPS YAW (both) - open	8	
10	Sequencer & CM RCS activation (req) After MSFN AOS SECS LOGIC (both) - on (up) Report logic arm ELS AUTO - AUTO ELS LOGIC - on (up) After GO from MSFN ELS AUTO - MAN ELS LOGIC - OFF SECS PYRO ARM (2) - on (up)		Lever lock.
	CM RCS PRPLNT (both) - on (up) (verify)	1	Guarded.
CMP		8	Guarded. Lever lock.
		2	On position is momentary.

4.15.1.4

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	CM RCS PRPLNT tb (both) - gray	2	Gray indicates fuel and oxidizer isolation valves open.
	CM RCS PRESS - on (up)		Guarded. On position is momentary.
	RCS IND sel - CM 1, then 2		Immediately after pressurization, He pressure less than 3300-3500 psia.
	CM RCS He PRESS ind - 3300-3500 psia (after ≈15 min)		
	CM RCS MANF PRESS ind - 287-302 psia		
11	If deorbit		
	SM RCS SEC FUEL PRESS (4) - OPEN		OPEN position is momentary. No talkbacks. Activates secondary fuel tanks for possible SM RCS deorbit.
	RCS IND sel - SM A		
12	If docking ring still in place (req)		
	CSM/LM FNL SEP (both) - on (up)		Guarded. On position is momentary. Jettisons docking ring.
CDR 13	SECS PYRO ARM (2) - SAFE	8	Lever lock.
14	If lunar return, test CM RCS jets		
	SC CONT - SCS	1	
CMP	RCS TRNFR - CM	2	CM position is momentary.
CDR	AUTO RCS CM 1 (6) - MNA	8	
	AUTO RCS CM 2 (6) - MNB		
	cb B/D ROLL, SCS PITCH & SCS YAW		
	MNA (3) - open		
	Test ring 2 jets		
	cb B/D ROLL, SCS PITCH & SCS YAW		
	MNA (3) - close		
	cb B/D ROLL, SCS PITCH & SCS YAW		
	MNB (3) - open		

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	Test ring 1 jets cb B/D ROLL, SCS PITCH & SCS YAW MNB (3) - close	8	
CMP	RCS TRNFR - SM	2	SM position is momentary.
CDR	SC CONT - CMC	1	
EI			
	-30:00		
LMP 15	If lunar return TAPE RCDR FWD - REWIND	3	
CMP 16	If hatch counterbalance deactivated for EVA (req) Activate counterbalance mechanism, 4.5.7.3, step b	Side hatch	
17	Strut unlock lanyard (2) - unstow & attach handle ends to MDC (req)		
18	If SCS, sel P00		
19	If deorbit Go to THRUSTING, 4.13		
20	If lunar return Go to CM/SM Sep, 4.15.2		

4.15.1.4

DEORBIT OR LUNAR RETURN VEHICLE PREPARATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.15.2 CM/SM SEPARATION	LMP 1 If SM RCS deorbit or lunar return	250	Prepares for battery preloading prior to CM/SM separation and verifies batteries transferred to main buses. (Previously configured in SPS or Hybrid Deorbit Thrusting of 4.13.2.1, 4.13.2.3, 4.13.3.1 or 4.13.3.3.)
	<u>CAUTION</u>		
	If either bat bus A(B) current fails to incr after cycling MN BUS TIE switch, configure bats to mn buses using cb BAT C TO BAT BUS A(B).		
-12:00	MN BUS TIE BAT A/C - on (up) Verify bat bus A current incr &/or bat volt decr MN BUS TIE BAT B/C - on (up) Verify bat bus B current incr &/or bat volt decr	5	Verification of current increase for appropriate battery bus via DC AMPS indicator (panel 3) confirms successful operation of main bus tie motor switches. MN BUS TIE BAT A/C and B/C switches at on provide 2 batteries on line if cb MNA & B BAT C (2) - open, or 3 batteries on line for entry if circuit breakers closed (panel 275).
CDR	2 Configure RCS AUTO RCS B/D ROLL B1 & B2 - MNA AUTO RCS B/D ROLL D1 & D2 - MNB AUTO RCS PITCH A3 & C4 - MNB AUTO RCS PITCH C3 & A4 - MNA AUTO RCS YAW B3 & D4 - MNA AUTO RCS YAW D3 & B4 - MNB	8	Assumes desired Attitude Control mode, 4.7.1, previously selected.

CM/SM SEPARATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	SM RCS PRPLNT (4) - OPEN (verify)	2	OPEN position is momentary. Opens 16 quad isolation valves.
	SM RCS PRPLNT tb (8) - gray (verify)		Gray indicates quad fuel and oxidizer isolation valves open.
	SM RCS SEC FUEL PRESS (4) - OPEN (verify)		OPEN position is momentary. No talkbacks. Opens helium isolation valves between quad helium regulators and secondary fuel tanks.
	3 Mnv'r to sep att		Nominally deorbit burn attitude plus a 45° yaw out of plane.
CDR	If CMC cont SC CONT - SCS or CMC MODE - FREE	1	During separation, CSM RCS DAP acting upon CM would produce undesirable rates.
CMP	4 If earth orb RCS TRNFR - CM Test jets RCS TRNFR - SM	2	If lunar mission, jets test fired in Deorbit or Lunar Return Vehicle Preparation, 4.15.1.
CDR	5 ATT DBD - MAX RATE - HI	1	Conserves propellant between separation and .05 G.
LMP	6 Configure telcom VHF AM (2) - off (ctr) S BD ANT OMNI A - C S BD ANT OMNI - OMNI If RCS deorbit TAPE RCDR FWD - FWD	3	

4.15.2

CM/SM SEPARATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
LMP 7	Preload bats		
-08:00	FC2 MNA - OFF	3	Barber pole indicates fuel cell not connected to bus.
	FC2 MNA tb - bp		
-05:00	FC PUMPS (all) - OFF	5	
CMP	HI GAIN ANT PWR - OFF	2	
8	Configure ECS		
CDR	PRIM GLY TO RAD - BYP (pull)	325	Assures CM O2 supply full before CM/SM separation.
	REPRESS PKG vlv - FILL	326	
	SURGE TK - ON (verify)		
CMP	O2 PRESS IND sw - SURGE TK	2	
	CRYO O2 PRESS 1 ind - 865-935 psia		
CDR	REPRESS PKG vlv - ON	326	
	SM O2 SUP vlv - OFF		
LMP	cb ECS RAD CONT/HTRS (2) - open	5	
	cb WASTE H2O/URINE DUMP HTRS (2) - open		
	cb RAD HTRS OVLD (2) - open		
CMP	POT H2O HTR - OFF	2	
9	Arm SECS		
	SECS LOGIC (both) - on (up) (verify)	8	SECS LOGIC and PYRO ARM lever lock switches required for sequencing of separation and landing events.
	SECS PYRO ARM (2) - on (up)		
10	PRPLNT DUMP - RCS CMD (verify)	2	Was set to RCS CMD 42 seconds after lift-off. CM RCS activated in 4.15.1.4.
	EMS MODE - STBY (verify)	1	Should remain at STBY until just prior to entry interface to preclude false .05 G sensing.
11	Sep from SM		
00:00	CM/SM SEP (both) - on (up)	2	Guarded. On position is momentary. Low limit SM system lights on at separation.
	SM C/W lts - on		
	C/W CSM - CM		

CM/SM SEPARATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	MASTER ALARM pb/lt - on, push	1	
CMP	SM C/W lts - out	2	
	RCS TRNFR - CM		CM position is momentary. Backup to automatic RCS transfer.
CDR	CM RCS LOGIC - OFF	1	
12	Sel Att Cont mode, 4.7.1 Mnvr to entry att (or to SM RCS deorbit att if hybrid deorbit) R ____, P ____, Y ____		Entry DAP not turned on.
13	Set up for CM/RCS sys 1 (omit for hybrid deorbit) AUTO RCS A/C ROLL (4) - OFF AUTO RCS CM 1 (6) - MNA or MNB AUTO RCS CM 2 (6) - OFF	8	G&N entry DAP will function with either one or both CM/RCS systems enabled. Electrically isolates CM RCS system 2 for entry. If a problem develops in system 1, disable affected channel and use direct RCS control.
14	Go to P61 Entry Prep, 4.15.3.1		
	or Go to SCS Entry, 4.15.4		
	or If G&N Hybrid Deorbit, go to 4.13.2.3 (step 16)		
	or If SCS Hybrid Deorbit, go to 4.13.3.3 (step 14)		

4.15.2

CM/SM SEPARATION

STA/T STEP	PROCEDURE	PANEL	REMARKS
4.15.3	G&N ENTRY		
4.15.3.1	<u>P61 Entry Preparation</u>		Displays predicted entry interface parameters and obtains EMS initialization parameters for comparison with MSFN values.
	Required CMC - on, 4.8.1.3 ISS - on & orient known, 4.8.1.3 & 4.14 SCS - on, 4.8.4.2		
CMP 1	DSKY - P61 (sel at end of deorbit burn)	2	
	or Key V37E 61E		
	Poss PROG alarm (4.8.1.16) (R41 - State Vector Integration)		R02.
	COMP ACTY 1t - on (R41) COMP ACTY 1t - flashes every 2 sec (ave G on)		Indicates state vector integration in process. Indicates integration complete, and average G on.
	Poss PROG alarm V05 N09 (10 sec) 01427 (IMU reversed)		Zero roll on FDAI is lift-down. -Ysm within 30° of <u>V</u> x <u>R</u> . Alarm 01427 always displayed following P40 or P41 deorbit if platform aligned to preferred orientation computed in P40 or P41.
	or 01426 (IMU unsatisfactory for entry)		Neither +Ysm or -Ysm within 30° of <u>V</u> x <u>R</u> .

P61 ENTRY PREPARATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS	
CMP 2	FL V06 N61	2		
	Impact Lat (+N)		XXX.XX DEG	Latitude and longitude of desired impact point.
	Impact Long (+E)		XXX.XX DEG	
	Hds Up/Dn (+up)		+/-00001	Heads up/down defines entry roll attitude.
	Accept PRO			
	Reject V25E, load desired values			Normally, these values loaded prior to deorbit.
	3 FL V06 N60 (entry data)			
	G max		XXX.XX G	Predicted maximum G level for an entry at nominal bank angle (L/D = 0.18)
	V pred		XXXXX. FPS	Predicted inertial velocity at entry interface (65.8 NM, 400,000 feet) above Fischer ellipsoid.
	Gamma EI		XXX.XX DEG	Flight path angle (between inertial velocity vector and local horizontal) at 65.8 NM (400,000 feet) above Fischer ellipsoid. Minus indicates flight path below horizontal plane.
Rcd values				
PRO				
4	FL V16 N63		Display relative to erasable preloaded altitude value above Fischer ellipsoid.	
	RTOGO (.05 G to splash)	XXXX.X NM	Range to go from preloaded erasable altitude value to splash.	
	VIO (at .05 G)	XXXXX. FPS	Predicted inertial velocity at preloaded altitude value.	

4.15.3.1

P61 ENTRY PREPARATION

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	TFE (time from .05 G) XXBXX MIN-SEC Rcd & compare with MSFN	2	Predicted time from now to preloaded altitude value (updated every 2 seconds). Predicts about 3 minutes longer than actual, following hybrid deorbit when called half hour before .05 G. Error varies, depending on how early P61 called after deorbit. 59B59 maximum reading (-above, +below).
CDR	EMS MODE - STBY EMS FUNC - RNG SET (CW) Set RNG ind - RTOGO from .05 G (MSFN value) Align scroll Vo to exact entry velocity (if req) EMS FUNC - ENTRY	1	Do not go through EMS TEST positions. Range to go from preloaded value to splashdown. Predicted entry velocity may have been preset in EMS Entry Test, 4.15.1.3. Scroll can be slewed only one inch in reverse. In Vo SET position, both initial velocity in range integrator and scroll velocity change simultaneously.
CMP	Accept PRO (exit P61) P61 calls P62 Go to G&N Entry, 4.15.3.2 Reject V32E, recycle to 3	2	Obtains new state vector and updated N60.

P61 ENTRY PREPARATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.15.3.2	<p><u>P62, P63, P64, P65, P66, P67 Entry</u></p> <p>Required</p> <p>CMC - on, 4.8.1.3</p> <p>ISS - on & orient known, 4.8.1.3 & 4.14</p> <p>SCS - on, 4.8.4.2</p> <p>CMP 1 DSKY - P62</p> <p>Auto sel by P61 (bypasses state vctr extrapolation reqt)</p> <p>or If FL V37</p> <p>Key 62E</p> <p>or Key V37E 62E (ave G reinitiated)</p> <p>Poss PROG alarm (4.8.1.16)</p> <p>(R41 - State Vector Integration)</p> <p>COMP ACTY lt - on (R41)</p> <p>COMP ACTY lt - flash every 2 sec (ave G on)</p> <p>Poss PROG alarm</p> <p>V05 N09 (10 sec)</p> <p>01427 (IMU reversed)</p> <p>or 01426 (IMU unsatisfactory for entry)</p>	2	<p>R02.</p> <p>R41 bypassed if P62 called by P61.</p> <p>Indicates integration in process.</p> <p>Indicates integration complete, and average G on.</p> <p>Zero roll on FDAI is lift-down. -Ysm within 30° of <u>V</u> x <u>R</u>. Alarm 01427 always displayed following P40 or P41 deorbit if platform aligned to preferred orientation computed in P40 or P41.</p> <p>Neither +Ysm or -Ysm within 30° of <u>V</u> x <u>R</u>.</p>

4.15.3.2

P62, P63, P64, P65, P66, P67 ENTRY

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 2	FL V50 N25 00041 (request CM/SM sep)	2	If CM and SM not separated prior to this step, separation should be accomplished now per 4.15.2. V37s inhibited after response to this display, except P00; programs not requiring DAP control may then be selected from P00. P62 should be reselected before entry into atmosphere because average G terminates by going to P00.
3	PRO		Starts entry DAP. Roll attitude error scaling changed in G&N for compatibility with 50/15/50/10 FDAI scale position. After PRO and until 50/15/50/10 selected, full scale roll error 20°, not 5°.
4	FL V06 N61 Impact lat (+N) XXX.XX DEG Impact long (+E) XXX.XX DEG Hds up/down (+Hds up) +/-00001 Accept PRO If $\alpha < 45^\circ$ - DSKY P63, go to 6 Reject V25E, load new data		Latitude and longitude of desired impact point. Defines entry roll attitude. If α within 45° of (-) velocity vector, P63 automatically called.
5	V06 N22 (mon) R, P, Y XXX.XX DEG If $\alpha > 45^\circ$ 21 sec after $\alpha < 45^\circ$, DSKY P63		Final gimbal angles at EI. Display bypassed and P63 called if α within 45° .
6	ORDEAL Pitch - ___° (Hds up) ORDEAL Pitch - ___° (Hds down)		IMU inertial attitude on FDAI 1 and ORDEAL local vertical attitude on FDAI 2.
7	DSKY - P63		

P62, P63, P64, P65, P66, P67 ENTRY

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR 8	After CM/SM sep & CM stab at entry att EMS MODE - NORM	1	Left in STBY until after separation and stabilization; if no postburn update, and for RCS deorbit, start EMS by positioning EMS MODE from STBY to BU at MSFN supplied value of RET .05 G. Also refer to 4.6.1.1, note 9.
CDR,CMP	ATT DBD - MAX RATE - HI FDAI SCALE - as desired Mon FDAIs & RSI	1,2	
CDR	XXX X If abnormal veh dynamics Damp rates with dir RCS RHC PWR DIR (both) - OFF If abnormal veh dynamics continue RHC PWR DIR (both) - MNA/MNB Damp rates with dir RCS AUTO RCS (affected axis) - OFF Continue with dir RCS (affected axis) XXX X	1 8	This procedure sequence minimizes failure isolation time. (Another functionally acceptable method disables AUTO RCS switches first, then RHC direct power.)
CMP 9	V06 N64 (mon) Drag accel XXX.XX G VI XXXXX. FPS Range to splash XXXX.X NM (+ overshoot)	2	N68 and N74 available if desired. Inertial velocity (nominal). Range to go to desired splashpoint located at calculated impact time (decreasing). Display bypassed on first 2-second cycle.

4.15.3.2

P62, P63, P64, P65, P66, P67 ENTRY

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STA/T STEP	PROCEDURE	PANEL	REMARKS
LMP	PCM BIT RATE - HI TAPE RCDR RCD - RCD TAPE RCDR FWD - FWD	3	
CDR	BMAG MODE (3) - RATE 2 MAN ATT (3) - RATE CMD SC CONT - CMC CMC MODE - AUTO, HOLD, or FREE	1	Cages attitude BMAGs. Prevents SCS-driven FDAI roll stability indicator from jumping when GAL BMAGs automatically cage at .05 G. Configuration required for auto G&N entry and normally selected at last status check prior to .05 G. Entry DAP does not look at CMC MODE switch.
CMP	DSKY - P64 (at .05 G)	2	CMC changes Entry DAP from attitude hold in alpha and beta to rate damping in pitch and yaw (roll unchanged).
CDR	.05 G sw - on (up) EMS ROLL - on (up) .05 G lt - on XXX X If no .05 G indication by RET .05 G +3 sec EMS MODE - BU X XXX	1	.05 G and EMS ROLL switches should be placed on simultaneously to minimize EMS error. .05 G lt will not necessarily occur simultaneously with P64 on DSKY. At .05 G +10 seconds, one lift vector light will come on; disregard light.
	Scroll slews to left RNG ind decr		

P62, P63, P64, P65, P66, P67 ENTRY

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 10	V06 N74 (mon) Beta XXX.XX DEG VI XXXXX. FPS Drag accel XXX.XX G Compare RSI & ball for lift vctr G-V plot within limits	2 1	N64 and N68 available if desired. Commanded bank angle. Inertial velocity (decreasing). Drag acceleration (increasing). Violation of an EMS G onset ray should be followed by an orientation to lift vector up. Violation of an EMS G offset ray should be followed by an orientation to lift vector down. If at point of tangency, G&N not commanding lift-up or lift-down, manually orient CM and terminate G&N steering.
11	If DSKY - P67 Go to 18	2	P64 calls P67 at 0.2 G if VI at .05 G (step 10) <27K fps. Entry velocities <u>></u> 27K fps are possible from RCS deorbits.
12	DSKY - P65 (entry up-cont) Indicates VI <u>></u> 27K fps & constant drag cont has brought range prediction to within 25 NM of desired range		P65 not applicable to low earth orbital mission. Executes entry up-control guidance, which steers CM to calculated reference trajectory, and establishes entry up-control displays for crew use with EMS to determine whether backup procedures should be implemented. Also selects entry-ballistic phase program (P66) if D <DL (≈ 0.196 G) sensed, or selects final phase program (P67) if D >DL (≈ 0.196 G) sensed, R dot negative, and V sufficiently low.
CDR	EMS disp - approach DSKY disp DL & VL	1	
CMP 13	FL V16 N69 (computed exit conditions) Beta XXX.XX DEG DL XXX.XX G VL XXXXX. FPS	2	Commanded bank angle. Drag acceleration at end of up control. Velocity at end of up control.

4.15.3.2

P62, P63, P64, P65, P66, P67 ENTRY

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Rcd data for later use with EMS		
	PRO	2	N69 may be terminated by PRO, or selection of either P66 or P67 by entry guidance provides automatic termination.
	FDAI att err _____ deg rates _____ deg/sec		
14	V06 N74		N64 and N68 available if desired.
	Beta XXX.XX DEG		
	VI XXXXX. FPS		
	Drag accel XXX.XX G		
15	If DSKY - P67		P67 occurs if drag >DL, R dot negative, and V sufficiently low.
	Go to 18		
16	DSKY - P66 (entry-ballistic)		Automatically selected by P65 when D <DL (≈ 0.196 G). Not applicable to low earth orbit mission. N64, N68, N74 available if desired.
			Maintains CM attitude during ballistic (skipout) phase for atmospheric re-entry and selects P67 when re-entry (drag acceleration builds up to $Q7F +0.5$ fps squared, ≈ 0.2 G) sensed.
17	V06 N22 (desired gmb1 angles)		
	R, P, Y XXX.XX DEG		
	Check FDAI tot att = DSKY values		
	FDAI att err < _____ deg		
	rates < _____ deg/sec		
	(Three-axis DAP cont regained when $<.05$ G sensed, & relinquished when $.05$ G again sensed)		

P62, P63, P64, P65, P66, P67 ENTRY

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 0.2 G			
18	DSKY - P67	2	P67 continues entry guidance from ≈0.2 G until termination of steering when CM velocity with respect to earth = 1000 ft/sec (≈10.7 NM altitude). N64, N68, and N74 available if desired.
CDR	EMS - 0.2 G (if 10 sec since .05 G)	1	
CMP 19	V06 N66 (mon)	2	Commanded bank angle (-command will correct for + cross range error). CMC solution for cross range error (+ target south of direction of motion). CMC solution for down range error (decreasing); + is overshoot. 9999.9 after overshoot of target.
	Beta XXX.XX DEG		
	CRSRNG ERR XXXX.X NM		
	DWNRNG ERR XXXX.X NM		
	Key VERB (freeze disp) Compare DWNRNG ERR to pad data (DWNRNG ERR within 100 NM of pad data)		
	XXX X If DWNRNG ERR not within 100 NM Maintain BBA entry X XXX		
CDR			
CMP	KEY REL (reinstates V06 N66 mon)		
CDR	Fly roll cmd Mon lift vectr on RSI & ball	1	

4.15.3.2

P62, P63, P64, P65, P66, P67 ENTRY



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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 20	FL V16 N67 (mon) Range to splash XXXX.X NM (+ overshoot) Lat present position XXX.XX DEG (+N) Long present position XXX.XX DEG (+E) (V REL = 1000 fps at ≈65K')	2	Range to go to desired splashpoint (+ is overshoot). Latitude and longitude of present position.
CDR	If R1 = -, lift-up; +, lift-down Mon altimeter Rcd lat, long, & voice to RECY at 10K' Rcd EMS RTOGO EMS MODE - STBY EMS FUNC - OFF	1	
21	Go to Earth Ldg Phase (<50K'), 4.16		

P62, P63, P64, P65, P66, P67 ENTRY

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.15.4	SCS ENTRY	1	Assumes CM and SM separated. During entry, do not "fly to" a pegged rate needle. For this contingency, control to operational attitude ball or out-the-window visual cues.
	CMC - on (desired), 4.8.1.3 ISS - on & orient known (desired), 4.8.1.3 & 4.14 SCS - on (req), 4.8.4.2 RSI aligned, 4.15.1.2		
CDR	1 Verify/mnvr to entry att		SCS acceleration command recommended until .05 G for failure takeover considerations.
	EMS Entry Test, 4.15.1.3		
	2 EMS MODE - STBY EMS FUNC - RNG SET (CW)		May have been done during Deorbit or Lunar Return Vehicle Preparation, 4.15.1.
	Set RNG ind - RTGO from .05 G (MSFN value)		Do not go through EMS TEST positions. The following steps to be done as soon as possible after deorbit ΔV.
	3 EMS FUNC - Vo SET Realign scroll Vo to exact entry velocity (if req)		Predicted entry velocity preset in step 1 (EMS Entry Test). Scroll can be slewed only one inch in reverse. In Vo SET position, both initial velocity in range integrator and scroll velocity change simultaneously.
	4 EMS FUNC - ENTRY		
	5 Align RSI to desired angle (if necessary) ATT SET - GDC EMS ROLL - on (up)		This alignment may be performed prior to launch or prior to deorbit.

4.15.4

SCS ENTRY



STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	GDC ALIGN pb - push, hold ATT SET YAW tw - position RSI GDC ALIGN pb - rel EMS ROLL - OFF ATT SET YAW tw - rset GDC ALIGN pb - push (32 sec max)	1	EMS roll stability indicator alignment provides indication of backup bank angle (BBA).
6	After CM SM sep & CM stab at entry att EMS MODE - NORM ATT DBD - MAX RATE - HI FDAI SCALE - 50/15/50/10 BMAG MODE (3) - RATE 2 MAN ATT ROLL - ACCEL CMD MAN ATT PITCH & YAW - RATE CMD		Left in STBY until after separation and stabilization; if no postburn update, and for RCS deorbit, start EMS by positioning MODE switch from STBY to BU at MSFN supplied value of RET .05 G. Also refer to 4.6.1.1, note 9.
LMP	PCM BIT RATE - HI TAPE RCDR RCD - RCD TAPE RCDR FWD - FWD	3	Cages attitude BMAGs, preventing SCS-driven FDAI RSI jumping at .05 G when GA 1 attitude BMAGs automatically caged to furnish rate information for SCS-driven FDAI RSI. This configuration can be delayed, as close to .05 G as convenient, for propellant conservation.
CDR,CMP	Mon FDAIs & RSI	1,2	

SCS ENTRY

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	Mnvr to BBA & maintain until range potential guidelines can be interpreted, then null range err using range potential guidelines & EMS RNG ind. While nulling range err, avoid tangency to G on-set lines. Reverse bank angle at RETRB to null lateral range err.	1	BBA is backup bank angle. Disregard corridor lamps (as corridor verification cues) for entry from earth orbit (entry velocity <35K fps). RETRB is retrofire elapsed time to reverse bank.
8	Go to Earth Ldg Phase (<50K'), 4.16		

SCS ENTRY

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.16	EARTH LANDING PHASE (<50K')		
CDR 50K'	CAB PRESS RELF vlv (2) - BOOST/ENTR (safety latch on) Report CM stable	325	
	XXX X		
	CM unstable		
CMP 40K'	RCS CMD - OFF	2	OFF position is momentary.
CDR	APEX COVER JETT pb - push	1	Guarded.
	DROG DPLY pb - push (2 sec after apex cover jett)		Guarded.
	X XXX X		
30K'	ELS LOGIC - on (up) ELS AUTO - AUTO		Guarded.
CMP	SEC COOL EVAP - off (ctr)	2	Required only if secondary loop in operation.
	GLY EVAP H2O FLOW - off (ctr)		
24K'	SCS RCS disable (auto)		
	XXXXXXXXXXXXXXXXXXXXX X		
	RCS CMD - OFF		OFF position is momentary.
	X XXXXXXXXXXXXXXXXXXXXX X		
	Apex cover jett (auto)		The apex cover will be jettisoned at 24K feet plus 0.4 seconds.
	XXX X		
CDR	APEX COVER JETT pb - push	1	Guarded.
	X XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX X		

4.16

EARTH LANDING PHASE (<50K')

STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	Drogue chutes deployed (auto)		Drogue parachutes deployed at 24K feet plus 2.0 seconds. The CM may be very unstable until the drogue chutes disreef in ≈11 seconds.
	XXXXXXXXXXXXXXXXXXXXXXXXXXXXX DROG DPLY pb - push	1	Guarded.
	XXXXXXXXXXXXXXXXXXXXXXXXXXXXX If no drogue deployment ELS AUTO - MAN Stab CM with dir RCS 5K' MN DPLY pb - push ELS AUTO - AUTO		Guarded.
	XXXXXXXXXXXXXXXXXXXXXXXXXXXXX		
CMP 23.5K'	Mon CAB PRESS ind - starts incr	2	No increase indicates cabin pressure relief valve failure.
	XXXXXXXXXXXXXXXXXXXXXXXXXXXXX		
CDR	If no incr by 17K' rh CAB PRESS RELF vlv - DUMP (safety latch off)	325	RH valve has four positions.
CMP	If still no incr CAB PRESS DUMP vlv - open (CCW)	Side hatch	
	XXXXXXXXXXXXXXXXXXXXXXXXXXXXX		

EARTH LANDING PHASE (<50K')

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 10K'	Mn chutes & VHF recovery ant deploy (auto)		Auto deployment occurs between 10,950 and 9,100 feet. Parachutes disreef in ≈15 seconds after pilot mortars fire.
CDR	MN DPLY pb - push (within 1 sec)	1	Guarded. MN DPLY pushbutton should be pushed within 1 second after pilot mortars fire to ensure simultaneous deployment of main parachutes.
	SRG TK 02 vlv - OFF	326	
	REPRESS PKG vlv - OFF		
	DIRECT 02 vlv - OPEN (CCW)	7	
LMP	Set up entry comm		
	VHF ANT - RECY	3	
	VHF AM A - SIMPLEX		If VHF AM B SIMPLEX or VHF AM A DUPLEX required, turn off beacon during period of communication.
	VHF BCN - ON		
CDR	Transmit voice (VHF AM) reporting Position Mn chutes disreefed Splash err Crew stat		Continue voice transmission until touchdown.
CMP	Crew couch struts (4) - unlock		
CDR	CM RCS LOGIC - on (up)	1	Must be on to power CM PRPLNT DUMP switch.
	<u>CAUTION</u>		
	CM PRPLNT DUMP should be init immediately after mn chute dis- reefing. If mn or pyro bus lost, use RHCs for burn, not CM PRPLNT DUMP sw.		

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4.16

EARTH LANDING PHASE (<50K')

NORMAL/BACKUP

STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	CAB PRESS RELF vlv (2) - CLOSE (safety latch off)	325	
CMP	XX X If CAB PRESS DUMP vlv used to equalize ΔP, CAB PRESS DUMP vlv - close (CW) XX X	Side hatch	
CDR	CM PRPLNT DUMP - on (up) (dump burn is audible)	1	Guarded.
CMP	RCS IND sel - CM 1 & 2 RCS He PRESS ind - decr XX X	2	
CDR, CMP	No burn or no press decr RHC (both) - fire all RCS jets (except + pitch) until prplnts are depleted XX X		One RHC positioned to command plus yaw and roll (excluding plus pitch) and other RHC positioned to command minus yaw, pitch, and roll.
CDR	When prplnt dump burn completed CM PRPLNT PURG - on (up) (purge is audible)	1	Guarded. Both CM RCS LOGIC and CM PRPLNT DUMP switches must be on (up) to power CM PRPLNT PURG switch. Visible fire from RCS engine nozzle extension surfaces, after burn to depletion and during purge, expected and normal.

EARTH LANDING PHASE (<50K')

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX CM RCS He DUMP pb - push	1	Guarded. CM RCS He DUMP pushbutton should be used to initiate purge following a normal dump operation if CM PRPLNT PURG switch fails to initiate purge.
CDR,CMP	If RHC (both) used for prplnt dump burn RHC (both) - fire all jets (except + pitch) XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX		One RHC positioned to command plus yaw and roll (excluding plus pitch) and other RHC positioned to command minus yaw, pitch and roll.
CDR	CAB PRESS RELF vlv (2) - BOOST/ENTR (safety latch off) XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	325	
CMP	If CAB PRESS DUMP vlv used to equalize ΔP, CAB PRESS DUMP vlv - open (CCW) XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	Side hatch	
CDR	If night ldg cb FLOAT BAG (all) - close PL BCN LT - LO	8 15	The postlanding beacon light has longer operating life in LO.
LMP	cb FLT/PL BAT BUS A, B & BAT C (3) - close	275	Connects battery bus A, B, and battery C to flight and postlanding bus.
CDR	cb FLT/PL MNA & B (2) - open cb SPS PITCH (2) - open cb SPS YAW (2) - open	8	

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	CM RCS PRPLNT (both) - OFF	2	OFF position is momentary. Prevents RCS fume ingestion into cabin at 3K' when CAB PRESS RELF vlv - DUMP.
	CM RCS PRPLNT tb (both) - bp		Barber pole indicates at least one valve (fuel or oxidizer) closed in the particular system 1 or 2.
3K' CDR	rh CAB PRESS RELF vlv - DUMP (safety latch off)	325	Assures minimum cabin-to-ambient negative ΔP for landing impact.
	FLOOD FIXED - POST LDG	8	Provides power from flight and postlanding bus to one floodlight in LH couch area and one floodlight in center couch area. Minimize floodlight use during postlanding. Maximum utilization should be 9.6 hours per 48-hour period.
	FLOOD DIM - 1 or 2		Position 1 provides power to two secondary floodlights and position 2 provides power to two primary floodlights when FLOOD LTS FIXED switch in POST LDG position after dc main buses deactivated.
800'	CAB PRESS RELF vlv (2) - CLOSE (safety latch off)	325	Valves must be closed prior to touchdown to prevent water from entering CM.
CMP	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX X If CAB PRESS DUMP vlv used to equalize ΔP, CAB PRESS DUMP vlv - close (CW) X XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX X	Side hatch	
CDR	ELS AUTO - AUTO (verify) ELS LOGIC - on (up) (verify)	1	Guarded.

EARTH LANDING PHASE (<50K')

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STA/T STEP	PROCEDURE	PANEL	REMARKS
LMP	MN BUS TIE (2) - OFF <u>CAUTION</u> MN BUS TIE sws must be left in OFF position to ensure that bats A, B, and C are used to pwr the PL bus only, & to prevent bat shorting caused by water entering the CM feed-thru connectors. cb BAT RLY BUS (2) - open Postlanding Check, 4.17	5	Removes battery power from dc main buses.

4.16

EARTH LANDING PHASE (<50K')

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.17	POSTLANDING		
4.17.1	POSTLANDING STABILIZATION		
LMP CMP	cb MN REL (2) - close MN REL - on (up)	229 2	Guarded. On position is momentary. Releases main parachutes.
	XXX X		
CDR	If no mn chute rel ELS AUTO - AUTO (verify)	1	Switch should have been on at least 14 seconds to allow timer to time out and enable MN REL switch.
CMP	ELS LOGIC - on (up) (verify) MN REL - on (up)	2	Guarded. Guarded. On position is momentary.
	X XXX X		
	<u>WARNING</u>		
	If fire or smoke after impact, refer to Fire/Smoke in CM During Postlanding, 5.3.3.1.		
CDR	SECS PYRO ARM (2) - SAFE SECS LOGIC (both) - OFF	8	Lever lock. Lever lock.
ALL LMP	If not in contact with recovery forces VHF AM (3) - RCV VHF AM A - off (ctr) VHF AM RCV - A	9,10,6 3	

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4.17.1

POSTLANDING STABILIZATION



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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	cb PL VENT FLT/PL - close	8	
	cb FLOAT BAG (all) - close		
LMP	cb UPR SYS COMPR (both) - close	278	
	If floating upright		
	<u>CAUTION</u>		
	Wait 10 min prior to init bag fill. This allows the ablator to cool sufficiently prior to inflation. Heat can destroy bags.		
CDR	FLOAT BAG (all) - FILL for 7 min, then OFF	8	Lever lock. Wait 15 minutes prior to running compressors again.
	XXX		
	X		
	If floating inverted		
	FLOAT BAG (all) - FILL		Lever lock.
LMP	VHF BCN - OFF	3	
	VHF AM A - off (ctr)		
	Two min after upright		
CDR	FLOAT BAG (all) - OFF	8	Lever lock.
LMP	VHF BCN - ON	3	
	If in contact with recovery forces prior to floating inverted		
	VHF AM A - SIMPLEX		
	If VHF AM B SIMPLEX or VHF AM A DUPLEX required, turn off beacon during period of communication.		

POSTLANDING STABILIZATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
	If CM fails to upright in 7 min & CM rolls CW		Crew reposition procedures may be required if uprighting does not occur in 7 minutes and sea state is minimal.
CDR	FLOAT BAG 2 R - OFF (Continue uprighting for 8 additional min)	8	Lever lock.
CMP,LMP	If uprighting does not occur in 3 min, reposition to area behind CDR's couch & CMP's couch as near as poss to B3 stowage locker		
CDR	or CM rolls CCW FLOAT BAG 1 L - OFF (Continue uprighting for 8 additional min)		Lever lock.
CDR,CMP	If uprighting does not occur in 3 min, reposition to area behind LMP's couch & CMP's couch		
CDR	or No roll FLOAT BAG 3 CTR - OFF (Continue uprighting for 8 additional min)		Lever lock.

4.17.1

POSTLANDING STABILIZATION

STA/T STEP	PROCEDURE	REMARKS
CMP,LMP	<p>If uprighting does not occur in 3 min, reposition to area on top of or along lower equip bay cstr</p> <p style="text-align: center;"><u>WARNING</u></p> <p>If CM still does not upright, prepare to egress within 15 min (because of environ- mental conditions) after completing above uprighting procedure. Refer to Stable II Water Egress Procedure, 4.17.4.3</p> <p>X XXX X</p>	

POSTLANDING STABILIZATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.17.2 POST STABILIZATION AND VENTILATION			
ALL LMP	Release footstraps Release restraint harness cb MNA BAT BUS A & BAT C (2) - open cb MNB BAT BUS B & BAT C (2) - open cb FLT/PL BAT C - open cb PYRO A/SEQ A - open cb PYRO B/SEQ B - open DC IND sel - BAT BUS A,B DC VOLTS ind - >27.5 vdc	 275 250 3	 Battery C held in reserve for use after depletion of battery A and B charge.
XXX			
	X If BAT BUS A(B) <27.5 vdc cb FLT/PL BAT BUS A(B) - open Go to Comm Low Pwr Procedures, 4.17.3.3	 275	
	If BAT BUS A & B (2) <27.5 vdc cb FLT/PL BAT BUS A & B (2) - open cb FLT/PL BAT C - close Go to Comm Low Pwr Procedures, 4.17.3.3, & mon BAT C voltage		
XXX			
CMP	PLV distribution duct (3) - unstow & install Remove debris trap from left X-X head strut at MDC PL VENT VLV - PULL (unlock)	 2	Stowed in aft bulkhead stowage area. Allows cabin air to flow to PL valve exhaust port on forward bulkhead.

4.17.2

POST STABILIZATION AND VENTILATION



STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	PL VENT - HI or LO	15	PLV fan can operate in high flow for 12 hours maximum. During periods of no PLV fan operation, cycle PLV 5 minutes every half hour. If RCS fumes are noticed, prepare to egress immediately. PL VENT should be cycled from HI to LO prior to using manual backup procedure.
	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX X		
	If no PLV operation To initially open vlvs PLVC sw - OPEN To close vlvs PL VENT - OFF To reopen vlvs PL VENT - HI or LO	376	Prepare to egress CM in 30 minutes after landing if valves cannot be opened.
	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX X		
	PL BCN LT - LO		After dark only. Place switch at HI only at request of recovery forces.
	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX X		
	If no flashing lt		Perform backup duty cycle at request of recovery forces.
	FLOOD FIXED - POST LDG for 1/2 min OFF for 1/2 min	8	
	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX X		
	Deploy dye marker & swimmer umbilical DYE MARKER - on (up)	15	Guarded. On (up) position is momentary.

POST STABILIZATION AND VENTILATION

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STA/T STEP	PROCEDURE	PANEL	REMARKS
ALL	INTERCOM (3) - T/R (verify)	9,10,6	Required for swimmer umbilical operation.
CDR	Deploy line grappling hook (if req) CAB PRESS DUMP vlv - remove Grappling hook & line - deploy thru vlv opening Cover plate - secure	Side hatch	Grappling hook deployed at request of recovery forces. It is located in aft bulkhead stowage area and is for snagging sea anchors deployed by recovery forces. Adapter E and driver R tools required to remove cabin pressure dump valve and secure cover plate on side hatch (over valve opening).

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.17.3 POSTLANDING COMMUNICATIONS			
4.17.3.1 <u>Normal Postlanding Communications</u>			
LMP	<p>VHF BCN - ON (verify) VHF ANT - RECY (verify)</p> <p>If no contact with recovery forces VHF AM B - SIMPLEX Mon for VHF bcn 1000 Hz tone (2 sec on, 3 sec off) VHF AM B - off (ctr) If VHF bcn not audible Remove survival transceiver from stowage & mount ant Sel VOICE on transceiver Mon VHF bcn for 1000 Hz tone (2 sec on, 3 sec off) If VHF bcn operating Turn off survival transceiver Stow transceiver in RHFEB</p> <p>XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX X</p> <p>If no VHF bcn sig, turn off transceiver, remove ant, & conn transceiver to ant per 4.17.3.2 Sel BCN on transceiver Mon VHF AM for comm initiated by recovery aircraft</p> <p>XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX X</p>	3	Government-furnished survival transceiver stowed in RHFEB.

POSTLANDING COMMUNICATIONS

STA/T STEP	PROCEDURE	PANEL	REMARKS
<u>4.17.3.2 Survival Transceiver Communications</u>			
LMP	VHF BCN - OFF (if no contact after 24 hours) Survival transceiver - conn to VHF BCN ant cable Remove survival transceiver from stowage Unlatch & open VHF ant access door Disconnect Pl12 conn from bcn Attach transceiver cable Pl conn to transceiver (verify) Conn transceiver cable J1 conn to Pl12 conn Select BCN on transceiver	3	Conserve spacecraft power for terminal phase of recovery operations. Transceiver is stowed in RHFEF. A 5/32" hex wrench, for opening two hex fasteners on antenna cable access door, stowed in aft bulkhead stowage area. An adjustable wrench, stowed in aft bulkhead stowage area, used to loosen 5/8" hex on coax connector.
<u>4.17.3.3 Communications Low Power Procedures</u>			
CDR	VHF BCN - OFF	8	Turns off postlanding floodlights.
LMP	FLOOD FIXED - OFF	8	
LMP	VHF AM A - off (ctr) VHF AM RCV - A	3	
CDR	PL VENT sys - minimize use Survival transceiver - conn to VHF BCN ant cable (refer to Survival Transceiver Comm, 4.17.3.2)		
<u>4.17.3.4 Spacecraft Power Down</u>			
LMP	PL VENT - OFF cb ENTRY/PL BAT A, B, C (3) - open	15 250	

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.17.4	UNAIDED EGRESS PROCEDURES		
4.17.4.1	<u>Egress Preparation</u>		
ALL	Disconnect umbilicals (if suited)		
	Neck dams on (if suited)		
	Configure couch seat pans		
	Center couch - 270° position		
	L & R couch - 270° position (if stable		
	II egress anticipated)		
CDR, LMP	Armrests folded (stowed)		
ALL	If unsuited, transfer scissors from suit		Scissors may be required to cut mooring lanyard in an emergency.
	to coveralls		
	Tape flight penlight to wrist (night		
	egress)		
LMP	Survival kits removed from stowage	R-4	
	Remove lanyards from rucksack kit No. 2		
	& reclose rucksack		
CMP	Conn liferaft mooring line (olive drab)		
	to CM		
	Conn lanyard titled (attach to first		
	crewman out) to suit (if unsuited attach		
	to buckle on life vest)		
LMP	Conn lanyard titled (attach to second		
	crewman out) to suit (if unsuited attach		
	to buckle on life vest)		
CDR	Conn lanyard titled (attach to third		
	crewman out) to suit (if unsuited attach		
	to buckle on life vest)		

UNAIDED EGRESS PROCEDURES

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.17.4.2	<u>Stable I Water Egress</u>		
CMP	PL VENT - OFF	15	
LMP	cb ENTRY/PL BAT A, B, C (3) - open	250	
CMP	Charge hatch counterbalance	Side hatch	
	GN2 ratchet handle - opr		
	GN2 vlv handle - unlock and push		
	outboard		
	Open side hatch		
	XXX		
	If side hatch was closed by backup		
	proced in 4.5.7.2, loosen jack-		
	screws by screwing wing nuts CCW		
	Disengage hooks from catches on hatch		
	Disengage jackscrew lever from hatch		
	frame		
	If any hatch latches are latched,		
	complete side hatch opening proced;		
	if not, open hatch		
	XXX		
	Lock pin rel knob - UNLOCK		
	Gear box sel - UNLATCH		
	Actr handle sel - U (unlatch)		
	Actr handle rel - push or squeeze		
			Push button or squeeze for release on actuator handle for operation.

4.17.4.2

UNAIDED EGRESS PROCEDURES



STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Actr handle - opr (until hatch can be opened) Push hatch open	Side hatch	
CDR	Actr handle sel - N (neut) Remove life raft from rucksack kit No. 2 Simultaneously throw life raft overboard & pull inflation lanyard		
LMP	Throw rucksacks No. 1 & 2 overboard		
CMP	Egress, inflate life vest, board raft		
CMP	Egress, inflate life vest, board raft		
CMP	Egress, inflate life vest, board raft		
	4.17.4.3 <u>Stable II Water Egress</u>		
	PWR (3) - OFF	6,9,10	
	SUIT PWR (3) - OFF		
	PRESS EQUAL vlv - OPEN	Fwd hatch	Pull detent knob on end of handle, then pivot up 90°. Rotate crank ≈3 turns CCW to fully open valve. This will flood tunnel prior to opening hatch.
	<u>WARNING</u>		
	To prevent injury to crew members, do not unlock hatch until flooding stops & press equalizes in CM.		
	Actr handle rel - pull & rotate		To free actuator handle for operation, release rotated to mechanical stop.
	Actr handle - pull to stop		Actuator handle should move ≈80°.
	Actr handle sel - U (unlatch) (CCW 90°)		

UNAIDED EGRESS PROCEDURES

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Actr handle - push to stop Actr handle sel - stow (CW 90°) Actr handle - push to stowed position	Fwd hatch	Actuator handle should move 60° to release hatch.
CMP,LMP	Remove & stow fwd hatch		Forward hatch weighs ≈85 lbs and is stowed in LHEB.
CMP	Put survival rucksacks down tunnel Exit feet first; when clear of CM, inflate water wings		
LMP	Exit feet first; when clear of CM, inflate water wings		
CMP,LMP	Remove life raft from rucksack No. 2 & inflate raft		
CDR	Disconnect life raft mooring line (olive drab) from CM & return end of line (CDR's discretion) Exit feet first; when clear of CM inflate water wings Reconnect life raft mooring line (olive drab) to SC exterior - sea anchor hardpoint or EVA handles (CDR's discretion)		
4.17.4.4 <u>Rough Sea Side Hatch Operations</u>			
CMP	Close side hatch GN2 vlv handle - pull (inboard) GN2 press ind - min Open door rel handle - pull Verify latches are in open position Close hatch	Side hatch	Vents counterbalance piston chamber. Squeeze handle to unlock. D-ring.

4.17.4.4

UNAIDED EGRESS PROCEDURES



STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Actr handle sel - L (latch) Gear box sel - LATCH Open door rel handle - stow Actr handle rel - push or squeeze Actr handle - opr (while holding hatch closed) Lock pin rel knob - LOCK (auto) LOCK PIN ind - not extd Actr handle - stowed Re-open side hatch Lock pin rel knob - UNLOCK Gear box sel - UNLATCH Actr handle sel - U (unlatch) Actr handle rel - push or squeeze GN2 vlv handle - push (outboard) GN2 press ind - green Actr handle - opr (until hatch can be opened)	Side hatch	Verify lock pin has automatically engaged. Indicates lock pin engaged. Pin can be sheared if left in LOCK position. Push button or squeeze (bar) releases actuator handle for operation. Actuator handle should not be operated until immediately prior to egress.

UNAIDED EGRESS PROCEDURES

4.18 LUNAR ORBIT EXPERIMENTS

Procedures presented in this section represent a single cycle of each experiment operation. The operational periods will be defined by the mission time line (or flight plan) including status of deployment mechanisms after data collection periods. All experiments except S-band transponder (S164) and Bi-static Radar (S170) require that SIM door be jettisoned prior to conducting experiments. The following matrix identifies experiments having electrical interface with CSM requiring crew participation.

EXP. No.	Name	CSM			
		112	113	114	115
S160	Gamma Ray Spectrometer	X	X		
S161	X-Ray Fluoresence Spectrometer	X	X		
S162	Alpha-Particle Spectrometer	X	X		
S163	Optical Bar Panoramic Camera	X	X	X	X
S164	S-Band Transponder	X	X	X	X
S165	Mass Spectrometer	X	X		
S166	3-inch Mapping Camera	X	X	X	X
S169	Far Ultra-Violet Spectrometer			X	X
S170	Bi-Static Radar				X
S171	IR Scanning Radiometer			X	X
S173/174	Subsatellite	X		X	X
S175	Laser Altimeter	X	X	X	X

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4.18.1 GENERAL OPERATIONAL REQUIREMENTS

The following considerations are applicable to lunar orbit experiment procedures:

1. SM RCS jets A2, A4, B1 and B4 are inhibited during experiment operation to reduce contamination and thermal gradients in the SIM bay after the SIM door is jettisoned. In addition, jets C1 and C3 are inhibited whenever the mass spectrometer boom is deployed.
2. Particle-sensitive experiments should be scheduled as long as possible after ECS dumps and purges to preclude degradation of experimental data.
3. If required during experiment operation, mission time and duration of dumps and purges must be recorded for postflight analysis of experimental data.
4. Local vertical attitude hold will be maintained during experiment operations, except for experiment calibration and possibly for IMU alignments.
5. During spacecraft maneuvers in lunar orbit, direct sunlight impingement into the SIM bay should be avoided to prevent damage to experiments.

GENERAL OPERATIONAL REQUIREMENTS

STA/T STEP	PROCEDURE	PANEL	REMARKS
4.18.2	SIM DOOR JETTISON AND EXPERIMENT TIE-DOWN RELEASE		
	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		
CDR	All jets OFF except AUTO RCS B/D ROLL B2 & D1 - MNA or MNE AUTO RCS PITCH A3 & C4 - MNA or MNB AUTO RCS YAW B3 & D4 - MNA or MNB	8	Jets are disabled to prevent SIM bay contamination and enables single jet control until SIM experiments completed.
	Mnvr to jett SIM door R <u> </u> °, P <u> </u> °, Y <u> </u> °		SIM door to impact lunar surface.
LMP	FC REACS VLVS - LATCH	3	Holding voltage prevents SIM door jettison shock from inadvertently closing FC reactants valves.
CMP	Arm SIM door & jett cb LOGIC PWR (2) - close (verify) LOGIC PWR - JETT DOOR JETT - on (up)	181	Guarded - On (up) position momentary.
LMP	FC REACS VLVS - NORM Rel booms	3	
	NONESS BUS - MNA (MNB) (verify) cb INST SCI EQUIP (3) - close (verify)	5	
CMP	SM/AC PWR - on (up), then OFF	181	Releases gamma-ray and mass spectrometer booms and subsatellite launcher tie-downs.
	DOOR JETT - off (down) LOGIC PWR - OFF		Guarded.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
	<p>Go to boom & camera/altimeter deploy, 4.18.3.1, 4.18.3.3 & 4.18.3.5 as req</p>		

SIM DOOR JETTISON AND EXPERIMENT TIE-DOWN RELEASE

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.18.3	DEPLOY & RETRACT GAMMA RAY & MASS SPECTROMETER BOOMS & MAPPING CAMERA		
4.18.3.1	<u>Deploy Gamma Ray Boom</u>		
CMP	cb LOGIC PWR MNA - close (verify)	181	
	LOGIC PWR - DPLY/RETR		
	GAMMA RAY BOOM DPLY - on (up)	230	If gamma-ray spectrometer is to be operated in retracted position, omit this and following step. Maximum continuous operating time in retracted position is 3 hours because of thermal considerations.
	GAMMA RAY BOOM DPLY tb - bp, then gray		Barber pole when boom is in any position except fully extended or retracted. ≈100 seconds required to fully extend boom.
	LOGIC PWR - OFF	181	
4.18.3.2	<u>Retract Gamma Ray Boom</u>		
	<u>WARNING</u>		
	Boom must be retracted prior to SPS mnvrs or structural failure may result.		
	cb LOGIC PWR MNA - close (verify)		
	LOGIC PWR - DPLY/RETR		
	GAMMA RAY BOOM DPLY - RETR	230	≈100 seconds required to retract boom.
	GAMMA RAY BOOM DPLY tb - bp, then gray		Barber pole when boom is in any position except fully extended or retracted.

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4.18.3.2

DEPLOY & RETRACT GAMMA RAY SPECTROMETER BOOM



STA/T STEP	PROCEDURE	PANEL	REMARKS
	XXX X If no boom retract, jett exp pkg prior to SPS thrusting CMP cb LOGIC PWR (2) - close (verify) 181 LOGIC PWR - JETT GAMMA RAY BOOM JETT - on (up) 230 GAMMA RAY BOOM JETT tb - bp, then gray		On position momentary. Jettisons experiment package.
	X XXX LOGIC PWR - OFF 181		
	4.18.3.3 <u>Deploy Mass Spectrometer Boom</u> cb LOGIC PWR MNA - close (verify) LOGIC PWR - DPLY/RETR MASS SPECT BOOM DPLY - on (up) 230 MASS SPECT BOOM DPLY tb - bp, then gray		Barber pole while boom is extending. ≈84 seconds required to fully extend boom.
	LOGIC PWR - OFF 181		
	4.18.3.4 <u>Retract Mass Spectrometer Boom</u> <u>WARNING</u> Boom must be retracted prior to SPS mnvrs or structural failure may result. cb LOGIC PWR MNA - close (verify) LOGIC PWR - DPLY/RETR		

DEPLOY & RETRACT MASS SPECTROMETER BOOM

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	MASS SPECT ION SOURCE - OFF (verify)	230	Must be OFF when boom is retracted in SIM bay or instrument damage may result.
	MASS SPECT BOOM DPLY - RETR		
	MASS SPECT BOOM DPLY tb - bp, then gray		Barber pole while boom retracting. ~84 seconds required to fully retract boom.
	XXX		
	If no boom retract, jett exp pkg prior to SPS thrusting		
	cb LOGIC PWR (2) - close (verify)	181	
	LOGIC PWR - JETT		
	MASS SPECT BOOM JETT - on (up)	230	On position momentary.
	MASS SPECT BOOM JETT tb - bp, then gray		
	XXX		
	LOGIC PWR - OFF	181	
4.18.3.5	<u>Deploy Mapping Camera & Laser Altimeter</u>		
	cb LOGIC PWR MNA - close (verify)		
	LOGIC PWR - DPLY/RETR		
	MAP CAMR TRACK - EXTD	230	
	MAP CAMR TRACK tb - bp, then gray		Barber pole while camera/altimeter extending.
	LOGIC PWR - OFF	181	
4.18.3.6	<u>Retract Mapping Camera & Laser Altimeter</u>		
	cb LOGIC PWR MNA - close (verify)		
	LOGIC PWR - DPLY/RETR		



STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	MAP CAMR TRACK - RETR MAP CAMR TRACK tb - bp, then gray LOGIC PWR - OFF	230 181	Barber pole while camera/altimeter retracting.

DEPLOY AND RETRACT MAPPING CAMERA

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.18.4	SIM EXPERIMENTS PREPARATION & SHUTDOWN		
4.18.4.1	<u>System Preparation</u>		
	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		Recommended rates and deadbands - <u>TBD</u> .
CDR	Verify all jets off, except AUTO RCS B/D ROLL B2 & D1 - MNA or MNB AUTO RCS PITCH A3 & C4 - MNA or MNB AUTO RCS YAW B3 & D4 - MNA or MNB	8	Jets disabled to prevent SIM bay contamination and maintain balanced SM RCS single jet rotation control until SIM experiments completed.
LMP	SIM Data Sys Prep Configure TLM, 4.5.6.1, except PCM BIT RATE - HI	3	
CMP	Activate Data Sys DATA SYS ON - ON	230	Allow 15-minute warmup prior to calibration.
	DATA SYS CAL - on (up) Repeat following three times Wait one sec DATA SYS CAL - on (up)		On position (momentary) puts a known calibration signal into voltage control oscillator of FM analog channel. Three-step calibration required.
4.18.4.2	<u>Systems Shutdown</u>		
	When all SIM exp complete DATA SYS CAL - on (up)		On position momentary.

4.18.4.2

SIM EXPERIMENTS PREPARATION & SHUTDOWN

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	Repeat following three times Wait one sec DATA SYS CAL - on (up) DATA SYS ON - OFF	230	Three-step calibration required prior to shutdown.

SIM EXPERIMENTS PREPARATION & SHUTDOWN

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.18.5	SENSOR CALIBRATION Mvnr to calib att R _____°, R _____°, Y _____° Att hold for 15 min Mvnr to exp att Resume exp oper		Performed once each day on lunar darkside by pointing sensor toward deep space. Calibration data obtained by taking background level measurements of deep space. Roll to point sensor 135°-180° (toward deep space) from local vertical.

4.18.5

SENSOR CALIBRATION



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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.18.6 S160 - GAMMA RAY SPECTROMETER	Verify SIM Door Jett, 4.18.2 Sys Prep, 4.18.4.1 MnvR to exp att R ___°, P ___°, Y ___° (detector at lcl vert)		Normal lunar orbit operation periods will utilize local vertical mode, with SIM pointing toward moon.
LMP	Establish lcl vert att hold, <u>TBD</u> Deploy Gamma Ray Boom, 4.18.3.1 Activate exp cb SCI EQUIP SEB 2 - close (verify) NONESS BUS - MNA (MNB) (verify)	5	No warmup required.
CMP	GAMMA RAY EXP - ON GAMMA RAY GAIN - STEP (as req)	230	STEP position momentary. Increases sensitivity. Positioned per flight plan or as directed by MSFN in real time.
	GAMMA RAY GAIN - ctr Terminate exp GAMMA RAY EXP - OFF		
	If boom to be retracted, refer to 4.18.3.2		Mission time line or flight plan will determine whether boom to be retracted between data collection periods.

EXPERIMENT S160

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.18.7	S161 - X-RAY FLUORESENCE SPECTROMETER		
	Verify SIM Door Jett, 4.18.2 Sys Prep, 4.18.4.1		
	<u>CAUTION</u>		
	Avoid Sun entering instrument FOV (<u>+30°</u> from SIM pointing line) or instrument will be destroyed. If direct sunlight exposure is anticipated pwr to the instrument must be removed by placing X RAY EXP sw to STBY.		
	Mnvr to exp att R____°, P____°, Y____° (snsr at lcl vert)		Normal lunar orbital operation periods will utilize local vertical mode, with SIM pointing toward moon.
	Establish lcl vert att hold, <u>TBD</u>		
	Open solar snsr door		
LMP	cb SCI EQUIP HATCH - close (verify)	5	
CMP	cb LOGIC PWR MNB - close (verify)	181	
LMP	NONESS BUS - MNA (MNB) (verify)	5	
CMP	LOGIC PWR - JETT	181	
	X RAY DR DPLY - on (up)	230	On position momentary. Opens X-ray solar sensor door. Door not retractable.
	LOGIC PWR - OFF	181	
	Activate exp		
	X RAY EXP - ON	230	No warmup required.

4.18.7

EXPERIMENT S161



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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	If calib req, refer to 4.18.5 To term exp X RAY EXP - OFF	230	Calibration required once each day.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
	<p>4.18.8 S162 - ALPHA PARTICLE SPECTROMETER</p> <p>Verify SIM Door Jett, 4.18.2 Sys Prep, 4.18.4.1</p> <p style="text-align: center;"><u>CAUTION</u></p> <p>Avoid sun entering instrument FOV (+45° from SIM pointing line), or damage to instrument will result.</p> <p>Mnvr to exp att R ____°, P ____°, Y ____° (snsr at lcl vert)</p> <p>Establish lcl vert att hold, <u>TBD</u> Activate exp</p> <p>LMP cb SCI EQUIP HATCH - close (verify) 5 NONESS BUS - MNA (MNB) (verify)</p> <p>CMP ALPHA RAY - ON 230</p> <p>If calib req, refer to 4.18.5</p> <p>To term exp ALPHA RAY - OFF</p>		<p>Normal lunar orbital operation periods will utilize local vertical mode, with SIM pointing toward moon. Limit exposure of detector to direct solar radiation for not more than 5 consecutive minutes with a total exposure time not to exceed 30 minutes.</p> <p>Warmup not required.</p> <p>Calibration required once each day on lunar dark side.</p>

4.18.8

EXPERIMENT S163

STA/T STEP	PROCEDURE	PANEL	REMARKS
4.18.9	S163 - OPTICAL BAR PANORAMIC CAMERA		
4.18.9.1	<u>Panoramic Camera Boost Mode</u>		Boost mode required during boost, TLI and SPS thrusting periods until panoramic camera operations are complete.
LMP	1 Boost Mode On NONESS BUS - MNA (MNB) (verify) cb SCI EQUIP SEB 1 & 2 (2) - close (verify)	5	
CMP	cb SM SECTOR 1 AC2 (3) - close (verify) PAN CAMR MODE - STBY (verify) PAN CAMR PWR - BOOST	181 230	
	2 Boost Mode Off PAN CAMR PWR - off (ctr) SM/AC PWR - OFF	181	
4.18.9.2	<u>Panoramic Camera Standby Mode</u>		When thrusting is completed.
LMP	1 Stby Mode On NONESS BUS - MNA (verify) cb SCI EQUIP SEB 1 - close (verify)	5	
CMP	cb SM SECTOR 1 AC2 (3) - close (verify) SM/AC PWR - on (up) (verify) PAN CAMR PWR - ON PAN CAMR MODE - STBY (verify) PAN CAMR SELF TEST - off (ctr)	181 230	
	2 Stby Mode Off PAN CAMR PWR - off (ctr)		

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.18.9.3	<u>Panoramic Camera Heater Mode</u>		≈10 hours of warmup time in heater mode required before camera operation.
LMP	1 Htr Mode On NONESS BUS - MNB	5	
CMP	cb SCI EQUIP SEB 1 - close (verify)	181	
	SM/AC PWR - on (up) (verify)	230	
	PAN CAMR SELF TEST - HTRS		
	2 Htr Mode Off PAN CAMR SELF TEST - off (ctr)		
4.18.9.4	<u>Panoramic Camera Self Test</u>		Panoramic camera must be operated every 24+6 hours to prevent film set. Panoramic camera self-test or camera operation will satisfy this requirement.
LMP	NONESS BUS - MNA (verify)	5	
	cb SCI EQUIP SEB 1 - close (verify)		
CMP	cb SM SECTOR 1 AC2 (3) - close	181	
	SM/AC PWR - on (up) (verify)	230	
	PAN CAMR MODE - STBY (verify)		
	PAN CAMR PWR - ON		
	PAN CAMR SELF TEST - on (up)		On position momentary.
	PAN CAMR OPR tb - bp to gray		Barber pole until completion of five test frames; if barber pole remains, panoramic camera no-go.
	At completion of self-test PAN CAMR PWR - off (ctr)		
	SM/AC PWR - OFF	181	
4.18.9.5	<u>Panoramic Camera Operation</u>		
	Verify SIM Door Jett, 4.18.2		
	Sys Prep, 4.18.4.1		0.5° attitude and 0.05°/sec rate deadbands for this experiment.

4.18.9.5

EXPERIMENT S163

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NORMAL/BACKUP

STA/T STEP	PROCEDURE	PANEL	REMARKS
	Mnvr to exp att R ____°, P ____°, Y ____°		Normal lunar orbital operation periods will utilize local vertical mode, with SIM pointing toward moon. +0.5° attitude hold deadband is recommended in roll and yaw. Camera is direction-sensitive; plus X-axis into velocity vector.
	Verify gamma-ray & mass spectrometer booms retracted, 4.18.3.2 & 4.18.3.4		Photo degradation will result if gamma-ray and mass spectrometer booms extended.
	Pan Camr Htr Mode On, 4.18.9.3, step 1		≈10 hours of warmup time in heater mode required before camera operation.
LMP CMP	Pan camr oper Change oper modes (htr to stby) NONESS BUS - MNA cb SM SECTOR 1 AC2 (3) - close SM/AC PWR - on (up) PAN CAMR SELF TEST - off (ctr)	5 181 230	These steps represent the delta between modes.
	Start pan camr PAN CAMR MODE - OPR		Camera starts operating. Camera operation limited to 20 minutes.
	PAN CAMR OPR tb - bp, then gray		Talkback gray after 2 seconds and remains gray. If barber pole appears, camera not operating.
	Stop pan camr PAN CAMR MODE - STBY PAN CAMR PWR - off (ctr) SM/AC PWR - OFF	181	
	EVA req for film cassette retrieval, 4.10.3		Film cassette retrieved during TEC. Cassette is 19 inches in diameter 7 inches wide and weighs ≈88 pounds.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.18.10	S164 - S-BAND TRANSPONDER		
	<p>The S-band transponder experiment is conducted with a solo CSM in lunar orbit (LM on lunar surface). The experiment consists of a data collection period of two lunar revolutions with the number of data collection periods dependent upon CSM orbit inclination. During each experimental period, MSFN will track CSM while it is being held in a G&N attitude hold (minimum deadband). This hold will be maintained by SM RCS jets operating in balanced couples, minimizing high gain antenna motion relative to MSFN tracking stations, and should be completed prior to SIM door jettison to avoid SIM bay contamination. Also, to prevent unnecessary motion during the experiment, H2O boiler operation, purges, water dumps, etc., will be avoided.</p>		
CDR	<p>CMC - on (req), 4.8.1.3 ISS - on & orient known (desired), 4.8.1.3 & 4.14 SCS - on (desired), 4.8.4.2 RCS DAP - load & activate (req), 4.8.2.1 AUTO RCS (16) - as req Mnvr to exp att R ___°, P ___°, Y ___° Sel telecom basic config, 4.5.6.1 except</p>	8	<p>0.5° attitude deadband and 0.5°/sec rates are recommended.</p>
LMP	PCM BIT RATE - HI	3	

4.18.10

EXPERIMENT S164



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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.18.11	S165 - MASS SPECTROMETER		
	Operational Requirements		
	<ul style="list-style-type: none"> ● Prior to initial operation in lunar orbit, the mass spectrometer must have accumulated 6 hours of warmup operation with its boom extended. If dumps or boom retractions occur during the 6-hour period, each dump or retraction will necessitate an additional 1/2-hour warmup. Additionally, at least 1 hour of uninterrupted warmup is required immediately prior to data collection. Subsequent lunar orbit operations require 30-minute warmup periods. Prior to TEC operations, a 3-hour warmup is required. The same continuity and interference constraints imposed on lunar orbit warmup apply to TEC warmup. 		
	<ul style="list-style-type: none"> ● In lunar orbit, a minimum of three data collection periods of at least two revolutions per collection period are required. During each of the three periods the minus X-axis of the CSM will be aligned to the velocity vector. Additionally, a minimum of one revolution is required while the CSM plus X-axis is aligned to the velocity vector. 		
	<ul style="list-style-type: none"> ● Data collection during TEC should not begin within 6 hours of an SPS or RCS translation burn. 		
4.18.11.1	<u>Mass Spectrometer Operation</u>		
	Verify SIM Door Jett, 4.18.2		
	Sys Prep, 4.18.4.1		
	Mnvr to exp att		
	R <u> </u> °, P <u> </u> °, Y <u> </u> °		
	Xsc aligned along velocity vctr & detector at lcl vert		
	Initiate orb rate <u>TBD</u>		
	Deploy Mass Spect Boom, 4.18.3.3		
			Normal lunar orbital operation periods will utilize local vertical mode, with SIM pointing toward moon.

EXPERIMENT S165

STA/T STEP	PROCEDURE	PANEL	REMARKS
LMP	Warmup cb SCI EQUIP SEB 1 - close (verify)	5	Prior to <u>initial</u> operation, mass spectrometer must have accumulated 6 hours of warmup operation (boom extended) with MASS SPECT EXP and MASS SPECT ION SOURCE switches at STBY. If dumps or boom retractions occur during the 6-hour period, each dump or retraction will necessitate an additional 1/2 hour of warmup. Additionally, at least one hour of uninterrupted warmup is required immediately prior to data collection. Subsequent lunar orbit operations require 30 minute warmup periods.
CMP	NONESS BUS - MNA (MNB) (verify) MASS SPECT EXP - STBY MASS SPECT ION SOURCE - STBY (wait 30 min)	230	
	Activate exp MASS SPECT EXP - ON MASS SPECT ION SOURCE - ON MASS SPECT MULT - as req MASS SPECT DSCRM - as req		
	Term exp If in lunar orb MASS SPECT ION SOURCE - OFF MASS SPECT EXP - off (ctr) If boom to be retracted, refer to 4.18.3.4 or If in transearth coast MASS SPECT BOOM DPLY - RETR for 20 sec then off (ctr) MASS SPECT BOOM DPLY tb - gray (wait 7 min)		
			MASS SPECT MULT and MASS SPECT DSCRM switches positioned per flight plan or as directed in real time by MSFN.
			The mission timeline or flight plan will determine whether boom is to be retracted between data collection periods.
			Boom retracted in five stages. Assumes 3 ips retract rate.
			While boom is in motion, tb is bp.

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	<p>Repeat above seq 3 times</p> <p>MASS SPECT BOOM DPLY - RETR MASS SPECT BOOM DPLY tb - bp, then gray MASS SPECT BOOM DPLY - off (ctr) (wait 7 min)</p> <p>MASS SPECT ION SOURCE - OFF MASS SPECT EXP - off (ctr)</p> <p>or If no boom retract, refer to backup, 4.18.3.4</p>	230	<p>Gray tb while DPLY switch is in RETR indicates experiment is fully retracted.</p>

EXPERIMENT S165

STA/T STEP	PROCEDURE	PANEL	REMARKS
4.18.12	S166 - THREE INCH MAPPING CAMERA		
4.18.12.1	<u>Mapping Camera Cycling</u>		After film has been loaded, camera must be cycled every 24+6 hours to prevent film set.
	Mapping Camr Stby Mode On, 4.18.12.2, step 1		
CMP	MAP CAMR ON - ON (for 2 min), then STBY	230	2 minutes cycles film five frames.
	Mapping Camr Stby Mode Off 4.18.12.2, step 2		
4.18.12.2	<u>Mapping Camera Standby Mode</u>		
	1 Stby Mode On		
LMP	NONESS BUS - MNA (MNB) (verify)	5	Standby mode required during boost, TLI, and SPS thrusting periods until cassette recovery. Standby may be required for 25 hours (worst cold case) prior to initial operation. SIM door may be on or off during the warmup period; camera should be retracted. Note: if hot condition (worst case) the camera should be extended for cool down.
CMP	cb SCI EQUIP-SEB 2 - close (verify)	181	
	cb LOGIC PWR MNB - close (verify)		
	cb SM SECTOR 1 AC2 (3) - close (verify)		
	SM/AC PWR - on (up)		
	MAP CAMR ON - STBY	230	
	<u>CAUTION</u>		
	The following seq must be performed to prevent loss of GN2. Loss of GN2 results in film degradation.		
	2 Stby Mode Off		
	MAP CAMR ON - OFF		
	SM/AC PWR - OFF (if pan camr not in oper)	181	When thrusting complete.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
<p>4.18.12.3 <u>Mapping Camera Operation</u></p> <p>Verify SIM Door Jett, 4.18.2 Sys Prep, 4.18.4.1 Mnavr to exp att R ____°, P ____°, Y ____° Initiate orb rate Verify gamma-ray & mass spectrometer booms retracted, 4.18.3.2 & 4.18.3.4 Extd mapping camr, 4.18.3.5 CMP LASER ALTM - ON Mapping Camr Stby Mode On, 4.18.12.2, step 1 Start mapping camr MAP CAMR ON - ON MAP CAMR IMAGE MTN - as req</p> <p>Stop mapping camr MAP CAMR ON - STBY Mapping Camr Stby Mode Off, 4.18.12.2, step 2 LASER ALTM - OFF EVA req for film cassette retrieval, 4.10.3</p>		<p>230</p>	<p>Operation is direction sensitive with plus X-axis into velocity vector.</p> <p>Photo degradation will result if the gamma ray and mass spectrometer booms remain extended.</p> <p>Switch position per flight plan or as directed in real time by MSFN.</p> <p>Film cutter is manually triggered during EVA.</p>

EXPERIMENT S166

STA/T STEP	PROCEDURE	PANEL	REMARKS
4.18.13	S173/S179 - SUBSATELLITE		
	SIM Door Jett, 4.18.2 (verify)		
	Sys Prep, 4.18.4.1		
	Mnvr to subsatellite launch att		
	R <u> </u> °, P <u> </u> °, Y <u> </u> °		
CMP	cb LOGIC PWR MNA (MNB) - close (verify)	181	
	Report to MSFN		
	After Go From MSFN		
	LOGIC PWR - JETT		
	SUB SAT - LAUNCH	230	SUB SAT tb is gray, then bp for 20 seconds, and returns to gray
	After SUB SAT tb returns to gray		
	SUB SAT - off (ctr)		
	LOGIC PWR - off (ctr)	181	
4.18.14	S169 - FAR ULTRA-VIOLET SPECTROMETER		
	The far ultra-violet spectrometer is used to determine the composition & density of the lunar atmosphere.		
4.18.14.1	<u>Far Ultra-Violet Spectrometer Operation (TBD)</u>		
4.18.15	S171 - INFRA-RED SCANNING RADIOMETER		
	The infra-red scanning radiometer is used to locate and identify, for study, irregularly hot and/or cold regions of the lunar surface that are not illuminated.		
4.18.15.1	<u>Infra-Red Scanning Radiometer Operation (TBD)</u>		

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STA/T STEP	PROCEDURE	PANEL	REMARKS
4.18.16	S175 - LASER ALTIMETER		
	<p>The laser altimeter provides precise time-correlated altitude information for use in conjunction with tracking data and pictures taken by mapping camera, 4.18.12, and panoramic camera, 4.18.9. CSM pointing altitude should be maintained within <u>+2</u> degrees of nadir with a maximum drift rate of 0.05 degree-per-second during data collection.</p>		
4.18.16.1	<u>Independent Operation of Laser Altimeter</u>		
1	Start Laser Altm Verify that instrument temps lie between <u>TBD & TBD</u> Deploy mapping camr sys, 4.18.3.5 LASER ALTM - ON	230	<p>Laser cavity temperature critical.</p> <p>In the automatic mode, the laser altimeter is not slaved to the mapping camera and it cycles once every 20 seconds.</p>
2	Stop Laser Altm LASER ALTM - OFF		

EXPERIMENT S175

STA/T STEP	PROCEDURE	PANEL	REMARKS
4.18.17	S170 - DOWNLINK BI-STATIC RADAR OBSERVATIONS OF MOON		
	<p>This experiment will utilize CSM S-band and VHF-AM transmitters as lunar orbiting radar beacons, and will be conducted during the front side pass of lunar orbits which are visible to Goldstone and Stanford facilities. The experiment period is divided into two phases: Phase A is initiated when the CSM crosses earth-moon line of centers and terminates when the CSM has traversed 120° west longitude; phase B is initiated when the CSM is at 120° east longitude and terminates when the CSM crosses earth-moon line of centers. It is highly desirable that both the S-band and VHF aspect of the experiment be conducted simultaneously. Operation of either or both experiments during additional passes is also highly desirable.</p>		
4.18.17.1	<u>S-Band Experiment Operation</u>		
	<p>The reflected signal from the lunar surface and diverted signal from the back lobe of the CSM high-gain antenna will both be received by 210-foot Goldstone antenna. The S-band high-gain antenna is positioned to a predetermined orientation relative to CSM axes and the CSM is maneuvered such that the reflected beam will be parallel to earth-moon line of centers and the CSM will not occlude high-gain antenna during experiment. There is no modulation of downlink carrier. CSM voice and LBR PCM will be recorded during the experiment for dump to MSFN after experiment phase.</p>		
1	<p>CSM att cont CMC - on (req), 4.8.1.3 ISS - on & orient known (desired), 4.8.1.3 & 4.14 RCS - on (desired), 4.8.4.2 RCS DAP - load & activate (req), 4.8.2.1 Mnvr to exp att R ___°, P ___°, Y ___ Initiate orb rate</p>		MSFN will provide initial CSM attitude.

4.18.17.1

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STA/T STEP	PROCEDURE	PANEL	REMARKS
ALL LMP	2 Sel telecom basic config, 4.5.6.1, except S BD (3) - RCV S BD MODE PCM - ctr S BD MODE RNG - OFF S BD AUX TAPE - DN VOICE BU S BD ANT OMNI - HI GAIN	9,10,6 3	
CMP	3 HGA HI GAIN ANT TRACK - MAN HI GAIN ANT SERVO - PRIM HI GAIN ANT BEAM - WIDE HI GAIN ANT PWR - on (up) HI GAIN ANT PITCH & YAW cont (2) - set in req coords	2	MSFN will provide antenna coordinates.
	4.18.17.2 <u>VHF AM Experiment Operation</u>		
	The reflected signal from the lunar surface and direct signal from the CSM VHF scimitar antenna will be received by 150-foot Stanford antenna. The CSM attitude will be that which is optimum for S-band experiment. One of two VHF scimitar antennas will be selected to provide favorable reception. This experiment will not be conducted during lunar surface EVA.		
	1 CSM att cont, 4.18.15.1, step 1		
ALL LMP	2 Sel telecom basic config, 4.5.6.1, except VHF AM (3) - RCV VHF AM A - off (ctr) VHF AM B - DUPLEX VHF RNG - on (up) VHF ANT - as req	9,10,6 3	

EXPERIMENT S170

STA/T STEP	PROCEDURE	PANEL	REMARKS
4.19	CAMERA SUPPORT PROCEDURES		
4.19.1	HASSELBLAD ELECTRIC CAMERA - 70mm		
CMP 1	<p>Set up camr for oper Unstow camr, mount bracket, intervalometer, T-cable & associated compnts Intervalometer sw - OFF (verify) Install camr at window position Connect T-cable to pnl & camr Connect intervalometer to T-cable</p>	227	<p>Connection is for PCM signal only. Camera is powered by self-contained battery.</p>
2	<p>Dismantle camr setup At completion of camr oper Intervalometer sw - OFF (verify) Disconnect T-cable at pnl & camr Remove camr, mount bracket, & intervalometer & stow all equipment</p>		
4.19.2	DATA ACQUISITION CAMERA - 16mm		
1	<p>Set up camr for oper Unstow camr, mount bracket, pwr cable & associated compnts UTIL PWR - OFF (verify) (on pnl selected for pwr source) Install camr at desired location Connect pwr cable to camr & pnl UTIL PWR - on (up)</p>	15,16,100	<p>Power cable may be connected to panel 15, 16, or 100. Includes right-angle mirror.</p>

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 2	Dismantle camr setup At completion of camr oper UTIL PWR - OFF Disconnect pwr cable from camr & pnl Remove camr & mount bracket & stow all equipment	15,16,100	

CAMERA SUPPORT PROCEDURES

SECTION 5
CONTINGENCY PROCEDURES

INTRODUCTION

Contingency procedures consist of operational and trajectory analysis for situations other than normal that may occur during all mission phases. This will provide the crew with decision-making guidance as to aborting the mission, selecting and implementing an alternate mission, or continuing the mission under degraded conditions. The procedures include the corrective action that must be taken and the limitations that may be imposed. Contingency procedures consist of the following:

- Abort procedures. These procedures may be considered as a specialized form of backup procedures which involve early mission termination.
- Malfunction procedures. These procedures encompass the recognition, diagnosis, and corrective action for system malfunctions.
- Emergency procedures. These procedures are another form of backup procedures where safety of the flight crew requires instant action (other than an abort).

5.1 ABORT PROCEDURES

During the ascent phase, an abort can be accomplished in an LES, RCS, or SPS mode. An abort in the LES mode is accomplished by utilizing the launch escape system, which has solid propellant motors mounted on a tower above the command module. During a normal mission, the launch escape tower is jettisoned approximately 36 seconds after second-stage booster ignition. After launch escape tower jettison, an abort can be accomplished in the RCS or SPS mode by utilizing the SM RCS to attain a safe separation distance from the SIVB. The SPS engine is then used, as needed, to correct trajectory for the desired landing site, or insert the CSM into earth orbit.

5.1.1 LES ABORT MODES

An abort may be initiated automatically by the emergency detection system (EDS) when two L/V engines fail, L/V excessive rates detected, breakup between IU and CM, or manually when the commander's translation control is rotated to the full CCW position. Upon receipt of an abort signal, regardless of its source, the booster is cut off (if after T +30 seconds), the CM is separated from the SM, and simultaneous ignition of the launch escape and pitch control motors takes place. Firing of the pitch control motor is inhibited 42 seconds after lift-off. Cutoff of the booster engines is inhibited for the first 30 seconds after lift-off by circuitry in IU because of range safety restrictions. The LES motors provide thrust to propel the command module away from the launch pad or trajectory of the launch vehicle.

Certain events that occur during an abort are controlled automatically by controllers in the sequential events control system (SECS). The earth landing sequence controller (ELSC) contains high-altitude and low-altitude baroswitches. The opening of these baroswitches inhibit ELS operations and the closing initiates the operations. The high-altitude baroswitch controls automatic LES tower jettison, apex cover jettison, and drogue parachute mortar fire. The high-altitude baroswitch is designed to open at 38,500 feet and close at 24,000 feet. Because of venting lag, the high-altitude baroswitch will not open until 40,500 feet during ascent. On an abort initiated under 30,000 feet (low part of abort mode I-B), the 24K feet baroswitch will remain closed and allow automatic LES tower jettison, apex cover jettison, and drogue parachute and main parachute

LES ABORT MODES

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deployment on a timed sequence controlled by time-delay relays. On an abort initiated between 30,000 feet and 3 minutes 18 seconds, automatic LES tower jettison, apex cover jettison, and drogue parachute deployment are delayed until the command module descends to the closing altitude of the high-altitude baroswitch (24,900 to 21,500 feet).

The low-altitude (10K') baroswitch is closed at 10,000 feet, open at 18,000 feet. Opening of the low-altitude baroswitch will delay automatic deployment of the pilot-main parachutes until the command module descends to the closing altitude (10,950 to 9100 feet).

The LES abort is divided into three different modes as follows:

- Mode 1-A (launch pad to 42 seconds)
- Mode 1-B (42 seconds to 1 minute 56 seconds)
- Mode 1-C (1 minute 56 seconds to LES tower jettison)

During a Mode 1-A abort, CM RCS oxidizer automatically dumps overboard through a hole in the aft heat shield. CM RCS fuel automatically dumps overboard through another hole in the aft heat shield 5 seconds after oxidizer dump started, and requires about 11 seconds for depletion. CM RCS helium automatically begins purging the system 13 seconds after fuel dump started.

During a Mode 1-B or Mode 1-C abort after the main parachutes disreef, manual initiation fires 10 CM RCS jets to expend all propellant, followed by manually initiated helium expenditure through the jets to purge the system.

The two engines out, LV rates, and auto abort capability is switched off prior to S-1C/S-II staging, and the crew must be ready to manually initiate an abort if these conditions arise. During a Mode 1-C abort (over 100K'), it is possible to jettison the LET and accomplish a normal entry provided certain conditions prevail. There must be sufficient TFF (100 sec) to perform the entry maneuver, a reliable attitude reference, and launch escape vehicle (LEV) rates must be within tolerance. If any of these conditions are not met, the LET must be retained to ensure capture of



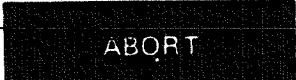
the LEV with the heat shield oriented forward. The altitude and velocity of the LEV is such that a possibility exists that it could enter the atmosphere canard and escape tower forward. The LEV would remain in this condition until descending below 100,000 feet and Mach 3.8. At this time a fast turnaround would occur which would be detrimental to crew safety. The crew will prevent canard forward capture by manual intervention shortly after abort initiation. A positive pitch rate of over 5° per second will be commanded and maintained until the canard starts trailing the CM upon descending to an altitude under 100,000 feet. Escape tower jettison and ELS activation will automatically occur at approximately 24,000 ft provided that the ELS AUTO sw is in the AUTO position.

The ELS decelerates the CM to a safe touchdown speed. Crew couch attenuators reduce the touchdown impact and start operating at approximately 15 G when they are unlocked. If they are not unlocked, a pin will shear in the lock at approximately 21 G and allow them to operate.

LES ABORT MODES

STA/T STEP	PROCEDURE	PANEL	REMARKS
5.1.1.1 Mode 1A LES Abort (00:00 - 00:42)			
CDR 1	Abort initiation	X	If manual backup required for any auto event after abort initiation it must be performed after LE motor burnout (abort T +00:05) because of high G environment during LE motor burn.
	auto or man	X	
	THC - CCW	X	
		X	
		X	
	XXXXXXXXXXXXXXXXXXXXXXXXXXXX		
	X		
CMP	X CM/SM SEP (both) - on	X	
	X (up)	X	
	X	X	
	XXXXXXXXXXXXXXXXXXXXXXXXXXXX		
		X	
	BECO (auto after	X Request grd	Guarded. On position is momentary. If abort is initiated with CM/SM SEP switches, subsequent events may require manual initiation and must be performed after LE motor burnout.
	T +00:30)	X cmd BECO	
		X	
00:00	Evt Thr rset &	X	
	counting up (auto)	X	
		X	
	CM/SM deadface (auto)	X	
		X	
	SM C/W lts - on	X	
		X	
		X	
	MASTER ALARM pb/lt -	X	Because of switching transients, AC BUS 1 and 2 C/W lights will go on and MN BUS A and MN BUS B UV lights might go on if abort initiated prior to T -01:00.
	on	X	

SM2A-03-BLOCK II-5-(2)
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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	CM RCS press (auto)	X >	MN BUS TIE switches set to AUTO by T -30:00 and then to ON at T -01:00. DC main buses must be energized to provide power for RCS transfer, propellant dump, and purge.
		X	
	RCS cont trnfr (auto)	X >	
		X	
	Entry bats to	X >	
	mn buses (auto if	X	
	abort init prior to	X	
	T -01:00)	X	
		X	
	CM RCS oxid dump	X >	
	(auto)	X	
		X	
	CM RCS isolation vlvs	X >	
	close (auto)	X	
		X	
00:00.1	CM/SM sep (auto)	X	
		X	
	LE & PC mot fire	X >	
	(auto)	X	
		X	
00:01.8	CM/SM sep pyro	X	
	deadface (auto)	X	
		X	
00:05	CM RCS fuel dump	X	
	(auto)	X	
		X	
	XXXXXXXXXXXXXXXXXXXXXXXXXXXX		
	X		
	X If abort init with		
	X CM/SM SEP (both)		
	X or BU req for any		
	X auto evnt		

LES ABORT MODE IA

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	X EVNT TMR RSET - RSET X		RSET position is momentary.
	X EVNT TMR START - START X		START position is momentary.
CMP	X CM RCS PRESS - on (up) X		Guarded. On position is momentary.
	X RCS TRNFR - CM X		CM position is momentary.
LMP	X MN BUS TIE (2) - on (up) X		
CMP	X Verify PRPLNT DUMP - X AUTO X		
	X CM RCS PRPLNT (both) - OFF X		OFF position is momentary.
CDR	X LES MOT FIRE pb - push X		Guarded. Pitch control motor will not fire if LES MOT FIRE pushbutton used as backup 1.8 sec after abort initiation.
	XXXXXXXXXXXXXXXXXXXXXXXXXXXXX X		
00:11	Canard deploy (auto) X X No BU req X on Mode 1A X X X X		CNRD DPLY pushbutton should not be used as backup on Mode 1A. Since adverse attitudes and critical timing is involved, canard deployment at wrong time could be detrimental to crew safety. Launch escape vehicle will operate satisfactorily without canard deployment.
CMP	2 C/W CSM - CM X X		Extinguishes all SM C/W lights and enables CM RCS C/W lights.
	3 MASTER ALARM pb/lt - X push X		

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LES ABORT MODE 1A

STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR		X	
00:14	ELS logic arm (auto)	X	
		X	
4	ELS LOGIC - on (up)	X	Guarded.
		X	
	LES TWR jett (auto)	X	
		X	
CMP	a. Docking ring sep	X CSM/LM FNL SEP	Guarded. On position is momentary.
		X (both) - on (up)	
		X	
	b. TWR attach nuts detonate	X TWR JETT	Guarded. On position is momentary.
		X (both) - on (up)	
		X	
	c. SCS RCS disable	X RCS CMD - OFF	OFF position is momentary.
		X	
	d. TWR jett mot fire	X	
		X	
CDR		X	
00:14.4	Apex cover jett (auto)	X APEX COVER JETT	Guarded.
		X pb - push	
		X	
00:16	Drogue chutes deploy (auto)	X DROG DPLY pb -	Guarded.
		X push (2 sec	
		X after apex cover	
		X jett)	
	<u>WARNING</u>	X	
		X	
	Below alidade	X Altitude = 0.4 NM	
	marker on altimeter,	X	
	MN DPLY pb - push	X	

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR		X	
00:18	CM RCS helium purge (auto)	X CM RCS He DUMP X pb - push X CM PRPLNT DUMP - X on (up) X X CM PRPLNT PURG - X on (up) X	Guarded. Guarded. CM PRPLNT DUMP and PURG switches provided alternate means of initiating He dump. Guarded.
>10K'	Main chutes & VHF recovery ant deploy (auto)	X X X X	Main parachutes disreef in ≈15 seconds.
5	MN DPLY pb - push (within 1 sec)	X X X	Guarded. MN DPLY pushbutton should be pushed within 1 second after pilot chute mortars fire to ensure simultaneous deployment of main parachutes.
LMP 6	Set up entry comm VHF ANT - RECY VHF AM A - SIMPLEX VHF BCN - ON	X X X X X	If VHF AM B SIMPLEX or VHF AM A DUPLEX required, turn off beacon during period of communication.
CDR	Xmit voice (VHF AM) reporting Position Mn chutes disreefed Splash err Crew status	X X X X X X X	Continue voice transmission until touchdown.
CMP 7	Crew couch struts (4) - unlock	X X	

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STA/T STEP	PROCEDURE	PANEL	REMARKS	
LMP 8	cb FLT/PL BAT BUS A, B & BAT C (3) - close	X X X X	Connects battery bus A, B, and battery C to flight and postlanding bus.	
9	cb FLT/PL MNA - open	X X		
10	cb FLT/PL MNB - open	X X		
11	cb RAD HTRS OVLD (2) - open	X X X		
CDR 12	cb SPS PITCH (2) - open	X X		
13	cb SPS YAW (2) - open	X X		
3K' 14	rh CAB PRESS RELF vlv - DUMP (safety latch off)	X X X X		Assures minimum cabin-to-ambient negative ΔP for landing impact.
CDR 15	FLOOD FIXED - POST LDG	X X X X		Provides power from flight and postlanding bus to one floodlight in LH couch area and one floodlight in center couch area.
16	FLOOD DIM - 1 or 2	X X X X X		Position 1 provides power to two secondary floodlights, and position 2 provides power to two primary floodlights when FLOOD FIXED switch is in POST LDG position and dc main buses are deactivated.
CMP 17	Verify RCS IND sel - CM 1	X X		Provides means of monitoring He pressure.

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STA/T STEP	PROCEDURE	PANEL	REMARKS	
CDR		X		
800' 18	CAB PRESS RELF vlv (2) -	X	Valves must be closed prior to touchdown to prevent water from entering CM.	
	CLOSE (safety latch off)	X		
		X		
19	ELS LOGIC - on (up)	X		
	(verify)	X		
		X		
CMP 20	CM RCS PRPLNT (both) -	X		OFF position is momentary.
	OFF	X		
	CM RCS PRPLNT tb	X		Barber pole indicates at least one valve closed in each system.
	(both) - bp	X		
		X		
CDR 21	DIRECT O2 vlv - OPEN	X		
	(CCW)	X		
		X		
LMP 22	MN BUS TIE (2) - OFF	X	Removes battery power from dc main buses.	
		X		
	<u>CAUTION</u>	X		
		X		
	Sw must be left in OFF	X		
	position to ensure that	X		
	bats A, B & C are used	X		
	to pwr postlanding sys	X		
	only, & to prevent bat	X		
	shorting caused by	X		
	water entering CM feed-	X		
	thru conn.	X		

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STA/T STEP	PROCEDURE	PANEL	REMARKS
LMP 23	cb BAT RLY BUS (2) - open	X X X	
24	Postlanding check, 4.17	X	

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STA/T STEP	PROCEDURE	PANEL	REMARKS
5.1.1.2 Mode 1B LES Abort (00:42 - 01:56)			
CDR 1	Abort initiation	X	If manual backup required for any auto event after abort initiation, it must be performed after LE motor burnout (abort T +00:05) because of high G environment during LE motor burn.
	auto or man	X	
	THC - CCW	X	
		X	
	XXXXXXXXXXXXXXXXXXXXXXXXXXXX		
	X		
CMP	X CM/SM SEP (both) - on	X	
	X (up)	X	
	X	X	
	XXXXXXXXXXXXXXXXXXXXXXXXXXXX		
	BECO (auto)	X Request grd X cmd BECO	
00:00	Evnt Tmr rset & counting up (auto)	X	
	CM/SM deadface (auto)	X	
	SM C/W lts - on	X	
LMP	MASTER ALARM pb/lt - on	X	
CDR	CM RCS press (auto)	X	

Guarded. On position is momentary. If abort initiated with CM/SM SEP switches, subsequent events may require manual initiation and must be performed after LE motor burnout.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	RCS cont trnfr (auto)	X	
		X	
00:00.1	CM/SM sep (auto)	X	
		X	
	LE motor fire (auto)	X	
		X	
00:01	SCS/RCS enbl (auto)	X	
		X	
00:01.8	CM/SM sep pyro dead- face (auto)	X	
		X	
		X	
	XXXXXXXXXXXXXXXXXXXXXXXXXXXX		
	X		
00:05	X If abort init with		
	X CM/SM SEP (both) or		
	X BU req for any auto		
	X evnt		
	X		
	X EVNT TMR RSET - RSET		RSET position is momentary.
	X		
	X EVNT TMR START - START		START position is momentary.
	X		
CMP	X CM RCS PRESS - on (up)		Guarded. On position is momentary.
	X		
	X RCS TRNFR - CM		CM position is momentary.
	X		
CDR	X LES MOT FIRE pb - push		Guarded.
	X		
CMP	X RCS CMD - ON		ON position is momentary.
	X		
	XXXXXXXXXXXXXXXXXXXXXXXXXXXX		

LES ABORT MODE IB

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR 00:11	Canard deploy (auto)	X CNRD DPLY pb - push	Guarded.
CMP 2	C/W CSM - CM	X	Extinguishes all SM C/W lights and enables CM RCS lights.
		X	
		X	
LMP 3	MASTER ALARM pb/lt - push	X	
		X	
CDR 00:14	ELS logic arm (auto)	X ELS LOGIC - on (up)	Guarded.
24K'	LES TWR jett (auto)	X	
		X	
CMP	a. Docking ring sep	X CSM/LM FNL SEP	Guarded. On position is momentary.
		X (both) - on (up)	
		X	
	b. TWR attach nuts detonate	X TWR JETT	Guarded. On position is momentary.
		X (both) - on (up)	
		X	
	c. SCS RCS disable	X RCS CMD - OFF	OFF position is momentary.
		X	
	d. TWR jett mot fire	X	
		X	
CDR	Apex cover jett (auto)	X APEX COVER JETT	Guarded.
		X pb - push	
		X	
	Drogue chutes deploy (auto)	X DROG DPLY pb - push	Guarded.
		X (2 sec after	
		X apex cover jett)	

5.1.1.2

LES ABORT MODE IB

STA/T STEP	PROCEDURE	PANEL	REMARKS	
CDR	23.5K' 4 Mon CAB PRESS ind - starts incr	X X If not incr by 17K' X rh CAB PRESS X RELF vlv - X DUMP (safety X latch off) X If still no incr	No increase indicates cabin pressure relief valve failure.	
CMP		X CAB PRESS DUMP X vlv - open X (CCW) X		
10K'	Mn chutes & VHF recovery ant deploy (auto)	X X X X		
CDR 5	MN DPLY pb - push (within 1 sec)	X X X X		Auto deployment occurs between 10,950 feet and 9,100 feet. Parachutes disreef in ≈15 seconds.
	<u>CAUTION</u>	X		
	CM PRPLNT DUMP should be init immediately after mn chute disreefing. If mn or pyro bus lost, use RHCs for burn, not CM PRPLNT DUMP sw.	X X X X X X X		
		X		
		X		
		X		
		X		
		X		
		X		
		X		
CDR 6	CAB PRESS RELF vlv (2) - CLOSE (safety latch off)	X If CAB PRESS DUMP vlv used to equalize ΔP, CAB PRESS DUMP vlv - close (CW)	Guarded. MN DPLY pushbutton should be pushed within one second after pilot chute mortars fire to ensure simultaneous deployment of main parachutes.	
CMP				

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR 7	CM PRPLNT DUMP - on (up) X (dump burn is audible) X X		Guarded.
CMP 8	RCS IND sel - CM 1 X CM RCS He PRESS ind - X decr X	RCS IND sel - CM 2 X CM RCS He PRESS X ind - decr X If not decr or X RCS jets not X firing X	
CDR,CMP	X X X X X X X X X	RHC (both) - X Fire all RCS X jets (except X plus pitch) X until X prplnts X are depleted X	One RHC positioned to command plus yaw and roll (excluding plus pitch) and other RHC positioned to command minus yaw, pitch and roll.
LMP 9	Set up entry comm X VHF ANT - RECY X VHF AM A - SIMPLEX X VHF BCN - ON X X		If VHF AM B SIMPLEX or VHF AM A DUPLEX required, turn off beacon during period of communication.
CDR	Xmit voice X (VHF AM) reporting X Position X Mn chutes X disreefed X Splash err X Crew status X		Continue voice transmission until touchdown.

5.1.1.2

LES ABORT MODE IB



ABORT

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 10	Crew couch struts (4) -	X	Initial display will contain zeros (present time). If not changed by astronaut, calculations will be based on present time.
	unlock	X	
11	Grd track determination	X	
	a. Key V37E 21E	X	
	b. FL V04 N06	X	
	Option code 00002	X	
	CMC assumed option	X	
	0000X	X	
	Verify	X	
	R2 = 00001	X	
	PRO	X	
	c. FL V06 N34	X	
	GET Lat Long	X	
	00XXX. HRS	X	
	000XX. MIN	X	
	OXX.XX SEC	X	
	Accept PRO	X	
	Reject Key V25E	X	
	Load	X	
	desired	X	
GET Lat	X		
Long	X		

LES ABORT MODE IB

STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	d. FL V06 N43	X	Altitude above launch pad radius. At this point, altitude/10, VI, and gamma available by keying N73E.
	Lat (+N)	X	
	XXX.XX DEG	X	
	Long (+E)	X	
	XXX.XX DEG	X	
	Alt XXXX.X NM	X	
12	When prplnt dump burn completed	X	Both CM RCS LOGIC and CM PRPLNT DUMP switches must be on to power CM PRPLNT PURG switch.
		X	
CDR	CM PRPLNT PURG - on (up) (purge is audible)	X	Guarded. CM RCS He DUMP pb should be used to initiate purge following normal dump operation if CM PRPLNT PURG switch fails to initiate purge. Visual fire from RCS engine nozzle extension surfaces after burn to depletion and during purge, is expected and normal.
		X	
CDR,CMP		X	One RHC positioned to command plus yaw and roll (excluding plus pitch) and other RHC positioned to command minus yaw, pitch and roll.
		X	
		X	
		X	
		X	
		X	
		X	
		X	
13	CAB PRESS RELF vlv (2) - BOOST/ENTR (safety latch off)	X	If CAB PRESS DUMP vlv used to equalize ΔP, CAB PRESS DUMP vlv - open (CCW)
		X	
		X	
		X	
		X	
LMP 14	cb FLT/PL BAT BUS A, B & BAT C (3) - close	X	Connects battery bus A, B, and battery C to flight and postlanding bus.
		X	

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STA/T STEP	PROCEDURE	PANEL	REMARKS
LMP 15	cb FLT/PL MNA - open	X	
		X	
16	cb FLT/PL MNB - open	X	
		X	
17	cb RAD HTRS OVLD (2) - open	X	
		X	
CDR 18	cb SPS PITCH (2) - open	X	
		X	
19	cb SPS YAW (2) - open	X	
		X	
3K' 20	rh CAB PRESS RELF vlv - DUMP (safety latch off)	X	Ensures minimum cabin-to-ambient negative ΔP for landing impact.
		X	
		X	
21	FLOOD FIXED - POST LDG	X	Provides power from flight and postlanding bus to one floodlight in LH couch area and one floodlight in center couch area.
		X	
		X	
22	FLOOD DIM - 1 or 2	X	Position 1 provides power to two secondary floodlights and position 2 provides power to two primary flood- lights when FLOOD FIXED switch in POST LDG position after dc main buses deactivated.
		X	
		X	
800' 23	CAB PRESS RELF vlv (2) -	X	Valves must be closed prior to touchdown to prevent water from entering CM.
CMP	CLOSE (safety latch off)	X	
		X	If CAB PRESS DUMP vlv used to
		X	equalize ΔP , CAB
		X	PRESS DUMP vlv -
		X	close (CW)

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LES ABORT MODE IB

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STA/T STEP	PROCEDURE	PANEL	REMARKS
5.1.1.3 Mode 1C LES Abort (01:56 - 03:18)			
CDR 1	Abort initiation	X	If manual backup required for any auto event after abort initiation it must be performed after LE motor burnout (abort T +00:05) because of the high G environment during LE motor burn.
	auto or man	X	
	THC - CCW	X	
		X	
		X	
	XXXXXXXXXXXXXXXXXXXXXXXXXXXX		
	X		
CMP	X CM/SM SEP (both) - on	X	
	X (up)	X	
	X	X	
	XXXXXXXXXXXXXXXXXXXXXXXXXXXX		
		X	
	BECO (auto)	X Request grd	
		X cmd BECO	
		X	
00:00	Evt Tmr rset & counting up (auto)	X	
		X	
		X	
	CM/SM deadface (auto)	X	
		X	
	SM C/W lts - on	X	
		X	
LMP	MASTER ALARM pb/lt - on	X	
		X	
		X	
CDR	CM RCS press (auto)	X	
		X	

Guarded. On position is momentary. If abort is initiated with CM/SM SEP switches, subsequent events may require manual initiation and must be performed after LE motor burnout.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	RCS cont trnfr (auto)	X >	
		X	
00:00.1	CM/SM sep (auto)	X	
		X	
	LE mot fire (auto)	X >	
		X	
00:01	SCS/RCS enbl (auto)	X >	
		X	
00:01.8	CM/SM sep pyro dead- face (auto)	X	
		X	
		X	
00:05	XXXXXXXXXXXXXXXXXXXXXXXXXXXX		
	X		
	X If abort init with CM/		
	X SM SEP (both) or BU		
	X req for any auto		
	X evnt		
	X		
00:00	X EVNT TMR RSET - RSET		RSET position is momentary.
	X		
	X EVNT TMR START - START		START position is momentary.
	X		
CMP	X CM RCS PRESS - on (up)		Guarded. On position is momentary.
	X		
	X RCS TRNFR - CM		CM position is momentary.
	X		
CDR	X LES MOT FIRE pb - push		Guarded.

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5.1.1.3

LES ABORT MODE IC

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP	b. TWR attach nuts detonate	X	
		X	
		X	
CDR	c. TWR jett mot fire	X	
		X	
	6 Damp rates	X	
		X	
	7 Mnvr to entry att R 0°, P 135°, Y 0°	X	
		X	
		X	
	8 BMAG MODE (3) - ATT 1/ RATE 2	X	
		X	
		X	
	9 ATT DBD - MAX	X	
		X	
	10 Set up for CM RCS sys 1 AUTO RCS CM 1 (6) - MNA/MNB AUTO RCS CM 2 (6) - OFF	X	
		X	
X			
X			
X			
X			
11 BMAG MODE (3) - RATE 2	X	Prevents FDAI roll bug jump.	
	X		
12 EMS FUNC - ENTRY	X		
	X		
13 EMS MODE - NORM	X		
	X		
14 When .05 G lt - on .05 G sw - on	X		
	X		

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR 15	EMS ROLL - on (up)	X X	
16	Maintain full lift	X X	
50K' 17	Proceed to Earth Ldg Phase, 4.16	X X	
	(LET descent from step 4)		
18	Establish & maintain min 5 to 10°/sec + pitch rate with RHC	X X X X X	Pitchup rate of at least 5°/second should be maintained until canard and LET begin trailing CM upon descending below entry interface. SCS ATT mode is rate command in all three axes at this time and RHC maximum command is 7°/second.
CMP 24K'	LES TWR jett (auto)	X X	
a.	Docking ring sep	X CSM/LM FNL SEP X (both) - on (up) X	Guarded. On position is momentary.
b.	TWR attach nuts detonate	X TWR JETT X (both) - on (up) X	Guarded. On position is momentary.
c.	SCS RCS disable	X RCS CMD - OFF X	OFF position is momentary.
d.	TWR jett mot fire	X X	
CDR	Apex cover jett (auto)	X APEX COVER JETT X pb - push X	Guarded.
	Drogue chutes deploy (auto)	X DROG DPLY pb - X push (2 sec after X apex cover jett)	Guarded.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
23.5K'		X	
CDR 19	Mon CAB PRESS ind - starts incr	X If not incr by 17K'	No increase indicates cabin pressure relief valve failure.
		X rh CAB PRESS RELF	
		X vlv - DUMP	
		X (safety latch	
		X off)	
		X If still no incr	
CMP		X CAB PRESS DUMP	
		X vlv - open	
		X (CCW)	
		X	
10K'	Mn chutes & VHF recovery ant deploy (auto)	X	Auto deployment occurs between 10,950 feet and 9,100 feet. Parachutes disreef in ≈15 seconds.
		X	
		X	
CDR 20	MN DPLY pb - push (within 1 sec)	X	MN DPLY pushbutton should be pushed within one second after pilot chute mortars fire to ensure simultaneous deployment of main parachutes.
		X	
		X	
	<u>CAUTION</u>	X	
		X	
	CM PRPLNT DUMP should be init immediately after mn chute disreefing. If mn or	X	
	pyro bus lost, use RHCs for burn, not CM PRPLNT	X	
	DUMP sw.	X	
		X	
		X	
CMP 21	CAB PRESS RELF vlv (2) - CLOSE (safety latch off)	X If CAB PRESS DUMP	
		X vlv used to	
		X equalize ΔP, CAB	
		X PRESS DUMP vlv -	
		X close (CW)	

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR 22	CM PRPLNT DUMP - on (up) X (dump burn is audible) X X		Guarded.
CMP 23	RCS IND sel - CM 1 X CM RCS He PRESS ind - X decr X X X X X X X	RCS IND sel - CM 2 X CM RCS He PRESS X ind - decr X If not decr or X RCS jets not X firing X RHC (both) - X Fire all RCS X jets (except X plus pitch) X until prplnt X are depleted X	One RHC positioned to command plus yaw and roll (excluding plus pitch) and other RHC positioned to command minus yaw, pitch, and roll.
LMP 24	Set up entry comm X VHF ANT - RECY X VHF AM A - SIMPLEX X VHF BCN - ON X X		If VHF AM B SIMPLEX or VHF AM A DUPLEX required, turn off beacon during period of communication.
CDR	XMIT voice (VHF) X AM) reporting X Pos X Mn chute X disreefed X Splash err X Crew stat X X		Continue voice transmission until touchdown.
CMP 25	Crew couch struts (4) - X unlock X		

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STA/T STEP	PROCEDURE	PANEL	REMARKS
26	Grd track	X	
	determination	X	
		X	
CMP	a. Key V37E 21E	X	
		X	
	b. FL V04 N06	X	
	Option code 00002	X	
	CMC assumed option	X	
	0000X	X	Initially set to 00001 (this vehicle).
	Verify	X	
	R2 = 00001	X	
	PRO	X	
		X	
	c. FL V06 N34	X	Initial display will contain zeros (present time).
	GET Lat Long	X	If not changed by astronaut, calculations will be
	00XXX. HRS	X	based on present time.
	000XX. MIN	X	
	OXX.XX SEC	X	
		X	
	Accept PRO	X	
	Reject Key V25E	X	
	Load	X	
	desired	X	
	GET Lat	X	
	Long	X	
		X	
	d. FL V06 N43	X	
	Lat (+N)	X	
	XXX.XX DEG	X	
	Long (+E)	X	
	XXX.XX DEG	X	
	Alt XXXX.X NM	X	Altitude is above launch pad radius. At this point,
		X	altitude/10, VI, and gamma is available by keying
		X	N73E.

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STA/T STEP	PROCEDURE	PANEL	REMARKS			
CDR	27 When prplnt dump burn complete	X X	Both CM RCS LOGIC and CM PRPLNT DUMP switches must be on to power CM PRPLNT PURG switch. Guarded pushbutton. CM RCS He DUMP pushbutton should be used to initiate purge following normal dump operation if CM PRPLNT PURG switch fails to initiate purge. Visual fire from RCS engine nozzle extension surfaces, after burn to depletion and during purge, expected and normal. One RHC positioned to command plus yaw and roll (excluding plus pitch) and other RHC positioned to command minus yaw, pitch, and roll.			
	CM PRPLNT PURG - on (up) (purge is audible)	X X X				
	CDR,CMP	CM RCS He DUMP pb - push		X		
		If RHC (both) used for prplnt dump burn		X X X		
		RHC (both) - Fire all jets (except plus pitch)		X X X		
		28 CAB PRESS RELF vlv (2) - BOOST/ENTR (safety latch off)		If CAB PRESS DUMP vlv used to equalize ΔP, CAB PRESS DUMP vlv - open (CCW)	X X X X	
				LMP 29 cb FLT/PL BAT BUS A, B & BAT C (3) - close	X X X	
					30 cb FLT/PL MNA - open	X X
					31 cb FLT/PL MNB - open	X X
	32 cb RAD HTRS OVLD (2) - open	X X				

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR 33	cb SPS PITCH (2) - open	X	
		X	
34	cb SPS YAW (2) - open	X	
		X	
3K' 35	rh CAB PRESS RELF vlv - DUMP (safety latch off)	X X X	Ensures minimum cabin-to-ambient negative ΔP for CM impact.
36	FLOOD FIXED - POST LDG	X X X	Provides power from flight and postlanding bus to one floodlight in LH couch area and one floodlight in center couch area.
37	FLOOD DIM - 1 or 2	X X X X X	Position 1 provides power to two secondary floodlights, and position 2 provides power to two primary floodlights when FLOOD FIXED switch in POST LDG position and dc main buses deactivated.
800' 38	CAB PRESS RELF vlv (2) -	X	Valves must be closed prior to touchdown to prevent water from entering CM.
CMP	CLOSE (safety latch off)	X If CAB PRESS DUMP X vlv used to X equalize ΔP , CAB X PRESS DUMP vlv - X close (CW) X	
CDR 39	ELS LOGIC - on (up) (verify)	X X X	Guarded.
CMP 40	CM RCS PRPLNT (both) - OFF	X X	OFF position is momentary.
	CM RCS PRPLNT tb (both) - bp	X X	Barber pole indicates at least one valve closed in each system.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR 41	DIRECT O2 vlv - OPEN (CCW)	X X X	
LMP 42	MN BUS TIE (2) - OFF	X X X	Removes battery power from dc main buses.
	<u>CAUTION</u>	X X	
	MN BUS TIE sw must be left in OFF position to ensure that bats A, B, & C are used to pwr postlanding sys only, & to prevent bat shorting caused by water entering CM feed-thru conn.	X X X X X X X X	
43	cb BAT RLY BUS (2) - open	X X X	
44	Postlanding check, 4.17	X	

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5.1.2 RCS/SPS ABORT MODES II, III, IV

Mode II, III, and IV aborts are manually initiated and utilize the SM RCS to provide a safe separation distance from the SIVB. After separation and CSM stabilization, the abort possibilities separate into three categories.

- CM/SM separation and coast-to-landing site (MODE II).
- Shaped trajectory abort utilizing an SPS variable maneuver to correct the trajectory for the desired landing site in the Atlantic Recovery Area (MODE III).
- Abort-to-earth-orbit utilizing the SPS to attain earth orbital altitude and speed (MODE IV).



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STA/T STEP	PROCEDURE	PANEL	REMARKS
	5.1.2.1 Mode II RCS Abort (03:18 to 10:08)		
CDR 1	THC - CCW (4.0 sec min)	X X X X X	Direct ullage commanded when THC placed CCW. THC must be left in CCW detent for 4.0 seconds to allow 3.0-second timer (adapter separation) and 0.8-second timer (RCS enable) to operate.
00:00	Evnt Tmr rset & counting up (auto)	X EVNT TMR RSET - X RSET X EVNT TMR START - X START	RSET position is momentary. START position is momentary.
	BECO (auto)	X Request grd	
	SII Stage - LV ENG 1, 2, 3, 4 & 5 lts - on	X cmd BECO X	
	SIVB Stage - LV ENG 1 lt - on	X	
	Dir ullage started (auto)	X DIR ULL pb - push X	
00:03	Adapter sep (auto)	X CSM/LV SEP pb - X push	Guarded.
	All LV ENG lts - out	X	
CMP		X	
00:03.8	RCS/SCS enbl (auto)	X RCS CMD - ON	ON position is momentary.
	Key V82E	X	Calls R30 for meaningful display of N50.
	FL V16 N44	X	
	Ha XXXX.X NM	X	Apogee altitude.
	Hp XXXX.X NM	X	Perigee altitude.
	TFF XXBXX MIN-SEC	X	Time of free fall to 49.4 NM (300,000 feet).
		X	
CDR 2	THC - ARMED, ctr & +X trans	X DIR ULL pb - push X	Automatic direct ullage terminated when THC returned to center.

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RCS ABORT MODE II

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CMP 3	Key N50E	X	Negative for undershoot, positive for overshoot. If TFF <100 seconds, maneuver to entry attitude must be initiated immediately and separation performed at entry attitude.
		X	
	Splash error	X	
	XXXX.X NM	X	
	Hp	XXXX.X NM X	
	TFF	XXBXX MIN- X	
		SEC X	
		X	
		X	
		X	
CDR 00:24 4	Term +X trans	X	
5	If TFF <2 min	X	
	Yaw 45° left (out of plane)	X	
	Start R&P mnvr to entry att R 0°, P 120°	X	
		X	
		X	
		X	
		X	
		X	
		X	
		X	
6	EMAG MODE (3) -	X	
	ATT 1/RATE 2	X	
		X	
CMP 7	CSM/LM FNL SEP (both) - on (up)	X	Guarded. On position is momentary. Jettisons docking ring.
		X	
8	CM/SM SEP (both) - on (up)	X	Guarded. On position is momentary. CM/SM umbilical and tension ties severed.
	CM/SM deadface (auto)	X	
	SM C/W lts - on	X	
		X	

5.1.2.1

RCS ABORT MODE II



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STA/T STEP	PROCEDURE	PANEL	REMARKS
LMP	MASTER ALARM pb/lts - on	X X	
CDR	CM RCS press (auto)	X CM RCS PRESS - on X (up)	Guarded. On position is momentary.
CMP	RCS cont trnfr (auto) CM/SM sep (auto) C/W CSM - CM	X RCS TRNFR - CM X X X	CM position is momentary. Extinguishes all SM C/W lights and enables CM RCS C/W lights.
LMP	MASTER ALARM pb/lt - push	X X X	
CDR 9	Start yaw mnvr to entry att Y 0°	X X X X X	
10	ATT DBD - MAX	X	
11	Note TFF	X X X	Maneuver-to-entry attitude must be completed prior to TFF = 0 seconds.
01:40		X	
12	Mnvr to entry att R 0°, P 126°, Y 0°	X X X	BEF, heads down, full lift.
13	Set up for CM RCS sys 1 AUTO RCS CM 1 (6) - MNA or MNB AUTO RCS CM 2 (6) - OFF	X X X X X X	
14	EMAG MODE (3) - RATE 2	X	Prevents roll bug jump when .05 G switch set to on.

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RCS ABORT MODE II

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR 15	EMS FUNC - ENTRY	X	
		X	
16	EMS MODE - NORM	X	
		X	
17	When .05 G lt - on, .05 G sw - on (up)	X	
		X	
18	EMS ROLL - on (up)	X	
		X	
19	Maintain full lift	X	
		X	
20	Proceed to Earth Ldg Phase, 4.16	X	
		X	

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RCS ABORT MODE II

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STA/T STEP	PROCEDURE	PANEL	REMARKS
5.1.2.2 <u>Mode III SPS Abort (10:08 to Insertion)</u>			
CDR 1	THC - CCW (4.0 sec min)	X X X X X	Direct ullage commanded when THC placed CCW. THC must be left in CCW detent for 4.0 seconds to allow 3.0-second timer (adapter separation) and 0.8-second timer (RCS enable) to operate.
00:00	Evnt Tmr rset & counting up (auto)	X EVNT TMR RSET - X RSET X EVNT TMR START - X START	RSET position is momentary. START position is momentary.
	BECO (auto)	X Request grd cmd X SIVB BECO	
	LV ENG 1 lt - on	X	
	Dir ullage started (auto)	X DIR ULL pb - push X	
00:03	Adapter sep (auto)	X CSM/LV SEP pb -	Guarded.
	LV ENG 1 lt - out	X push	
CMP		X	
00:03.8	RCS/SCS enbl (auto)	X RCS CMD - ON X	ON position is momentary.
	Key V82E	X	Calls R30 for meaningful display of N50.
	FL V16 N44	X	
	Ha XXXX.X NM	X	Apogee altitude.
	Hp XXXX.X NM	X	Perigee altitude.
	TFF XXBXX MIN-SEC	X X	Time of free fall to 49.4 NM (300,000 ft).
CDR 2	LV IND/GPI sw - GPI	X	

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SPS ABORT MODE III

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR 3	THC - ARMED, ctr & +X trans	X DIR ULL pb - push X X	Automatic direct ullage terminated when THC returned to center.
CMP 4	Key N50E Splash err	X X	Negative for undershoot, positive for overshoot.
	XXXX.X NM	X	
	Hp XXXX.X NM	X	
	TFF XXBXX MIN-	X	If TFF <100 seconds, maneuver to entry attitude immediately.
		SEC X	
CDR 00:24 5	Term +X trans	X X	
6	Mnvr to retro att R 180°, P 194°, Y 0°	X X	BEF, heads up.
7	Obtain retro update	X X	
8	BMAG MODE (3) - ATT 1/ RATE 2	X X X	
9	RATE - LO	X X	
10	Verify SPS GMBL ind (2) = SPS GMBL tw (2) settings	X X X	
11	EMS MODE - NORM	X X	
01:50 12	Start ullage	X X	

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR 13	ΔV THRUST A - NORM	X	Guarded.
		X	
02:05		X	
14	SPS THRUST - DIR ON	X	Lever lock.
		X	
	If no SPS IGN	X	
	ΔV THRUST B - NORM	X	
	If still no SPS IGN	X	
	THRUST ON pb - push	X	
		X	
15	RATE - HI	X	Bypasses noise problem in SCS gyro assemblies because of thrusting vibration levels and provides backup to auto selection high rate in pitch and yaw TVC.
		X	
		X	
16	Term ullage -	X	
	IGN +1 sec	X	
		X	
17	ΔV ind = desired value	X	
	or ΔR = 0	X	
		X	
	If TFF >2 min	X	
	Yaw 45° right (out of	X	
	plane) before CM/SM	X	
	sep	X	
		X	
	If TFF <2 min, go to 18	X	
		X	
18	ΔV THRUST (2) - OFF	X	Guarded.
		X	
19	EMS MODE - STBY	X	

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SPS ABORT MODE III

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR 20	Mnvr to entry att	X	
	R 0°, P 105°, Y 0°	X	
		X	
CMP 21	CSM/LM FNL SEP (both) -	X	Guarded. On position is momentary. Jettisons docking ring.
	on (up)	X	
22	CM/SM SEP (both) - on	X	Guarded. On position is momentary. CM/SM umbilical and tension ties severed.
	(up)	X	
	CM/SM deadface (auto)	X	
	SM C/W lts - on	X	
	MASTER ALARM pb/lt - on	X	
	CM RCS press (auto)	X CM RCS PRESS - on	
		X (up)	
23	RCS cont trnfr (auto)	X RCS TRNFR - CM	CM position is momentary.
	CM/SM sep (auto)	X	
		X	
LMP 24	C/W CSM - CM	X	Extinguishes all SM C/W lights and enables CM RCS C/W lights.
		X	
CDR 25	MASTER ALARM pb/lt -	X	
	push	X	
		X	
26	ATT DBD - MAX	X	
		X	
CDR 27	Note TFF	X	Maneuver-to-entry attitude must be completed prior to TFF = 0 seconds.
		X	
		X	
	Complete mnvr to entry att	X	
		X	BEF, heads down, full lift.



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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR 28	Set up for CM RCS sys 1	X	Prevents roll bug jump when .05 G switch is set to on.
	AUTO RCS CM 1	X	
	(6) - MNA OR MNB	X	
	AUTO RCS CM 2	X	
	(6) - OFF	X	
		X	
29	BMAG MODE (3) - RATE 2	X	
		X	
30	EMS FUNC - ENTRY	X	
		X	
31	EMS MODE - NORM	X	
		X	
32	Maintain full lift to .05 G	X	
		X	
33	When .05 G lt - on, .05 G sw - on (up)	X	
		X	
34	EMS ROLL - on (up)	X	
		X	
35	Maintain half lift	X	
		X	
50K' 36	Proceed to Earth Ldg Phase, 4.16	X	
		X	

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SPS ABORT MODE III

STA/T STEP	PROCEDURE	PANEL	REMARKS
5.1.2.3 <u>Mode IV SPS Abort (09:00 to Insertion)</u>			
CDR 1	THC - CCW (4.0 sec min)	X X X X	Direct ullage is commanded when THC placed CCW. THC must be left in CCW detent for 4.0 seconds to allow 3.0-second timer (adapter separation) and 0.8-second timer (RCS enable) to operate.
00:00	Evnt Tmr rset & counting up (auto)	X EVNT TMR RSET - X RSET	
	BECO (auto)	X EVNT TMR START - X START	
	LV ENG 1 lt - on	X Request grd cmd	
	Dir ullage started (auto)	X SIVB BECO	
00:03	Adapter sep (auto)	X DIR ULL pb - X push	
	LV ENG 1 lt - out	X CSM/LV SEP pb - X push	
CMP		X	
00:03.8	RCS/SCS enbl (auto)	X RCS CMD - ON	
		X	
CDR 2	LV IND/GPI sw - GPI	X	Guarded.
		X	
3	THC - ARMED, ctr & +X tran	X DIR ULL pb - push X X	
CMP 4	Key V82E	X	
	FL V16 N44	X	
	Ha XXXX.X NM	X	
	Hp XXXX.X NM	X	
	TFF XXBXX MIN-SEC	X	
		X	
		X	
		X	Automatic direct ullage terminated when THC returned to center.

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR		X	
00:24 5	Term +X trans	X	
		X	
6	Mnvr to insertion att	X	
	R 180°, P 350°, Y 0°	X	
		X	
7	Obtain insertion update	X	
		X	
8	EMAG MODE (3) - ATT 1/ RATE 2	X	
		X	
9	RATE - LO	X	
		X	
10	Verify SPS GMBL ind (2) = SPS GMBL tw (2) settings	X	
		X	
		X	
11	EMS MODE - NORM	X	
		X	
01:00		X	
12	Start ullage	X	
		X	
13	ΔV THRUST A - NORM	X	Guarded.
		X	
02:05		X	
14	SPS THRUST - DIR ON	X	Lever lock.
		X	
	If no SPS IGN	X	
	ΔV THRUST B - NORM	X	
		X	
	If still no SPS IGN	X	
	THRUST ON pb - push	X	

SPS ABORT MODE IV

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STA/T STEP	PROCEDURE	PANEL	REMARKS	
CDR 15	RATE - HI	X X X X	Bypasses noise problem in SCS gyro assemblies because of thrusting vibration levels and provides backup to auto selection of high rate in pitch and yaw TVC.	
16	Term ullage - IGN +1 sec	X X X		
17	EMAG MODE PITCH - RATE 1 SPS GMBL tw - maintain pitch profile (VI, H dot, H)	X X X X		
18	AV THRUST (2) - OFF on VI	X X X		
19	SPS THRUST - NORM	X X		Lever lock.
20	EMS MODE - STBY SECO +40 sec Stat from grd	X X X X		
21	SAFE ORBIT PRO (exit R30) Key V37E OOE	X X X X		
CMP 22	Postorbital Insertion Check, 4.3.2	X X		

5.1.2.3

SPS ABORT MODE IV

5.2 MALFUNCTION PROCEDURES

INTRODUCTION

Malfunction procedures encompass the recognition, diagnosis, and corrective action for system malfunctions. In most cases, the crew is alerted to a malfunction condition by C&WS lights and indicators, or by the absence of a scheduled function or event. The crew will then locate, correct, or isolate the malfunction and determine its effect on the scheduled mission. In general, the procedures cover significant single failures. Double unrelated failures are not covered to prevent procedures from becoming complex and unmanageable.

The malfunction procedures are presented in logic flow diagram format and arranged by symptom routines. The symptom routines contain the primary malfunction procedures and are backed up by special subroutines and system reconfiguration routines where necessary. A three column format is used for symptom routine logic flow diagrams. A description and use of each of these columns is as follows:

Symptom Column. The primary purpose of the symptom column is to allow entry into the malfunction procedures. Two types of symptom logic blocks are used in this column. These are the "C/W Status Light" and "Other Symptom" blocks. These two blocks, along with the supporting information under each block, explain and qualify the situation so the reader fully understands the symptom or condition that exists. All symptoms are arranged by systems, i.e., G&C, SPS, RCS, EPS, etc., and are numbered in sequence starting with number 1 for each system. A subsymptom that is directly related to a major symptom is identified by using the same number followed by a lower case letter, 1a, 1b, 1c, etc.

Procedure Column. The procedure column presents a step-by-step logic flow diagram of actions and decisions used to isolate or correct a malfunction symptom. This information is presented with several types of logic blocks. These blocks contain the procedures, decisions, and actions to locate and isolate the failure. Caution and Warning blocks alert the crew to situations which, if not corrected, may degrade the operational integrity of the SC systems or may have critical crew safety consequences. Remote event symbols are used to reference items in the Remarks column or to refer to other procedural steps.

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Remarks Column. This column will include the following information:

- a. Amplifying additional remarks related to the symptom, i.e., relief valve vents at ___ psia, burst disc ruptures at ___ psia, or to notify the user of the urgency that he must treat a particular symptom, etc.
- b. Amplifying remarks which relate to a decision and/or action items (e.g., why a step is taken, possible system time lag, etc.).
- c. Explain resultant system status or operational capability after a failure has been identified, i.e., how subsystem is degraded, can degraded subsystem support primary mission, early termination of mission, etc.
- d. Cautions or Warnings, as necessary, to cover conditions that may exist because of a failure.

MALFUNCTION PROCEDURES

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5.2.1.1 <u>Guidance and Control</u>		
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MALFUNCTION PROCEDURES

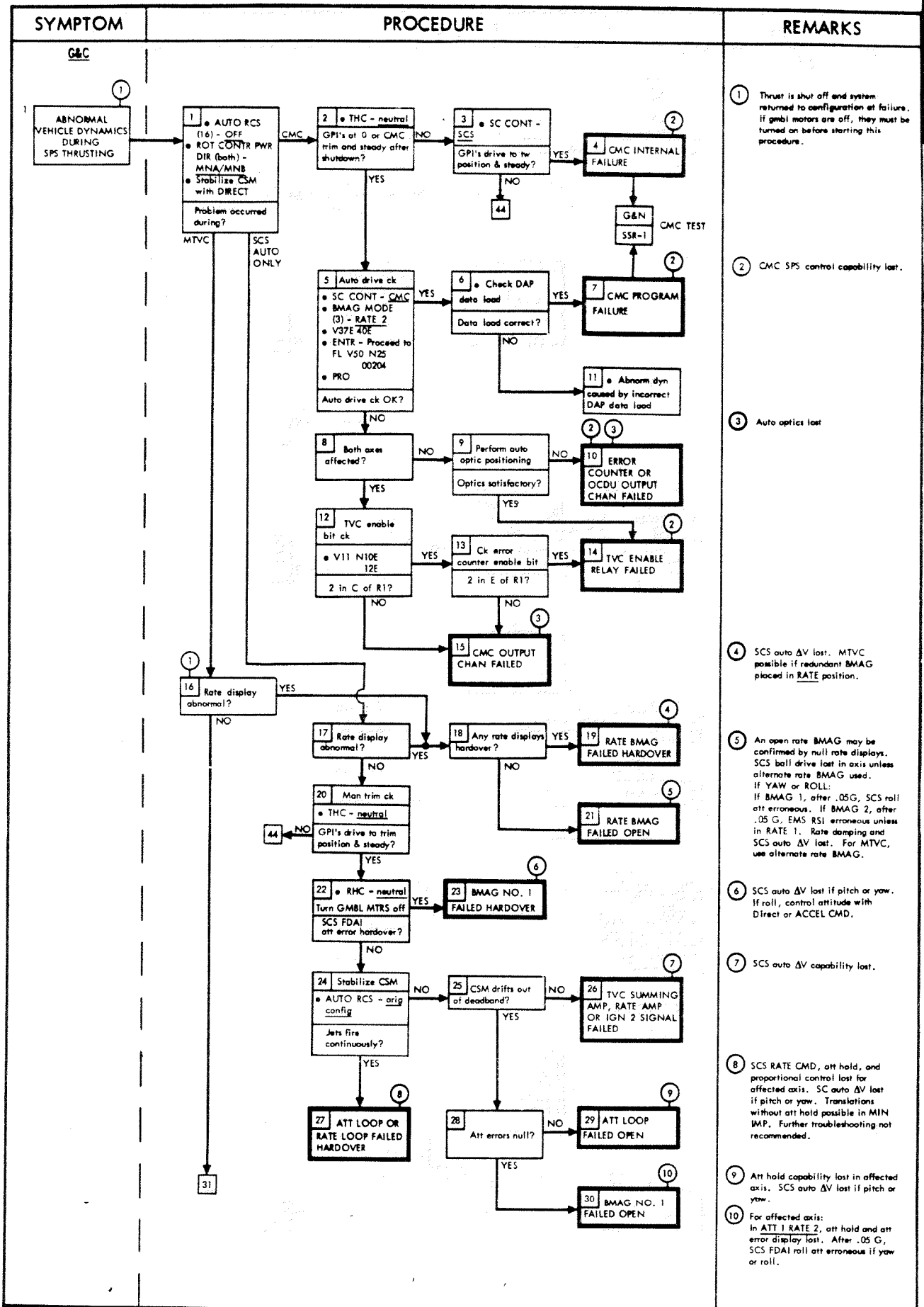
The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes the need for transparency and accountability in financial reporting. The text also highlights the role of internal controls in preventing fraud and ensuring the integrity of the data.

The second part of the document provides a detailed overview of the company's financial performance over the past year. It includes a breakdown of revenue, expenses, and profit, along with a comparison to the previous year. The analysis shows a steady increase in revenue and a decrease in expenses, resulting in a higher profit margin.

The third part of the document discusses the company's strategic goals and objectives for the upcoming year. It outlines the key areas of focus, such as expanding into new markets, improving operational efficiency, and investing in research and development. The text also identifies the risks and challenges that the company may face and provides strategies to mitigate them.

The fourth part of the document provides a summary of the company's overall financial health and outlook. It concludes that the company is well-positioned to achieve its strategic goals and maintain a strong competitive advantage in the market. The text also expresses confidence in the company's ability to continue to grow and prosper in the future.

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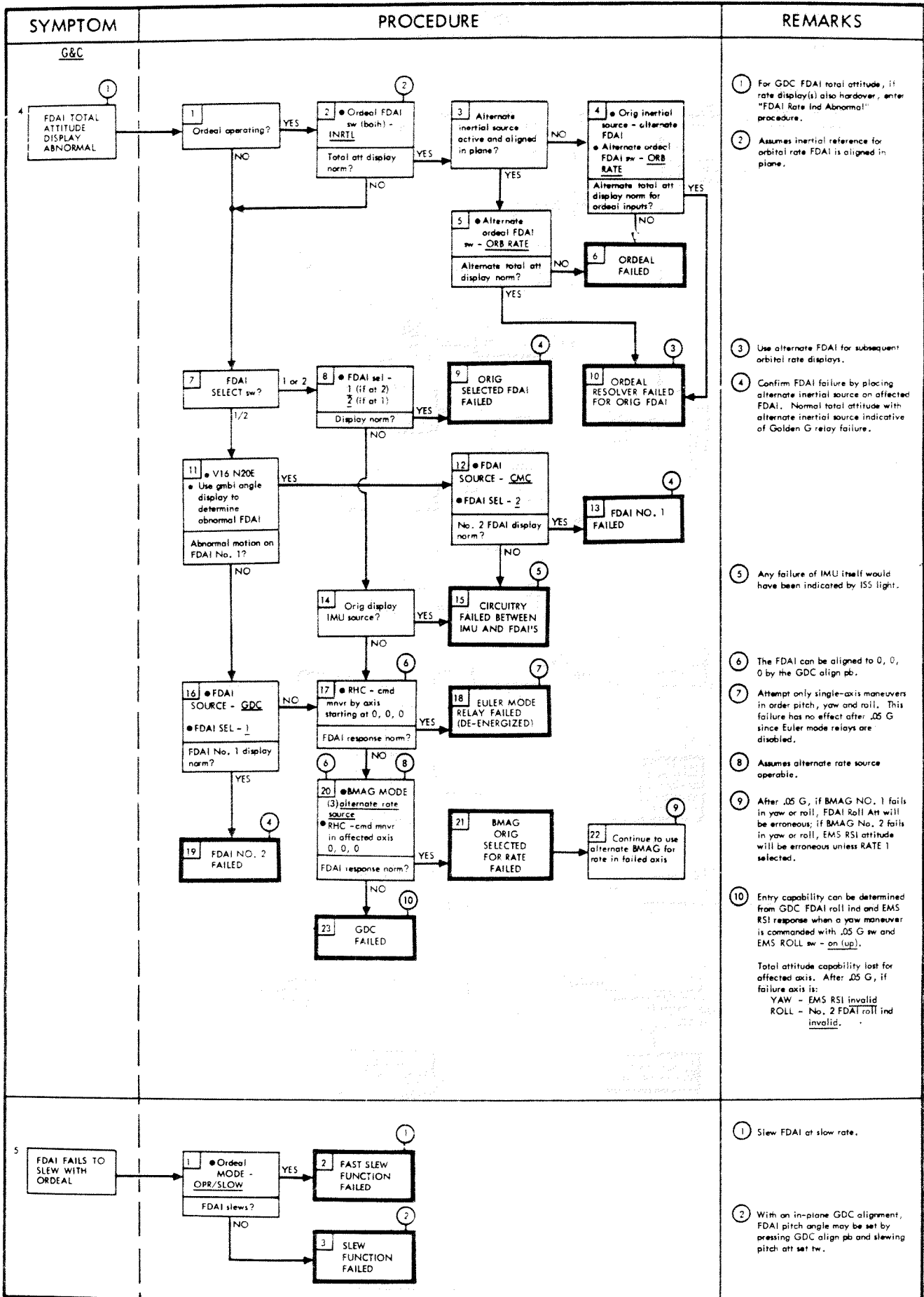


APOLLO OPERATIONS HANDBOOK

SYMPTOM	PROCEDURE	REMARKS
<p>G&C</p> <p>1 (Cont)</p>		<p>① SCS proportional control and MTVC lost for failed RHC.</p> <p>② One probable failure could be loss of MTVC integrator in which case during MTVC the gimbal position directly follows the stick position.</p> <p>③ SCS proportional control and MTVC lost for both RHC's.</p> <p>④ If THC - CW at time of failure, servo #2 being used, select servo #1.</p> <p>⑤ No MTVC capability. RATE CMD lost in affected axis. Att hold possible if RHC's locked (or neutral) or ROT CONTR PWR NORM (2) - OFF. Disable affected axis if direct used.</p> <p>⑥ MTVC and proportional cont available with unaffected RHC if affected RHC ROT CONT PWR NORM sw is OFF or RHC locked.</p> <p>⑦ CMC ΔV unaffected. On affected servo, SCS auto ΔV and trim lost, but MTVC without trim remains.</p> <p>⑧ Affected servo lost for all ΔV's.</p>

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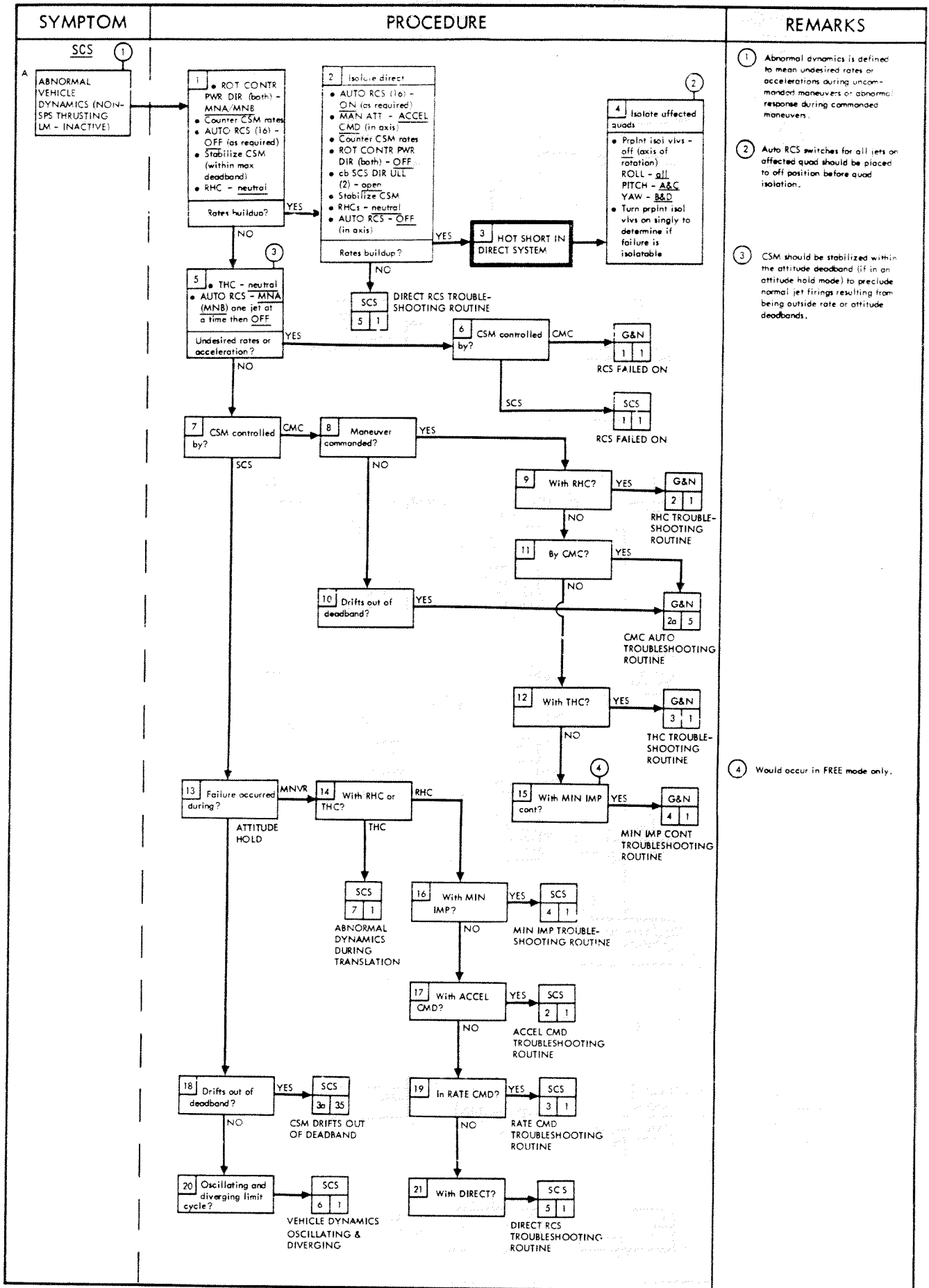
SYMPTOM	PROCEDURE	REMARKS
<p>G&C</p> <p>①</p> <p>2 FDAI ATT ERROR ABNORMAL</p>		<p>① May be single or multi axis.</p> <p>② RATE 1 operation from this BMAG may not be available.</p> <p>③ CMC attitude error, coarse align and STVB attitude control lost for axis that showed abnormal in error counter check.</p> <p>④ Cycling ATT SET sw may free sticking relays.</p> <p>⑤ Attitude error functions are inoperative when FDAI SOURCE switch at ATT SET.</p> <p>⑥ Failure of GDC enable relays will be determined by an inability to align GDC by GDC ALIGN pb.</p> <p>⑦ SCS att set error display lost. If ATT SET - IMU, attitude errors displayed will be Euler angles.</p> <p>⑧ IMU function of ATT SET sw lost.</p>
<p>3 FDAI RATE IND ABNORMAL</p>		<p>① May be single or multiple axes.</p> <p>② Attitude error display and attitude hold capability lost. SCS auto ΔV lost if pitch or yaw: for roll place MAN ATT ROLL - ACCEL CMD and control roll manually. If failure is No. 1 roll or yaw BMAG after .05 G, No. 2 FDAI roll ind will spin up.</p> <p>③ If BMAG No. 2 failed: SCS auto ΔV lost unless in roll, then place BMAG MODE ROLL - ATT 1 RATE 2 and LIM CYCLE - on (up). RCS attitude hold available in all axes with BMAG MODE (3) - ATT 1 RATE 2 and LIM CYCLE on (up). If roll or yaw BMAG No. 1 failed, No. 2 FDAI roll ind erroneous after .05 G.</p>

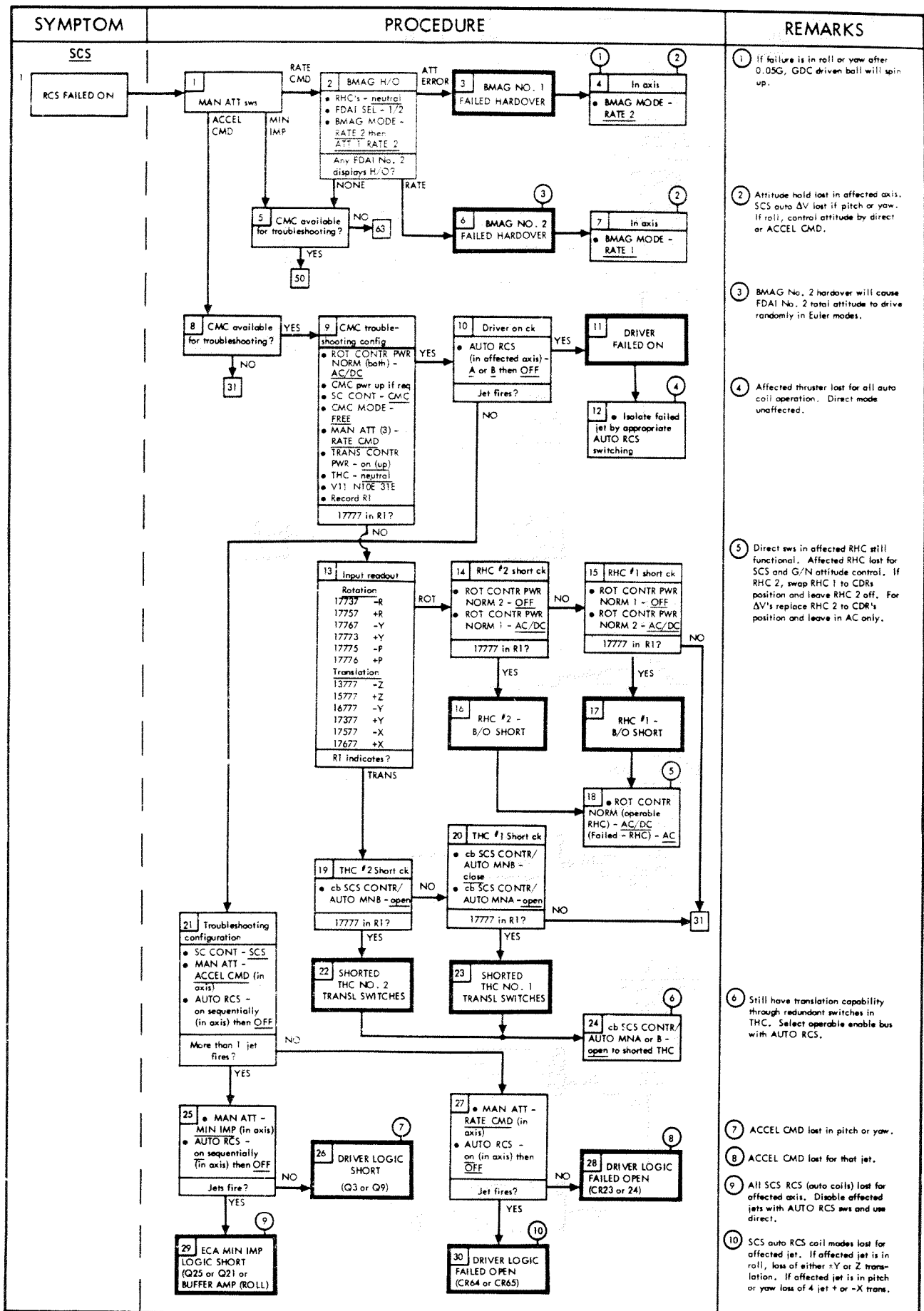


SYMPTOM	PROCEDURE	REMARKS
<p>G&C</p> <p>①</p> <p>6</p> <p>FDAI TOTAL ATT DOES NOT RESPOND TO GDC ALIGN</p>		<p>① May be single or multiple axes.</p> <p>② Att set error displays still operational.</p> <p>③ GDC can be aligned to an arbitrary position by:</p> <ol style="list-style-type: none"> Fly CSM to indicated attitude to which GDC is to be aligned. Disable GDC. Fly CSM to prescribed inertial attitude (star or visual reference). Re-enable GDC.
<p>7</p> <p>GPI/FUEL PRESS IND(S) PEGGED OR ZERO</p>		<p>① Total attitude, attitude error & rate display lost for 1 FDAI.</p> <p>② Check GPI operation during first gimbal drive and trim check.</p> <p>③ Utilize MSFN to monitor tank press.</p>
<p>8</p> <p>BMAG 1 (2) TEMP</p> <p>Yellow lit on if temp <168 >172</p>		<p>① BMAG rate information relatively unaffected by temperature out-of-tolerance. However attitude error information degrades ~4% per degree out of tolerance.</p> <p>② Time that the BMAG TEMP lit is off is an indication of the temperature rate increase and period of accuracy for subsequent BMAG use.</p>

G&C MALFUNCTION

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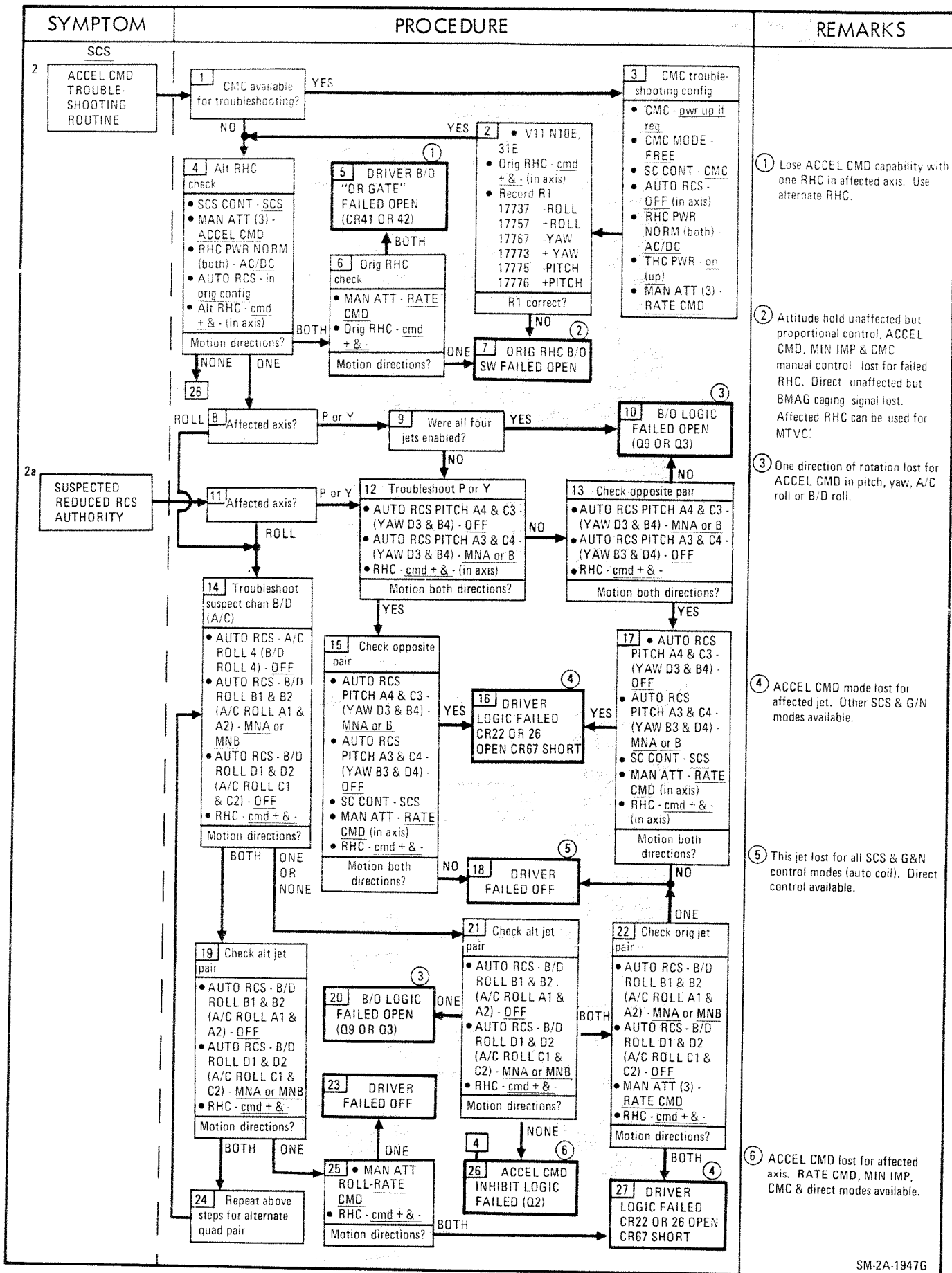


APOLLO OPERATIONS HANDBOOK

SYMPTOM	PROCEDURE	REMARKS
<p>1 Cont <u>SCS</u></p>		<p>(11) All SCS RCS (auto coils) lost for affected axis. Disable affected jets with AUTO RCS sws and use direct control.</p> <p>(12) ACCEL CMD lost in pitch or yaw. Use alternate quad pair for roll.</p> <p>(13) This jet lost for all SCS & G/N control modes. Disable jet with AUTO RCS sws and use direct control.</p> <p>(14) ACCEL CMD lost for this jet.</p> <p>(15) SCS AUTO RCS coil modes lost for affected jet. If affected jet is in roll loss of either $\pm Y$ or Z trans. If affected jet is in pitch or yaw, loss of 4 jet \pm or $-X$ trans.</p> <p>(16) Direct sws in affected RHC still functional. Affected RHC lost for SCS and G/N attitude control. If RHC 2, swap RHC 1 to CDR's position and leave RHC 2 off. For ΔV's replace RHC 2 to CDR's position and leave in AC only.</p> <p>(17) Still have translation capability through redundant sws in THC. Select operable enable bus with AUTO RCS.</p>

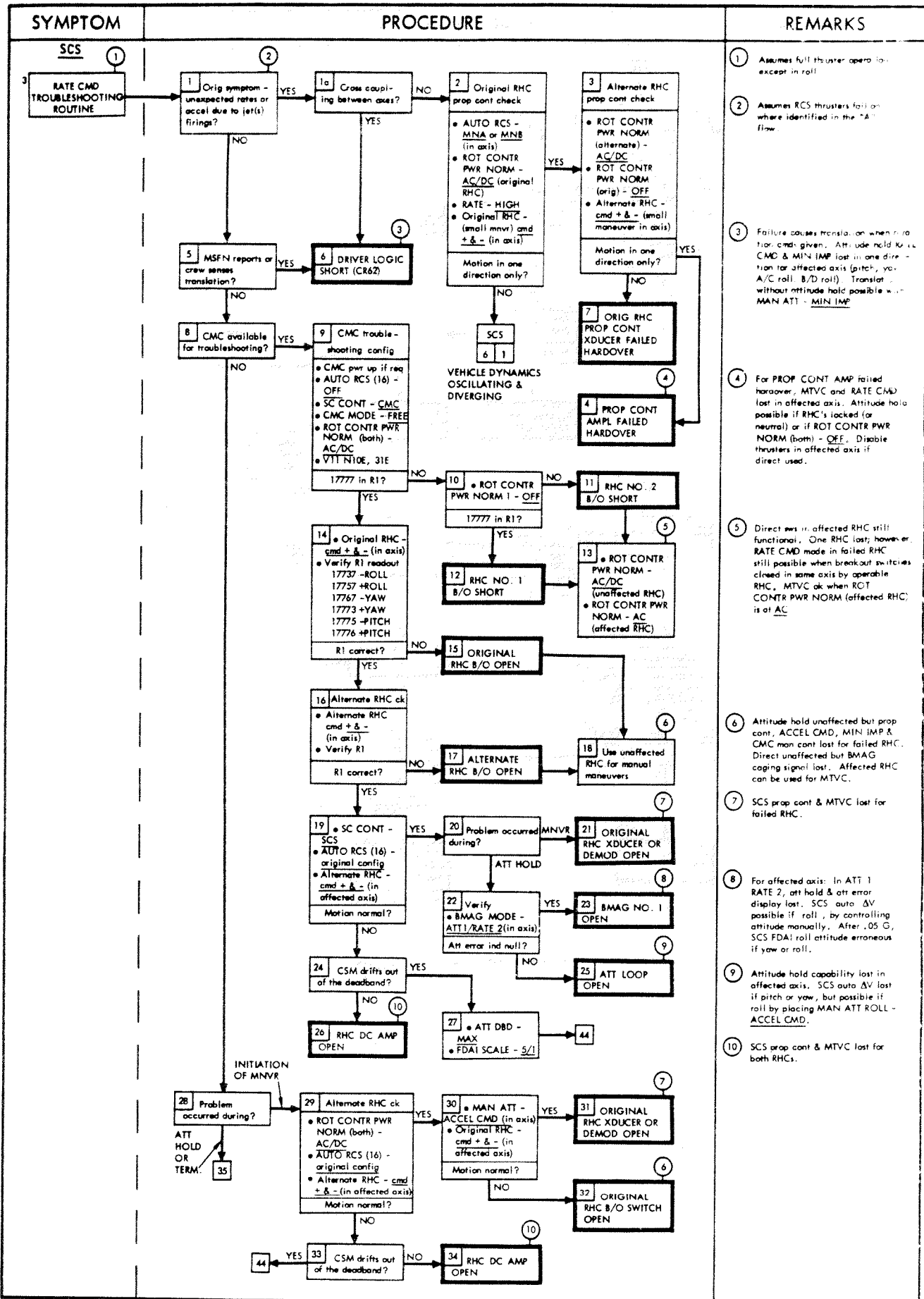
APOLLO OPERATIONS HANDBOOK

SYMPTOM	PROCEDURE	REMARKS
<p>SCS</p> <p>1 cont</p>	<pre> graph TD 50[50 CMC trouble-shooting config] -- NO --> 51[51 THC #1 short ck] 50 -- YES --> 55[55 Driver on ck] 51 -- YES --> 52[52 SHORTED THC NO. 2 TRANSL SWITCHES] 51 -- NO --> 54[54 SHORTED THC NO. 1 TRANSL SWITCHES] 52 --> 18[18] 54 --> 53[53 cb SCS CONTR AUTO MNA or MNB - open to shorted THC] 55 -- Jet fires? --> YES --> 59[59 DRIVER FAILED ON] 55 -- Jet fires? --> NO --> 56[56 Troubleshooting configuration] 56 -- More than 1 jet fires? --> YES --> 57[57 MAN ATT - MIN IMP in axis] 56 -- More than 1 jet fires? --> NO --> 60[60 DRIVER LOGIC FAILED OPEN CR64 or CR65] 57 -- Jets fire? --> YES --> 58[58 ECA MIN IMP LOGIC SHORT Q25 or Q21 or BUFFER AMP ROLL] 57 -- Jets fire? --> NO --> 61[61 ECA RATE CMD LOOP FAILED HARDOVER] 59 --> 20[20] 60 --> 21[21] 61 --> 22[22] 53 --> 56 63[63 Troubleshooting configuration] -- 1 Jet --> 64[64 SC CONT - CMC] 63 -- 2 OR MORE --> 68[68 In axis] 64 -- Jet fires? --> YES --> 66[66 DRIVER FAILED ON] 64 -- Jet fires? --> NO --> 65[65 DRIVER LOGIC FAILED OPEN CR64 or CR65] 66 --> 20[20] 68 -- Jets fire? --> YES --> 70[70 cb SCS CONTR AUTO MNB - closed] 68 -- Jets fire? --> NO --> 69[69 SHORTED THC NO. 2 TRANSL SWITCH] 70 -- Jet fires? --> YES --> 73[73 MAN ATT - MIN IMP in axis] 70 -- Jet fires? --> NO --> 71[71 SHORTED THC NO. 1 TRANSL SWITCH] 71 --> 72[72 cb SCS CONTR AUTO MNA or MNB - open to shorted THC] 73 -- Jets fire? --> YES --> 76[76 ECA MIN IMP LOGIC SHORT Q25 or Q21 or BUFFER AMP ROLL] 73 -- Jets fire? --> NO --> 74[74 ECA RATE CMD LOOP FAILED HARDOVER] 74 --> 75[75 cb SCS CONTR AUTO MNA - closed] 76 --> 19[19] 69 --> 23[23] 72 --> 23[23] </pre>	<p>18 Still have translation capability through redundant sws in THC. Select operable enable bus with AUTO RCS.</p> <p>19 All SCS RCS (auto coils) lost for affected axis. Disable affected jets with AUTO RCS sws and use direct control.</p> <p>20 This jet lost for SCS & G&N control modes. Use direct control in affected axis.</p> <p>21 SCS AUTO RCS coil modes lost for affected jet. If affected jet is in roll loss of either +Y or Z trans. If affected jet is in pitch or yaw loss of 4 jet + or -X trans.</p> <p>22 SCS RATE CMD, attitude hold & prop cont lost for affected jet. SCS auto ΔV lost if pitch or yaw but operable in roll in ACCEL CMD. Translation without attitude hold possible in MIN IMP or ACCEL CMD.</p> <p>23 Still have translation capability through redundant sws in THC. Select operable enable bus with AUTO RCS.</p>



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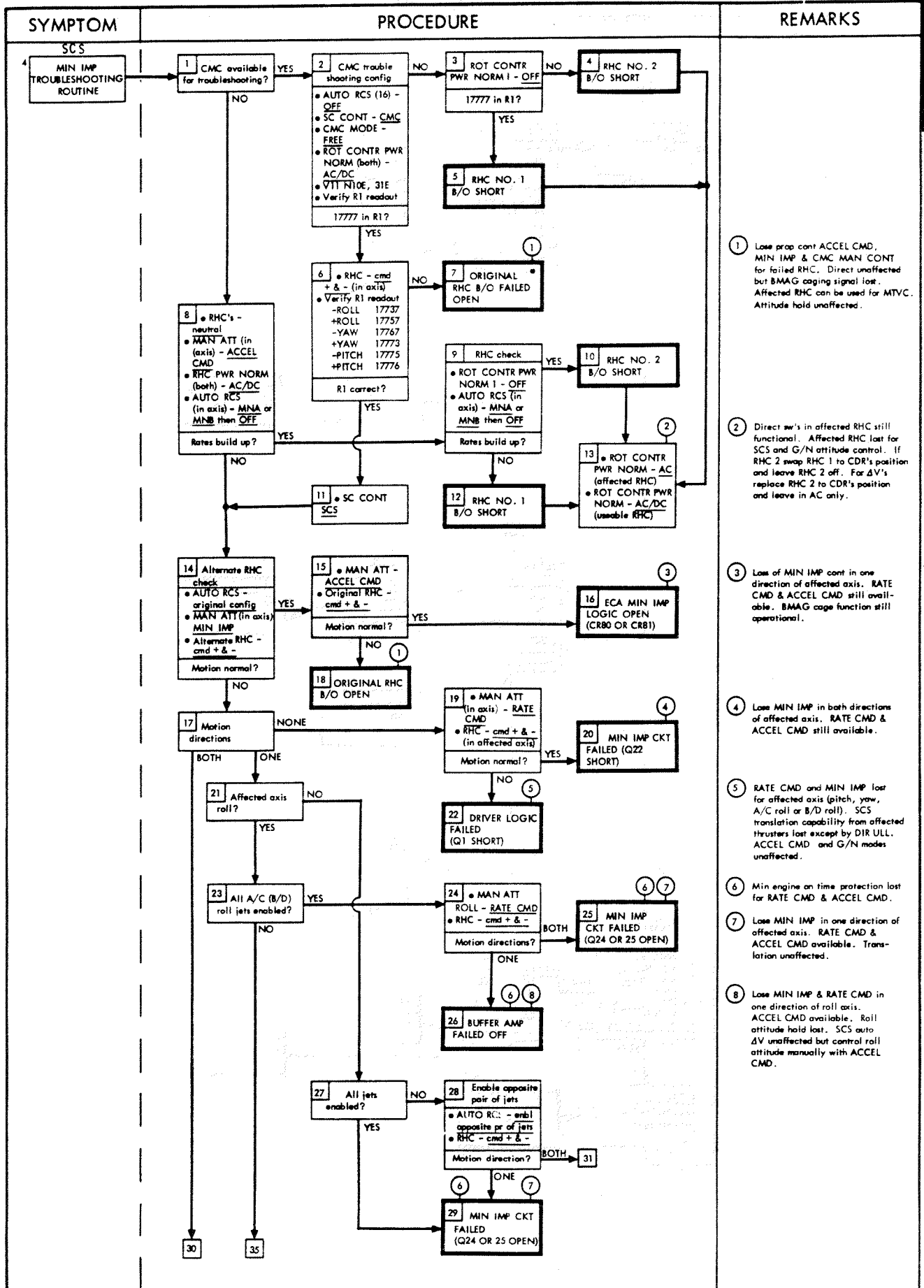
GSC MAINTENANCE

SM-2A-1950G

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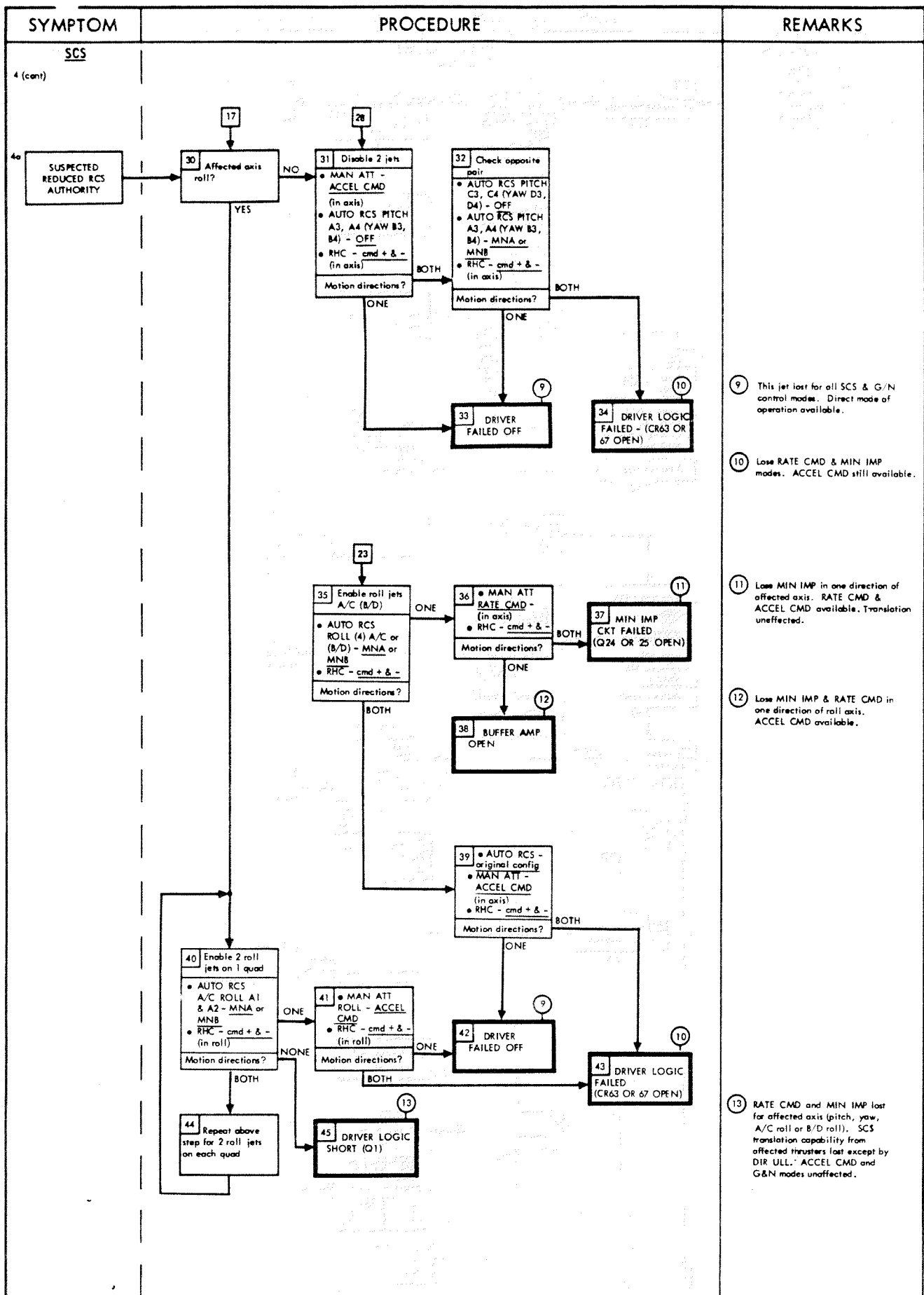
SYMPTOM	PROCEDURE	REMARKS
<p style="text-align: center;"><u>SCS</u></p> <p>3a CSM DRIFTS OUT OF DEADBAND</p>		<p>11 Attitude hold capability lost in affected axis. SCS auto ΔV lost if pitch or yaw, but possible if roll by placing MAN ATT ROLL - ACCEL CMD.</p> <p>12 For affected axis: In ATT 1 RATE 2, att hold & att error display lost. SCS auto ΔV possible if roll, by controlling att manually. After .05 G, SCS FDAI roll attitude erroneous if yaw or roll.</p> <p>13 Direct axis in affected RHC still functional. One RHC lost; however, RATE CMD mode in failed RHC still possible when breakout switches closed in same axis by operable RHC. MTVC ok when ROT CONTR PWR NORM (affected RHC) is at AC.</p> <p>14 All RATE CMD & attitude hold capability lost for affected axis. Translation possible with MAN ATT or in RATE CMD & attitude control in affected axis by direct or MIN IMP.</p> <p>15 Lose all SCS modes except ACCEL CMD. No Translation on affected axis. Direct control available.</p> <p>16 One polarity lost in RATE CMD & MIN IMP. Translation capability remains but attitude hold lost.</p>

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SM-2A-1952D

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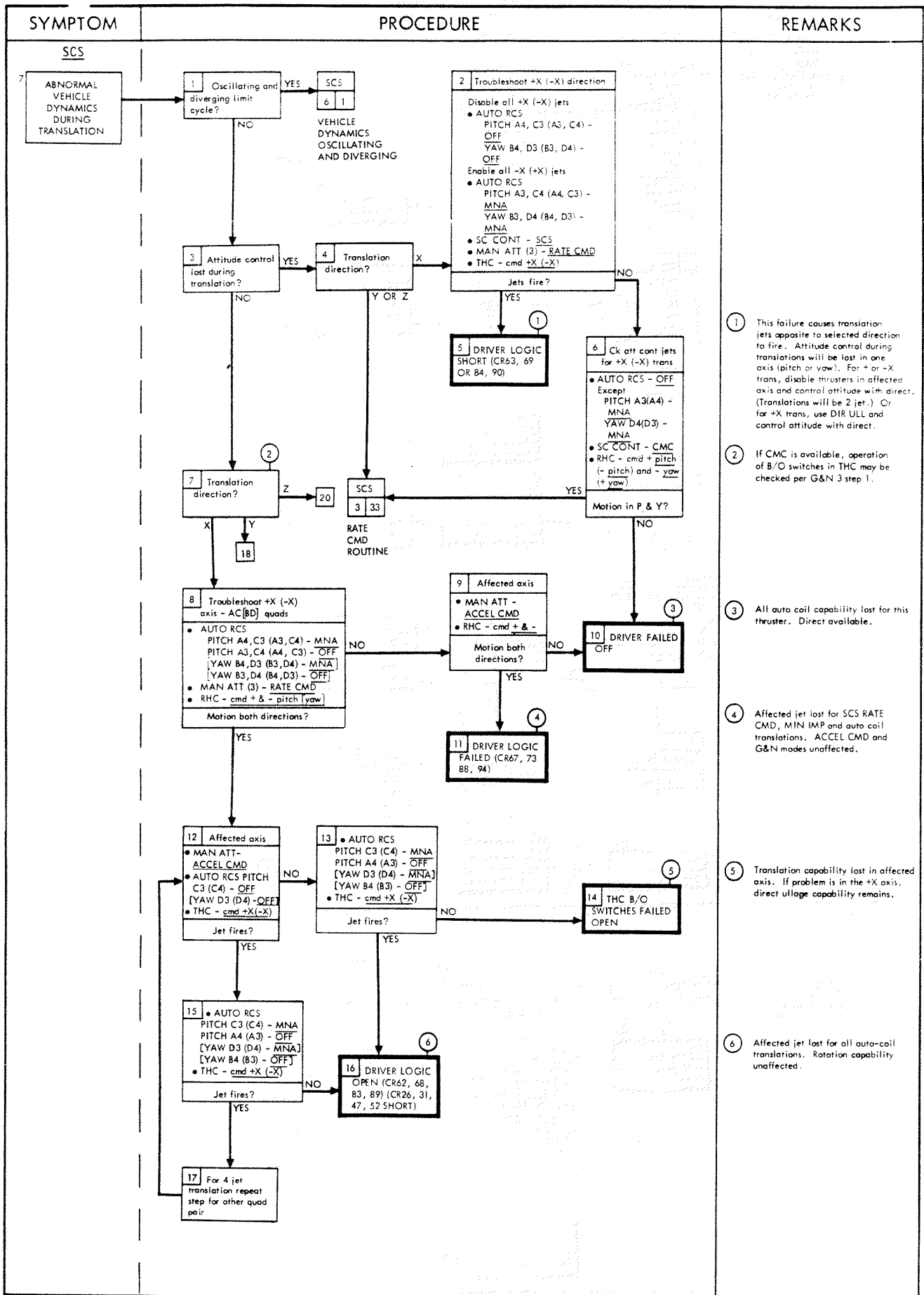


SM-2A-1953D

APOLLO OPERATIONS HANDBOOK

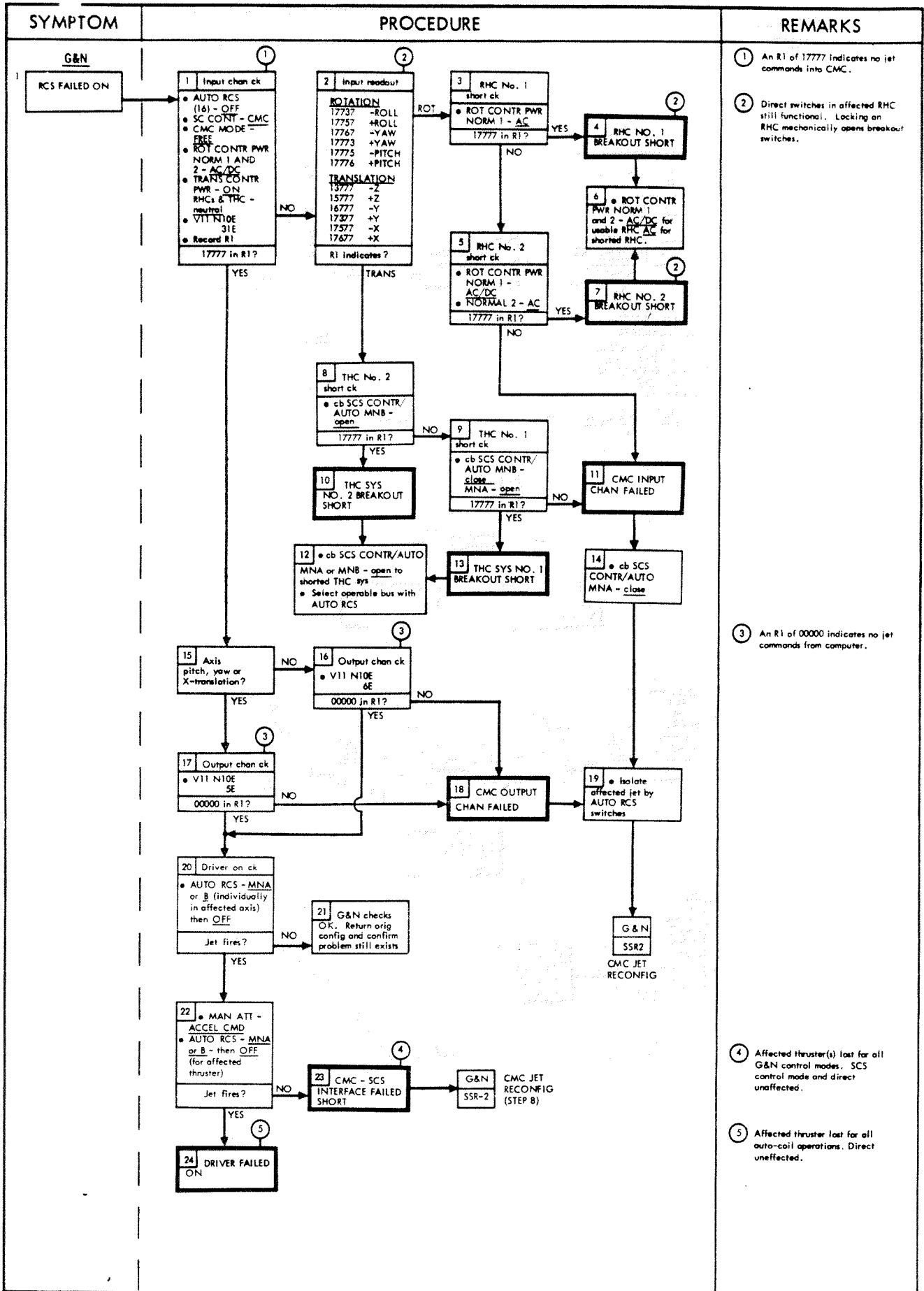
SYMPTOM	PROCEDURE	REMARKS
<p>5</p> <p>SCS</p> <p>DIRECT RCS TROUBLESHOOTING ROUTINE</p>	<p>1 • Verify that ROT CONTR PWR DIR sw was in MNA/MNB position for RHC being used for commanded maneuver</p> <p>• AUTO RCS - MNA or MNB (as required)</p> <p>Was problem jet firing?</p> <p>NO → 2</p> <p>YES → 5</p> <p>2 Alternate RHC ck</p> <p>• ROT CONTR PWR DIR - MNA/MNB</p> <p>• Cmd motion in affected axis</p> <p>Motion as commanded?</p> <p>YES → 3</p> <p>NO → 4</p> <p>3 ORIGINAL RHC DIRECT SWITCH FAILED OPEN</p> <p>4 DIRECT RCS CKT FAILURE</p> <p>5 RHC No. 1 Check</p> <p>• cb SCS CONTR 1 DIR (2) - open</p> <p>• ROT CONTR PWR DIR 1 - MNA/MNB</p> <p>• cb SCS CONTR 1 DIR MNA - close</p> <p>Jet fires?</p> <p>YES → 6</p> <p>NO → 9</p> <p>6 cb SCS CONTR 1 DIR MNA - open and MNB - close</p> <p>Jet fires?</p> <p>YES → 7</p> <p>NO → 10</p> <p>7 RHC NO. 1 DIRECT SHORT (both sets of redundant sws in axis)</p> <p>8 • cb SCS CONTR 1 DIR MNB - open</p> <p>10 ONE SET OF REDUNDANT SWS IN RHC SHORTED</p> <p>11 Leave ROT CONTR PWR DIR 1 - MNA/MNB with cb SCS CONTR 1 DIR MNA - open</p> <p>9 • cb SCS CONTR 1 DIR MNB - close</p> <p>Jet fires?</p> <p>YES → 12</p> <p>NO → 15</p> <p>12 ONE SET OF REDUNDANT SWS IN RHC SHORTED</p> <p>13 • ROT CONTR PWR DIR 1 - MNA with cb SCS CONTR 1 DIR MNB - open</p> <p>14 • cb DIR ULL (2) - close</p> <p>15 RHC No. 2 Check</p> <p>• cb SCS CONTR 2 DIR (2) - open</p> <p>• ROT CONTR PWR DIR 2 - MNA/MNB</p> <p>• cb SCS CONTR 2 DIR MNA - close</p> <p>Jet fires?</p> <p>YES → 16</p> <p>NO → 19</p> <p>16 • cb SCS CONTR 2 DIR MNA - open and MNB - close</p> <p>Jet fires?</p> <p>YES → 17</p> <p>NO → 20</p> <p>17 RHC NO. 2 DIRECT SHORT (both sets of redundant sws in axis)</p> <p>18 • cb SCS CONTR 2 DIR MNB - open</p> <p>20 ONE SET OF REDUNDANT SWS IN RHC SHORTED</p> <p>21 • ROT CONTR PWR DIR 2 - MNB with cb SCS CONTR 2 DIR MNA - open</p> <p>• cb DIR ULL (2) - close</p> <p>19 cb SCS CONTR 2 DIR MNB - closed</p> <p>Jet fires?</p> <p>YES → 23</p> <p>NO → 22</p> <p>22 DIR ULL pb SHORTED</p> <p>23 ONE SET OF REDUNDANT SWS IN RHC SHORTED</p> <p>24 Leave ROT CONTR PWR DIR 2 - MNA/MNB and pull cb SCS CONTR 2 DIR MNA - open</p>	<p>1 Direct operation with original RHC results in reduced authority in affected axis through redundant switch</p> <p>2 Direct operation with affected RHC lost.</p> <p>3 Direct operation with RHC No. 1 functional through redundant set of sws.</p> <p>4 Loss of one set of redundant direct sws results in reduced authority in affected axis.</p> <p>5 Operation with RHC No. 2 functional through redundant set of sws.</p> <p>6 Close direct ullage cbs one at a time to isolate the failure within the DIR ULL pb. DIR ULL MNA powers quad B.D. MNB powers quad A.C jets. This will provide 2-jet direct ullage.</p>
<p>6</p> <p>VEHICLE DYNAMICS OSCILLATING & DIVERGING</p>	<p>1 LIM CYCLE - on (up)?</p> <p>NO → 2</p> <p>YES → 4</p> <p>2 Original symptom - FDAI rate displays zero?</p> <p>YES → 3</p> <p>NO → 5</p> <p>3 BMAG NO. 2 FAILED OPEN</p> <p>4 PSEUDO - RATE FAILED OPEN</p> <p>5 RATE - LOW</p> <p>• FDAI SCALE - 5:1</p> <p>• BMAG MODE - RATE 1 (in axis)</p> <p>• AUTO RCS SEL - MNA or MNB (in axis)</p> <p>• RHC - cmd mnvr (in axis)</p> <p>Maneuver rate limited?</p> <p>NO → 8</p> <p>YES → 6</p> <p>6 BMAG NO. 2 DEMOD FAILED OPEN</p> <p>7 • BMAG MODE (affected axis) - RATE 1</p> <p>• Realign GDC</p> <p>NOTE: If ATT HOLD is desired</p> <p>• BMAG MODE (affected axis) - ATT 1 RATE 2</p> <p>• LIM CYCLE - on (up)</p> <p>8 RATE LOOP AC OR DC AMP FAILED OPEN</p> <p>9 • BMAG MODE - ATT 1 - RATE 2 (in axis)</p> <p>• LIM CYCLE - on (up)</p>	<p>1 SCS ball drive lost in affected axis in RATE 2 or ATT 1 RATE 2. EMS-RSI erroneous after .05 G if yaw or roll, unless switched to RATE 1.</p> <p>2 No SCS auto ΔV if pitch or yaw; if in roll SCS auto ΔV possible if BMAG mode - ATT 1 RATE 2 & LIM CYCLE - ON.</p> <p>3 This failure noticeable only if BMAG 2 power is off.</p> <p>4 Displays & RATE 1 unaffected.</p> <p>5 For affected axis all rate damping lost. RATE CMD response similar to ACCEL CMD.</p>

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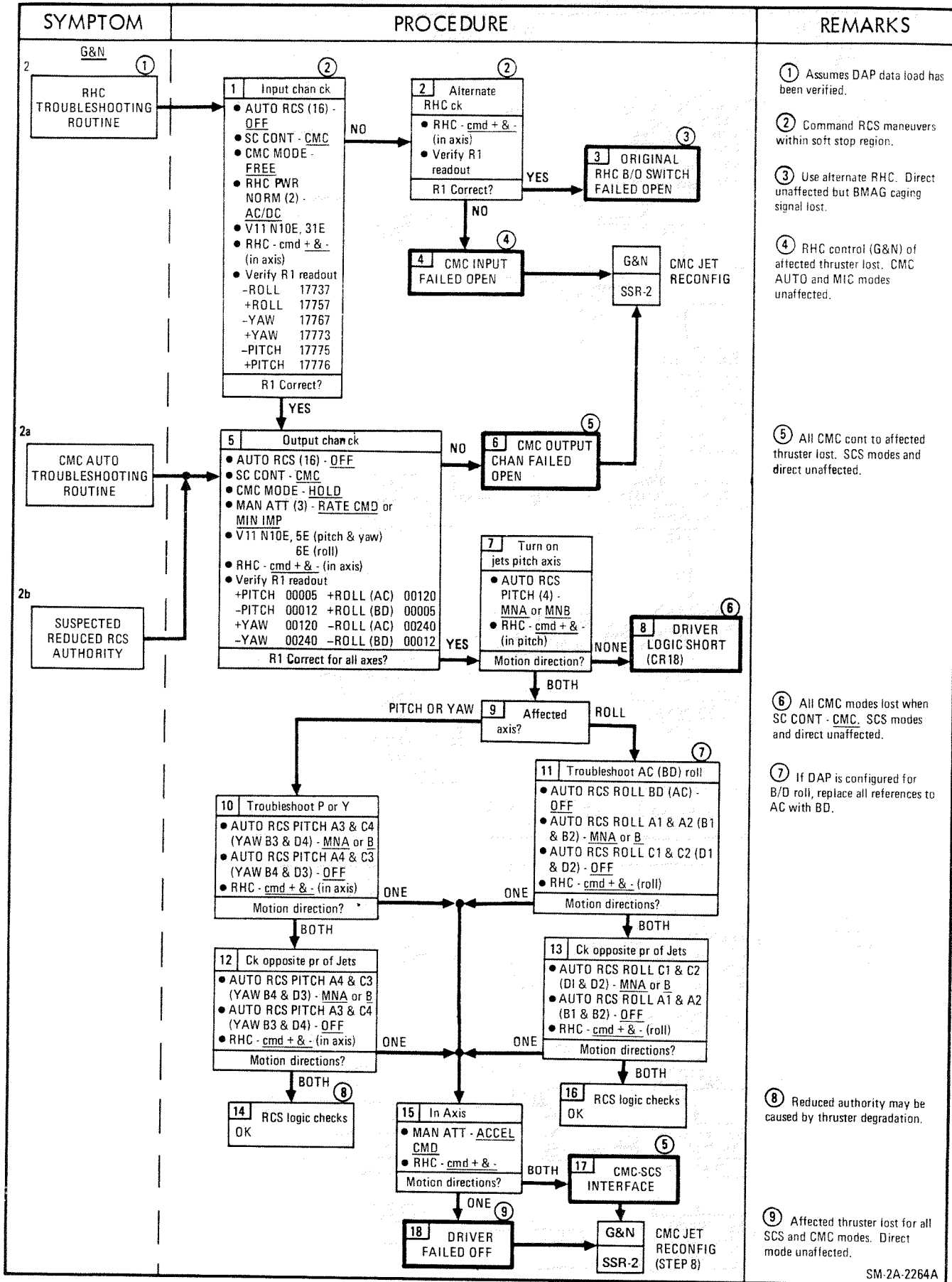
SYMPTOM	PROCEDURE	REMARKS
<p>SCS</p> <p>7 (Cont)</p>	<pre> graph TD Start((7)) --> Box18[18 Troubleshoot +Y (-Y) axis] Start --> Box20[20 Troubleshoot +Z (-Z) axis] Box18 --> J18{Jets fire?} Box20 --> J20{Jets fire?} J18 -- YES --> Box19[19 DRIVER LOGIC SHORT] J20 -- YES --> Box19 J18 -- NO --> Box21[21 Troubleshoot +Y (-Y)] J20 -- NO --> Box22[22 Troubleshoot +Z (-Z)] Box21 --> M18{Motion both directions?} Box22 --> M20{Motion both directions?} M18 -- YES --> Box23[23 MAN ATT ROLL - ACCEL CMD] M20 -- YES --> Box23 Box23 --> M23{Motion both directions?} M23 -- YES --> Box24[24 DRIVER LOGIC FAILED] M23 -- NO --> Box25[25 DRIVER FAILED OFF] M18 -- NO --> Box26[26 MAN ATT ROLL - ACCEL CMD] M20 -- NO --> Box29[29 MAN ATT ROLL - ACCEL CMD] Box26 --> J26{Jet fires?} Box29 --> J29{Jet fires?} J26 -- YES --> Box31[31 AUTO RCS A/C ROLL A1(A2) - MNA] J29 -- YES --> Box32[32 AUTO RCS B/D ROLL B1(B2) - MNA] J26 -- NO --> Box27[27 AUTO RCS A/C ROLL A1(A2) - MNA] J29 -- NO --> Box28[28 AUTO RCS B/D ROLL B1(B2) - MNA] Box27 --> J27{Jet fires?} Box28 --> J28{Jet fires?} J27 -- YES --> Box33[33 DRIVER LOGIC OPEN] J28 -- YES --> Box33 J27 -- NO --> Box30[30 THC B/O SWITCHES FAILED OPEN] J28 -- NO --> Box30 Box31 --> J31{Jet fires?} Box32 --> J32{Jet fires?} J31 -- YES --> Box33 J32 -- YES --> Box33 J31 -- NO --> Box33 J32 -- NO --> Box33 Box33 --> Box34[34 SCS translation checks OK] Box19 --> Box34 Box24 --> Box34 Box25 --> Box34 Box30 --> Box34 Box34 --> End(()) </pre>	<p>7 One direction of Y or Z translation lost.</p> <p>8 Affected jet lost for SCS RATE CMD, MIN IMP and auto coil translations. ACCEL CMD and G/N modes unaffected.</p> <p>9 All auto coil capability lost for this thruster. Direct available.</p> <p>10 Translation capability lost in affected axis. If problem is in the +X axis, direct ullage capability remains.</p> <p>11 Affected jet lost for all auto-coil translations. Rotation capability unaffected.</p> <p>12 Abnormal dynamics may be due to thruster degradation.</p>

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SYMPTOM	PROCEDURE	REMARKS
<p>3 THC TROUBLE-SHOOTING ROUTINE</p> <p align="center">G&N ①</p>		<p>① Assumes DAP data load has been verified.</p> <p>② Check cb SCS CONTR AUTO MNA and MNB - <u>close</u> prior to future THC cmd. If MNB cb open, original THC switch failed in system A; if MNA cb open, original THC switch failed in system B.</p> <p>③ The remote possibility of both THC system translation switches failed open can be determined with the SC CONT - <u>SCS</u>.</p> <p>④ Translation lost in CMC modes for affected directions.</p> <p>⑤ All CMC control to affected thruster lost. SCS modes and direct unaffected.</p>
<p>4 MIN IMP CONT TROUBLE-SHOOTING ROUTINE</p> <p align="center">①</p>		<p>① Assumes DAP Data Load has been verified.</p> <p>② An R1 of XXX77 indicates no input commands to CMC.</p> <p>③ CMC MIN IMP lost for controller in LEB. CMC or SCS MIN IMP available with RHC.</p> <p>④ CMC & SCS MIN IMP lost for affected RHC. CMC MIN IMP available with MIC in LEB. Also lost, FDAI att error & att control (BMAG caged in axis). MTVC pitch & yaw not affected. During SCS-SPS thrusting, have FDAI att errors and control after IGN 2 signal.</p>

SM 2A-2263

SYMPTOM	PROCEDURE	REMARKS																														
<p>5</p> <p>CMC</p> <p>RED</p> <p>Light on if: CMC prime pwr fails Scaler fails Counter fails Repeated restarts</p>		<p>① All CMC functions lost.</p> <p>② The R1 readout indicates a CMC FAIL signal to CMC.</p> <p>③ Subsequent CMC malfunction indication from unaffected CMC light.</p> <p>④ If the LEB CMC It is on, all gyrr torquing and PIPA capability lost, CMC monitor and control of both TVC and entry lost.</p>																														
<p>6</p> <p>ISS</p> <p>RED</p> <p>Light on if: IMU fails ICDU fails PIPA fails during thrust</p>		<p>① Subsequent ISS malfunction indications from unaffected ISS It.</p> <p>② The following alarm codes are generated by the listed failures (or by transient fail discrettes): 04777 - PIPA and ICDU fail 10777 - PIPA and IMU fail 13777 - IMU and ICDU fail 14777 - PIPA, IMU and ICDU fail</p> <p>If any of these alarm codes occur, proceed sequentially to each of the steps indicated. A "no" answer to each step is indicative that a transient fail discrete has been generated.</p> <table border="1"> <thead> <tr> <th>Function Remaining</th> <th>A/D Failure</th> <th>D/A Failure</th> </tr> </thead> <tbody> <tr> <td>Fine align</td> <td>NO</td> <td>YES</td> </tr> <tr> <td>Coarse align</td> <td>NO</td> <td>N/C</td> </tr> <tr> <td>Att err signal</td> <td>NO</td> <td>N/O</td> </tr> <tr> <td>Total att to FDAI</td> <td>YES</td> <td>YES</td> </tr> <tr> <td>GmbI angles to CMC</td> <td>NO</td> <td>YES</td> </tr> <tr> <td>IMU stabilization loop</td> <td>YES</td> <td>YES</td> </tr> <tr> <td>Cage mode</td> <td>YES</td> <td>YES</td> </tr> <tr> <td>IMU fail detect ckt</td> <td>YES</td> <td>YES</td> </tr> <tr> <td>Coarse align in gmbI lock</td> <td>NO</td> <td>YES</td> </tr> </tbody> </table> <p>③</p> <p>④ CMC can perform functions not requiring IMU inputs. After each maneuver, state vectors must be updated via P27.</p> <p>⑤ CMC monitor and control of both TVC and entry lost.</p> <p>⑥ Affects assurance of an ISS command. Subsequent indicator of an ISS failure loss.</p>	Function Remaining	A/D Failure	D/A Failure	Fine align	NO	YES	Coarse align	NO	N/C	Att err signal	NO	N/O	Total att to FDAI	YES	YES	GmbI angles to CMC	NO	YES	IMU stabilization loop	YES	YES	Cage mode	YES	YES	IMU fail detect ckt	YES	YES	Coarse align in gmbI lock	NO	YES
Function Remaining	A/D Failure	D/A Failure																														
Fine align	NO	YES																														
Coarse align	NO	N/C																														
Att err signal	NO	N/O																														
Total att to FDAI	YES	YES																														
GmbI angles to CMC	NO	YES																														
IMU stabilization loop	YES	YES																														
Cage mode	YES	YES																														
IMU fail detect ckt	YES	YES																														
Coarse align in gmbI lock	NO	YES																														
<p>7</p> <p>GIMBAL LOCK</p> <p>YELLOW</p> <p>Light on if: MGA > 70°</p>		<p>① IMU in coarse align and must be realigned to a new inertial reference.</p>																														

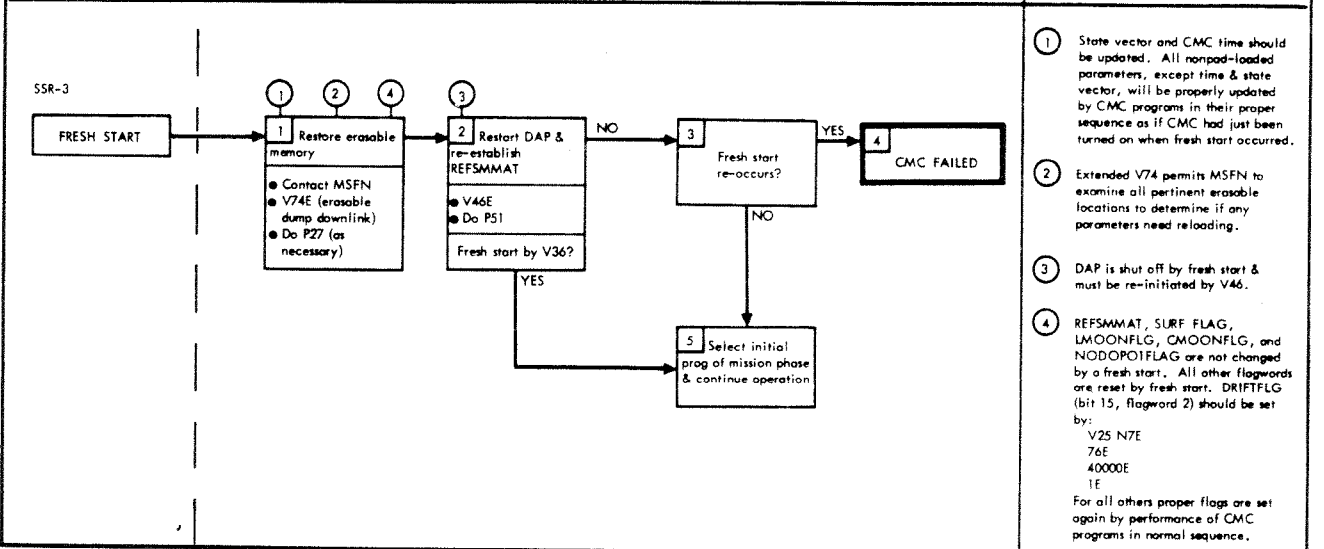
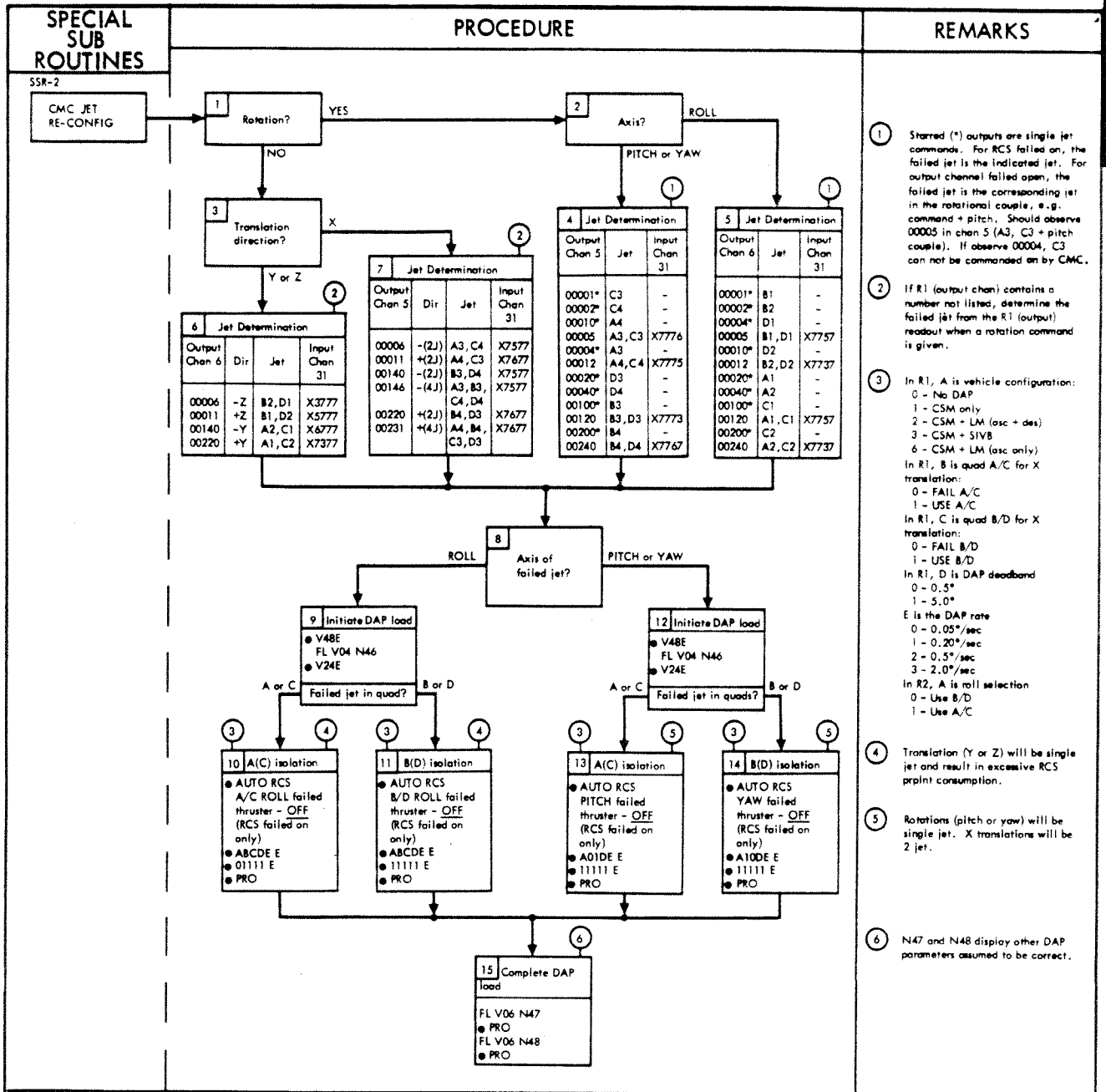
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SYMPTOM	PROCEDURE	REMARKS
<p>8</p> <p style="text-align: center;">G&N</p> <p style="text-align: center;">TEMP</p> <p style="text-align: center;">YELLOW</p> <p>Light on if: IMU temperature is out of limits <126 or >134°F.</p>	<p style="text-align: center;">①</p> <p>1 Attempt reset • RSET TEMP It out?</p> <p>YES → 4 Continue norm operation</p> <p>NO → 2 Input chan ck • V11 N10E, 30E 0, 1, 2, 3 in A of R1?</p> <p>YES → 3 Output chan ck • V11 N10E, 11E 1, 3, 5, 7 in D of R1?</p> <p>YES → 4 CMC OUTPUT CHAN FAILED</p> <p>NO → 6 NOTE: G&N performance will be unaffected by IMU temp out-of-tolerance for at least 15 min. Critical maneuvers can be continued within this time.</p> <p>6 → 8 IMU stability ck • FDAI SEL - 1/2 No. 1 FDAI stable when compared with No. 2 or visual cues?</p> <p>YES → 9 MSFN reports PIPA temps Temp normal?</p> <p>YES → 10 IMU TEMP SENSOR FAILED</p> <p>NO → 11 IMU TEMP CONTROL FAILED</p> <p>7 TEMP RELAY IN DSKY FAILED CLOSED</p>	<p>① This R1 readout indicates IMU temp within limits.</p> <p>② All IMU temp abnormal indications lost. Temp available from MSFN only.</p> <p>③ IMU temp abnormal indication available from unaffected DSKY.</p> <p>④ Transient abnormal condition.</p> <p>⑤ Assumes normal operation of No. 1 FDAI has been verified.</p> <p>⑥ IMU may be used as long as FDAI No. 1 indicates that the IMU is stable.</p>
<p>9</p> <p style="text-align: center;">RESTART</p> <p style="text-align: center;">YELLOW</p> <p>Lighted by any of the following: PARITY FAIL RUPT LOCK TC TRAP NIGHT WATCHMAN or VOLTAGE FAIL</p>	<p style="text-align: center;">①</p> <p>1 DSKY blank, except status lights?</p> <p>YES → 4 • V5 N9E Verify Alm 01107</p> <p>NO → 2 Attempt reset • RSET RESTART It off?</p> <p>YES → 3 Continue norm operation</p> <p>NO → 5 CMC It on?</p> <p>YES → 6 Attempt fresh start • SC CONT - SCS • MSFN contact req • V74E After 1-1/2 min, • V36E • RSET</p> <p>NO → 7 Compare DSKYs RESTART It on, both DSKYs?</p> <p>YES → 8 Program running?</p> <p>YES → 9 Continue operation with caution</p> <p>NO → 10 Lamp test • V37E 00E • V34E RESTART It on, both DSKYs?</p> <p>YES → 12 RESTART LT RELAY FAILED CLOSED</p> <p>NO → 11 RESTART LT RELAY FAILED OPEN (UNLIT DSKY)</p> <p>11 → 13 CMC FAILED</p> <p>13 → 14 • Simultaneously push - RSET and MARK REJECT pb RESTART It off?</p> <p>YES → 14 → 13</p> <p>NO → 14 → 6</p> <p>14 → 13</p>	<p>① If PROG It on, display the alarm code and perform the required action before proceeding.</p> <p>② Restarts at a higher rate than ≈ 1/sec will trigger CMC light. Restarts at a rate higher than ≈ 1/2 second will sustain CMC light.</p> <p>③ Recurring restarts at a rate insufficient to trigger CMC light.</p> <p>④ Restart indication available from unaffected DSKY.</p> <p>⑤ All CMC functions lost.</p>
<p>10</p> <p style="text-align: center;">TRACKER</p> <p style="text-align: center;">YELLOW</p> <p>Light on if: Optics CDU failed or VHF ranging data missing or no good.</p>	<p style="text-align: center;">①</p> <p>1 Attempt reset • RSET TRACKER It off?</p> <p>YES → 5 VHF ranging data being used by CMC?</p> <p>NO → 2 Compare DSKYs TRACKER It on, both DSKYs?</p> <p>YES → 3 • V11 N10E, 30E 2 or 6 in C of R1?</p> <p>YES → 4 CMC OUTPUT CHAN FAILED</p> <p>NO → 6 • OPT ZERO ZERO - (15 sec) • RSET TRACKER It off during zero mode?</p> <p>YES → 7 OCCDU FAILED</p> <p>NO → 8 VHF ranging data being used by CMC?</p> <p>YES → 9 • OPT MODE CMC • V37E 00E • V41 N91E • Load 8.4° SHAFT and 4.4° TRUN< • V16 N91E Optics drive to angles loaded?</p> <p>YES → 13 OCCDU FAIL DETECTOR FAILED</p> <p>NO → 10 • V11 N10E, 33E E of R1 = ?</p> <p>YES → T/C EMS RANGE DISPLAY ABNORMAL</p> <p>NO → 11 Continue norm operation</p> <p>12 • OPT MODE MAN TRACKER It on?</p> <p>YES → 7</p> <p>NO → 11</p> <p>5 TRACKER LT RELAY FAILED CLOSED</p>	<p>① This R1 readout indicates on OCCDU failed.</p> <p>② All tracker abnormal indications lost.</p> <p>③ Tracker abnormal indications available from unaffected DSKY only.</p> <p>④ Use alternate IMU alignment program (P53 and P54). ISS and CMC unaffected. CMC control of G&N ΔV lost. TVC DAP attitude error still usable.</p> <p>⑤ If caused by VHF ranging data no good, the light will return on in < 1 min (CMC samples VHF ranging data every minute).</p> <p>⑥ This R1 readout indicates a VHF ranging data no good input to the CMC.</p> <p>⑦ Transient abnormal condition.</p>

SM-2A-2262

SYMPTOM	PROCEDURE	REMARKS
<p>G&N</p> <p>11</p> <p>PROG YELLOW</p> <p>Light on if: CMC program alarm or by bad PIPA reading during nonthrusting modes.</p>		<p>① PROG light failed on. Program alarm indication available by keying V5 N9E, if not displayed as a main alarm.</p> <p>② Program alarms are of 3 classes: a. Main alarm - Alarm code displayed. Program halts awaiting crew action. b. Side alarm - Alarm code not displayed. Program continues. c. Restart alarm - Alarm code not displayed. Program executes a restart. CMC can store multiple alarms. First alarm appears in R1; second in R2; last in R3.</p> <p>③ Program alarm indication available from other DSKY.</p>
<p>ALARM CODES</p> <p>12</p> <p>00205 PIPA saturated</p> <p>00207 ISS TURN ON not present for 90 sec</p> <p>00210 IMU not operating</p> <p>00213 IMU not operating with turn on request</p> <p>00211 Coarse Align Error</p> <p>00212 PIPA Fail</p> <p>00217 Bad return from STALL routine</p> <p>01105 Downlink Too Fast</p> <p>01106 Uplink Too Fast</p> <p>01107 Phase Table Failure</p> <p>01407 VG Increasing</p>		<p>① Assumed to have occurred without an ISS light.</p> <p>② This R1 readout checks the presence of a turn-on request from the IMU.</p> <p>③ This R1 readout checks the presence of an IMU operate discrete from the IMU.</p> <p>④ 00211 will occur only during coarse alignment, either by an alignment program or by DSKY command (V41 N20).</p> <p>⑤ IMU must be aligned by an alignment program—i.e., by gyro torquing rather than coarse align.</p> <p>⑥ IMU usable only as a backup attitude reference.</p> <p>⑦ Downlink data transmitted at time of alarm may not be correct. Update must be manually verified.</p> <p>⑧ Perform subsequent CMC ground updates by voice link.</p> <p>⑨ Uplink data being sent when alarm occurred should be transmitted.</p>

SYMPTOM	PROCEDURE	REMARKS
<p>SPECIAL SUB ROUTINES</p> <p>SSR-1</p> <p>CMC TEST</p>		<p>① R2 00001 for 7 SEC R2 00002 for 43 SEC</p> <p>② Subsequent use of CMC dependent on MSFN evaluation (via downlink) of the succeeding steps in self-test.</p> <p>③ Problem is in erasable memory.</p> <p>④ CMC self check tests only erasable and fixed memory. Other internal problems cannot be determined by self check.</p> <p>⑤ All CMC functions lost.</p> <p>⑥ Do not use CMC control for attitude maneuvers.</p> <p>⑦ RCS DAP unusable since T6 counter controls DAP jet firing times.</p> <p>⑧ TVC DAP and auto optics positioning lost.</p> <p>⑨ Optics/CMC interface lost. Use alternate LOS marking routine (P53, P54).</p> <p>⑩ CMC uplink unusable.</p> <p>⑪ IMU cannot be fine aligned.</p> <p>⑫ IMU cannot be coarse aligned. Align by caging and/or fine align. CMC attitude error display lost in axis. CMC control of SIVB lost.</p> <p>⑬ CMC TVC and entry control lost.</p> <p>⑭ IMU usable as attitude reference only.</p>



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SYMPTOM	PROCEDURE	REMARKS
<p>①</p> <p>2</p> <div style="border: 1px solid black; padding: 5px; width: fit-content;"> PITCH (YAW) GMBL 1 (2) </div> <p>YELLOW</p> <p>Light on if:</p> <p>Overcurrent occurs in respective drive motor or gimbal actuator.</p>	<p>1</p> <div style="border: 1px solid black; padding: 5px;"> After SPS shutdown and before SPS GMBL MOT shutdown <ul style="list-style-type: none"> • TVC GMBL DR PITCH (YAW) - 1 (2) • Perform gimbal trim check Gimbal control maintained? </div> <p>NO → Caution Gimbal drive circuits are not C/B protected. Before proceeding with step 2, MSFN may be able to provide failure identification.</p> <p>YES → 4</p> <div style="border: 1px solid black; padding: 5px; width: fit-content;"> C/W FAILURE </div> <p>2</p> <div style="border: 1px solid black; padding: 5px;"> DC load check <ul style="list-style-type: none"> • DC IND sel - FC 1 (2, 3) • SPS GMBL MOT PITCH (YAW) - 1 (2) - Start and hold for check Amps abnormally high? </div> <p>NO → 5</p> <div style="border: 1px solid black; padding: 5px; width: fit-content;"> OVERCURRENT SENSOR FAILED </div> <p>YES → 3</p> <div style="border: 1px solid black; padding: 5px; width: fit-content;"> GIMBAL MOTOR FAILED </div>	<p>① Automatic transfer from the primary system to secondary occurs with an overcurrent provided the TVC GMBL DR switch is at AUTO.</p> <p>② For subsequent ΔV's, place TVC GMBL DR sw to alternate servo position in affected axis.</p> <p>③ Selected gimbal motor is operational when SPS Pitch (Yaw) 1 (2) cb is opened while affected gimbal motor switch is held at START. However, overcurrent protection and switch-over capability will not be available. Close the cb to turn off the gimbal motor.</p>
<p>3</p> <div style="border: 1px solid black; padding: 5px; width: fit-content;"> SPS PREMATURE SHUTDOWN </div> <p>NO SPS IGNITION</p>	<p>1</p> <div style="border: 1px solid black; padding: 5px;"> Single or dual bank? </div> <p>DUAL → 2</p> <div style="border: 1px solid black; padding: 5px;"> SC CONT mode? </div> <p>CMC → 3</p> <div style="border: 1px solid black; padding: 5px;"> Output chan ck <ul style="list-style-type: none"> • ΔV THRUST (2) - OFF • Recycle to ignition in P40 • FL V99 N40 • PRO • VOI N10E, 11E 1 in A of R1? </div> <p>NO → 4</p> <div style="border: 1px solid black; padding: 5px; width: fit-content;"> CMC INTERNAL PROBLEM </div> <p>G&N SSR-1 CMC TEST</p> <p>YES → 5</p> <div style="border: 1px solid black; padding: 5px;"> CMC-SCS INTERFACE FAILED OPEN </div> <p>3</p> <div style="border: 1px solid black; padding: 5px;"> VLV PAIR FAILED CLOSED </div> <p>5</p> <div style="border: 1px solid black; padding: 5px;"> ENG VLV CKTRY FAILED </div> <p>6</p> <div style="border: 1px solid black; padding: 5px;"> EMS ΔV counter < 0.1 fps </div> <p>YES → 12</p> <div style="border: 1px solid black; padding: 5px;"> EMS COUNTER RESET PREMATURELY </div> <p>NO → 13</p> <div style="border: 1px solid black; padding: 5px;"> SPS THRUST It - on? </div> <p>NO → 14</p> <div style="border: 1px solid black; padding: 5px;"> ΔV THRUST (2) - OFF AUTORECS SEL +X (4) - OFF THC - cmd +X THRUST ON pb - push </div> <p>SPS THRUST It - on? YES → 16</p> <div style="border: 1px solid black; padding: 5px; width: fit-content;"> ONE BANK FAILED </div> <p>NO → 18</p> <div style="border: 1px solid black; padding: 5px;"> THC - CW THC - cmd +X THRUST ON pb - push </div> <p>SPS THRUST It - on? YES → 19</p> <div style="border: 1px solid black; padding: 5px; width: fit-content;"> SC CONT ENABLE PWR LOST </div> <p>NO → 22</p> <div style="border: 1px solid black; padding: 5px;"> cb DIR ULL (2) - open DIR ULL pb - push THRUST ON pb - push </div> <p>SPS THRUST It - on? YES → 23</p> <div style="border: 1px solid black; padding: 5px; width: fit-content;"> +X TRANS LOGIC FAILED </div> <p>NO → 24</p> <div style="border: 1px solid black; padding: 5px;"> EMS-SCS INTERFACE FAILED SHORT </div> <p>SINGLE → 6</p> <div style="border: 1px solid black; padding: 5px;"> All SPS INJ VLV ind (4) CLOSE? </div> <p>NO → 7</p> <div style="border: 1px solid black; padding: 5px;"> VLV PAIR FAILED CLOSED </div> <p>YES → 8</p> <div style="border: 1px solid black; padding: 5px;"> cb SPS He VLV or cb PILOT VLVs - open? </div> <p>YES → 9</p> <div style="border: 1px solid black; padding: 5px;"> ENG VLV CKTRY FAILED </div> <p>NO → 10</p> <div style="border: 1px solid black; padding: 5px;"> SC CONT mode? </div> <p>SCS → 11</p> <div style="border: 1px solid black; padding: 5px;"> EMS ΔV counter < 0.1 fps </div> <p>YES → 12</p> <div style="border: 1px solid black; padding: 5px;"> EMS COUNTER RESET PREMATURELY </div> <p>NO → 13</p> <div style="border: 1px solid black; padding: 5px;"> SPS THRUST It - on? </div> <p>NO → 14</p> <div style="border: 1px solid black; padding: 5px;"> ΔV THRUST (2) - OFF AUTORECS SEL +X (4) - OFF THC - cmd +X THRUST ON pb - push </div> <p>SPS THRUST It - on? YES → 16</p> <div style="border: 1px solid black; padding: 5px; width: fit-content;"> ONE BANK FAILED </div> <p>NO → 18</p> <div style="border: 1px solid black; padding: 5px;"> THC - CW THC - cmd +X THRUST ON pb - push </div> <p>SPS THRUST It - on? YES → 19</p> <div style="border: 1px solid black; padding: 5px; width: fit-content;"> SC CONT ENABLE PWR LOST </div> <p>NO → 20</p> <div style="border: 1px solid black; padding: 5px;"> Output chan ck <ul style="list-style-type: none"> • ΔV THRUST (2) - OFF • Recycle to ignition in P40 • FL V99 N40 • PRO • VOI N10E, 11E 1 in A of R1? </div> <p>NO → 20</p> <div style="border: 1px solid black; padding: 5px; width: fit-content;"> CMC INTERNAL PROBLEM </div> <p>G&N SSR-1 CMC TEST</p> <p>YES → 17</p> <div style="border: 1px solid black; padding: 5px;"> SPS THRUST It - on? </div> <p>NO → 21</p> <div style="border: 1px solid black; padding: 5px;"> CMC-SCS INTERFACE FAILED OPEN </div>	<p>① Troubleshooting assumes original switch positions at time of shutdown.</p> <p>② All G&N SPS capability lost.</p> <p>③ Manual on-off procedure a. At TIG -1 min, SPS THRUST - DIR ON b. At TIG, ΔV THRUST A(B) - NORM c. At TIG +3 sec, ΔV THRUST 8(A) - NORM (if dual bank) d. Terminate burn on ΔV or time by ΔV THRUST (2) - OFF.</p> <p>④ G&N SPS on-off control lost. TVC DAP unaffected.</p> <p>⑤ ΔV capability lost for affected bank.</p> <p>⑥ Perform EMS ΔV test and if OK, use ΔV counter to monitor burn. Use manual on-off procedure (Remark 3).</p> <p>⑦ Affected bank may still be available using SPS THRUST - DIR ON. Alternate bank unaffected.</p> <p>⑧ THC must be CW for SCS ΔV capability. SCS auto ΔV lost.</p> <p>⑨ For SCS ΔV use DIR ULL pb for eng initiation (+X TRANS logic function lost).</p> <p>⑩ CMC ΔV capability unaffected. SCS ΔV auto on-off lost. For SCS ΔV use manual on-off procedure (Remark 3).</p>

SM2A-03-BLOCK II-J-(2)
 APOLLO OPERATIONS HANDBOOK

SYMPTOM	PROCEDURE	REMARKS
<p>4 SPS ENG DOES NOT SHUT DOWN AUTO</p> <p>4a SPS THRUST LT ON - NON THRUSTING</p>		<p>① Assumes SPS engine was shut down with the ΔV thrust switches.</p> <p>② All G&N SPS capability lost.</p> <p>③ SCS auto cutoff lost, use manual thrust on-off procedure presented in Remark 5.</p> <p>④ Since failure could be SPS thrust lt on only, for ΔV's perform single bank ignition per Remark 5.</p> <p>⑤ Auto thrust on-off lost for one and possibly both banks. Use manual on-off procedure:</p> <ol style="list-style-type: none"> At TIG-1 min, SPS THRUST DIR ON At TIG, ΔV THRUST A(B) - NORM At TIG +3 sec, ΔV THRUST B(A) - NORM (if dual bank) Terminate burn on ΔV or time by ΔV THRUST (2) - OFF <p>or for single bank operation:</p> <p>At TIG -2 sec, ΔV THRUST (alt bank) - NORM</p> <ol style="list-style-type: none"> If SPS lts, auto thrust on-off lost for both banks, use manual on-off procedure above. If no SPS ign, auto on-off remains for alt bank. <p>⑥ SCS ΔV capability remains but must terminate burn with time. Perform entry self test to determine EMS capability for entry.</p> <p>⑦ This step must be done while still in P40. After check has been made exit P40 to terminate average G.</p> <p>⑧ SCS auto cutoff lost. Manual cutoff required.</p> <p>⑨ G&N auto eng on-off control lost only.</p>
<p>5 SPS Pc ABNORMAL > 110 psia < 90 psia</p>		<p>① Failed bank should not be used except in an emergency.</p> <p>② SPS engine operable until engine indications require shutdown. Engine chugging may occur if SPS Pc is < 60 psi.</p>
<p>6 SPS He VLV tb - ABNORMAL</p>		<p>① When fuel and oxidizer press decreases to 140 psia, place OXID FLOW VLV - DECR.</p> <p>② SPS engine operable until engine indications require shutdown. Engine chugging may occur if Pc is < 60 psi. Corresponding fuel & oxid pressure is ≈ 85 psia.</p> <p>③ Open and close He valves manually for each burn.</p>

SPS MALFUNCTION

APOLLO OPERATIONS HANDBOOK

SYMPTOM	PROCEDURE	REMARKS
<p>7 He PRESS LOW OR DECR</p>	<pre> graph TD 1[1 MSFN verifies SPS He PRESS low or decr?] -- YES --> 2[2 LEAK IN He SUPPLY] 1 -- NO --> 3[3 He INSTRUMENTATION FAILURE] </pre>	<p>① MSFN will monitor redundant He press instrumentation.</p> <p>② He depletion imminent. SPS engine operable until engine indications require shutdown. Engine chugging may occur if SPS Pc is <60 psi. Corresponding fuel & oxid pressure is ≈85 psia.</p> <p>③ When fuel and oxidizer press decreases to 140 psia, place OXID FLOW VLV - DECR.</p>
<p>8 GN2 A (B) PRESS LOW <400 PSI</p> <p>8a SPS INJ VLV PARTIALLY OPEN</p>	<pre> graph TD 1[1 Ind check SPS PRESS IND w/ N2A, N2B, He Press normal?] -- NO --> 2[2 IND FAILED] 1 -- YES --> 3[3 GN2 A (B) LEAK OR FAILED SNSR] 3 --> 4[4 Operate engine on alternate bank] </pre>	<p>① Operation at <350 psi results in partially open ball vlvs and hazardous engine operation.</p>
<p>9 SPS INJ VLV IND ABNORMAL</p> <p>One open during non-thrusting One or two closed during burn period (or burn attempt)</p>	<pre> graph TD 1[1 SPS thrusting?] -- YES --> 2[2 Double or single bank operation?] 2 -- DOUBLE --> 3[3 Continue burn MSFN verifies vlv closed?] 3 -- YES --> 4[4 ONE PAIR OF BALL VLVS FAILED CLOSED] 3 -- NO --> 6[6 INSTRUMENTATION FAILURE] 2 -- SINGLE --> 5[5 INSTRUMENTATION FAILURE] 1 -- NO --> 7[7 MSFN verifies vlv open?] 7 -- YES --> 8[8 ONE PAIR OF BALL VLVS FAILED OPEN] 7 -- NO --> 9[9 INSTRUMENTATION FAILURE] 8 --> 10[10 ΔV THRUST Failed bank - OFF] </pre>	<p>① SPS operable on redundant bank if one bank failed.</p> <p>② Failed bank should not be used except in an emergency.</p>
<p>10 NO PRPLNT TEMP CONTROL</p>	<pre> graph TD 1[1 SPS PRPLNT TEMP ind?] -- LOW AND DECR --> 2[2 SYS TEST (2) - SA SPS oxid line temp low?] 2 -- NO --> 3[3 INSTRUMENTATION FAILURE] 2 -- YES --> 6[6 SPS LINE HTRS - √B Temp incr?] 6 -- YES --> 7[7 SPS LINE HTRS A INSUFFICIENT OR FAILED OFF] 6 -- NO --> 10[10 SPS LINE HTRS √ SA/B FAILED OFF] 1 -- HIGH AND INCR --> 4[4 SYS TEST (2) - SA SPS oxid line temp high?] 4 -- YES --> 5[5 SPS LINE HTRS FAILED ON] 4 -- NO --> 8[8 INSTRUMENTATION FAILURE] 5 --> 9[9 cb SPS HTRS (2) - open] </pre>	<p>① Normal range 45-75°F.</p> <p>② Assumes CSM not in inertial hold mode which might normally result in differences between SPS prplnt temp and SPS oxid line temp.</p> <p>③ Use oxid line temp for SPS prplnt temp.</p> <p>④ Prplnt temp may be incr by CSM orientation or by firing SPS engine. At 27°F the propellants become slushy and the fuel & oxid ratio becomes unpredictable.</p>

APOLLO OPERATIONS HANDBOOK

SYMPTOM	PROCEDURE	REMARKS
<p>11 NO RESPONSE OF SPS OXID VLV #6 DURING FLOW ADJUST</p> <p>(OXID FLOW VLV PRIM - PRIM)</p>	<pre> graph TD S1[1 OXID FLOW VLV INCR - NORM Wait 3 seconds: OXID FLOW VLV PRIM - SEC OXID FLOW VLV INCR - INCR (DECR) SPS OXID FLOW VLV #6 correct?] -- NO --> S2[2 OXID FLOW VLV #6 FAILED] S1 -- YES --> S3[3 OXID FLOW VLV INCR - NORM Wait 3 seconds: OXID FLOW VLV PRIM - PRIM OXID FLOW VLV INCR sw - as desired] S3 --> S4[4 PRIM OXID FLOW VLV FAILED] </pre>	<p>① OXID FLOW VLV INCR sw cannot operate unless power applied through a thrust on signal or through the SPS QTY TEST sw. If flow vlv position was changed by the SPS QTY TEST sw, % FUEL & % OXID quantity readouts must be returned to original values.</p> <p>② The secondary sliding gate vlv must be in the nominal flow position (either than INCR or DECR) before switching to the prim oxid flow vlv or misalignment of the secondary vlv could make the primary vlv inoperative.</p> <p>③ Sec vlv has sufficient range to compensate for prim vlv failure in any position and still provide vlv openings for INCR, NORM or DECR oxid flow.</p>
<p>12 SPS OXID UNBAL IND ERRATIC OR REGGED</p>	<pre> graph TD S1[1 PUG MODE - AUX OXID UNBAL ind normal?] -- NO --> S2[2 OXID UNBAL ind check SPS QTY TEST - 1 for 10 sec, then 2 for 10 sec OXID UNBAL ind normal?] S1 -- YES --> S5[5 PRIM UNBAL SYS FAILED] S2 -- YES --> S5 S2 -- NO --> S3[3 OXID UNBAL ind FAILED] S3 --> S4[4 Return to normal PUG mode PUG MODE - PRIM Perform qty test PUG MODE - NORM] </pre>	<p>① Assumes qty indicating sys normal.</p> <p>② The unbalance meter will behave erratically for approximately 25 seconds after engine ignition. This is caused by propellant dynamics.</p> <p>③ Assumes CSM is still thrusting. If thrust has terminated, proceed with step 2.</p> <p>④ Actuation of SPS QTY TEST sw here will realign digital display to prim sys.</p>
<p>13 SPS OXID (FUEL) QTY IND READOUT ABNORMAL</p>	<pre> graph TD S1[1 PUG MODE - AUX % OXID (% FUEL) readout normal?] -- YES --> S2[2 Prim qty test PUG MODE - PRIM SPS QTY TEST - 1 Incr % oxid by 5.0% % Fuel incr by 2.3±1%?] S1 -- NO --> S4[4 Aux qty test SPS QTY TEST - 1 Incr % oxid by 5.0% % Fuel incr by 5±1%?] S2 -- YES --> S3[3 CAPACITANCE PROBE FAILED] S2 -- NO --> S5[5 PRIM SYS SERVO AMP FAILED] S4 -- YES --> S2 S4 -- NO --> S7[7 DISPLAY FAILED] S3 --> S6[6 Use aux sys PUG MODE - AUX] S5 --> S6 </pre>	<p>① Assumes SPS is still thrusting. If thrusting terminated before step 1 is complete, proceed to step 4.</p> <p>② Complete thrusting prior to qty test.</p> <p>③ MSFN must now supply any printout quantity data.</p>

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APOLLO OPERATIONS HANDBOOK

SYMPTOM	PROCEDURE	REMARKS
<p>RCS</p> <p>1</p> <p>SM RCS A (BCD)</p> <p>YELLOW</p> <p>Light on if: PKG TEMP < 75°F > 205°F MANF PRESS < 145 psi > 215 psi</p> <p>4</p> <p>SM RCS PKG TEMP LOW < 115°F</p> <p>10</p> <p>SM RCS PKG TEMP HIGH > 175°F</p> <p>1c</p> <p>SM RCS SEC FUEL PRESS LOW < 170 psi</p> <p>1d</p> <p>SM RCS SEC FUEL PRESS HIGH > 200 psi</p>	<p>2</p> <p>1 Isolate He sys • SM RCS He 1 & 2 A (BCD) - CLOSE • RCS IND sel - SM A (BCD)</p> <p>SM RCS pkg temp?</p> <p>HIGH</p> <p>NORMAL</p> <p>LOW</p> <p>3</p> <p>Caution If SM RCS PKG TEMP is < 55°F do not actuate eng vlvs. Isolate quad electrically</p> <p>2</p> <p>2 Activate sec httrs • SM RCS HTRS A (BCD) - SEC • SM RCS He 1 & 2 A (BCD) - OPEN</p> <p>Temp incr?</p> <p>YES</p> <p>3</p> <p>3 SM RCS PRIM HTRS A (BCD) FAILED OFF</p> <p>4</p> <p>4 System usable with sec httrs</p> <p>5</p> <p>5 Orient CSM • Orient CSM quad heating</p> <p>Temp incr?</p> <p>YES</p> <p>6</p> <p>6 SM RCS PRIM & SEC HTRS A (BCD) FAILED OFF</p> <p>7</p> <p>7 System usable by orientation</p> <p>8</p> <p>8 INSTRUMENTATION FAILURE</p> <p>9</p> <p>9 • SM RCS HTRS A (BCD) - PRIM system usable</p> <p>10</p> <p>10 Deactivate httrs • SM RCS HTRS A (BCD) - OFF</p> <p>Pkg temp decr < 175°F?</p> <p>YES</p> <p>11</p> <p>11 SM RCS PRIM HTRS A (BCD) FAILED ON</p> <p>12</p> <p>12 Activate sec httrs • SM RCS HTRS A (BCD) - SEC • SM RCS He 1 & 2 A (BCD) - OPEN</p> <p>13</p> <p>13 Orient CSM • SM RCS He 1 & 2 A (BCD) - OPEN • Orient CSM for quad cooling</p> <p>Temp decr?</p> <p>NO</p> <p>14</p> <p>14 INSTRUMENTATION FAILURE</p> <p>15</p> <p>15 System usable with sec httrs</p> <p>YES</p> <p>16</p> <p>16 ORIENTATION PROBLEM</p> <p>17</p> <p>17 • SM RCS HTRS A (BCD) - PRIM System usable</p> <p>18</p> <p>18 RCS SEC FUEL PRESS ind?</p> <p>NORMAL</p> <p>19</p> <p>19 C/W CIRCUITRY FAILURE</p> <p>20</p> <p>20 • SM RCS He 1 & 2 A (BCD) - OPEN System usable</p> <p>HIGH</p> <p>LOW</p> <p>21</p> <p>21 • SM RCS He 1 & 2 A (BCD) - CLOSE</p> <p>He press low?</p> <p>NO</p> <p>22</p> <p>22 MSFN verifies He Manf press</p> <p>NORMAL</p> <p>23</p> <p>23 INSTRUMENTATION FAILURE</p> <p>YES</p> <p>24</p> <p>24 • SM RCS He 1 & 2 A (BCD) - CLOSE</p> <p>MSFN can verify by Helium manf press, the accuracy of the SEC FUEL PRESS ind</p> <p>Manf press (fuel) decr with use?</p> <p>YES</p> <p>25</p> <p>25 LEAK IN HELIUM SUPPLY</p> <p>26</p> <p>26 DUAL He REG ASSY FAILED CLOSED</p> <p>LOW</p> <p>27</p> <p>27 When sec fuel press is < 170 psi • SM RCS He 1 A (BCD) - OPEN Returns high?</p> <p>NO</p> <p>28</p> <p>28 SM RCS He 2 A (BCD) REG ASSY FAILED OPEN</p> <p>YES</p> <p>29</p> <p>29 INSTRUMENTATION FAILURE</p> <p>30</p> <p>30 • SM RCS He 1 & 2 A (BCD) - OPEN</p> <p>31</p> <p>31 • SM RCS He 1A (BCD) - CLOSE • SM RCS He 2A (BCD) - OPEN</p> <p>32</p> <p>32 SM RCS He 1 A (BCD) REG ASSY FAILED OPEN</p>	<p>1 Illumination during boost or immediately following orbit insertion may be due to boost heating.</p> <p>2 Anticipated PKG TEMP operating range is 115-175°F. Safe operating range is 55-210°F</p> <p>3 Actuation at < 55°F might result in eng explosion. Four AUTO RCS switches and both ROT CONTR PWR DIRECT switches must be OFF to elec isolate the affected quad. If there were eng vlv actuations while PKG TEMP was < 55°F, close prplnt isolation vlvs in the affected quad. Reactivate the quad only in emergency. If quad is reactivated, the first pulse on each jet should be ≥ 1 second.</p> <p>4 Sensors powered by cb 3 (Quads A, C) and cb 4 (Quads B, D) 11VST PWR CONT (pni 276).</p> <p>5 Use temp of other quads to estimate the temp of affected quad.</p> <p>6 Anticipated He operating press is 175-195 psi. In addition to the MANF PRESS, MSFN can read out fuel & oxid manf press of each quad.</p> <p>7 MSFN must be used for SM RCS SEC FUEL PRESS indication of affected quad.</p> <p>8 Quad usable until SM RCS SEC FUEL PRESS drop < 75 psi. Place SM RCS PRPLNT A (BCD) - OFF. Firing jets at press < 75 psi may cause eng wall burn-through due to inadequate film cooling.</p> <p>9 A prplnt leak will not cause low sec fuel pressure when He isolation vlvs are open.</p> <p>10 Relf vlv burst disk ruptures at 220-236 psi. Relief vlvs open at 225-248 psi and reseats at no less than 220 psi.</p> <p>11 MSFN must be relied upon for SM RCS SEC FUEL PRESS indications.</p> <p>12 SM RCS SEC FUEL PRESS may increase to > 200 psia during boost until jets are fired.</p>

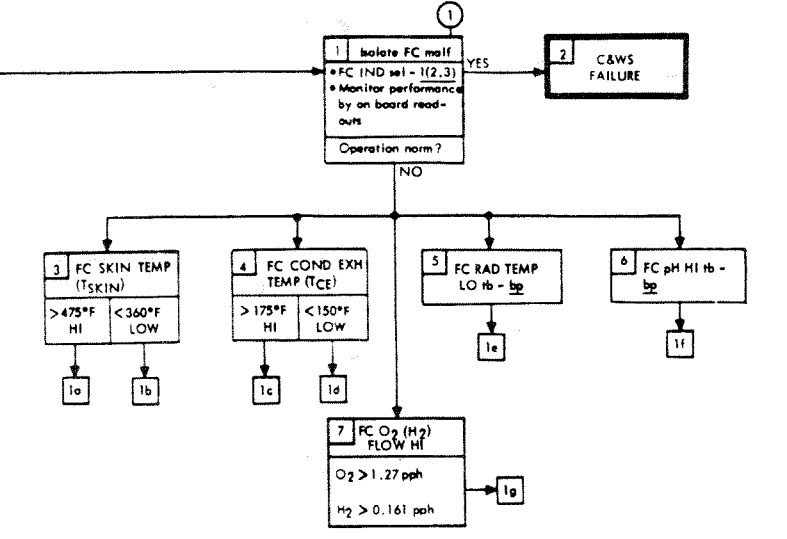
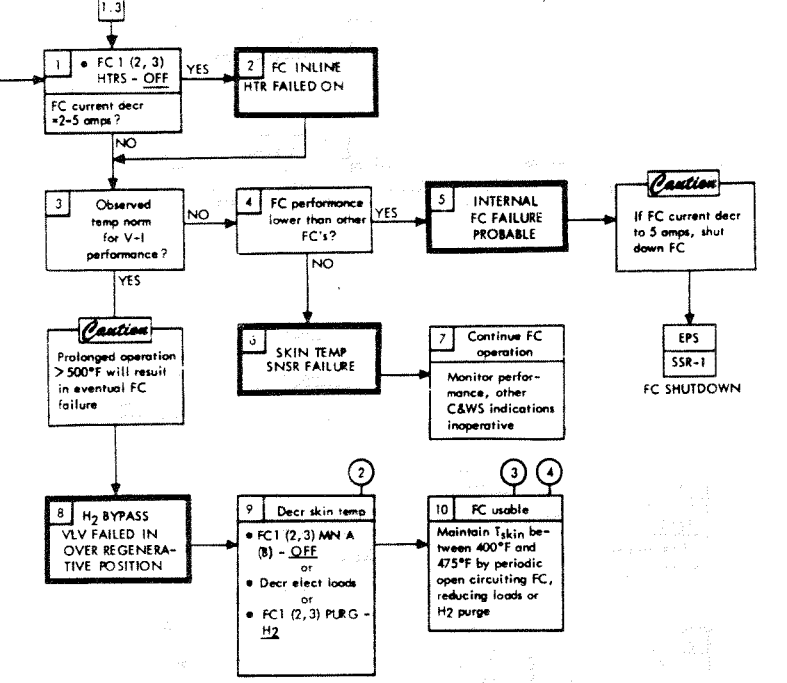
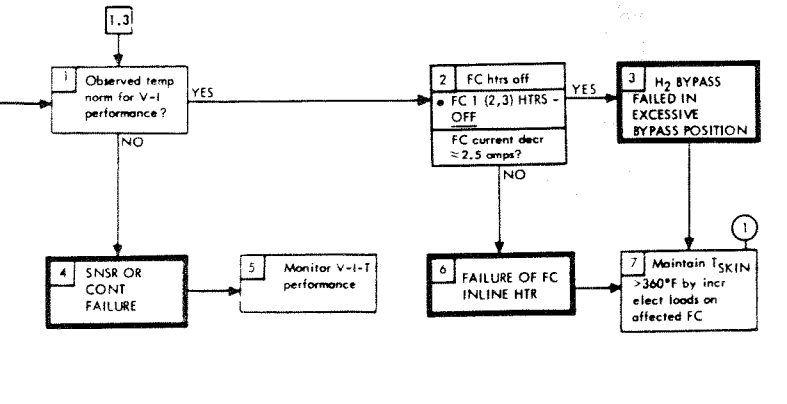
APOLLO OPERATIONS HANDBOOK

SYMPTOM	PROCEDURE	REMARKS
<p>RCS</p> <p>1 SM RCS He PRESS LOW OR DECR</p> <p>2a SM RCS PRPLNT QTY LOW OR DECR</p>		<ol style="list-style-type: none"> ① Sensors powered by cb 3 (Quads A, C) and cb 4 (Quads B, D) INST PWR CONT (pnl 276). ② He press can be estimated from PRPLNT QTY remaining, or obtained from MSFN. ③ Differentiation between a helium and prplnt leak not determinable from onboard instrumentation. Subsequent operational capability may be determined with MSFN. ④ Quad usable until SM RCS SEC FUEL PRESS (fuel) drops to <75 psi. Place SM RCS PRPLNT A (BCD) - CLOSE. Firing jets at press <75 psi may cause engine wall burn-through due to inadequate film cooling. ⑤ If prplnt leak is at eng vlv, firing of engine may result in an explosion
<p>3 CM RCS 1 (2)</p> <p>Light on if: MANF PRESS < 260 psi > 330 psi</p> <p>3a CM RCS MANF PRESS HIGH > 310 psi</p> <p>3b CM RCS MANF PRESS LOW < 280 psi SYS PRESS < 80 psi SYS UNPRESS</p>		<ol style="list-style-type: none"> ① Anticipated operating range 285-305 psi. ② Prior to system pressurization, MSFN must aid in determining failure identification from redundant manifold pressure instrumentation. ③ All CM RCS sensors for ring 1 (2) powered by cb 1 (cb 2) INST PWR CONT (pnl 276). ④ No limit for low fuel and oxid press for safe eng operation (at 65 psi, thrust is approximately 29 pounds). ⑤ Relf vlv diaphragm ruptures at 332-348 psi. Relf vlv relieves at 332-360 psi and reseats at 327 psi minimum.
<p>4 CM RCS He PRESS LOW OR DECR</p>		<ol style="list-style-type: none"> ① All CM RCS sensors for ring 1 (2) powered by cb 1 (cb 2) INST PWR CONT (pnl 276). ② System can be pressurized to normal reg press if He press is >600 psi. ③ Degraded sys usable if necessary. Leakage may be He or prplnt. Prplnt leakage into CM area is not aggravated by use of CM RCS engs. ④ As a last resort, the He systems can be interconnected by placing the CM RCS LOGIC - on (up) then the CM PRPLNT DUMP - on (up) momentarily, then OFF. Once interconnected, systems cannot be isolated and all He could be lost.
<p>5 CM RCS ENG TEMP FAILS TO INCR</p>		<ol style="list-style-type: none"> ① Six RCS engs are instrumented. SYS TEST (2) in positions 6-A, B, C, D checks temp in engs 12, 14, 16 and 21. SYS TEST (2) in positions 5-C and D checks temp in engs 24 and 25. ② Htrs sw failure can be verified by observing DC AMPS indicator for change during sw operation.

APOLLO OPERATIONS HANDBOOK

SYMPTOM	PROCEDURE	REMARKS
<p style="text-align: center;">CRYO</p> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p style="text-align: center;">CRYO PRESS</p> <p style="text-align: center;">YELLOW</p> <p>Light on if: $O_2 > 950$ psia < 300 psia $H_2 > 270$ psia < 220 psia</p> </div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p style="text-align: center;">O_2 (H₂) CRYO PRESS HI</p> <p>$O_2 > 940$ psia $H_2 > 265$ psia</p> </div> <div style="border: 1px solid black; padding: 5px;"> <p style="text-align: center;">O_2 (H₂) CRYO PRESS LOW</p> <p>$O_2 < 840$ psia $H_2 < 220$ psia</p> </div>	<p style="text-align: center;">1 O_2 (H₂) cryo press?</p> <p style="text-align: center;">NORMAL (BOTH IND'S) → 2 C/W FAILURE</p> <p style="text-align: center;">LOW → 3 Both tks hi?</p> <p style="text-align: center;">HI → 3 Both tks hi?</p> <p style="text-align: center;">3 Both tks hi? NO → 4 INSTRUMENTATION FAILURE</p> <p style="text-align: center;">3 Both tks hi? YES → 5 O_2 (H₂) HTRS & FANS (4) - off (ctr) Press continues to rise? YES → 6 Decr tk press NO → 7 AUTO PRESS CONTROL FAILURE</p> <p style="text-align: center;">6 Decr tk press • cb CRYO O_2 (H₂) HTR (2) - open (pnl 226) • FC PURG (3) - H_2 (1 min 20 sec) O_2 (2 min) or (if O_2) • DIRECT O_2 vlv - OPEN (ccw) NOTE: Do not let surge tk press drop < 800 psi</p> <p style="text-align: center;">7 AUTO PRESS CONTROL FAILURE → 8 Man press cont req'd • cb CRYO O_2 (H₂) HTR (2) - close (pnl 226) • O_2 (H₂) HTRS & FANS - ON (as req'd)</p> <p style="text-align: center;">9 Both tks low? NO → 10 Affected tk • O_2 (H₂) HTRS & FANS (2) - ON Press rises? NO → 11 INSTRUMENTATION FAILURE YES → 12 Affected tk • O_2 (H₂) HTRS & FANS (2) - AUTO</p> <p style="text-align: center;">10 Affected tk Press rises? YES → 13 Observe next cycle • O_2 (H₂) HTRS & FANS (4) - AUTO Press rises next cycle? NO → 14 AUTO HTR CIRCUIT DIODE FAILED OPEN YES → 17 CRYO STRATIFICATION</p> <p style="text-align: center;">13 Observe next cycle Press rises next cycle? YES → 17 CRYO STRATIFICATION</p> <p style="text-align: center;">15 Raise tk press • O_2 (H₂) HTRS & FANS (4) - ON Press increases? YES → 16 Observe next cycle • O_2 (H₂) HTRS & FANS (4) - AUTO Press rise next cycle? YES → 17 CRYO STRATIFICATION NO → 18 HIGH CRYO FLOW</p> <p style="text-align: center;">16 Observe next cycle Press rise next cycle? YES → 17 CRYO STRATIFICATION NO → 19 AUTO PRESS CONTROL FAILURE</p> <p style="text-align: center;">18 HIGH CRYO FLOW → 19 AUTO PRESS CONTROL FAILURE</p> <p style="text-align: center;">19 AUTO PRESS CONTROL FAILURE → 20 Man press cont req'd for affected tk (s) • O_2 (H₂) HTRS & FANS (4) - ON (as req'd)</p> <div style="margin-top: 20px;"> <p>EPS-FC FC FLOW HI 1g 1</p> <p>ECS O_2 FLOW HI 1 1</p> <p>ECS CABIN PRESS HI 4 1</p> </div>	<p>1 MSFN may have valid press signal. If O_2, a check of surge tk press will validate cryo tk press within high limits.</p> <p>2 An immediate drop in press upon htr/fan operation is indicative of stratification. Allow sufficient time for press rise indication.</p> <p>3 Use unaffected tk to estimate cryo press.</p> <p>4 Observation of more than one cycle may be necessary.</p> <p>5 Resultant flow rate will be detectable in other systems.</p>

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<p><u>FUEL CELL</u></p> <p>FC 1 (2,3)</p> <p>YELLOW</p> <p>Light on if: One or more of the six monitored functions exceeds its limits.</p>	 <pre> graph TD Start[1] --> Step1[1 Isolate FC malif • FC IND sel - 1(2,3) • Monitor performance by on board read-outs Operation norm?] Step1 -- YES --> Step2[2 C&WS FAILURE] Step1 -- NO --> Step3[3 FC SKIN TEMP (Tskin) >475°F HI <360°F LOW] Step1 -- NO --> Step4[4 FC COND EXH TEMP (Tce) >175°F HI <150°F LOW] Step1 -- NO --> Step5[5 FC RAD TEMP LO lb - bp] Step1 -- NO --> Step6[6 FC pH HI lb - bp] Step1 -- NO --> Step7[7 FC O2 (H2) FLOW HI O2 > 1.27 pph H2 > 0.161 pph] Step3 --> Step3a[1a] Step3 --> Step3b[1b] Step4 --> Step4c[1c] Step4 --> Step4d[1d] Step5 --> Step5e[1e] Step6 --> Step6f[1f] Step7 --> Step7g[1g] </pre>	<p>① FC pump ch's, O₂ and H₂ flow low, O₂ and H₂ reg out press. and sys performance are part of sys verification, but are not monitored by Caution and Warning sys.</p>
<p>1a</p> <p>FC 1 (2,3) SKIN TEMP HI</p> <p>> 450°F</p>	 <pre> graph TD Start[1,3] --> Step1[1 • FC 1 (2,3) HTRS - OFF FC current decr ≈ 2-5 amps?] Step1 -- YES --> Step2[2 FC INLINE HTR FAILED ON] Step1 -- NO --> Step3[3 Observed temp norm for V-I performance?] Step3 -- YES --> Step8[8 H2 BYPASS VLV FAILED IN OVER REGENERATIVE POSITION] Step3 -- NO --> Step4[4 FC performance lower than other FC's?] Step4 -- YES --> Step5[5 INTERNAL FC FAILURE PROBABLE] Step4 -- NO --> Step6[6 SKIN TEMP SNSR FAILURE] Step6 --> Step7[7 Continue FC operation Monitor performance, other C&WS indications inoperative] Step7 --> Step8 Step5 --> Step5a[Caution If FC current decr to 5 amps, shut down FC] Step5a --> Step5b[EPS SSR-1 FC SHUTDOWN] Step8 --> Step9[9 Decr skin temp • FC1 (2,3) MN A (B) - OEE or • Decr elect loads or • FC1 (2,3) PURG - H2] Step9 --> Step10[10 FC usable Maintain Tskin between 400°F and 475°F by periodic open circuiting FC, reducing loads or H2 purge] Step10 --> Step8 Step10 --> Step10a[3] Step10 --> Step10b[4] </pre>	<p>① If TCE also abnormal, enter appropriate TCE procedure (1c or 1d).</p> <p>② Purging H₂ will tend to reduce FC temp. H₂ purge flow is 0.7 pph. H₂ purge should be preceded whenever possible by ≈ 20 min of H₂ purge line htr operation. Criticality of operation above 500°F may preclude this operation.</p> <p>③ Reactivate inline htr on open circuit F/C.</p> <p>④ MASTER ALARM and FC BUS DISC lts will come on when re-connecting open-circuited FC to bus.</p>
<p>1b</p> <p>FC 1 (2,3) SKIN TEMP LOW</p> <p>≤ 360°F</p>	 <pre> graph TD Start[1,3] --> Step1[1 Observed temp norm for V-I performance?] Step1 -- YES --> Step2[2 FC hrs off • FC1 (2,3) HTRS - OFF FC current decr ≈ 2.5 amps?] Step2 -- YES --> Step3[3 H2 BYPASS FAILED IN EXCESSIVE BYPASS POSITION] Step2 -- NO --> Step4[4 SNRSR OR CONT FAILURE] Step4 --> Step5[5 Monitor V-I-T performance] Step5 --> Step6[6 FAILURE OF FC INLINE HTR] Step6 --> Step7[7 Maintain Tskin > 360°F by incr elect loads on affected FC] Step3 --> Step1 Step7 --> Step1 </pre>	<p>① If T_{SKIN} continues to decr, FC operation may continue until ≈ 330°F with degraded output.</p>

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SYMPTOM	PROCEDURE	REMARKS
<p>FUEL CELL</p> <p>1c FC1 (2,3) MOD COND EXH TEMP HI >175°F</p>		<p>① Cyclic overheats to 250°F may be tolerated. Use H₂ purge to prevent steady state T_{ce} from exceeding 225°F at 25 amps.</p> <p>② If possible, H₂ PURGE LINE HTR should be ON (up) 20 min prior to purge.</p> <p>③ FC load changes may affect rates of temperature change.</p> <p>④ If coolant pump failure is confirmed by MSFN reporting rad in and rad out temps converging, turn FC PUMPS - OFF for affected FC.</p> <p>⑤ Loss of glycol pump will result in loss of H₂ pump due to overheating. H₂ pump loss will result in in-line htr burn out if used.</p> <p>⑥ MASTER ALARM and FC BUS DISC INs will come on when re-connecting open-circuited FC to bus.</p> <p>⑦ MSFN can determine if reduced flow condition exists.</p>
<p>1d FC 1 (2,3) COND EXH TEMP LOW <150°F</p>		<p>① Low T_{ce} is no restriction to FC operation if rad out and T_{skin} are maintained within limits.</p> <p>② If H₂ pump is not running, inline htr will burn out if used.</p> <p>③ MASTER ALARM and FC BUS DISC INs will come on when re-connecting open-circuited FC to bus.</p> <p>④ Since continuous operation with rad out temp <-30°F may result in rad freezing or high pressure drop and pump stall, consideration may be given to rad bypass. However, this procedure may be an irreversible action.</p> <p>⑤ Performance may be improved due to electrolyte dehydration. Voltage should be maintained within limits.</p>
<p>1e FC 1 (2,3) RAD TEMP LOW rb - bp <-30°F</p>		<p>① Since continuous operation with rad out temp <-30°F may result in rad freezing or high pressure drop and pump stall, consideration may be given to rad bypass. However, this procedure may be an irreversible action.</p> <p>② Use other FC rad out temp's for confirmation or MSFN can confirm snr failure from FC rad inlet temp's.</p>

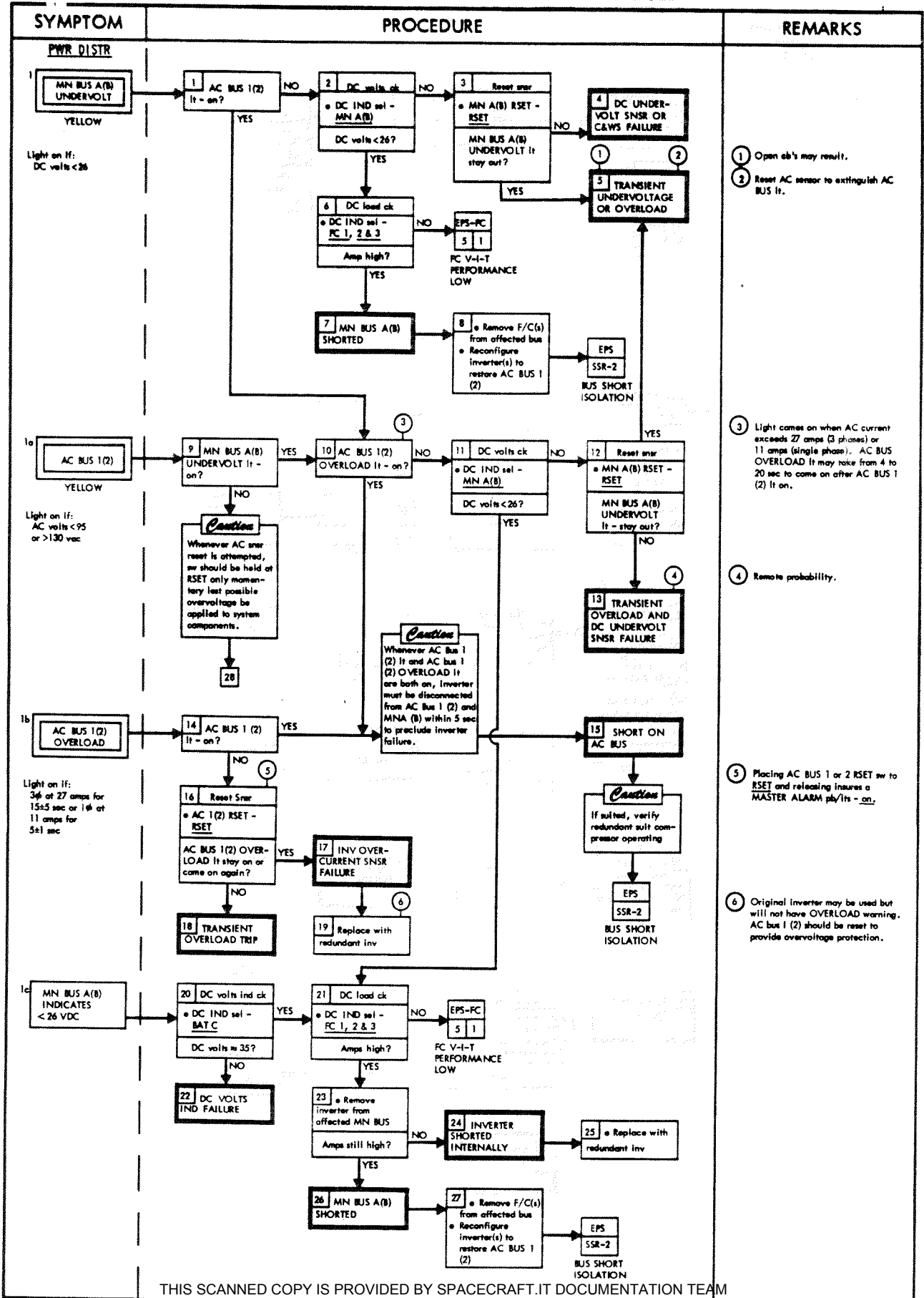
APOLLO OPERATIONS HANDBOOK

SYMPTOM	PROCEDURE	REMARKS
<p>FUEL CELL</p> <p>1f FC 1 (2, 3) pH HI fb -bp</p>		<p>1 Caution Do not purge FC if flooding is suspected. Plugging of common vent line may result.</p> <p>2 Caution Isolate potable H₂O tk for 60 min to direct contaminated H₂O to waste tk.</p>
<p>1g FC 1 (2, 3) O₂ (H₂) FLOW HI O₂ > 0.8 pph H₂ > 0.1 pph</p>		<p>1 H₂ purging will result and O₂ purging may result in FC C&WS alarm.</p> <p>2 $FC\ O_2\ FLOW = \frac{amps \times 2}{100}$ $FC\ H_2\ FLOW = \frac{amps \times 2.5}{1000}$</p> <p>3 An accurate magnitude of the internal short can be determined from the reactant flows when the FC is on open ckt.</p> <p>4 FC reactant conversion efficiency will continue to degrade with time.</p> <p>5 Future purges may result in high flow.</p>
<p>2 FC 1 (2, 3) O₂ (H₂) FLOW LOW O₂ < 0.3 pph H₂ < 0.04 pph</p>		<p>1 FC flow and press instrumentation powered by INST PWR CONT cb's (pn 276).</p> <p>2 Flooding is most probable cause. Isolate potable tank to direct possible contaminated H₂O to waste tank until FC condition is positively determined.</p> <p>3 If reactant ΔP drops to less than 2 psi above N₂, shut down FC to avoid flooding.</p> <p>4 Other reactant indicator may be used for affected flow indication.</p>
<p>3 FC REG O₂ (H₂) OUT PRESS HI >70 psi</p>		<p>1 pH HI fb may indicate bp. If so, isolate potable H₂O tank for 60 min. to direct contaminated H₂O to waste tank.</p> <p>2 Failure of N₂ regulator will raise H₂, O₂, and N₂ press but not dangerously. FC should continue to operate at new press with slight performance change. Heat transfer will not be affected by incr in accumulator press.</p>

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SYMPTOM	PROCEDURE	REMARKS
<p>FUEL CELL</p> <p>①</p> <p>4 cb FC 1 (2, 3) PUMPS AC - OPEN</p>	<p>① Attempt reset</p> <ul style="list-style-type: none"> cb FC 1(2,3) PUMPS AC - close cb reset? <p>NO → ② FC PUMP (H₂ OR GLY) FAILURE</p> <p>YES → ④ Continue FC operation</p> <p>Transient caused cb to open</p> <p>② FC usable for peak loads</p> <ul style="list-style-type: none"> Open circuit FC FC 1 (2, 3) HTRS - OFF Maintain Tskin > 380°F & < 475°F by periodic load operation 	<p>① This condition will result in low TCE and/or high TSKIN-</p> <p>② pH error lost since power is cut non to pumps.</p> <p>③ MASTER ALARM and FC BUS DISC lts will come on when re-connecting open-circuited FC to bus.</p>
<p>5 FC 1 (2, 3) V-I-T PERFORMANCE LOW</p>	<p>① Compare V-I-T performance of all FC's</p> <ul style="list-style-type: none"> Record V-I-T for each FC Compare with V-I-T curves <p>Performance low on all FC's?</p> <p>NO (1 FC LOW) → ② Purge 1 FC</p> <p>YES → ② Potable & waste tanks full?</p> <p>NO → ③ Purge all FC</p> <p>YES → ECS 31a 10</p> <p>WASTE H₂O OVERBOARD DUMP NOT DRAINING</p> <p>③ Repeat purge</p> <p>Continue purging as long as improved performance results</p> <p>④ DC volt check</p> <ul style="list-style-type: none"> DC IND sel - BATC Voltage 34-38V? <p>NO → ⑪ DC VOLTS IND FAILURE</p> <p>YES → ⑨ DC AMPS IND FAILURE</p> <p>⑨ Monitor performance by comparing with other FC's. MSFN provides V&I information for V-I-T check</p> <p>⑤ Affected FC current output much lower than other FC's and TSKIN ≈ or lower?</p> <p>NO → ⑫ TSKIN SNSR FAILURE</p> <p>YES → ⑬ Currents correspond to FC flow?</p> <p>NO → ⑮ INTERNAL FC FAILURE</p> <p>IF FC current decr to 5 amps, shut down FC</p> <p>Caution</p> <p>EPS SSR-L FC SHUTDOWN</p> <p>⑯ Open ckt affected FC</p> <ul style="list-style-type: none"> FC HTR 1, (2, 3) - OFF DC IND SEL - FC 1 (2, 3) Open ckt affected FC (momentarily) <p>FC flow > 0?</p> <p>NO → ⑮ AMMETER CIRCUITRY SHIFT</p> <p>YES → ⑰ INTERNAL FC SHORT (≈FC FLOW)</p>	<p>① If both potable & waste H₂O tanks are full, possible freezing of waste H₂O dump line may be cause.</p> <p>② Verify purge flow by incr in reactant flow.</p> <p>③ Ammeter accuracy can be verified by FC reactant flow</p> $FC\ O_2\ flow = \frac{amps \times 2}{100}$ $FC\ H_2\ flow = \frac{amps \times 2.5}{1000}$ <p>④ If only 2 FC's are in operation, both FC's should be tied to both buses for this check. Time must be allowed for TSKIN to stabilize.</p> <p>⑤ MASTER ALARM and FC BUS DISC lts will come on when reconnecting open-circuited FC to bus.</p> <p>⑥ Use reactant flow rates to estimate current.</p>

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SYMPTOM	PROCEDURE	REMARKS
<p>PWR DISTR</p> <p>ic cont</p> <p>AC BUS 1 (2) VOLTAGE LOW < 113 vac</p> <p>AC BUS 1 (2) VOLTAGE HIGH > 117 vac</p>	<pre> graph TD Start((9)) --> B28[28 AC volts ck • AC IND sel - BUS 1(2) BA, #B and BC AC volts normal (113 to 117)?] B28 -- YES --> B29[29 Reset swr • AC 1(2) RSET - RSET AC BUS 1(2) It - stay out?] B28 -- NO --> B31[31 AC BUS volts ck • AC 1(2) RSET - RSET (hold while noting voltage, anyphase) AC volts?] B29 -- YES --> B30[30 TRANSIENT AC UNDER VOLTAGE] B29 -- NO --> B32[32 AC SNRS FAILURE] B31 --> B33[33 • AC 1(2) RSET - OFF IF BAT BUS A or B amps >1.0] B31 --> B34[34 AC BUS 1(2) It - stay out?] B31 --> B39[39 INV OVER- VOLTAGE FAILURE] B34 -- YES --> B35[35 TRANSIENT OVER-VOLTAGE] B34 -- NO --> B37[37 OVER VOLT- AGE SNRS CKT FAILURE] B37 --> B38[38 • cb EPS SENSOR UNIT AC 1 (2) - green] B39 --> B36[36 • Replace with redundant Inv] B39 --> B40[40 All phases indicate same voltage?] B40 -- ALL HIGH --> B41[41 ONE PHASE OVERLOAD] B40 -- ONE LOW --> B41 B40 -- ALL LOW --> B43[43 Replace with redundant Inv • AC 1 (2) RSET - RSET AC bus 1 (2) It - stay out and voltage norm?] B41 --> B42[42 AC BUS 1 (2) OVERLOAD It - on?] B42 -- YES --> B44[44 SHORT ON AC BUS] B42 -- NO --> B43 B43 -- YES --> B45[45 AFFECTED INV UNDER-VOLTAGE FAILURE] B43 -- NO --> B44 B44 --> B46[Caution Whenever AC BUS 1 (2) It and AC BUS 1 (2) OVERLOAD It are both on, inverter must be disconnected from AC bus 1 (2) and MN A (B) within 5 sec to preclude inverter failure.] B46 --> B47[Caution If suited, verify redundant suit com- pressor operating] B47 --> B48[EPS SSR-2] B48 --> B49[BUS SHORT ISOLATION] </pre>	<p>8 Placing AC BUS 1 or 2 RSET sw to RSET and releasing insures a MASTER ALARM pb/1th - on.</p> <p>9 Subsequent auto inv disconnect for overvoltage lost. If sw left ON, overload indication available but overvoltage may not provide auto inverter disconnect.</p> <p>10 Subsequent auto inv disconnect for overvoltage and undervoltage indication lost. Overload indication unaffected.</p> <p>11 AC BUS OVERLOAD It may take from 4 to 20 sec to come on after AC BUS 1 (2) It on. Light comes on when AC current exceeds 27 amps (3 phase) or 11 amps (single phase).</p>
<p>2 INV 1 (2,3) TEMP HI YELLOW Light on if: Temp > 190 ± 3°F</p>	<pre> graph TD Start((2)) --> B1[1 Gly evap prim (sec) out temp hi?] B1 -- YES --> B16[ECS 16 I] B1 -- YES --> B21[ECS 21 I] B1 -- NO --> B2[2 • AC IND sel - BUS 1 (2) AC volts < 113 or > 117 vac?] B2 -- YES --> B5[5 INV FAILED INTERNALLY] B2 -- NO --> B3[3 Replace with redundant inv and turn original inverter off. INV 1 (2,3) TEMP HI It - out within 15 min?] B3 -- YES --> B5 B3 -- NO --> B4[4 INV 1 (2,3) TEMP HI INSTRU- MENTATION FAILURE] </pre>	<p>1 Refer to checklist for inverter changeover.</p> <p>2 Inv usable but no high temp indication available.</p>

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<p>PWR DISTR</p> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p>3 FC BUS DISCONNECT</p> <p>YELLOW</p> <p>Light - on Overload > 75 amp Recurrent > 4 amp (Assumes FC 1, 2 - MNA and FC 3 - MNB)</p> </div>		<p>① MASTER ALARM and FC BUS DISC lts will come on when reconnecting open-circuited FC to bus.</p> <p>② During actual overloads, the MN BUS UNDERVOLT lts may be on as long as 20 sec before the FC BUS DISC lts.</p>
<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p>4 SUSPECTED HI CURRENT FOR CSM CONFIG</p> </div>		<p>① $O_2 \text{ FLOW} \approx \frac{\text{amps} \times 2}{100}$</p> <p>$H_2 \text{ FLOW} \approx \frac{\text{amps} \times 2.5}{1000}$</p> <p>② a. ECS rad htrs operate: RAD PRIM OUT TEMP < -15°F RAD SEC OUT TEMP < +45°F</p> <p>b. Cryo htrs & fans operate: $O_2 < 865 \text{ psia}$ $H_2 < 225 \text{ psia}$</p> <p>c. FC htrs operate: $T_{SKIN} < 380^\circ\text{F}$</p> <p>d. SM RCS htrs operate at pkg temp: $\text{PRIM} < 115^\circ\text{F}$ $\text{SEC} < 115^\circ\text{F}$</p>

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<p>PWR DISTR</p> <p>5 BAT CHGR CURRENT ZERO</p>		<p>① Affected battery might still be charged through BAT TIE cb's</p> <p>② Battery charging capability lost.</p>
<p>6 BAT BUS A(B) CURRENT > 1.0 WITH MN BUS TIE (2) - QEE</p> <p>6a FC hb's ALL GRAY</p>		<p>① Bat bus current will be < 1.0 amps for all mission phases except:</p> <p>a. Prelaunch (< 3.0 amps)</p> <p>b. Boost & insertion</p> <p>c. ΔV maneuvers</p> <p>d. Deorbit & entry.</p> <p>② If a, b & c bats on MN buses, cycling MN bus tie switches may correct the problem. If not, MN bus tie will have to be accomplished by cb action. May have to change battery through other battery bus.</p> <p>③ Not valid after CM/SM separation.</p>
<p>7 PYRO BAT VOLTAGE < 35 VDC</p>		<p>① It is crew option to leave a main battery connected to a known short to retain redundant pyro circuit capability. If dc amps > 30, expect cb PYRO A(B) BAT BUS A(B) to open within 1 to 5 min and loss of redundant pyro circuit.</p>
<p>SPECIAL SUB ROUTINE</p> <p>SSR-1 FUEL CELL SHUTDOWN</p>		<p>① FC will not reach $T_{SKIN} = 200^{\circ}F$ for approximately 24 hours.</p> <p>KOH will be solidified at $T_{SKIN} \leq 200^{\circ}F$. The press is relieved to reduce the possibility of corrosive fluid leaking into the SM and to insure sealing of the check vlv, isolating the potable water from the FC.</p>

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SSR-2 BUS SHORT ISOLATION		<p>① If short circuit amps < 2.0, it is a crew option to maintain bat relay bus powered to retain AC bus sensors and FC overcurrent/reverse current protection functions. Increased battery recharge cycle may be required. If short circuit > 2.0 amps, close bat relay bat A or bat B cb's only when required to operate equipment connected to bat relay bus.</p>

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	<div style="text-align: center;"> </div>	<p>② MASTER ALARM and FC BUS DISC lts will come on when reconnecting open-circuited FC to bus.</p> <p>③ Place two batteries on remaining bus for SPS maneuvers.</p>
	<p>THIS SCANNED COPY IS PROVIDED BY SPACECRAFT.IT DOCUMENTATION TEAM</p>	<p>SM-2A-2249</p>

EPS MALFUNCTION

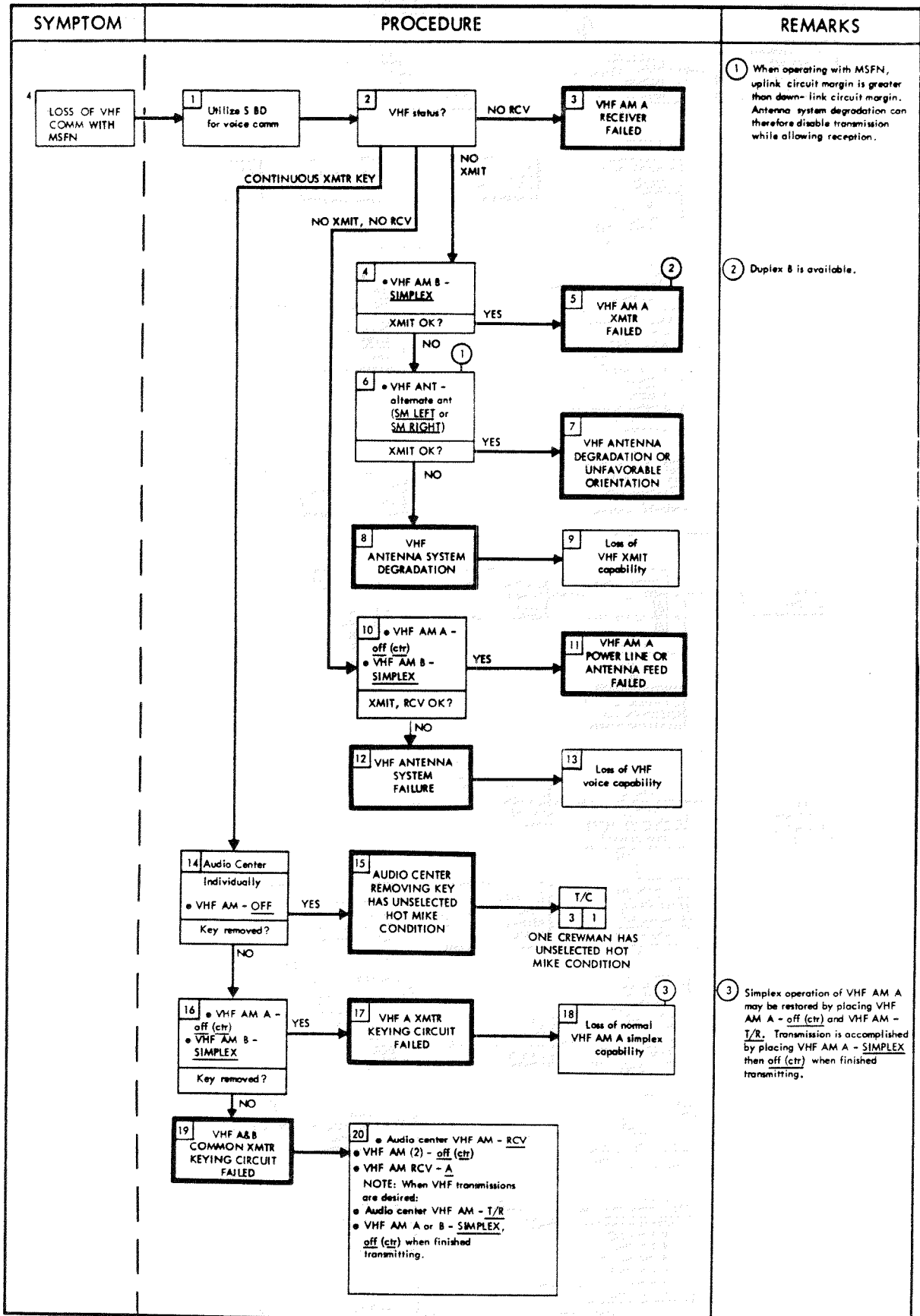
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SYMPTOM	PROCEDURE	REMARKS
SSR-2 (CONT)	<div style="text-align: center;"> <p>2</p> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p>22 Bat chgr to bat bus</p> <ul style="list-style-type: none"> ● cb ENTRY/PL PWR BAT A (B) - open (pnl 250) ● cb BAT RLY BUS BAT A (B) - open ● BAT CHG - A (B) ● DC IND sel - BAT CHGR <p>Bat chgr amps > 0?</p> </div> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <p>NO</p> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p>24 BAT A (B) current > 0?</p> </div> <p>NO</p> </div> <div style="text-align: center;"> <p>YES</p> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p>25 DRAIN ON BAT BETWEEN BAT AND BUS OR BAT CURRENT INST FAILED</p> </div> </div> </div> <div style="text-align: center;"> <p>NO</p> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p>23 Return to original configuration. Close cb's to isolate affected equip.</p> </div> </div> </div> <div style="text-align: center; margin-top: 10px;"> <p>YES</p> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p>26 Current drain on bat bus (bus loss depends on magnitude of current drain)</p> </div> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p>BAT BUS A</p> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p>27 BAT BUS A reconfiguration</p> <ul style="list-style-type: none"> ● ECS RAD HTR - PRI 2 ● cb PYRO A/SEQ A - open If MN BUS TIE BAT A/C is closed: <ul style="list-style-type: none"> ● cb MNA BAT BUS A - open ● cb MNB BAT C - open (verify) For subsequent Main Bus ties: <ul style="list-style-type: none"> ● cb MNA BAT C - close ● MN BUS TIE BAT B/C - on (up) If MN BUS TIE BAT A/C is open: <ul style="list-style-type: none"> ● cb MNB BAT BUS B - open ● cb MNA BAT C - open (verify) ● MN BUS TIE BAT B/C - on (up) For subsequent Main Bus ties: <ul style="list-style-type: none"> ● cb MNA BAT C - close ● cb MNB BAT BUS B - close </div> <div style="text-align: center;"> <p>BAT BUS B</p> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p>28 BAT BUS B reconfiguration</p> <ul style="list-style-type: none"> ● ECS RAD HTR - PRI 1 ● cb PYRO B/SEQ B - open If MN BUS TIE BAT B/C is closed: <ul style="list-style-type: none"> ● cb MNB BAT BUS B - open ● cb MNA BAT C - open (verify) For subsequent Main Bus ties: <ul style="list-style-type: none"> ● cb MNB BAT C - close ● MN BUS TIE BAT A/C - on (up) If MN BUS TIE BAT B/C is open: <ul style="list-style-type: none"> ● cb MNA BAT BUS A - open ● cb MNB BAT C - open (verify) ● MN BUS TIE BAT A/C - on (up) For subsequent Main Bus ties: <ul style="list-style-type: none"> ● cb MNB BAT C - close ● cb MNA BAT BUS A - close </div> </div> </div> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p>BAT BUS A</p> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p>29 BAT BUS A non-transferable loads</p> <p>EPS/CRYO</p> <ul style="list-style-type: none"> ● Mn bus tie bat A/C mot sw <p>ECS</p> <ul style="list-style-type: none"> ● Prim rad 1 htr ovlid sensor <p>RCS</p> <ul style="list-style-type: none"> ● SECS auto RCS trnfr to trnfr mot sw 1 <p>SPS</p> <ul style="list-style-type: none"> ● Pitch & yaw (prim) gmb1 mot cont <p>SCS</p> <ul style="list-style-type: none"> ● AUTO RCS SEL MNA (if not previously enabled) <p>SECS</p> <ul style="list-style-type: none"> ● SECS & ELS sys A ● Float bag compr 1 ● Float bat 1 mot sw & cont vlv ● EDS voting logic 1 </div> </div> <div style="text-align: center;"> <p>BAT BUS B</p> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p>30 BAT BUS B non-transferable loads</p> <p>EPS/CRYO</p> <ul style="list-style-type: none"> ● Mn bus tie bat B/C mot sw <p>ECS</p> <ul style="list-style-type: none"> ● Prim rad 2 htr ovlid sensor ● Sec rad htr ovlid sensor <p>RCS</p> <ul style="list-style-type: none"> ● SECS auto RCS trnfr to trnfr mot sw 2 <p>SPS</p> <ul style="list-style-type: none"> ● Pitch & yaw (sec) gmb1 mot cont <p>SCS</p> <ul style="list-style-type: none"> ● AUTO RCS SEL MNB (if not previously enabled) <p>SECS</p> <ul style="list-style-type: none"> ● SECS & ELS sys B ● Float bag compr 2 ● Float bag 2 mot sw & cont vlv ● EDS voting logic 3 </div> </div> </div> </div> </div>	<p>4 If cb RAD HTRS OVLD BAT A and/or BAT B are opened to reduce battery drain, they should not be closed unless batteries are tied to main buses. This prevents possible disconnect of ECS radiator heaters by a false overload signal.</p>

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SYMPTOM	PROCEDURE	REMARKS
<p>1 ONE CREWMAN HAS NO INTERCOM CAPABILITY</p>		<p>① CMP's audio center only) verify S BD MODE VOICE - not in RELAY.</p> <p>② Procedure removes all power from CCU.</p> <p>③ No hot mike intercom available. S BD or VHF AM sidetone may be used as a backup intercom. Pad comm will be 10 times normal volume after liftoff.</p> <p>④ Affected crewman's PTT switch is inoperative. In the event of intercom diode switch failure, transmissions to ground are available by returning AUDIO CONT - NORM.</p>
<p>2 LOSS OF INTERCOM (ALL CREWMEN)</p>		<p>① Pwr lost to audio center equip and VHF AM. Capability to xmit and rcv voice via VHF AM, S BD or Intercom is lost. Down voice substitute is crew alert light.</p> <p>② Transmitted signal is not audible in this failure mode.</p> <p>③ No hot mike intercom available. S BD or VHF AM sidetone may also be used as backup intercom.</p>
<p>3 ONE CREWMAN HAS UNSELECTED HOT MIKE CONDITION</p>		<p>① Results in A/G transmissions for all equipment selected to T/R.</p> <p>② Selecting the alternate audio center is necessary to avoid the HOT MIKE conditions and continuous S BD voice transmissions regardless of the position of the audio center S BD switch.</p> <p>③ The PTT sw of affected crewman will be inoperative.</p> <p>④ Procedure removes all power from CCU.</p> <p>⑤ The audio center is still usable in the hot mike mode; undesired air-to-ground transmissions can be eliminated by placing the audio center S BD and VHF switches to OFF or RCV.</p>

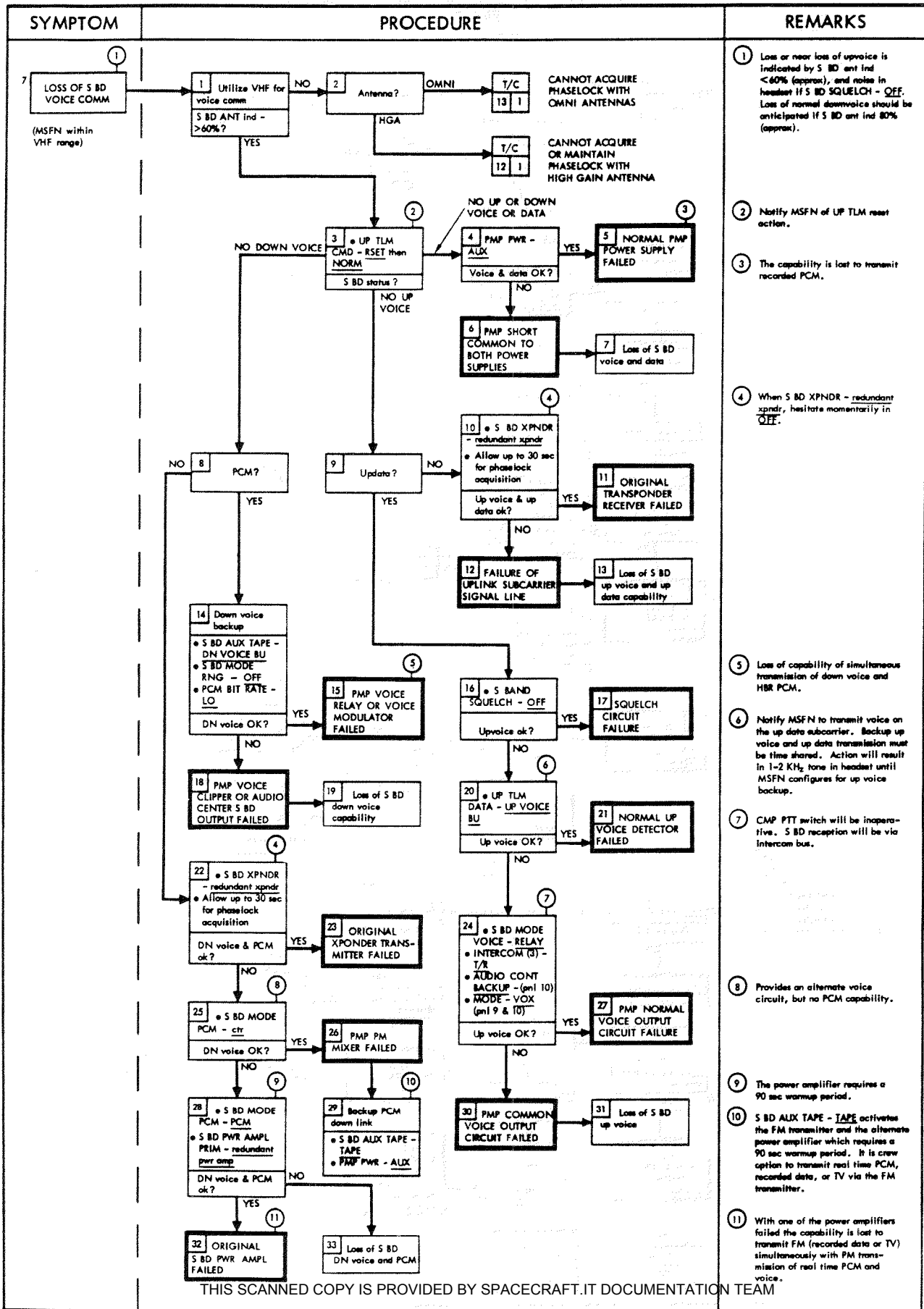
SM2A-03-BLOCK II-J-(2)
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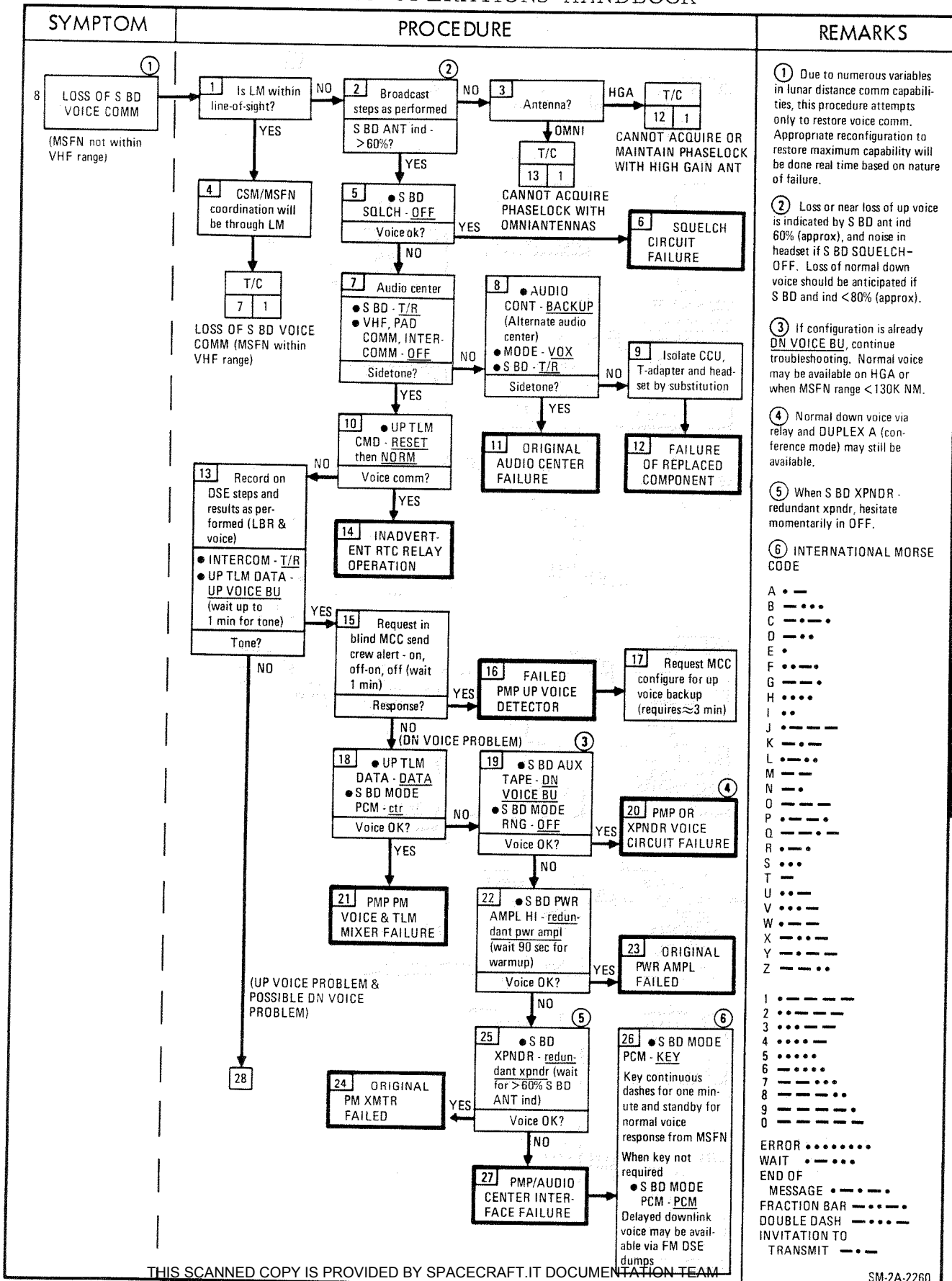
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SYMPTOM	PROCEDURE	REMARKS
<p>5 LOSS OF VHF COMM WITH LM</p>	<pre> graph TD S5[5 LOSS OF VHF COMM WITH LM] --> Q1{1 Sidetone during VHF transmission?} Q1 -- YES --> Q6{6 Alternate VHF antenna} Q1 -- NO --> B2[2 Audio center • AUDIO CONT - BACKUP Backup audio center • VHF - T/R • MODE - VOX Comm ok?] Q6 -- YES --> B7[7 FAILED ANT OR INCORRECT ANT SELECTED] Q6 -- NO --> B9[9 Audio center • MODE - VOX Comm ok?] B2 -- YES --> B5[5 AUDIO CENTER FAILED] B2 -- NO --> Q3{3 Connect to alternate audio center umbilical • PWR - AUDIO/TONE • MODE - as desired • VHF AM - T/R Sidetone ok?} B9 -- YES --> B10[10 PTT KEYING CIRCUIT FAILED OPEN] B9 -- NO --> B13[13 Audio center • AUDIO CONT - BACKUP Backup audio center • PWR - AUDIO • VHF - T/R • MODE - VOX Comm ok?] B10 -- YES --> B10 B10 -- NO --> B14[14 Set up VHF simplex Audio center • AUDIO CONT - NORM • MODE - as desired • VHF AM A - SIMPLEX • VHF AM B - SIMPLEX • VHF AM RCV - OFF (ctr) • VHF RNG - OFF Initiate call to LM at least once every 3 min if no MSFN AOS Comm ok?] B13 -- YES --> B18[18 ORIGINAL AUDIO CENTER VHF DIODE SW FAILURE] B13 -- NO --> B14 B14 -- YES --> B19[19 Utilize S BD for voice comm when AOS Verify LM is reconfigured for A & B SIMPLEX Comm ok?] B14 -- NO --> B16[16 CSM OR LM XMTR OR RCVR FAILURE] B19 -- YES --> B16 B19 -- NO --> B21[21 CSM VHF status? NO XMTR NO RCVR] B21 -- NO --> B20[20 VHF XMTR/AUDIO CENTER INTERFACE FAILURE] B21 -- NO --> B22[22 VHF AM A - OFF VHF AM B - DUPLEX Comm ok?] B22 -- YES --> B23[23 VHF A&B COMMON XMTR KEYING CIRCUIT FAILURE (Continuous xmtr key)] B22 -- NO --> B25[25 VHF RCVR/AUDIO CENTER INTERFACE FAILURE] B16 --> B11[11 Utilize alternate headset Sidetone ok?] B11 -- YES --> B12[12 HEADSET FAILURE] B11 -- NO --> B15[15 SUIT HARNESS OR CWG ADAPTER FAILURE] B15 --> B17[17 Utilize spare adapter] B17 --> B16 B16 --> B4[4 Return to original audio center. Isolate failed components by substitution (exclude headset and CWG adapter) Failed audio panel • PWR - OFF • SUIT PWR - OFF • VHF AM - OFF • AUDIO CONT - NORM Panel 3 • S BD MODE PCM - PCM or ctr • Replace comm components individually] B4 --> B8[8 FAILURE OF REPLACED COMPONENT] </pre>	<p>1 Coordination between the two spacecraft can narrow the failure to a XMTR/RCVR combination. The specific combination depends upon which equipment was in use (i.e., whether LM data transfer or VHF ranging is in use).</p> <p>Possible loss of VHF ranging and/or data transfer capability.</p> <p>2 VHF ranging still available.</p> <p>3 Loss of all VHF functions.</p>
<p>6 EMS RANGE DISPLAY ABNORMAL</p>	<pre> graph TD S6[6 EMS RANGE DISPLAY ABNORMAL] --> Q1{1 VHF RNG - RSET (wait 15 sec) Display ok?} Q1 -- YES --> B4[4 DIGITAL RANGING GENERATOR FAILURE] Q1 -- NO --> Q2{2 Tones audible during wait period?} Q2 -- YES --> B3[3 Utilize CMC for VHF range readouts • P20 running V87E (wait 1 minute) V6 N2E 3703E R1 = VHF RANGE XXX.XX NM CMC range display abnormal?] Q2 -- NO --> Q6{6 VHF comm with LM ok?} B3 -- YES --> B4 B3 -- NO --> B7[7 EMS OR EMS/VHF INTERFACE FAILURE] Q6 -- YES --> Q10{10 SUIT PWR - OFF Depress and hold PTT button VHF RNG - RSET (Wait 15 sec) SUIT PWR - on (up) Display ok?} Q6 -- NO --> B9[9 Alternate VHF antenna Comm ok?] Q10 -- YES --> B11[11 DIGITAL RANGING GENERATOR OR LM RANGING TONE TRANSFER ASSEMBLY FAILURE] Q10 -- NO --> B13[13 LOSS OF AUTOMATIC VHF RNG XMTR KEY FUNCTION] B9 -- YES --> B12[12 FAILED ANT OR INCORRECT ANTENNA SELECTED] B9 -- NO --> B5[5 MOMENTARY LOSS OF TRACK] B5 --> B13 B13 --> B14[14 VHF RNG available only while PTT button depressed] </pre>	<p>1 CMC TRACKER It should be on if computer is in P20 and V87 has been entered.</p> <p>2 Tones will be audible for 8 seconds after VHF reset. EMS display of range occurs 12 to 15 sec after reset.</p> <p>3 If R1 is negative, actual range = 327.67 NM minus absolute value of R1. This will occur any time the range exceeds 163.83 NM.</p> <p>4 Temporary signal loss may be caused by antenna nulls or antenna switching.</p> <p>5 Turning suit power off precludes audio interference with VHF ranging initialization.</p>

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T/C
 MALEFUNCTION

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SYMPTOM	PROCEDURE	REMARKS
8 (Cont)	<pre> graph TD 13[13] --> 28[28] 28 -- YES --> 29[29] 28 -- NO --> 35[35] 29 -- YES --> 32[32] 29 -- NO --> 30[30] 30 -- YES --> 33[33] 30 -- NO --> 31[31] 31 --> 34[34] 34 --> 36[36] 35 -- YES --> 38[38] 35 -- NO --> 36 36 -- YES --> 37[37] 36 -- NO --> 40[40] 40 -- YES --> 41[41] 40 -- NO --> 43[43] 41 --> 42[42] 43 -- YES --> 47[47] 43 -- NO --> 44[44] 44 -- YES --> 48[48] 44 -- NO --> 45[45] 45 -- YES --> 49[49] 45 -- NO --> 46[46] 46 --> 50[50] </pre>	<p>⑦ In relay mode for UP VOICE, CMP audio center DN VOICE not available. CMP select backup audio center. CDR and LMP use sidetone to copy up voice.</p> <p>④② DASH = Approx 10% increase for 10 secs DOT = Approx 10% increase in S BD indicator 5 secs. Cue ground when ready to copy.</p> <p>④② DASH = 1 DOT = 0 FILL = 9</p>
9	<pre> graph TD 9[9] --> 1[1] 1 -- YES --> 5[5] 1 -- NO --> 2[2] 2 -- YES --> 6[6] 2 -- NO --> 3[3] 3 --> 4[4] </pre>	<p>① Coordinate with MSFN.</p> <p>② When S BD XPNDR - redundant xpndr, hesitate momentarily in OFF.</p> <p>③ Skin tracking performed by ground radar; no crew action required.</p> <p>④ Original XPNDR is usable for all functions except ranging.</p>
10	<pre> graph TD 10[10] --> 1[1] 1 -- YES --> 2[2] 1 -- NO --> 3[3] </pre>	<p>① The capability is lost to transmit recorded PCM simultaneously with real time PCM.</p>

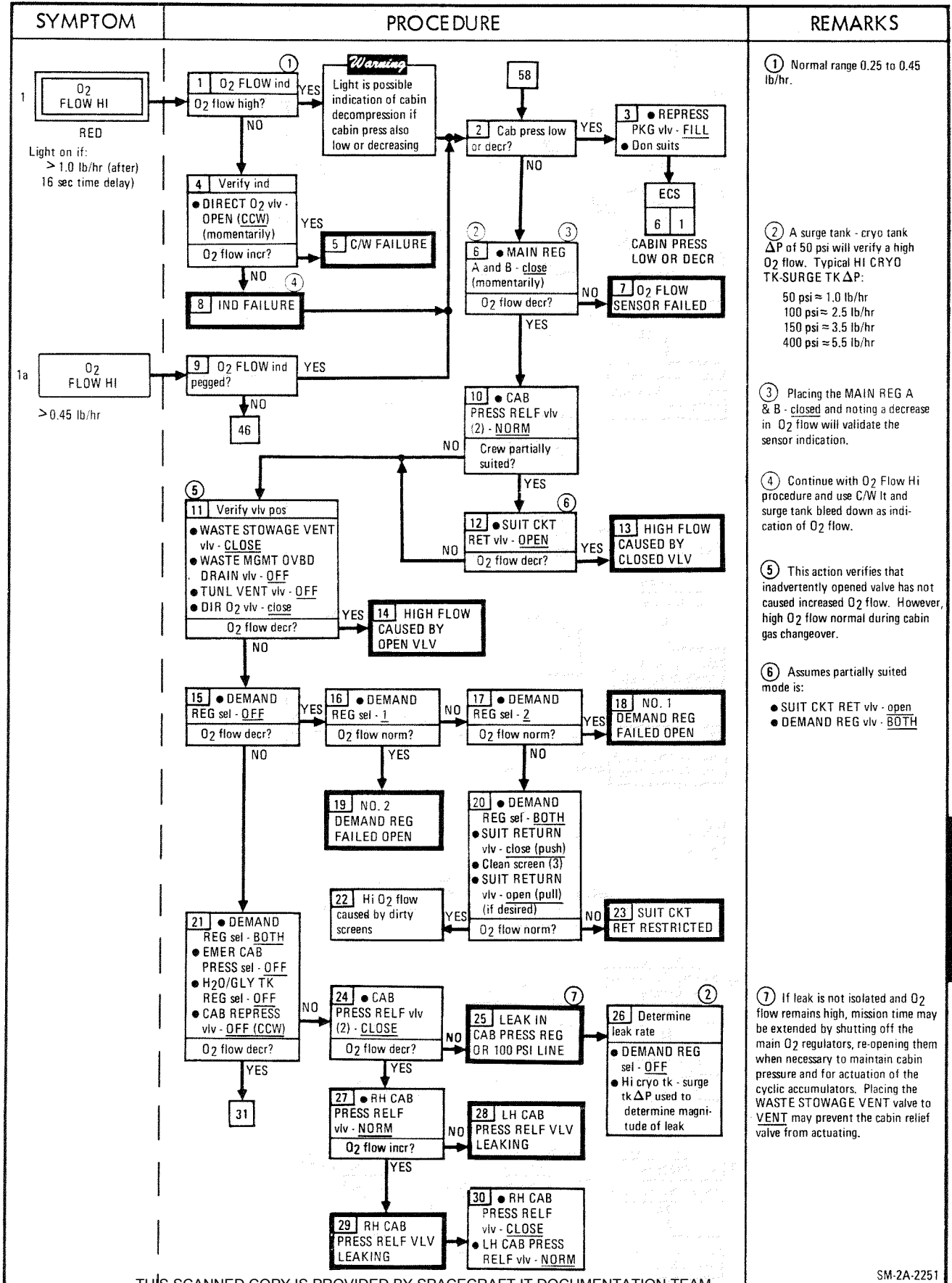
SM2A-03-BLOCK II-J-(2)
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SYMPTOM	PROCEDURE	REMARKS
<p>11 HI GAIN ANTENNA DOES NOT RESPOND PROPERLY TO MANUAL POINTING COMMANDS</p>		<p>1 Assumes that MANUAL MODE has been selected and that both HGA command dials have been rotated back and forth $\approx 30^\circ$ several times.</p> <p>2 If antenna pointing is incorrect, phase lock can still be achieved but with a reduced signal strength.</p> <p>3 If HGA usage mandatory orient CSM with HGA pointed toward earth; HI GAIN ANT BEAM - NARROW. Rotate HGA pitch and yaw command dials to correspond to meter readings.</p> <p>4 Indicators will display actual antenna position. If look angle is outside shadow area HGA may be utilized when CSM attitude permits.</p>
<p>12 CANNOT ACQUIRE OR MAINTAIN PHASELOCK WITH HIGH GAIN ANTENNA</p>		<p>1 Loss of uplink phase lock is indicated by noise in headset and S-BD antenna ind < 30%.</p> <p>2 When SBD XPNDR-redundant xpndr, hesitate momentarily in OFF.</p> <p>3 If in medium select wide.</p>

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SYMPTOM	PROCEDURE	REMARKS
<p>13 CANNOT ACQUIRE PHASELOCK WITH OMNIANTENNAS ^①</p>	<pre> graph TD Start[13 CANNOT ACQUIRE PHASELOCK WITH OMNIANTENNAS] --> Step1[1 Select V64E (check ant selected) Ant OK?] Step1 -- NO --> Step2[2 Select proper antenna (wait 1 min for phase lock) Phase lock acquired?] Step1 -- YES --> Step2 Step2 -- YES --> Box3[3 ORIGINAL ANT LOOK ANGLE BAD] Step2 -- NO --> Step4[4 S BD XPNDR - redundant XPNDR Allow up to 30 sec for phase lock acquisition Phase lock acquired?] Step4 -- YES --> Box8[8 ORIGINAL XPNDR FAILED] Step4 -- NO --> Step5[5 If VHF not available, wait 5 min for possible MSFN problem] Step5 --> Step6[6 UP TLM CMD - RESET then NORM Phase lock acquired?] Step6 -- YES --> Box7[7 INADVERTENT RTC RELAY OPERATION] Step6 -- NO --> Step9[9 Do attitude and propellant constraints allow roll maneuver?] Step9 -- YES --> Step12[12 Roll CSM not less than 45° Allow up to 30 sec for phase lock acquisition Attempt phase lock acquisition with all omniantennas Phase lock acquired?] Step9 -- NO --> Step10[10 S BD ANT OMNI - HI GAIN Attempt phase lock acquisition utilizing HGA Phase lock acquired?] Step10 -- YES --> Step14[14 FAILURE OF RF SWITCH TO HI GAIN POSITION OR OMNI-ANTENNA FAILED] Step10 -- NO --> Box13[13 TRIPLEXER OR RF COAX CABLE FAILED] Step12 -- YES --> Box15[15 OMNI-ANTENNA FAILED] Step12 -- NO --> Step10 Step14 --> Step16[16 S BD COMM limited to HGA or remaining omnis] </pre>	<p>① Loss of uplink phase lock is indicated by noise in headset and S BD antenna ind < 30%.</p> <p>② When SBD XPNDR-redundant xpndr. hesitate momentarily in OFF.</p> <p>③ Performing roll maneuver eliminates omniantenna as failure.</p>
	<p>11 Loss of uplink voice comm. Possible loss of downlink voice comm.</p> <ul style="list-style-type: none"> • PCM BIT RATE - LO • S BD AUX TAPE - DN VOICE BU • S BD MODE RNG - RNG <p>Continue optimum ant switching. Attempt voice comm at least once per hour on the GET hour as follows:</p> <ul style="list-style-type: none"> • S BD MODE PCM - ctr • PCM BIT RATE - HI • S BD MODE RNG - OFF • Perform comm check <p>If no contact -</p> <ul style="list-style-type: none"> • S BD MODE PCM - PCM • PCM BIT RATE - LO • S BD MODE RNG - RNG • Attempt DSE dump of recorded voice <p>At completion of dump -</p> <ul style="list-style-type: none"> • S BD AUX TAPE - DN VOICE BU <p>When range < 60 KNM</p> <ul style="list-style-type: none"> • VHF AM A - SIMPLEX • Audio Center VHF AM - T/R • Standby for MSFN call 	

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ECS MALFUNCTION

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SYMPTOM	PROCEDURE	REMARKS
<p>1a (Cont)</p>		<p>⑧ MSFN can distinguish between these two failures by reporting tank bladder pressure.</p> <p>⑨ PRESS-TO-TEST operation may reseal leaky peel valve.</p> <p>⑩ Removes power from H2O accumulator.</p> <p>⑪ H2O accumulator can be manually operated.</p> <p>⑫ Max O2 bleed into suit loop will be 0.55 lb/hr (from which metabolic use and cabin leakage will be taken).</p> <p>⑬ This failure does not necessarily preclude manual operation of the affected H2O accumulator.</p> <p>⑭ Cycling operation may free sticking valve.</p> <p>⑮ Loss of electrical cyclic control of affected H2O accumulator. Periodic manual valve operation the only means of actuating H2O accumulator.</p>
<p>2</p> <p>O2 FLOW LOW < 0.25 lb/hr</p>		<p>① Normal range 0.25 - 0.45 lb/hr.</p> <p>② May take up to 45 minutes max.</p> <p>③ MSFN can distinguish between these two failures.</p>
<p>3</p> <p>SURGE TANK PRESS HIGH > 935 psi</p>		<p>① Use highest cryo tank indication to estimate surge tank pressure.</p> <p>② Surge tank pressure may be determined by momentarily positioning REPRESS PKG vlv - FILL and read repress pack press meter after stabilization.</p>

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SYMPTOM	PROCEDURE	REMARKS
<p>4 CABIN PRESS HIGH OR INCREASING > 5.3 psi</p>	<p>1 Verify cab press inst SUIT PRESS ind ≈ CAB PRESS ind?</p> <p>YES → 2 O₂ flow high? YES → ECS 1 1 O₂ FLOW HI NO → ECS 5 1 SURGE TANK PRESS LOW</p> <p>NO → 3 CAB PRESS INST FAILURE → 4 Use SUIT PRESS ind to estimate cab press</p>	<p>① Cabin pressure > 5.3 psi is normal after insertion. Normal range is 4.7 to 5.3 psi</p>
<p>5 SURGE TANK PRESS LOW < 835 psi</p>	<p>1 • O₂ PRESS IND sw - TK 1 Cryo tk press low?</p> <p>YES → 2 CRYO O₂ STORAGE FAILURE → EPS-CRYO 1b 9 O₂ (H₂) CRYO PRESS LOW</p> <p>NO → 3 Sensor check • REPRESS PKG vlv - ON (momentarily) then OFF Repress pkg press decr?</p> <p>NO → 4 SURGE TK PRESS SENSOR FAILURE</p> <p>YES → 5 O₂ FLOW ind O₂ flow high?</p> <p>NO → 6 Line obstruction check • SM O₂ SUP vlv - ON • SRG TK O₂ vlv - OFF • DIRECT O₂ vlv - OPEN (CCW) • Incr O₂ flow to 0.95 lb/hr for 45 sec O₂ flow ind remains at 1.0 lb/hr?</p> <p>NO → 8 OBSTRUCTION OF O₂ RESTRICTORS, FILTERS, OR LINE → 7 Reopen O₂ vlv • REPRESS PKG vlv - ON (when surge tk decr to 500 psi) • SRG TK O₂ vlv - ON Warning An obstruction severely limits O₂ supply rate. May essentially limit supply to that available in CM (surge tk plus repress O₂ tk)</p> <p>YES → 9 • SRG TK O₂ vlv - OFF Surge tk press decr?</p> <p>YES → 10 • SRG TK RELF vlv - close (CCW) Surge tk press decr?</p> <p>YES → 11 SURGE TK PLUMBING LEAKING ①</p> <p>NO → 13 SURGE TK RELF VLV LEAKING → 14 • REPRESS PKG vlv - FILL • SRG TK O₂ vlv - ON ②</p> <p>NO → 15 • REPRESS O₂ RELF vlv - close (CCW) Repress O₂ supply press decr?</p> <p>YES → 16 REPRESS O₂ PLUMBING LEAK ③</p> <p>NO → 19 REPRESS O₂ RELF VLV LEAKING → 20 • REPRESS PKG vlv - FILL until REPRESS O₂ press ind reads 800 psi • REPRESS PKG vlv - OFF ④</p> <p>NO → 17 MAIN REG A VLV FAILED OPEN OR RELF VLV LEAKING → 18 • MAIN REG A - close Cab press stops incr?</p> <p>YES → 17</p> <p>NO → 22 • MAIN REG A - OPEN • MAIN REG B - close Cab press stops incr?</p> <p>YES → 23 MAIN REG B VLV FAILED OPEN OR RELF VLV LEAKING ⑤</p> <p>NO → 21 O₂ LEAK BETWEEN MAIN REG AND O₂ FLOW SENSOR</p>	<p>① REPRESS PKG vlv - FILL; repress O₂ supply to perform surge tank function.</p> <p>② Use REPRESS O₂ RELF vlv for surge tank pressure relief.</p> <p>③ If subsequent O₂ mask use is necessary, position REPRESS PKG vlv to FILL. Excessive O₂ consumption results.</p> <p>④ This step may require considerable time.</p> <p>⑤ MSFN can distinguish between these two failures by reporting O₂ system pressure.</p>

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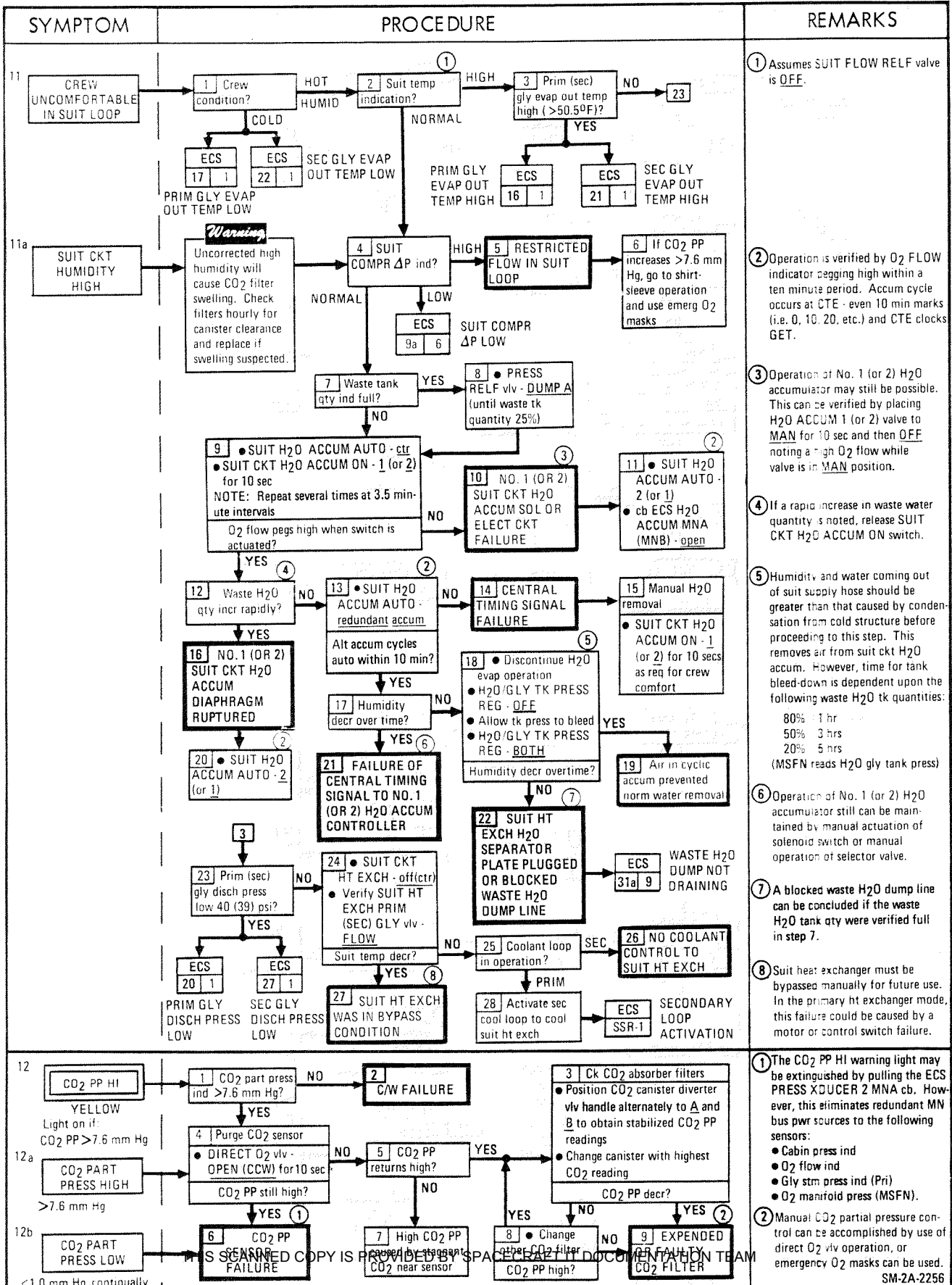
SYMPTOM	PROCEDURE	REMARKS
<p>6 CABIN PRESS LOW OR DECREASING <4.7 psi</p>		<p>① Maintain closed position on leaking valve. Cabin pressure relief valve redundancy lost.</p> <p>② Maintain fully suited mode. Excessive O₂ consumption if cabin pressure is maintained. The suit circuit should be purged to eliminate accumulated H₂ as follows: a. Periodic purge (every 6 hours) DIRECT O₂ vlv - <u>open</u> (fully) for one minute then <u>closed</u>. b. After use of water gun for drinking provided O₂ supply permits DIRECT O₂ vlv - <u>open</u> (fully) for 8 seconds then <u>closed</u>.</p>
<p>7 CREW UNCOMFORTABLE IN CABIN</p> <p>7a CABIN HUMIDITY HIGH</p>		
<p>8 CLINGING SUIT CAB PRESS > 4.2 psi Helmet/gloves doffed</p>		<p>① Valid only for nonreserved hose configuration.</p> <p>② MSFN can verify loss of 100 psi circuit. Open/close REPRESS vlv to maintain ≈ 5 psia cabin press.</p> <p>③ Doff PGA's closed suit operations are lost.</p> <p>④ Metabolic requirement per crewman is approximately 0.1 lb/hr.</p>

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SYMPTOM	PROCEDURE	REMARKS
<p>9 SUIT COMPRESSOR RED Light on if: Compressor ΔP <0.22 psi</p> <p>9a SUIT COMPRESSOR ΔP LOW <0.32 psi</p>		<p>① Subsequent compressor operation verified by monitoring supply hose flow and humidity level.</p> <p>② Unsuiting compressor ΔP of approximately 0.275 psid is normal with SUIT FLOW valve in SUIT FULL FLOW position.</p> <p>③ Pressure rise across suit compressor is 0.36 psi in cabin mode (5.0 psi) and 0.26 psi at emergency suit pressure (3.75 psi). Suit compr ΔP of 0.1 psi will adequately scrub cabin air for unsuited operation.</p> <p>④ Humidity and CO₂ control lost. Inadequate suit ventilation obtained by opening DIRECT O₂ vlv. PGAs will balloon up to 0.32 psi above cabin if in suited mode. Use emergency O₂ masks if in cabin mode since CO₂ indicator inoperative. Some consideration may be given to taping a CO₂ absorber element to the cabin fan inlet.</p> <p>⑤ With this vent open CO₂ PP will remain <7.6 mm Hg for 77 minutes after compressors failed.</p>
<p>10 BALLOONED PGAs</p>		<p>① Slightly ballooned can be verified by the suit-to-cabin ΔP indicator > zero. Cabin to suit ΔP maintained at 2.5 to 3.5 in. H₂O</p> <p>② Recycling valve several times may correct excessive O₂ flow.</p> <p>③ Leaking O₂ demand regulator is still operational and may be used for depressurizing cabin mode.</p> <p>④ H₂O accumulators may be used manually for H₂O removal with excessive O₂ usage.</p>

ECS MALFUNCTION

SM2A-03-BLOCK II-J-(2)
 APOLLO OPERATIONS HANDBOOK



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SYMPTOM	PROCEDURE	REMARKS				
<p>13</p> <p>CO₂ FILTER SEIZURE WITHIN CANISTER</p>	<p>1 EXCESSIVE SWELLING OF CO₂ FILTER</p> <p>2 Single canister operation</p> <ul style="list-style-type: none"> SUIT FLOW RELF - OFF CO₂ cstr divert vlv - both (ctr) Divert flow through sized filter momentarily when replacement of operational filter is required. Use CO₂ PP ind as filter replacement ind 	<p>1 Immediately replace a filter suspected of swelling.</p>				
<p>14</p> <p>GLYCOL TEMP LOW</p> <p>YELLOW</p> <p>Light on if: RAD PRIM OUT TEMP ind $\leq -30^{\circ}\text{F}$</p> <p>14a</p> <p>PRIM ECS RAD OUT TEMP LOW $< -20^{\circ}\text{F}$</p>	<p>1 Rad prim out temp ind $< -30^{\circ}\text{F}$?</p> <p>2 C/W FAILURE</p> <p>3 RAD PRIM HTR - redundant htr</p> <p>4 RAD PRIM HTR - off (ctr)</p> <p>5 Gly evap operation</p> <p>6 Determine deadhead discharge pressure</p> <p>7 PRIM HTR CIRCUIT FAILURE</p> <p>8 Ck for frozen rad</p> <p>9 RAD MAN SEL - RAD 2</p> <p>10 PRIM RAD OUT TEMP SENSOR FAILURE</p> <p>11 RAD 1 PANEL STAGNATED</p> <p>12 RAD 2 PANEL STAGNATED</p> <p>13 RAD PRIM HTR - 1</p> <p>14 Thaw stagnated panel</p> <p>15 Verify thawing by repeating step 8 at approx 20 min intervals.</p> <p>16 Resume normal rad operation</p> <p>17 PRIM GLY EVAP OUT TEMP HIGH</p> <p>18 PRIM GLY EVAP OUT TEMP LOW</p>	<p>1 Because of thermal constraints involved there would be time to verify ECS rad out temp with MSFN as rad temp was dropping.</p> <p>2 Htr operation can be confirmed during sw operation by Δ current (15 amps for full htr vs 7½ amps for single element).</p> <p>3 Heater is shut off to avoid possibility of boiling glycol in lines with low flow rates.</p> <p>4 MSFN can aid in determining gly evap operation by comparing gly evap temp in and temp out.</p> <p>5 Prim gly flow rate from MSFN can aid in determining frozen/stagnated panel.</p> <p>If GLY DISCH PRIM PRESS is < 40 psi, go to:</p> <table border="1"> <tr> <td>ECS</td> <td>GLY DISCH PRESS LOW</td> </tr> <tr> <td>20</td> <td>1</td> </tr> </table> <p>6 Use norm prim rad in temp and absence of H₂O boiling to estimate prim rad out temp.</p> <p>7 Panel 1 between +Y and +Z, Panel 2 between -Y and -Z.</p> <p>8 Rad flow blockage cannot be distinguished from stagnated panel. Reduce elec loads for single panel operation.</p>	ECS	GLY DISCH PRESS LOW	20	1
ECS	GLY DISCH PRESS LOW					
20	1					
<p>15</p> <p>PRIM ECS RAD OUT TEMP HIGH</p> <p>$> 65^{\circ}\text{F}$</p> <p>($> 80^{\circ}\text{F}$ for lunar orbit)</p>	<p>1 Gly disch prim press < 40 psi</p> <p>2 Gly evap prim stm press ind</p> <p>3 RAD PRIM HTR - off (ctr)</p> <p>4 PRIM 1 HTR FAILED ON</p> <p>5 Gly evap prim out temp $> 50.5^{\circ}\text{F}$?</p> <p>6 Check redundant flow cont</p> <p>7 RAD PRIM HTR - 2</p> <p>8 PRIM RAD OUT TEMP INST FAILURE</p> <p>9 FLOW PROPORTIONING CONT OR ISOLATION VLV FAILURE</p> <p>10 RAD FLOW CONT PWR - PWR</p> <p>11 POWER TO NO. 1 FLOW CONT AND RAD ISOLATION VALVES FAILED</p> <p>12 Determine deadhead discharge press</p> <p>13 RAD PRIM HTR - 1</p> <p>14 GLYCOL TEMP LOW</p>	<p>1 Primary radiator outlet temperature $> 65^{\circ}\text{F}$ not abnormal when associated with high electrical loads (> 2000 watts).</p> <p>2 PRIM GLY EVAP STM PRESS readings of 0.09 and 0.14 psi correspond to PRIM GLY EVAP OUT TEMP readings of 38°F and 43°F, respectively.</p> <p>3 Heater operation may be confirmed during switching operation by Δ current (15 amps for full heater vs 7½ amps for single element).</p> <p>4 Primary radiator inlet temperature and absence of water boiling can be used to estimate primary radiator outlet temperature.</p> <p>5 Flow proportioning valve not available in system No. 1 due to power loss, nor in system No. 2 due to inoperative rad isolation valves. Check cb RAD CONTR ACT.</p>				

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SYMPTOM	PROCEDURE	REMARKS
<p>16 PRIM GLY EVAP OUT TEMP HIGH >50.5°F</p>	<p>1 <i>Caution</i> If gly evap out temp reaches 60°F, activate sec gly evap with radiator bypassed.</p> <p>ECS SSR-1 SECONDARY LOOP ACTIVATION</p> <p>4 GLY EVAP TEMP INST FAILURE</p> <p>1 Rad prim out temp > 48°F</p> <p>NO → 2 GLY EVAP IN TEMP - MAN GLY EVAP IN TEMP vlv - MIN CCW Gly evap temp out decr?</p> <p>YES → 2 Perform J52/J53 connector change GLY EVAP IN TEMP - AUTO Evap out temp goes high again?</p> <p>NO → 7 J52 SENSOR FAILED</p> <p>YES → 8 Mixing vlv manual control Control GLY EVAP IN TEMP vlv manually to maintain evap out temp between 40-55°F</p> <p>3 GLY EVAP TEMP OUT INST FAILURE</p> <p>5 Gly evap stm press? < 0.09 psi → 4 > 0.14 psi → 9 GLY EVAP STM PRESS AUTO - MAN GLY EVAP STM INCR - DECR Stm press decr?</p> <p>NO → 11 SEC COOL PUMP - ACT SEC COOL EVAP - EVAP Sec gly evap stm press decr?</p> <p>YES → 12 PRIM STM PRESS VLV FAILED CLOSED ECS SSR-1 SECONDARY LOOP ACTIVATION</p> <p>NO → 13 FROZEN STM DUCT ECS SSR-2 FROZEN STM DUCT</p> <p>YES → 14 Perform J52/J53 connector change Evap temp out decr?</p> <p>NO → 14 Perform J52/J53 connector change Evap temp out decr?</p> <p>YES → 15 J52 SENSOR FAILED</p> <p>NO → 16 GLY EVAP STM PRESS AUTO - MAN GLY EVAP STM INCR - INCR (for 58 sec) Wait 20 min for evap to thaw GLY EVAP STM PRESS AUTO - AUTO Stm press > 0.09 psi for > 1 min?</p> <p>NO → 17 Reservice evap GLY EVAP STM PRESS AUTO - MAN GLY EVAP STM INCR - INCR (for 58 sec) Wait 15 min for evap to thaw GLY EVAP H₂O FLOW - ON (for 3 min) Stm press > 0.09 psi?</p> <p>NO → 18 GLY EVAP TEMP CONTROLLER FAILURE → 19 Man evap cont Cont evap stm press manually (not < 0.12 psi) to maintain gly evap out temp between 45 & 55°F</p> <p>YES → 20 GLY EVAP STM PRESS AUTO - AUTO Evap dries out again?</p> <p>NO → 21 TEMPORARY MIS-SEATING OF STM PRESS VLV OR TEMPORARY EVAP H₂O CONTROL PROBLEM</p> <p>YES → 24 GLY EVAP STM PRESS AUTO - MAN GLY EVAP STM INCR - INCR (for 58 sec) Perform J52/J53 connector change Wait 15 min for evap to thaw GLY EVAP H₂O FLOW - ON (for 3 min) GLY EVAP STM PRESS AUTO - AUTO Evap dries out again?</p> <p>NO → 27 J52 SENSOR FAILED</p> <p>YES → 26 TEMPORARY EVAP H₂O CONTROL PROBLEM DUE TO LOW CYCLIC LOADS OR H₂O FEED CAPABILITY LOST</p> <p>NO → 28 Continue servicing evap or activate sec loop with radiators bypassed per SSR-1, if PRIM GLY EVAP OUT TEMP > 60°F.</p> <p>22 EVAP WAS FROZEN NOTE: If problem recurs, change J52 with J53 and repeat step 16.</p> <p>23 PRIM EVAP H₂O CONT VLV FAILED CLOSED</p> <p>25 Activate sec loop with rad bypassed (per SSR-1) if prim rad out temp > 48°F</p>	<p>1 After the prim gly evap temp returns to normal, deactivate the secondary evaporator and continue trouble shooting.</p> <p>2 Procedure for changing J52 and J53 connectors</p> <ul style="list-style-type: none"> • GLY EVAP H₂O FLOW - off (center) • GLY EVAP STM PRESS AUTO - MAN • GLY EVAP IN TEMP - MAN • Change J52 and J53 • GLY EVAP H₂O FLOW - AUTO • GLY EVAP STM PRESS AUTO - AUTO • GLY EVAP IN TEMP - AUTO <p>3 Thaw times are based on a 50°F rad out. Shorter thaw times by 33% if rad out temp ≥ 60°F.</p> <p>4 Primary evaporator lost</p>
<p>16a PRIM STEAM PRESS LOW < 0.09 psi</p>	<p>16 GLY EVAP STM PRESS AUTO - MAN GLY EVAP STM INCR - INCR (for 58 sec) Wait 20 min for evap to thaw GLY EVAP STM PRESS AUTO - AUTO Stm press > 0.09 psi for > 1 min?</p> <p>NO → 17 Reservice evap GLY EVAP STM PRESS AUTO - MAN GLY EVAP STM INCR - INCR (for 58 sec) Wait 15 min for evap to thaw GLY EVAP H₂O FLOW - ON (for 3 min) Stm press > 0.09 psi?</p> <p>NO → 23 PRIM EVAP H₂O CONT VLV FAILED CLOSED</p> <p>YES → 25 Activate sec loop with rad bypassed (per SSR-1) if prim rad out temp > 48°F</p>	<p>4 Primary evaporator lost</p>

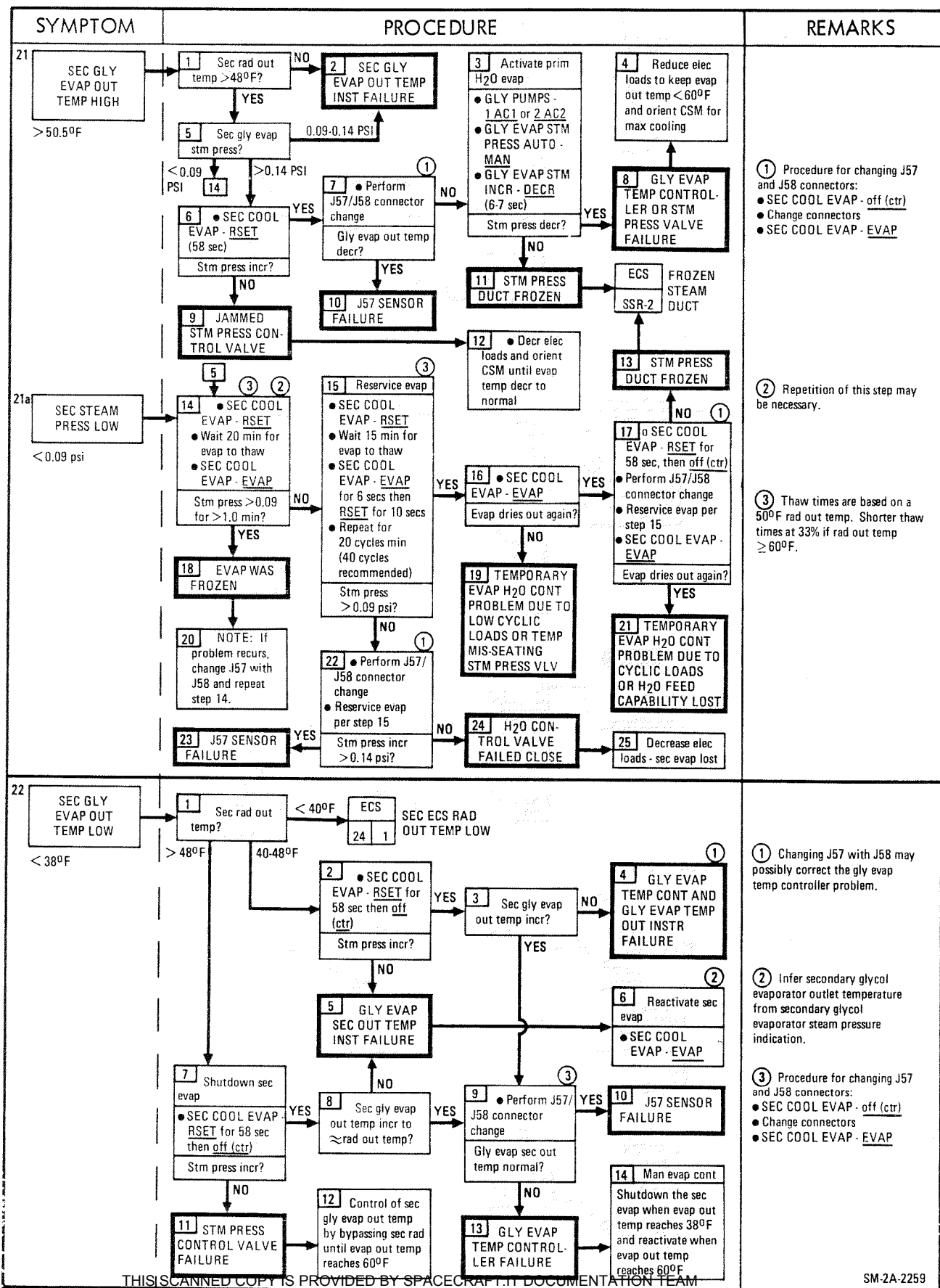
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SYMPTOM	PROCEDURE	REMARKS
<p>17 PRIM GLY EVAP OUT TEMP LOW <small>< 38°F</small></p>		<p>① An estimate of gly evap out temp can be made from steam press conversion and/or suit temp-5°F (unsuited); -10°F (suited).</p> <p>② Procedure for connector change</p> <ul style="list-style-type: none"> • GLY EVAP H₂O FLOW - off (center) • GLY EVAP STM PRESS AUTO - MAN • GLY EVAP IN TEMP - MAN • Change J52 with J53 • GLY EVAP H₂O FLOW - AUTO • GLY EVAP STM PRESS AUTO - AUTO • GLY EVAP IN TEMP - AUTO <p>③ Changing J52 and J53 may possibly correct the glycol evap control problem.</p>
<p>18 PRIM GLY ACCUM QTY HIGH <small>> 65%</small></p> <p>18a PRIM GLY DISCH PRESS HIGH <small>> 56 psi or > accum qty +40</small></p>		<p>① PRIM ACCUM QTY ind > 65% may result in accum bellows sticking. If sticking occurs, cycle ECS prim glycol pumps.</p> <p>② With GLY PUMPS - OFF, PRIM GLY DISCH PRESS should be 1/4 accum quantity.</p> <p>③ Localized boiling could have been caused by a reduction in glycol flow due to failed radiator isolation valve or a frozen radiator, or due to incorrect positioning of: GLY RSVR vlv (3) PRIM GLY TO RAD vlv SUIT HT EXCH PRIM GLY vlv. Radiator restrictions can be determined by 4 to 6 psi drop in PRIM GLY DISCH PRESS when the radiators are bypassed.</p>

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SYMPTOM	PROCEDURE	REMARKS
<p>19 PRIM GLY ACCUM QTY LOW OR DECREASING < 30%</p>	<pre> graph TD S19[19 PRIM GLY ACCUM QTY LOW OR DECREASING < 30%] --> B1((1)) B1 --> P1[1 • RAD PRIM HTR - off (ctr) • GLY PUMPS - OFF (momentarily)] P1 --> Q1{Gly disch press compatible with accum qty ind?} Q1 -- YES --> B5((5)) Q1 -- NO --> B4((4)) B5 --> Q2{Accum qty ind = 0?} Q2 -- YES --> B6[6 PRIM ACCUM BELLOWS STICKING] Q2 -- NO --> B7[7 Isolate all components • PRIM GLY TO RAD BYPASS (pull) NOTE: Bypass operation >15 minutes can lead to rad freezing. • SUIT HT EXCH PRIM GLY - BYPASS (CW) • PRIM GLY ACCUM vlv - close (CW) Accum qty decr stops?] B7 --> B8[8 UNISOLATABLE LEAK IN GLYCOL CIRCUIT] B8 --> P9[9 • GLY PUMPS - OFF] P9 --> S12[12 GLY reservoir as accum • RAD PRIM HTR - 1 • PRIM ACCUM FILL vlv - ON • PRIM GLY TO RAD - NORM • PRIM GLY ACCUM vlv - close (CW)] B7 --> B10[10 Check accum • PRIM GLY ACCUM vlv - open (CCW) Accum qty decr?] B10 -- YES --> B11[11 PRIM GLY ACCUM LEAKING] B10 -- NO --> B13[13 Rad leak check • PRIM ACCUM FILL vlv - ON qty = 30% then OFF • PRIM GLY TO RAD - NORM Accum qty decr?] B13 -- YES --> B14[14 Manually select rad 1 • RAD FLOW CONT PWR - MAIN SEL • RAD MAN SEL - RAD 1 After 17 sec, accum prim qty decr?] B13 -- NO --> B16[16 GLY LEAK IN SUIT HT EXCH] B16 --> B20[20 Activate sec cool loop for suit ht exch with rad bypassed] B14 --> B17[17 Select rad 2 • ECS RAD MAN SEL - RAD 2 Accum prim qty decr?] B14 -- NO --> B15[15 RAD PANEL 2 LEAKING] B17 -- YES --> B21[21 GLY LEAK IN LINE COMMON TO BOTH RAD PANELS] B17 -- NO --> B18[18 RAD PANEL 1 LEAKING] B15 --> B19[19 • RAD PRIM HTR - 1] B18 --> B19 B19 --> S12 B19 --> S1[1] B19 --> S2[2] B19 --> S3[3] B19 --> S4[4] B19 --> S5[5] B19 --> S6[6] B19 --> S7[7] B19 --> S8[8] B19 --> S9[9] B19 --> S10[10] B19 --> S11[11] B19 --> S12[12] B19 --> S13[13] B19 --> S14[14] B19 --> S15[15] B19 --> S16[16] B19 --> S17[17] B19 --> S18[18] B19 --> S19[19] B19 --> S20[20] B19 --> S21[21] B19 --> S22[22] B19 --> S23[23] B19 --> S24[24] B19 --> S25[25] B19 --> S26[26] B19 --> S27[27] B19 --> S28[28] B19 --> S29[29] B19 --> S30[30] B19 --> S31[31] B19 --> S32[32] B19 --> S33[33] B19 --> S34[34] B19 --> S35[35] B19 --> S36[36] B19 --> S37[37] B19 --> S38[38] B19 --> S39[39] B19 --> S40[40] B19 --> S41[41] B19 --> S42[42] B19 --> S43[43] B19 --> S44[44] B19 --> S45[45] B19 --> S46[46] B19 --> S47[47] B19 --> S48[48] B19 --> S49[49] B19 --> S50[50] B19 --> S51[51] B19 --> S52[52] B19 --> S53[53] B19 --> S54[54] B19 --> S55[55] B19 --> S56[56] B19 --> S57[57] B19 --> S58[58] B19 --> S59[59] B19 --> S60[60] B19 --> S61[61] B19 --> S62[62] B19 --> S63[63] B19 --> S64[64] B19 --> S65[65] B19 --> S66[66] B19 --> S67[67] B19 --> S68[68] B19 --> S69[69] B19 --> S70[70] B19 --> S71[71] B19 --> S72[72] B19 --> S73[73] B19 --> S74[74] B19 --> S75[75] B19 --> S76[76] B19 --> S77[77] B19 --> S78[78] B19 --> S79[79] B19 --> S80[80] B19 --> S81[81] B19 --> S82[82] B19 --> S83[83] B19 --> S84[84] B19 --> S85[85] B19 --> S86[86] B19 --> S87[87] B19 --> S88[88] B19 --> S89[89] B19 --> S90[90] B19 --> S91[91] B19 --> S92[92] B19 --> S93[93] B19 --> S94[94] B19 --> S95[95] B19 --> S96[96] B19 --> S97[97] B19 --> S98[98] B19 --> S99[99] B19 --> S100[100] </pre>	<p>1 Normal range is 30-65% Sensor powered by cb ECS PRESS XDUCER 1 MDC-5. If the glycol leak is slow (~5%/hr) the leak source may be more rapidly detected by momentarily placing the gly accum vlv off after each component is isolated.</p> <p>2 With pump off, glycol disch press should equal 1/4 accumulator quantity.</p> <p>3 Use gly disch press when pump off (momentarily) to estimate accum qty ind. With GLY PUMPS - OFF accumulator quantity should be 4 times pump disch press.</p> <p>4 Cycling the primary ECS glycol pump may free a sticking accumulator bellows.</p> <p>5 Radiator isolation valves take 17 sec to position.</p> <p>6 Half of radiator heat rejection capability lost.</p> <p>7 The secondary radiator will freeze unless secondary coolant loop activated.</p> <p>8 Use primary coolant loop in evaporative mode when required for G&N operation. Constraints are operator h2O consumption.</p>
<p>20 PRIM GLY DISCH PRESS LOW < 40 psi or < accum qty + 32 psi</p>	<pre> graph TD S20[20 PRIM GLY DISCH PRESS LOW < 40 psi or < accum qty + 32 psi] --> B1[1 Accum prim qty < 30%?] B1 -- NO --> P2[2 • RAD PRIM HTR - off (ctr) • ECS GLY PUMPS - OFF (momentarily)] B1 -- YES --> S19[19 1] P2 --> Q1{Gly disch press compatible for indicated gly accum qty?} Q1 -- YES --> B6[6 Check for cavitated pump • PRIM GLY ACCUM vlv - close (CW) • PRIM ACCUM FILL vlv - ON Gly disch press > 50 psig?] Q1 -- NO --> B3[3 Verify sensor • ECS GLY PUMPS - OFF • PRIM GLY ACCUM vlv - close (CW) • PRIM ACCUM FILL vlv - ON Gly disch press 18-22 psi?] B3 --> B4[4 GLY DISCH PRESS SENSOR FAILURE] B4 --> B3 B3 --> B5[5 ACCUM PRIM QTY IND FAILURE] B5 --> B6 B6 --> B10[10 • PRIM GLY ACCUM vlv - open (CCW) until gly disch press reads 50 psig • PRIM ACCUM FILL vlv - OFF] B6 --> B11[11 RAD PRIM HTR - orig config] B6 --> B9[9 GLY PUMP DEGRADED OR FAILED] B9 --> B12[12 • Switch to redundant pump • PRIM ACCUM FILL vlv - OFF • PRIM GLY ACCUM vlv - open (CCW)] B10 --> B11 B11 --> B12 B12 --> B12 B12 --> S1[1] B12 --> S2[2] B12 --> S3[3] B12 --> S4[4] B12 --> S5[5] B12 --> S6[6] B12 --> S7[7] B12 --> S8[8] B12 --> S9[9] B12 --> S10[10] B12 --> S11[11] B12 --> S12[12] B12 --> S13[13] B12 --> S14[14] B12 --> S15[15] B12 --> S16[16] B12 --> S17[17] B12 --> S18[18] B12 --> S19[19] B12 --> S20[20] B12 --> S21[21] B12 --> S22[22] B12 --> S23[23] B12 --> S24[24] B12 --> S25[25] B12 --> S26[26] B12 --> S27[27] B12 --> S28[28] B12 --> S29[29] B12 --> S30[30] B12 --> S31[31] B12 --> S32[32] B12 --> S33[33] B12 --> S34[34] B12 --> S35[35] B12 --> S36[36] B12 --> S37[37] B12 --> S38[38] B12 --> S39[39] B12 --> S40[40] B12 --> S41[41] B12 --> S42[42] B12 --> S43[43] B12 --> S44[44] B12 --> S45[45] B12 --> S46[46] B12 --> S47[47] B12 --> S48[48] B12 --> S49[49] B12 --> S50[50] B12 --> S51[51] B12 --> S52[52] B12 --> S53[53] B12 --> S54[54] B12 --> S55[55] B12 --> S56[56] B12 --> S57[57] B12 --> S58[58] B12 --> S59[59] B12 --> S60[60] B12 --> S61[61] B12 --> S62[62] B12 --> S63[63] B12 --> S64[64] B12 --> S65[65] B12 --> S66[66] B12 --> S67[67] B12 --> S68[68] B12 --> S69[69] B12 --> S70[70] B12 --> S71[71] B12 --> S72[72] B12 --> S73[73] B12 --> S74[74] B12 --> S75[75] B12 --> S76[76] B12 --> S77[77] B12 --> S78[78] B12 --> S79[79] B12 --> S80[80] B12 --> S81[81] B12 --> S82[82] B12 --> S83[83] B12 --> S84[84] B12 --> S85[85] B12 --> S86[86] B12 --> S87[87] B12 --> S88[88] B12 --> S89[89] B12 --> S90[90] B12 --> S91[91] B12 --> S92[92] B12 --> S93[93] B12 --> S94[94] B12 --> S95[95] B12 --> S96[96] B12 --> S97[97] B12 --> S98[98] B12 --> S99[99] B12 --> S100[100] </pre>	<p>1 With radiators by-passed, pump disch press is nominally 2 psi lower than with radiators operating.</p> <p>2 With GLY PUMPS - OFF, glycol discharge press should equal 1/4 accumulator quantity indication.</p> <p>3 Degraded glycol pump may be verified by checking GLY PRIM COLDPLATE flow rate with MSFN.</p>

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<p>23 SEC ECS RAD OUT TEMP HIGH</p> <p>> 70°F (except for Lunar Orbit)</p>		<p>① Heater operation can be confirmed by ammeter change during switching operation. Δ current will be: 30 amp - both operating 15 amp - one operating</p>
<p>24 SEC ECS RAD OUT TEMP LOW</p> <p>< 38°F</p>		<p>① Assumes secondary loop is in operation. Sensor is powered by cb ECS RAD CONT/HTRS MNA (MDC-5).</p> <p>② Heater operation can be confirmed by ammeter change during switching operation. Δ current will be: 30 amp - both operating 15 amp - one operating</p> <p>③ Use SEC GLY EVAP OUT TEMP indicator with ECS RAD SEC IN TEMP indicator to estimate secondary radiator outlet temperature.</p>
<p>25 SEC GLY ACCUM QTY HIGH</p> <p>> 55%</p>		<p>① Normal range 30-55%.</p> <p>② With glycol pump off, glycol discharge press should equal 1/4 accumulator quantity.</p>
<p>26 SEC GLY ACCUM QTY DECREASING</p>		<p>① This symptom is also valid when secondary glycol loop is not in operation. Accum qty and disch press sensors powered by cb SEC COOL XDUCER (MDC-5). Normal range is 30-55%.</p> <p>② With pump off, glycol discharge pressure should equal 1/4 gly accum quantity.</p> <p>③ Humidity control and suit loop cooling not available from secondary loop when suit ht exch is bypassed. A glycol leak will exist whenever the secondary suit ht exch is used and could result in glycol contamination in the suit loop.</p> <p>④ If leak is determined, temporary deactivation of pump may conserve glycol for future use. Radiator heater to be OFF when pump is OFF.</p>

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SYMPTOM	PROCEDURE	REMARKS
<p>27</p> <p>SEC GLY DISCH PRESS LOW</p> <p>< 39 psi or $\frac{\text{accum qty}}{4} + 31$</p>	<p>1 Verify sensor</p> <ul style="list-style-type: none"> SEC COOL PUMP - off (ctrl momentarily) <p>Gly disch sec press compatible with indicated gly accum qty?</p> <p>2 Sec accum qty (<30%)?</p> <p>3 SEC COOL PUMP - redundant bus</p> <p>Gly disch sec press incr?</p> <p>4 DEGRADED SEC COOL LOOP PUMP</p> <p>5 GLY DISCH SEC PRESS INST OR ACCUM SEC QTY INST FAILURE</p> <p>6 REDUCED PUMP OUTPUT DUE TO ELEC PROBLEM</p> <p>7 RAD SEC HTR - OFF (if gly pump $\Delta P < 20$)</p> <ul style="list-style-type: none"> Reduce elec loads <p>26 1</p> <p>SEC GLY ACCUM QTY DECREASING</p> <p>EPS-PD 1d 40</p> <p>AC BUS 1 (2) VOLTAGE LOW</p>	<p>1 Disch press and accum qty sensor powered by cb ECS SEC COOL XDCERS (2) (MDC-5).</p> <p>2 With glycol pump off, glycol discharge pressure should equal 1/4 accumulator quantity.</p>
<p>28</p> <p>H₂O DUMPING OVERBOARD</p>	<p>1 Pot or waste tk qty decr?</p> <p>2 Bypass H₂ separator</p> <ul style="list-style-type: none"> Disconnect QDs in following order: <ul style="list-style-type: none"> Red QD from H₂O IN Yellow QD from Urine/H₂O Sys Interconnect Green QD from H₂O OUT Reconnect QDs in following order: <ul style="list-style-type: none"> Red QD to H₂O OUT Yellow QD to original connection Green QD to H₂O IN <p>Dump stops?</p> <p>3 PRESS RELF sel - OFF</p> <p>Dump stops?</p> <p>4 PRESS RELF SEL FAILED IN OFF POS OR RUPTURE OF POT OR WASTE H₂O TK BLADDER</p> <p>5 LEAK IN H₂ SEPARATOR</p> <p>6 PRESS RELF SET FAILED IN RELF POS</p>	<p>1 Ice particles visible through windows with no manual dump scheduled. MSFN can also verify by H₂O dump nozzle temp.</p> <p>2 Yellow QD disconnected to gain access to QD at H₂O OUT connector.</p> <p>3 Dump flow will taper off rather than stop suddenly if leaking separator is bypassed. If dumping does not stop, reconnect QDs to original connections.</p>
<p>28a</p> <p>POTABLE H₂O QUANTITY DECREASING RAPIDLY</p>	<p>7 H₂O QTY IND sw - WASTE</p> <p>Waste H₂O qty $\leq 10\%$?</p> <p>8 WASTE TK IN vlv - CLOSE</p> <p>H₂O QTY IND sw - POT</p> <p>Decr stops?</p> <p>9 POT TK IN vlv - CLOSE</p> <p>Decr stops?</p> <p>10 LEAK IN POT H₂O SYS OR SENSOR FAILURE</p> <p>11 WASTE TK IN VLV FAILURE</p> <p>12 LINE LEAK BETWEEN POT TK IN VLV AND WASTE TK IN VLV</p> <p>13 PRESS RELF sel - OFF</p> <p>H₂O QTY IND sw - POT</p> <p>Decr stops?</p> <p>14 WASTE TK IN vlv - CLOSE</p> <p>Decr stops?</p> <p>15 PRESS RELF VLV FAILED OPEN</p> <p>16 LINE LEAK IN WASTE H₂O SYS</p>	<p>4 Incoming fuel cell water will still pass through this leak.</p> <p>5 This failure is not serious and will result in approximately equal quantities being maintained in potable and waste water tanks.</p> <p>6 Prim & sec evap unusable. Water evaporators can be used by periodically opening the waste tank inlet valve for approximately 2-3 minutes until the evaporator wicks are saturated. Water line leakage will occur during these periods.</p>
<p>28b</p> <p>WASTE H₂O QUANTITY DECREASING RAPIDLY</p>	<p>17 PRESS RELF sel - OFF</p> <p>Decr stops?</p> <p>18 LINE LEAKAGE IN WASTE H₂O SYS OR SENSOR FAILED</p> <p>19 PRESS RELF sel - 2</p>	<p>7 Monitor cabin humidity. Check for water in CM.</p>
<p>29</p> <p>FOOD PREP WATER TEMP LOW</p>	<p>1 POT H₂O HTR - redundant bus</p> <p>Water temp incr?</p> <p>2 CIRCUIT FAILURE FROM MN BUS A OR B</p> <p>3 POT H₂O HTR FAILED OR DEGRADED</p>	

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5M2A-1663J

ECS MALFUNCTION

APOLLO OPERATIONS HANDBOOK

SYMPTOM	PROCEDURE	REMARKS
<p>30 ENTRAPPED GAS IN POTABLE H₂O</p>		<p>① System is usable. Quantity gaging capability is compromised.</p> <p>② If suited, purge suit periodically.</p>
<p>31 URINE OVERBOARD DUMP NOT DRAINING</p> <p>31a WASTE H₂O OVERBOARD DUMP NOT DRAINING</p>		<p>① Allow 2 hrs for heater operation. Orient CSM for maximum external heat on dump nozzle (-Y-Z) in attempt to clear probable ice block.</p> <p>② Spare UTS receiver assy stowed in R-11.</p> <p>③ Water tanks H₂ and O₂ bleed capability lost unless waste H₂O dump line interconnected.</p> <p>④ Auxiliary dump capability through side hatch is also available.</p> <p>⑤ Battery vent capability lost unless urine dump line interconnected</p>
<p>32 INADEQUATE VENTILATION AFTER LANDING</p>		<p>① Postlanding vent switch must be cycled to OFF and back to HIGH (LOW) anytime CM attitude exceeds 60° to reset attitude control relay.</p> <p>② Ventilation available only by opening either hatch.</p>
<p>33 WATER INFLOW AFTER LANDING</p>		

SM-2A-2258

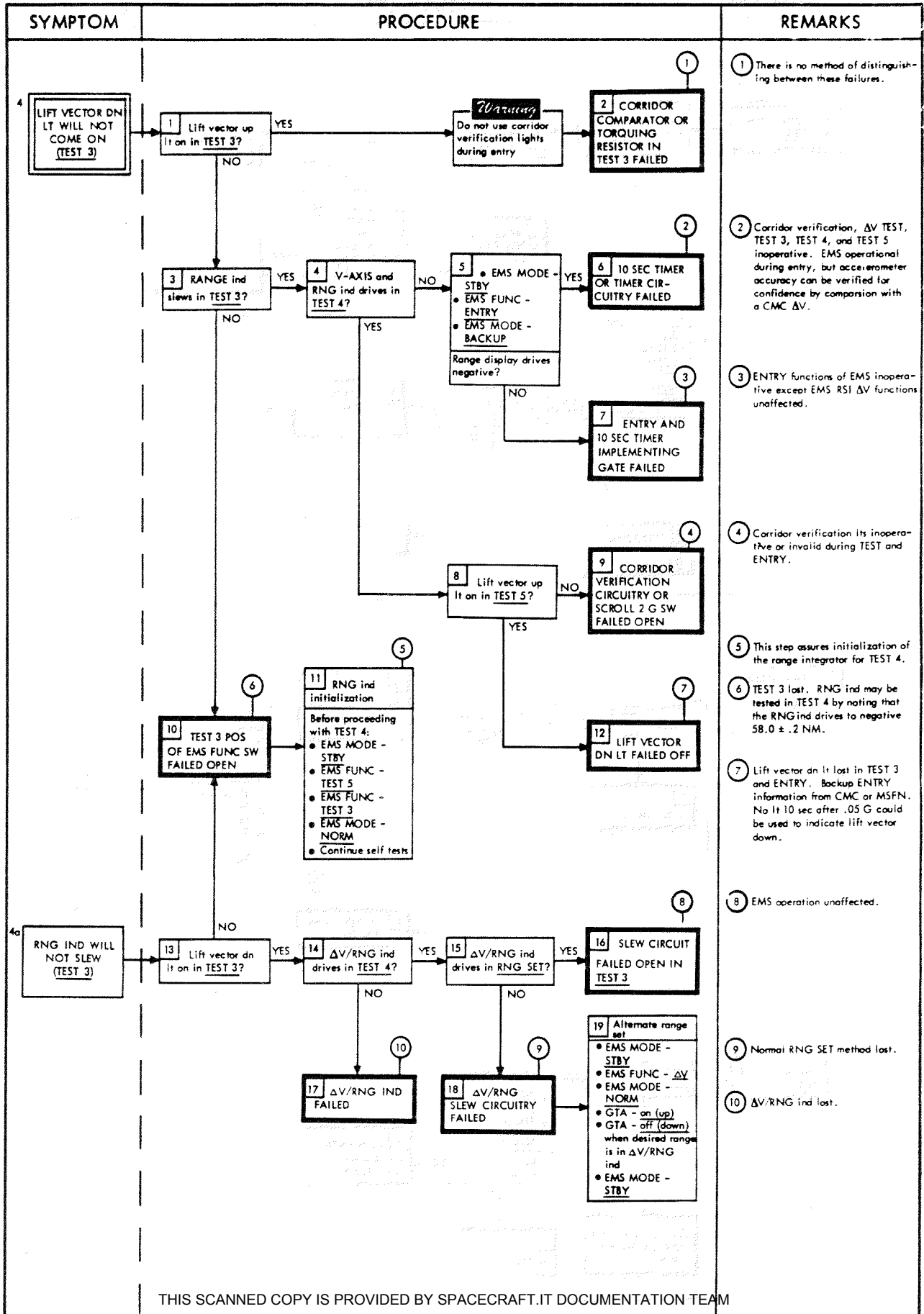
SM2A-03-BLOCK II-J-(2)
 APOLLO OPERATIONS HANDBOOK

SPECIAL SUB ROUTINES	PROCEDURE	REMARKS
<p>SSR-1</p> <p>SECONDARY LOOP ACTIVATION</p>		<p>① If one panel of the primary radiator is lost, the secondary radiator should be used, otherwise the secondary radiator will be lost due to freezing.</p> <p>② Operation of both coolant loops simultaneously may result in low rad out temp. To preclude rad freezing, terminate evap operation if possible.</p> <p>③ G&N, DSE, and Signal Conditions are not calculated on secondary loop. Usage limits for this equipment are as follows:</p> <p><u>G&N</u> 17% duty cycle with max on time of 1 hr 55 min.</p> <p><u>DSE</u> 66% duty cycle with max on time of 2 hrs.</p>
<p>SSR-2</p> <p>FROZEN STEAM DUCT</p>		<p>① Primary glycol evaporator temperature inlet can be approximated by secondary radiator inlet temperature.</p>

APOLLO OPERATIONS HANDBOOK

SYMPTOM	PROCEDURE	REMARKS
<p>1 <div style="border: 1px solid black; padding: 2px; display: inline-block;">.05G LT ON (TEST 1)</div></p>	<pre> graph TD S1[1 .05G LT ON TEST 1] --> Q1{1 Lift vector up It - on in TEST 3?} Q1 -- NO --> B1[6 TORQUING RESISTOR IN TEST 1 FAILED] Q1 -- YES --> Q2{2 Displays out of tolerance in TEST 4 and ΔV TEST?} Q2 -- NO --> B2[5 ACCEL LOW RANGE OUTPUT FAILED] Q2 -- YES --> Q3{3 Null bias check failed?} Q3 -- YES --> B3[4 EMS ACCELEROMETER FAILED] Q3 -- NO --> Q4{6 Compare EMS during CMC ΔV EMS agrees?} Q4 -- YES --> B3 Q4 -- NO --> B4[7 TORQUE PWR SUPPLY FAILED] Q1 --> Q5{8 EMS MODE - STBY EMS FUNC - ENTRY EMS MODE - NORM .05 G It on?} Q5 -- NO --> B1 Q5 -- YES --> Q6{9 RNG display drives in ENTRY?} Q6 -- NO --> B5[13 .05 G LT FAILED ON] Q6 -- YES --> B6[10 THRESHOLD COMPARATOR FAILED] B6 --> B7[11 EMS MODE - BACKUP at .05 G indication from MSFN or G&N] </pre>	<p>1 The EMS MODE sw assumed to be in STBY for at least 5 sec before self-test started.</p> <p>2 EMS lost except EMS RSI.</p> <p>3 All self test capability lost. For entry, G-Drive, and corridor verification will be erroneous. ΔV/RNG Ind, V AXIS and EMS RSI unaffected.</p> <p>4 AUTO position functions of EMS MODE sw lost for entry only.</p> <p>5 Corridor verification inoperative with EMS MODE sw - <u>BACKUP</u>.</p> <p>6 EMS FUNC - TEST 1 lost only.</p> <p>7 Loss of threshold cue only (.05 G It). RNG Ind operation is indication of .05 G.</p>
<p>2 <div style="border: 1px solid black; padding: 2px; display: inline-block;">G/V SCROLL ASSY DOES NOT SLEW (TEST 1)</div></p>	<pre> graph TD S2[2 G/V SCROLL ASSY DOES NOT SLEW TEST 1] --> Q1{1 RNG display drives in TEST 3?} Q1 -- NO --> B1[5 SLEW SW FAILED] Q1 -- YES --> Q2{2 V AXIS drives normally in TEST 4?} Q2 -- NO --> B2[6 V-AXIS DRIVE FAILED] Q2 -- YES --> B3[3 TEST 1 POS OF EMS FUNC SW FAILED OPEN] B3 --> B4[4 Slew scroll for TEST 4] </pre> <p style="font-size: small;">Alternate method: • EMS MODE - STBY • EMS FUNC - TEST 5 • Slew scroll to start of test pattern • EMS FUNC - TEST 1 • EMS MODE - NORM • Resume EMS self test</p>	<p>1 EMS FUNC - TEST 1 capability lost only.</p> <p>2 RNG SET capability lost. SCS ΔV possible only if ΔV display is driven positive by placing the GTA sw - on (up), then - off (down) at the desired value. G&N or ΔV maneuver with the SPS THRUST - DIR ON can be monitored by the change in the ΔV display (down to -9999 fps). Vo can be set by using EMS FUNC - TEST 4 (repeatedly if necessary), stopping the V drive at the desired value by EMS FUNC - TEST 5. No backup capability available.</p> <p>3 EMS lost for ENTRY except threshold, corridor, and EMS RSI. ΔV functions unaffected.</p>
<p>3 <div style="border: 1px solid black; padding: 2px; display: inline-block;">.05 G LT OUT (TEST 2)</div></p>	<pre> graph TD S3[3 .05 G LT OUT TEST 2] --> Q1{1 .05 G It on in other test positions?} Q1 -- NO --> B1[2 EMS MODE - STBY EMS FUNC - ENTRY EMS MODE - BACKUP Range display drives? YES] B1 -- YES --> B2[5 .05 G LT FAILED] Q1 -- YES --> B3[4 TEST 2 POS OF FUNC SW FAILED OPEN] B1 -- NO --> B4[3 MAN ENTRY IMPLEMENTING GATE FAILED] </pre>	<p>1 ENTRY functions of EMS inoperative except EMS RSI. ΔV functions unaffected.</p> <p>2 EMS FUNC - TEST 2 inoperative.</p> <p>3 EMS operation unaffected. RNG ind operation is indication of .05 G.</p>

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SYMPTOM	PROCEDURE	REMARKS
<p>5 V-AXIS ONLY OR MULTIPLE DISPLAYS ABNORMAL (TEST 4)</p>	<pre> graph TD S5[V-AXIS ONLY OR MULTIPLE DISPLAYS ABNORMAL (TEST 4)] --> Q1[V-AXIS fails to drive?] Q1 -- NO --> Q9[Other displays also out of tolerance in TEST 4?] Q1 -- YES --> Q2[Other displays fail to drive also?] Q2 -- ALL --> B3[TEST 4 POS OF EMS FUNC SW FAILED OPEN] Q2 -- V-AXIS AND RNG --> Q4[Perform ΔV TEST] Q4 -- ΔV test normal? --> YES4[YES] --> B5[EMS MODE - STBY, EMS FUNC - ENTRY, EMS MODE - BACKUP, Range ind drives?] Q4 -- ΔV test normal? --> NO4[NO] --> B7[10 SEC TIMER OUTPUT (T2) FAILED] B5 -- YES --> B6[TEST 4 CIRCUITRY OPEN FROM 10 SEC TIMER] B5 -- NO --> B8[PULSE SCALER AND RNG DISPLAY LOGIC CKT FAILED] Q9 -- ALL --> B14[TORQUING RESISTOR IN TEST 4 FAILED] Q9 -- V-AXIS AND RNG ONLY --> Q10[Range error > 2.2 NM?] Q9 -- V-AXIS ONLY --> Q15[Perform ΔV TEST] Q10 -- YES --> B11[10 SECOND TIMER OUT-OF-TOLERANCE] Q10 -- NO --> Q12[Perform ΔV TEST] Q12 -- ΔV test normal? --> YES12[YES] --> B13[PULSE SCALER OUT-OF-TOLERANCE] Q12 -- ΔV test normal? --> NO12[NO] --> Q17[ACCEL DIGITAL OUTPUT OUT-OF-TOLERANCE] Q15 -- ΔV test normal? --> YES15[YES] --> B16[VELOCITY DRIVE MOTOR CONTROLLER INTERMITTENT OR PULSE SCALER OUT-OF-TOLERANCE] Q15 -- ΔV test normal? --> NO15[NO] --> Q17 </pre>	<p>① EMS FUNC - TEST 4 capability lost. EMS operational but accelerometer accuracy can be verified only by performing a ΔV TEST.</p> <p>② TEST 4 and ΔV TEST only lost.</p> <p>③ V-axis and range display lost.</p> <p>④ This failure will invalidate the ΔV TEST and TEST 4, except the G-axis display. EMS should be operational but corridor verification erroneous during entry.</p> <p>⑤ V AXIS and RNG information erroneous only.</p> <p>⑥ EMS FUNC - TEST 4 lost but EMS operation during entry should be normal.</p> <p>⑦ V AXIS, ΔV and RNG information erroneous. Other EMS information unaffected. MSFN may be able to supply a correction factor for this error.</p> <p>⑧ There is no method of distinguishing between these two failures. Scroll velocity information will be erroneous. Range readout of uncertain validity.</p>
<p>6 RNG IND ONLY ABNORMAL (TEST 4)</p>	<pre> graph TD S6[RNG IND ONLY ABNORMAL (TEST 4)] --> Q1[Fails to drive?] Q1 -- NO --> Q2[Out-of-tol ck] Q1 -- YES --> Q3[Perform ΔV TEST] Q2 --> Q3 Q3 -- ΔV test normal? --> YES3[YES] --> B3[Range integrator int check] Q3 -- ΔV test normal? --> NO3[NO] --> B5[ΔV/RNG DISPLAY FAILED] B3 --> B3_1[EMS MODE - STBY] B3 --> B3_2[EMS FUNC - TEST 5] B3 --> B3_3[Slow V AXIS to next test pattern] B3 --> B3_4[EMS FUNC - TEST 3] B3 --> B3_5[Slow range to 58.0] B3 --> B3_6[EMS MODE - NORM] B3 --> B3_7[EMS FUNC - TEST 4] B3 -- RNG ind drives normally --> YES --> B4[INTEGRATOR RESET LOGIC OPEN IN TEST 3] B3 -- RNG ind drives normally --> NO --> B6[RANGE INTEGRATOR FAILED] </pre>	<p>① This check constrained by test pattern availability.</p> <p>② EMS ENTRY and ΔV functions unaffected.</p> <p>③ RNG and ΔV displays lost.</p> <p>④ RNG display lost.</p>
<p>7 G-AXIS ONLY ABNORMAL (TEST 4)</p>	<pre> graph TD S7[G-AXIS ONLY ABNORMAL (TEST 4)] --> Q1[Fails to drive?] Q1 -- NO --> B4[G-AXIS CIRCUITRY OUT-OF-TOLERANCE] Q1 -- YES --> Q2[G-AXIS drives in TEST 5?] Q2 -- YES --> B3[G-AXIS SELF TEST FAILED TEST 4 ONLY] Q2 -- NO --> B5[G-AXIS DRIVE FAILED] </pre>	<p>① Scroll G display erroneous.</p> <p>② Scroll G display lost. Backup G information from CMC or G meter.</p>

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SYMPTOM	PROCEDURE	REMARKS
<p>8 LIFT VECTOR UP LT NOT ON (TEST 5)</p>		<p>① Lift vector up Lt lost in TEST 5 and ENTRY. Backup entry angle information from CMC or MSFN. No Lt 10 sec after .05 G could be used to indicate lift vector up.</p> <p>② Corridor verification lost during TEST 5 and ENTRY. Backup entry angle information from MSFN or CMC.</p> <p>③ EMS FUNC - TEST 5 lost only.</p> <p>④ Scroll G display inoperative.</p>
<p>9 RNG IND DOES NOT SLEW IN RNG SET</p>		<p>① EMS operation unaffected. Use alternate RNG SET method.</p> <p>② ENTRY operation unaffected.</p> <p>③ This failure produces an error only in the initial phase of the G trace.</p>
<p>10 V-AXIS DOES NOT SLEW IN Vo SET</p>		<p>① Range display erroneous during ENTRY. Other ENTRY functions unaffected after Vo slewed by alternate methods.</p>

APOLLO OPERATIONS HANDBOOK

SYMPTOM	PROCEDURE	REMARKS
<p>11</p> <p>ΔV/RNG IND ABNORMAL IN ΔV TEST</p>		<p>1 ENTRY TEST patterns constrain option of ENTRY self test.</p> <p>2 ΔV/RNG ind lost for ΔV maneuver and ENTRY.</p> <p>3 ΔV TEST only lost.</p> <p>4 EMS RSI, V-AXIS and RNG displays unaffected during ENTRY, ΔV, G-AXIS and corridor verification lost.</p> <p>5 All ΔV, EMS velocity and RNG information erroneous during test modes. EMS should be operational, but corridor verification erroneous during ENTRY.</p> <p>6 EMS RSI unaffected. All other EMS functions lost.</p>
<p>12</p> <p>SPS THRUST LT NOT ON IN ΔV TEST</p>		<p>1 THRUST ON signal lost in ΔV TEST only.</p>
<p>13</p> <p>ΔV IND DOES NOT SLEW IN ΔV SET</p>		<p>1 Alternate ΔV SET necessary for SCS ΔV's. For CMC or MANUAL ΔV's (DIRECT THRUST sw), monitor the negatively driven ΔV ind for velocity change information.</p> <p>2 ΔV/RNG ind lost.</p> <p>3 Slew lost for ΔV SET only.</p>
<p>14</p> <p>ΔV/RNG IND FAILS TO COUNT DURING ΔV'S</p>		<p>1 Thrust cutoff discrete and ΔV functions of ΔV/RNG ind lost. Performing a post-burn ΔV TEST and/or ENTRY test will aid in failure identification.</p>
<p>15</p> <p>EITHER LIFT VECTOR LT ON AFTER 2 G</p>		<p>1 EMS functions unaffected.</p>

DM2A-03-BLOCK 11-J-(2)
APOLLO OPERATIONS HANDBOOK

SYMPTOM	PROCEDURE	REMARKS
<p>DOCKING</p> <p>1 DOCK PROBE WILL NOT FOLD</p>	<p>1 LM manned?</p> <p>NO</p> <p>YES</p> <p>2</p> <ul style="list-style-type: none"> Remove drogue from LM side Connect probe umbilicals (2) (yellow) cb DOCK PROBE (2) - close Verify LM tunnel hatch open and crew clear of tunnel PROBE EXT/REL - EXT/REL for 20 sec. max. Verify probe extension cb DOCK PROBE (2) - open Using tools F, W and I, remove nut and bolt from one end of shock struts (3) Fold support beams by pulling probe toward CSM Disconnect probe umbilicals (2) (yellow) and remove probe from tunnel <p>3</p> <ul style="list-style-type: none"> Verify probe support beams unloaded Using tools F, W and I, remove nut and bolt from one end of shock struts (3) Connect probe umbilicals (2) (yellow) Cock docking latches No. 1 & 3 cb DOCK PROBE (2) - closed cb SECS ARM (2) - closed After MSFN AOS, SECS LOGIC (both) - on (up) After go from MSFN, SECS PYRO ARM (2) - on (up) PROBE EXT/REL - RETRACT PROBE RETRACT SEC - 1 PROBE RETRACT (2) - off SECS PYRO ARM (2) - off SECS LOGIC (both) - off cb SECS ARM (2) - open Manually release docking latches 1 & 3 Preload the probe PROBE EXT/REL - EXT/REL for 20 sec. max. Verify extend latch indicator (red) is visible Depress probe BLEED button (red) at intervals to allow probe to extend slowly PROBE EXT/REL - EXT/REL and hold Pull probe aft (20 lb) to release from drogue PROBE EXT/REL - OFF (release) cb DOCK PROBE (2) - open Disconnect probe umbilicals (2) (yellow) and remove probe from tunnel 	
<p>2 DOCK PROBE EXT/REL tb A(B) REMAINS GRAY AFTER CAPTURE (TLD only)</p>	<p>1 Attempt retraction</p> <p>PROBE EXT/REL - RETR</p> <p>PROBE RETR - PRIM 1 (SEC 1)</p> <p>Retraction?</p> <p>YES</p> <p>5 tb OR tb CIRCUIT FAILURE</p> <p>NO</p> <p>2 PROBE RETR - PRIM 2 (SEC 2)</p> <p>Retraction?</p> <p>YES</p> <p>6 PYRO OR GN2 BOTTLE FAILURE</p> <p>NO</p> <p>3 PROBE RETR - SEC-1 (PRIM-1)</p> <p>Retraction?</p> <p>YES</p> <p>7 SYSTEM A (B) CIRCUIT FAILURE IN PROBE</p> <p>NO</p> <p>4 Troubleshoot System A(B) before removing probe as follows</p> <ul style="list-style-type: none"> PROBE RETR (2) - OFF cb DOCK PROBE (2) - open Interchange probe umbilical connectors (cut cable retainers if necessary) Cock docking latches 1 and 7 cb DOCK PROBE (2) - close PROBE EXT/REL - RETR <p>DOCK PROBE EXT/REL tb (A) - gray?</p> <p>YES</p> <p>8 Interchange umbilicals again</p> <ul style="list-style-type: none"> Use SEC 2 (PRIM 2) to initiate only available GN₂ bottle when required Manually release docking latches No.'s 1 and 7 <p>NO</p> <p>9 SYSTEM A (B) CIRCUIT FAILURE IN CSM</p> <p>10 Use SEC-1 (PRIM 1) and SEC-2 (PRIM 2) to initiate two available GN₂ bottles when required</p> <ul style="list-style-type: none"> Manually release docking latches No.'s 1 and 7 	

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SYMPTOM	PROCEDURE	REMARKS
<p style="text-align: center;">HATCH</p> <p style="text-align: center;">1</p> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p style="text-align: center;">FWD HATCH WILL NOT UNLATCH</p> </div>	<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p style="text-align: center;">1 Does actr handle drive clutch engage gearbox?</p> </div> <p style="text-align: center;">YES</p> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p style="text-align: center;">3 Assume failure is frozen gearbox.</p> </div> <p style="text-align: center;">NO</p> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p style="text-align: center;">2 Assume failure of actr handle to engage and drive gearbox</p> </div> <p style="text-align: center;">4</p> <ul style="list-style-type: none"> • Unstow actr handle and push to stop to unlock gearbox • AUX LATCH DRIVE - rotate 113° (use tool B) • Remove tool B and verify hatch unlatch </div> <p style="text-align: center;">5</p> <ul style="list-style-type: none"> • Remove gearbox mounting screws (3) and spacers (use tools Wand 4) • Unstow actr handle and rotate away from hatch approx 30° • Push actr handle out-board rotating gearbox approx 40° CCW to release latches • Remove hatch from tunnel </div> <div style="width: 45%;"> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p style="text-align: center;">6 To reinstall hatch</p> </div> <ul style="list-style-type: none"> • Align hatch in tunnel • Rotate gearbox approx 40° CW and reinstall gearbox mounting screws (3) </div>	

Basic Date 17 July 1970

Change Date

Date

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 APOLLO OPERATIONS HANDBOOK

STA/T STEP	PROCEDURE	PANEL	REMARKS
5.3	EMERGENCY PROCEDURES		
	INTRODUCTION		
	<p>Emergency procedures provide the crew with the necessary steps to quickly alleviate situations that have (or will) become both crew-hazardous and time-critical. These procedures require instant reaction on the part of the crew to prevent the conditions from becoming worse. In most instances the conditions are physically sensed by the crew rather than brought to their attention by the caution and warning system or voice communication from MSFN.</p>		
	5.3.1 PAD EMERGENCY PROCEDURES		
	5.3.1.1 <u>Rapid Hatch Opening</u>		To accomplish rapid hatch opening after engaging latches, the hatch must be configured for rapid egress as shown in 4.2.1 (step 6), Cabin Closeout.
CMP	1 Gear box sel - UNLATCH (verify)	Side hatch	
	2 Actr handle rel - push or squeeze		
	3 Actr handle - opr (until hatch is unlatched)		Lock pin will be sheared. About 5 cycles of actuator operation will open hatch.
	<p>XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX X If hatch fails to open GN2 ratchet handle - opr GN2 vlv handle - unlock & push (outbd)</p>		
	<p>X XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX X</p>		

5.3.1.1

EMERGENCY PROCEDURES

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STA/T STEP	PROCEDURE	PANEL	REMARKS
5.3.2 FLIGHT EMERGENCY PROCEDURES			
5.3.2.1 <u>Fire/Smoke in CM During Boost</u>			
LMP	1 CAB FAN (both) - OFF (verify)	2	
	2 Mon EPS inds for excess current. Immediately remove pwr from affected bus to prevent further damage to critical sys		
	3 If in abort mode I or II SUIT COMPR 1 (or 2) - on good ac bus	4	
CDR LMP	4 If in abort mode III & affected bus is MNA (or B) TVC GMBL DR (2) - 2 (or 1) INV 1 (or 2) AC1 (or 2) - OFF INV 2 (or 1) AC1 (or 2) - on (up)	1 3	Powers both ac buses with inverter from good main bus.
CDR	5 rh CAB PRESS RELF vlv - DUMP (safety latch off)	325	
	6 Continue appropriate abort		

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EMERGENCY PROCEDURES

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STA/T STEP	PROCEDURE	PANEL	REMARKS
5.3.2.2	<u>Fire/Smoke in CM - Orbital Operations</u>		
a. Suited Crew			
LMP	CAB FAN (both) - OFF (verify) Mon EPS inds for excess current. Immediately remove pwr from affected bus to prevent further damage to critical sys	2	
	SUIT COMPR 1 (or 2) - on good ac bus Fire extinguisher - use as appropriate	4	Water dispenser used on all open nonelectrical fires. Foam fire extinguisher used on fires behind panels, closed compartments, and electrical fires.
	Fire out		
	<u>WARNING</u>		
	Combustion products may be toxic. Smoke should be removed from cab per Contam in CM, 5.3.2.4 (step 3b) before removing helmets.		
	Fire persists Dump cab as follows		
CDR	SUIT RETURN vlv - close (push) (verify)	380	
CMP	EMER CAB PRESS sel - OFF (verify)	351	
CDR	REPRESS PKG vlv - OFF (verify)	326	
ALL	PGA - vis integrity check		

5.3.2.2

EMERGENCY PROCEDURES

EMERGENCY

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR,LMP	rh CAB PRESS RELF vlv - DUMP (safety latch off) until CAB PRESS ind 3.0 psia, then to BOOST/ENTR	325 2	Provides controlled cabin dump until suit circuit pressure verified. Time period is a function of equipment oxygen exposure and saturation level.
LMP	SUIT PRESS ind - holding >3.5 psia (verify)		
CDR,LMP	rh CAB PRESS RELF vlv - DUMP &/or CAB PRESS DUMP vlv - open (CCW)	325 Side hatch	
LMP	CAB PRESS ind - 0.0 psia for 6 min	2	
CDR,LMP	rh CAB PRESS RELF vlv - NORM (safety latch on) & CAB PRESS DUMP vlv - close (CW)	325 Side hatch	
<u>WARNING</u>			
Do not repress cab until fire source removed. Reignition may occur with additional damage. If condition lasts longer than 10 min, gly cir- culation & temp cont must be re-established.			
ALL	b. Unsuiting or Partially Suited Crew Don emer O2 mask (refer to Oper of Emer O2 Masks, 4.5.4.15)		
LMP	CAB FAN (both) - OFF (verify) SUIT COMPR (both) - OFF	2 4	

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STA/T STEP	PROCEDURE	PANEL	REMARKS
LMP	<p>Mon EPS inds for excess current. Immediately remove pwr from affected bus to prevent further damage to critical sys Fire extinguisher - use as appropriate</p> <p>Fire out</p> <p style="text-align: center;"><u>WARNING</u></p> <p>Combustion products may be toxic. Smoke should be removed from cab per Contam in CM, 5.3.2.4 (step 3b) before removing helmets.</p> <p>Fire persists</p>	3	<p>Water dispenser used on all open nonelectrical fires. Foam fire extinguisher used on fires behind panels, closed compartments, and electrical fires.</p>
ALL	<p>Don PGA except helmet (refer to PGA Mode Changes, 4.5.4.6)</p>		<p>O2 connections red-to-red and blue-to-blue. Use O2 masks as long as possible.</p>
CDR	<p>DIRECT O2 vlv - OPEN (CCW)</p>	7	<p>Purges suit inlet manifold, suit hoses, and PGA portion of suit circuit.</p>
ALL CMP	<p>Remove emer O2 mask & don helmet SUIT FLOW vlv (3) - 300,301,302 FULL FLOW</p>		
LMP	<p>SUIT COMPR 1 (or 2) - AC1 (or AC2)</p>	4	
CDR	<p>DIRECT O2 vlv - close (CW)</p>	7	
CMP	<p>EMER CAB PRESS sel - OFF</p>	351	
ALL CDR,LMP	<p>PGA - vis integrity check rh CAB PRESS RELF vlv - DUMP (safety latch off) until CAB PRESS ind 3.0 psia, then to BOOST/ENTR</p>	325 2	<p>Provides controlled cabin dump until suit circuit pressure is verified.</p>

5.3.2.2

EMERGENCY PROCEDURES

STA/T STEP	PROCEDURE	PANEL	REMARKS
LMP	SUIT PRESS ind - holding >3.5 psia (verify)	2	
CDR, LMP	rh CAB PRESS RELF vlv - DUMP &/or CAB PRESS DUMP vlv - open (CCW)	325 Side hatch	
LMP	CAB PRESS ind - 0.0 psia for 6 min	2	Time period is a function of equipment oxygen exposure and saturation level.
CDR, LMP	rh CAB PRESS RELF vlv - NORM (safety latch on) & CAB PRESS DUMP vlv - close (CW)	325 Side hatch	
<u>WARNING</u>			
Do not repress cab until fire source removed. Reignition may occur with additional damage. If condition lasts longer than 10 min, gly circulation & temp cont must be re-established.			
5.3.2.3 <u>Fire/Smoke in CM During Entry</u>			
CMP	1 CAB FAN (both) - OFF (verify)	2	
LMP	2 Mon EPS inds for excess current. Immediately remove pwr from affected bus to prevent further damage to critical sys	3	
CDR	3 RHC PWR DIR (both) - MNA/MNB, & maintain att if req	1	

EMERGENCY PROCEDURES

STA/T STEP	PROCEDURE	PANEL	REMARKS
LMP	4 If affected bus is MNA INV 1 AC1 - OFF INV 2 AC1 - on (up)	3	Powers both ac buses with inverter being powered from good dc main bus, providing ac power for suit compressors and SCS.
CDR	Set up for CM/RCS sys 2 AUTO RCS A/C ROLL (4) - OFF AUTO RCS CM 1 (6) - OFF AUTO RCS CM 2 (6) - MNB Use only RHCs to dump RCS prplnts, not CM PRPLNT DUMP sw	8	System 1 is normal and system 2 is redundant. If CM PRPLNT DUMP switch used with MNA bus failed, all oxidizer not expended.
LMP	5 If affected bus is MNB INV 2 AC2 - OFF INV 1 AC2 - on (up)	3	Powers both ac buses with inverter being powered from good dc main bus, providing ac power for suit compressors and SCS.
	Use only RHCs to dump RCS prplnts, not CM PRPLNT DUMP sw		If CM PRPLNT DUMP switch used with MNB bus failed, all fuel not expended.
CDR	6 rh CAB PRESS RELF vlv - DUMP (safety latch off)	325	
	7 Continue entry		
	5.3.2.4 <u>Contamination in CM</u>		Types, sources, and amount of contamination not defined. The very existence of contamination in CM is treated as an emergency.
ALL	1 Don emer O2 mask &/or PGA immediately (refer to Oper of Emer O2 Masks, 4.5.4.15 & PGA Mode Changes, 4.5.4.6)		

5.3.2.4

EMERGENCY PROCEDURES

STA/T STEP	PROCEDURE	PANEL	REMARKS
ALL	2 Evaluate contam level, & isolate or correct source of contam		
	3 If contam persists		
	a. Acpt contam level in cab		Slow removal of contamination accomplished with WASTE STOW valve (panel 252) in VENT position.
CDR,CMP	Retain O2 mask or remain in PGA If in PGA, adj DIRECT O2 vlv for SUIT CAB ΔP >2 in. H2O	7,2	
ALL	b. Dump & repress cab		
	Retain or don PGA (refer to PGA Mode Changes, 4.5.4.6)		
	PGA - vis integrity check		
	Perform CM Press Dump, 4.5.4.11		
	Perform CM Repressurization, 4.5.4.8a		
	5.3.2.5 <u>Contamination in Suit (Suited Crewman)</u>		Contamination originates within suit circuit if, after purging with oxygen, contamination still present.
LMP	1 SUIT COMPR 2 - AC1	4	
	2 SUIT COMPR 1 - OFF		
CDR	3 DIRECT O2 vlv - OPEN (CCW) for 1 min, then close (CW)	7	
	4 If condition persists		
LMP	SUIT COMPR 2 - OFF	4	
CDR	DIRECT O2 vlv - close (CW)	7	

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STA/T STEP	PROCEDURE	PANEL	REMARKS
ALL	<p>Doff helmet Don emer 02 mask (refer to Oper of Emer 02 Masks, 4.5.4.15) Determine contam cause</p> <p>5.3.2.6 <u>LET Fails to Jettison</u></p>		
CDR	<p>a. Tower legs cut/no jett mot ign LES MOT FIRE pb - push</p>	1	Guarded.
CMP	<p>If tower jett successful, TWR JETT (both) - OFF (ctr) Continue mission</p>	2	Guarded.
	<p>If tower jett unsuccessful TWR JETT (both) - OFF (ctr) Report to MSFN & go for orbit</p>		Guarded.
CDR	<p>b. No response to TWR JETT sws Verify the following cb SECS ARM (2) - close cb SECS LOGIC (2) - close cb EDS (all) - close SECS LOGIC (both) - on (up) SECS PYRO ARM (2) - on (up) EDS PWR - on (up)</p>	8	Lever lock. Lever lock.
CMP	<p>TWR JETT (both) - on (up) If tower jett successful TWR JETT (both) - OFF (ctr) Continue mission</p>	7 2	Guarded. On (up) position is momentary.
	<p>If tower jett unsuccessful TWR JETT (both) - OFF (ctr) Report to MSFN & go for orbit</p>		Guarded.

5.3.2.6

EMERGENCY PROCEDURES

STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	XXXXXXXXXXXXXXXXXXXXXXXX X DROG DPLY pb - push XXXXXXXXXXXXXXXXXXXXXXXX X	1	Guarded.
	XXXXXXXXXXXXXXXXXXXXXXXX X If no drogue deploy ELS AUTO - MAN Stab CM with direct RCS 5K' MN DPLY pb - push ELS AUTO - AUTO XXXXXXXXXXXXXXXXXXXXXXXX X		Guarded.
10K'	Main chutes & VHF recovery ant deploy (auto)		Auto deployment occurs between 10,950 and 9,100 feet. Parachutes disreef in ≈15 seconds after pilot mortars fire.
	MN DPLY pb - push (within 1 sec)		Guarded. MN DPLY pushbutton should be pushed within one second after pilot mortars fire to ensure simultaneous deployment of main parachutes.
10K'	+20 sec Immediately following mn chute disreefing, CMP must egress from ctr couch & position himself in an optimum stance to support fwd hatch (≈85 lbs)		
	When CMP in position CAB PRESS DUMP vlv - open (CCW) (full open)	Side hatch	
CMP	As press equalization allows fwd hatch to move, retrieve hatch & stow in hatch stowage bag		

5.3.2.7

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STA/T STEP	PROCEDURE	PANEL	REMARKS
	<u>CAUTION</u>		
	Care must be exercised in handling fwd hatch because it will be at a high temp.		
CDR LMP	CAB PRESS DUMP vlv - close (CW) Set up entry comm VHF ANT - RECY VHF AM A - SIMPLEX VHF BCN - ON	Side hatch 3	If VHF AM B SIMPLEX or VHF AM A DUPLEX is required, turn off beacon during period of transmission.
CDR	Xmit voice (VHF AM) reporting Position Mn chutes disreefed Splash err Crew stat Crew couch struts (4) - unlock		Continue voice transmission until touchdown.
	<u>WARNING</u>		
	RCS prplnts should not be purged because of open hatch.		
LMP	cb FLT/PL BAT BUS A, B, & BAT C (3) - close cb FLT/PL MNA - open cb FLT/PL MNB - open	275	
CDR	cb RAD HTRS OVLD (2) - open cb SPS PITCH (2) - open cb SPS YAW (2) - open	5 8	

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STA/T STEP	PROCEDURE	PANEL	REMARKS
3K' CDR	FLOOD FIXED - POST LDG	8	Provides power from flight and postlanding bus to one floodlight in LH couch area and one floodlight in center couch area. Minimize floodlight use during postlanding. Maximum utilization should be 9.6 hours per 48-hour period.
	FLOOD DIM - 1 or 2		Position 1 provides power to two secondary floodlights and position 2 provides power to two primary floodlights when FLOOD LTS FIXED switch in POST LDG position after dc main buses deactivated.
1000' CMP	CM RCS PRPLNT (both) - OFF	2	OFF position is momentary.
	CM RCS PRPLNT tb (both) - bp		Barber pole indicates at least one propellant isolation valve (fuel or oxidizer) closed in particular system 1 or 2.
CDR LMP	DIRECT O2 vlv - OPEN (CCW)	7	
	MN BUS TIE (2) - OFF	5	Removes battery power from dc main buses A and B.
	<u>CAUTION</u>		
	MN BUS TIE sw (2) must be left in OFF position to ensure bats A, B, & C are used to pwr postlanding bus only, & to prevent bat shorting caused by water entering CM feed-thru conns.		
	cb BAT RLY BUS (2) - open Postlanding Check, 4.17		

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5.3.2.7

EMERGENCY PROCEDURES

STA/T STEP	PROCEDURE	PANEL	REMARKS
5.3.2.8	<u>Emergency Safe of Apex Cover Jett</u>		
CDR	If no MSFN GO for pyro arm indicates apex cover jett	8	Lever lock.
	SECS LOGIC (both) - OFF cb ELS/CM SM SEP (2) - open SECS LOGIC (both) - on (up)		Lever lock.
	If MSFN GO cb ELS/CM SM SEP BAT A - close cb ELS/CM SM SEP BAT B - open (verify)		
	If MSFN GO cb ELS/CM SM SEP BAT B - open (verify), close at or after apex cover jett at 24K' Continue norm entry		
	If still indicates apex cover jett cb ELS/CM SM SEP BAT B - close cb ELS/CM SM SEP BAT A - open SECS LOGIC (both) - OFF, then ON		
	MSFN confirm GO cb ELS/CM SM SEP BAT A - open (verify), close at or after apex cover jett at 24K' Continue norm entry		
	If still indicates apex cover jett cb SECS LOGIC A - open		

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STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR	If MSFN GO cb SECS LOGIC A - open (verify), close at or after apex cover jett at 24K' Continue norm entry	8	
	If still indicates apex cover jett cb SECS LOGIC A - close cb SECS LOGIC B - open		
	If MSFN GO cb SECS LOGIC B - open (verify), close at or after apex cover jett at 24K' Continue norm entry		
	If still indicates apex cover jett		
	ELS AUTO - MAN	1	Guarded.
	ELS LOGIC - OFF		
	SECS LOGIC (both) - OFF	8	Lever lock.
	cb SECS LOGIC (2) - open		
	cb SECS ARM (2) - open		
CMP	cb PYRO A&B/SEQ A&B (2) - open	250	
LMP	Pyro bus A&B - 0 vdc (verify)	3	
CMP	Use tool E (5/32 allen head) to remove closeout pnl located beneath pnl 276 (≈10 fasteners on pnl)		
	Remove or cut all wires to conn (P545) marked "cut" with white tag. Tape ends of wires cut. Replace closeout pnl		
	cb PYRO A&B/SEQ A&B (2) - close	250	

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5.3.2.8

EMERGENCY PROCEDURES

STA/T STEP	PROCEDURE	PANEL	REMARKS
LMP CDR	Pyro bus A&B voltage - >35 vdc (verify) cb ELS/CM SM SEP (2) - close cb SECS LOGIC (2) - close cb SECS ARM (2) - open (verify) <u>DO NOT ARM PYRO BUSES</u>	3 8	
	Continue norm entry except Perform CM RCS Pressurization, 4.15.1.4, & CM/SM Separation, 4.15.2, together at which time arm pyros as follows		
	PYRO B ARM - SAFE (verify) PYRO A ARM - on (up)		Lever lock. Lever lock.
	To jett apex cover at 24K' PYRO B ARM - on (up)		Lever lock.
	Continue norm entry		
5.3.2.9	<u>One Y Strut Will Not Fully Extend and Lock</u>		The other Y strut should be extended and locked as the following operations are performed.
	1 Break lockwire on one Y strut adjustment jam nut of the affected Y strut		
	2 Using tool F, unscrew jam nut		
	3 Disengage washer key so that strut bearing pad will turn		
	4 Screw strut bearing pad inbd until strut can be extended & locked		
	5 Replace washer key, & tighten jam nut		Lockwire and key not required for water landing.

EMERGENCY PROCEDURES

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STA/T STEP	PROCEDURE	PANEL	REMARKS
5.3.2.10	<u>CM RCS Fails to Pressurize or Feed Propellant</u>		
CMP	1 Verify elect for pressurization cb EPS BAT BUS (2) - close	229	
	cb PYRO A/SEQ A - close	250	
	cb PYRO B/SEQ B - close		
CDR	cb SECS ARM (2) - close	8	
	SECS PYRO ARM (2) - on (up)		Lever lock.
	SECS LOGIC (both) - on (up)		Lever lock.
CMP	2 Cycle CM RCS PRESS - on (up)	2	
3	Verify elect to CM RCS prplnt vlvs		
	cb EPS GRP 1 & 3 (4) - close	229	
CDR	cb SM RCS HTR A&B (2) - close	8	
	cb RCS PRPLNT (2) - close		
CMP	4 Cycle CM RCS PRPLNT (both) - on (up)	2	
5	Open He & PRPLNT crossfeed		
	cb EPS GRP 5 (2) - close	229	
	cb RCS LOGIC (2) - close	8	
CDR	CM RCS LOGIC - on (up)	1	
	CM PRPLNT DUMP - on (up) (mom), then OFF		Guarded.
5.3.3	POSTLANDING EMERGENCY PROCEDURES		
5.3.3.1	<u>Fire/Smoke in CM During Postlanding</u>		
a.	Stable I		
ALL	Don emer O2 mask (refer to Oper of Emer O2 Masks, 4.5.4.15)	2	

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5.3.3.1 EMERGENCY PROCEDURES

STA/T STEP	PROCEDURE	PANEL	REMARKS
CDR CMP	DIRECT O2 vlv - close (CW) (verify) cb ENTRY/PL BAT A, B, C (3) - open cb PYRO A/SEQ A - open cb PYRO B/SEQ B - open Fire extinguisher - use as appropriate and/or Egress CM (refer to Stable I Water Egress Procedure, 4.17.4.2)	7 250	Water dispenser used on all open nonelectrical fires. Foam fire extinguisher used on fires behind panels, closed compartments, and electrical fires.
ALL	b. Stable II Don emer O2 mask (refer to Oper of Emer O2 Masks, 4.5.4.15)		
CDR CMF	DIRECT O2 vlv - close (CW) (verify) Fire extinguisher - use as appropriate Upright CM to Stable I (refer to Postlanding Stab, Floating Inverted, 4.17.1) & proceed to step a If CM fails to upright Perform Stable II Water Egress Procedure, 4.17.4.3	7	Water dispenser used on all open nonelectrical fires. Foam fire extinguisher used on fires behind panels, closed compartments, and electrical fires.

EMERGENCY PROCEDURES

APPENDIX B

CM PANEL ILLUSTRATIONS AND CONTROL/INDICATOR CONFIGURATION LIST FOR CSM 112

This section contains CM panel illustrations and a control/indicator configuration list for CSM 112. Panel illustrations present the location of the displays and controls as they appear on the panels in the CM. The control/indicator configuration list provides the configuration of the CM displays and controls prior to backup crew cabin ingress, at lift-off, and during powered down configuration (low power consumption periods). Those talkbacks (tb) are included which reflect the last position selected of spring loaded switches. (Talkback indicators that are operated by sensors will not be listed.) The CSM control/indicator configuration list presents the panels in numerical sequence. The switches are not to be sequentially positioned as listed.

Constraints applicable to the spacecraft when in a powered down configuration are as follows:

- No contingency modes are assumed. Power up capability exists at all times for all systems.
- All spacecraft systems draw minimal power except communications, caution and warning, and life support subsystems. Power is removed from all backup communications systems. The G&C system has been powered down to the level defined by: Power Down Program (P06), 4.8.1.2, Optics Power Control, 4.8.1.4 step 2, and SCS Power Down, 4.8.4.1.
- Power shall be removed from redundant monitoring and unnecessary flight qualification instrumentation by opening applicable circuit breakers.

NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 1			
EMS FUNC	OFF	ΔV	OFF
EMS MODE	STBY	STBY	STBY
GTA sw	off (down)	off (down)	N/A
EMS GTA COVER	Secure	Secure	N/A
CMC ATT	IMU	IMU	IMU
FDAI SCALE	5/1	5/5	5/1
FDAI SEL	1/2	1/2	1 or 2
FDAI SOURCE	CMC	CMC	CMC
ATT SET	GDC	GDC	IMU
MAN ATT ROLL	RATE CMD	RATE CMD	RATE CMD
MAN ATT PITCH	ACCEL CMD	ACCEL CMD	RATE CMD
MAN ATT YAW	RATE CMD	RATE CMD	RATE CMD
LIM CYCLE	OFF	OFF	on (up)
ATT DBD	MIN	MIN	MAX
RATE	HI	HI	LO

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THC PWR	OFF	on (up)	as desired
RHC PWR NORM 1	OFF	AC/DC	OFF
RHC PWR NORM 2	OFF	AC/DC	OFF
RHC PWR DIR 1	OFF	MNA/MNB	OFF
RHC PWR DIR 2	OFF	MNA/MNB	OFF
SC CONT	SCS	SCS	as desired
CMC MODE	FREE	FREE	FREE
BMAG MODE ROLL	RATE 2	RATE 1	RATE 2
BMAG MODE PITCH	RATE 2	RATE 1	RATE 2
BMAG MODE YAW	RATE 2	RATE 1	RATE 2
SPS THRUST	NORM (locked)	NORM (locked)	NORM (locked)
Δ V THRUST A	OFF (guarded)	OFF (guarded)	OFF (guarded)
Δ V THRUST B	OFF (guarded)	OFF (guarded)	OFF (guarded)
SCS TVC PITCH	RATE CMD	AUTO	as desired
SCS TVC YAW	RATE CMD	AUTO	as desired
GMBL MOT P1	OFF	OFF	OFF
GMBL MOT P2	OFF	OFF	OFF
GMBL MOT Y1	OFF	OFF	OFF

PANEL 1

NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 1 (CONT)			
GMBL MOT Y2	OFF	OFF	OFF
ΔV CG	LM/CSM	LM/CSM	CSM
ELS LOGIC	OFF (guarded)	OFF (guarded)	OFF (guarded)
ELS AUTO	AUTO	AUTO	N/A
CM RCS LOGIC	OFF	on (up)	OFF
CM PRPLNT DUMP	OFF (guarded)	OFF (guarded)	OFF (guarded)
CM PRPLNT PURG	off (down) (guarded)	off (down) (guarded)	off (down) (guarded)
IMU CAGE	off (down) (guarded)	off (down) (guarded)	off (down) (guarded)
EMS ROLL	OFF	OFF	OFF
.05 G sw	OFF	OFF	OFF
α/Pc IND sw	α	α	as desired
LV IND/GPI sw	SII/SIVB	SII/SIVB	GPI
TVC GMBL DR PITCH	AUTO	AUTO	1
TVC GMBL DR YAW	AUTO	AUTO	1

EVNT TMR RSET
EVNT TMR START
EVNT TMR MIN
EVNT TMR SEC

up (ctr)
ctr
ctr
ctr

up (ctr)
ctr
ctr
ctr

up (ctr)
STOP
ctr
ctr

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NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 2			
PL VENT VLV	push (lock)	push (lock)	push (lock)
PROBE EXTD/REL	OFF (guarded)	OFF (guarded)	OFF (guarded)
PROBE EXTD/REL A tb	gray	gray	gray
PROBE EXTD/REL B tb	gray	gray	gray
PROBE RETR PRIM	OFF	OFF	OFF
PROBE RETR SEC	OFF	OFF	OFF
EXT RUN/EVA LTS	OFF	OFF	OFF
EXT RNDZ LTS	off (ctr)	off (ctr)	off (ctr)
TUNL LTS	OFF	OFF	OFF
LM PWR	OFF	OFF	OFF
SM RCS A He 1	ctr (CLOSE*)	ctr (OPEN*)	N/A
SM RCS A He 1 tb	bp	gray	N/A
SM RCS B He 1	ctr (CLOSE*)	ctr (OPEN*)	N/A
SM RCS B He 1 tb	bp	gray	N/A
SM RCS C He 1	ctr (CLOSE*)	ctr (OPEN*)	N/A

SM RCS C He 1 tb	bp	gray	N/A
SM RCS D He 1	ctr (CLOSE*)	ctr (OPEN*)	N/A
SM RCS D He 1 tb	bp	gray	N/A
UP TLM CM	BLOCK	BLOCK	as desired
UP TLM IU	BLOCK	BLOCK	as desired
CM RCS PRESS	off (down) (guarded)	off (down) (guarded)	off (down) (guarded)
SM RCS IND sw	N/A	PRPLNT QTY	N/A
SM RCS A He 2	ctr (CLOSE*)	ctr (OPEN*)	N/A
SM RCS A He 2 tb	bp	gray	N/A
SM RCS B He 2	ctr (CLOSE*)	ctr (OPEN*)	N/A
SM RCS B He 2 tb	bp	gray	N/A
SM RCS C He 2	ctr (CLOSE*)	ctr (OPEN*)	N/A
SM RCS C He 2 tb	bp	gray	N/A
SM RCS D He 2	ctr (CLOSE*)	ctr (OPEN*)	N/A
SM RCS D He 2 tb	bp	gray	N/A
SM RCS A HTRS	OFF	OFF	N/A
SM RCS B HTRS	OFF	OFF	N/A

*Identifies last momentary position switched to.

PANEL 2

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NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 2 (CONT)			
SM RCS C HTRS	OFF	OFF	N/A
SM RCS D HTRS	OFF	OFF	N/A
SM RCS A PRPLNT	ctr (CLOSE*)	ctr (OPEN*)	as desired
SM RCS A PRIM PRPLNT tb	bp	gray	--
SM RCS A SEC PRPLNT tb	bp	gray	--
SM RCS B PRPLNT	ctr (CLOSE*)	ctr (OPEN*)	as desired
SM RCS B PRIM PRPLNT tb	bp	gray	--
SM RCS B SEC PRPLNT tb	bp	gray	--
SM RCS C PRPLNT	ctr (CLOSE*)	ctr (OPEN*)	as desired
SM RCS C PRIM PRPLNT tb	bp	gray	--
SM RCS C SEC PRPLNT tb	bp	gray	--
SM RCS D PRPLNT	ctr (CLOSE*)	ctr (OPEN*)	as desired
SM RCS D PRIM PRPLNT tb	bp	gray	--
SM RCS D SEC PRPLNT tb	bp	gray	--
RCS CMD	ctr (OFF*)	ctr (OFF*)	ctr (OFF*)

RCS TRNFR	ctr (SM*)	ctr (SM*)	N/A
CM RCS 1 PRPLNT	ctr (OFF*)	ctr (on, up*)	as desired
CM RCS 1 PRPLNT tb	bp	gray	--
CM RCS 2 PRPLNT	ctr (OFF*)	ctr (on, up*)	as desired
CM RCS 2 PRPLNT tb	bp	gray	--
RCS A SEC FUEL PRESS	ctr (OPEN*)	ctr (CLOSE*)	N/A
RCS B SEC FUEL PRESS	ctr (OPEN*)	ctr (CLOSE*)	N/A
RCS C SEC FUEL PRESS	ctr (OPEN*)	ctr (CLOSE*)	N/A
RCS D SEC FUEL PRESS	ctr (OPEN*)	ctr (CLOSE*)	N/A
EDS AUTO	OFF	on (up)	OFF
CSM/LM FNL SEP 1	off (down) (guarded)	off (down) (guarded)	off (down) (guarded)
CSM/LM FNL SEP 2	off (down) (guarded)	off (down) (guarded)	off (down) (guarded)
CM/SM SEP 1	off (down) (guarded)	off (down) (guarded)	off (down) (guarded)
CM/SM SEP 2	off (down) (guarded)	off (down) (guarded)	off (down) (guarded)
SIVB/LM SEP	off (down) (guarded)	off (down) (guarded)	off (down) (guarded)
PRPLNT DUMP	AUTO	AUTO	N/A
2 ENG OUT sw	AUTO	AUTO	OFF

*Identifies last momentary position switched to.

NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 2 (CONT)			
LV RATES sw	AUTO	AUTO	OFF
TWR JETT 1	AUTO (guarded)	AUTO (guarded)	OFF
TWR JETT 2	AUTO (guarded)	AUTO (guarded)	OFF
LV GUID sw	IU	IU	IU
LV STAGE	OFF (guarded)	OFF (guarded)	OFF (guarded)
XLUNAR INJECT	INJECT	INJECT	N/A
MN REL	off (down) (guarded)	off (down) (guarded)	off (down) (guarded)
MSN TMR HRS	ctr	ctr	ctr
MSN TMR MIN	ctr	ctr	ctr
MSN TMR SEC	ctr	ctr	ctr
C/W NORM	NORM	BOOST	NORM
C/W CSM	CSM	CSM	CSM
C/W PWR	1	1	1
C/W LAMP TEST	ctr	ctr	ctr
MSN TMR	STOP	START	START

RCS IND sel	CM 2	SM D	as desired
CAB FAN 1	OFF	OFF	OFF
CAB FAN 2	OFF	OFF	OFF
H2 HTRS 1	OFF	OFF	AUTO
H2 HTRS 2	OFF	OFF	AUTO
02 HTRS 1	OFF	OFF	AUTO
02 HTRS 2	OFF	OFF	AUTO
02 PRESS IND sw	TK 1	SURGE TK	N/A
H2 FANS 1	OFF	OFF	as req
H2 FANS 2	OFF	OFF	as req
02 FANS 1	OFF	OFF	as req
02 FANS 2	OFF	OFF	as req
ECS IND sel	PRIM	PRIM	N/A
RAD FLOW CONT AUTO	AUTO	AUTO	AUTO
ECS RAD tb	gray	gray	gray
RAD FLOW CONT PWR	off (ctr)	off (ctr)	PWR
RAD MAN SEL	RAD 1	RAD 1	RAD 1
RAD PRIM HTR	off (ctr)	off (ctr)	1

NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 2 (CONT)			
RAD SEC HTR	OFF	OFF	OFF
POT H2O HTR	OFF	OFF	OFF
SUIT H2O ACCUM AUTO	ctr	1	1
SUIT H2O ACCUM ON	ctr	ctr	N/A
SUIT HT EXCH	off (ctr)	off (ctr)	off (ctr)
SEC COOL EVAP	off (ctr)	off (ctr)	off (ctr)
SEC COOL PUMP	off (ctr)	off (ctr)	off (ctr)
H2O QTY IND sw	POT	POT	N/A
GLY EVAP IN TEMP	MAN	MAN	AUTO
GLY EVAP STM AUTO	MAN	MAN	AUTO
GLY EVAP STM INCR	ctr	ctr	N/A
GLY EVAP H2O FLOW	off (ctr)	off (ctr)	AUTO
CAB TEMP	MAN	MAN	AUTO
CAB TEMP tw	N/A	N/A	N/A
HI GAIN ANT TRACK	AUTO	AUTO	as desired

HI GAIN ANT BEAM	WIDE	WIDE	as desired
HI GAIN ANT PITCH cont	0°	0°	as desired
HI GAIN ANT YAW cont	180°	180°	as desired
HI GAIN ANT PWR	OFF	OFF	as desired
HI GAIN ANT SERVO	PRIM	PRIM	PRIM

NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 3			
VHF ANT	SM LEFT	SM LEFT	as desired
SPS INJ VLV A1 ind	CLOSE	CLOSE	CLOSE
SPS INJ VLV A2 ind	CLOSE	CLOSE	CLOSE
SPS INJ VLV B3 ind	CLOSE	CLOSE	CLOSE
SPS INJ VLV B4 ind	CLOSE	CLOSE	CLOSE
FC 1 RAD	off (ctr) (NORM*)	off (ctr) (NORM*)	off (ctr) (NORM*)
FC 1 RAD tb	gray	N/A	gray
FC 2 RAD	off (ctr) (NORM*)	off (ctr) (NORM*)	off (ctr) (NORM*)
FC 2 RAD tb	gray	N/A	gray
FC 3 RAD	off (ctr) (NORM*)	off (ctr) (NORM*)	off (ctr) (NORM*)
FC 3 RAD tb	gray	N/A	gray
FC 1 HTRS	on (up)	on (up)	on (up)
FC 2 HTRS	on (up)	on (up)	on (up)
FC 3 HTRS	on (up)	on (up)	on (up)
FC IND sel	2	2	as desired

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SPS QTY TEST	ctr	ctr	ctr
OXID FLOW VLV INCR	INCR	INCR	INCR
OXID FLOW VLV PRIM	PRIM	PRIM	as desired
PUG MODE	NORM	NORM	as desired
FC 1 PURG	OFF	OFF	OFF
FC 2 PURG	OFF	OFF	OFF
FC 3 PURG	OFF	OFF	OFF
FC 1 REACS	ctr (on, up*)	ctr (on, up*)	N/A
FC 1 REACS tb	gray	gray	gray
FC 2 REACS	ctr (on, up*)	ctr (on, up*)	N/A
FC 2 REACS tb	gray	gray	gray
FC 3 REACS	ctr (on, up*)	ctr (on, up*)	N/A
FC 3 REACS tb	gray	gray	gray
FC 1 MNA	ctr (on, up*)	ctr (on, up*)	ctr (on, up*)
FC 1 MNA tb	gray	gray	gray
FC 2 MNA	ctr (on, up*)	ctr (on, up*)	ctr (on, up*)
FC 2 MNA tb	gray	gray	gray

*Identifies last momentary position switched to.

PANEL 3

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NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 3 (CONT)			
FC 3 MNA	OFF	OFF	OFF
FC 3 MNA tb	bp	bp	bp
MNA RSET	ctr (RSET*)	ctr (RSET*)	ctr (RSET*)
FC 1 MNB	OFF	OFF	OFF
FC 1 MNB tb	bp	bp	bp
FC 2 MNB	OFF	OFF	OFF
FC 2 MNB tb	bp	bp	bp
FC 3 MNB	ctr (on, up*)	ctr (on, up*)	ctr (on, up*)
FC 3 MNB tb	gray	gray	gray
MNB RSET	ctr (RSET*)	ctr (RSET*)	ctr (RSET*)
DC IND sel	MN A	MN A	as desired
BAT CHG	OFF	OFF	OFF
SPS He VLV 1	AUTO	AUTO	AUTO
SPS He VLV 1 tb	bp	bp	bp
SPS He VLV 2	AUTO	AUTO	AUTO

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SPS He VLV 2 tb	bp	bp	bp
SPS LINE HTRS	off (ctr)	off (ctr)	as desired
SPS PRESS IND sw	He	He	as desired
S BD XPNDR	OFF	PRIM	as req
S BD PWR AMPL PRIM	PRIM	PRIM	as req
S BD PWR AMPL HI	off (ctr)	HI	HI
PWR AMPL tb	bp	gray	gray
S BD MODE VOICE	VOICE	VOICE	VOICE
S BD MODE PCM	PCM	PCM	PCM
S BD MODE RNG	RNG	RNG	as req
S BD AUX TAPE	ctr	ctr	ctr
S BD AUX TV	ctr	ctr	ctr
UP TLM DATA	DATA	DATA	DATA
UP TLM CMD	OFF	NORM	NORM
S BD ANT OMNI A	B	B	as req
S BD ANT OMNI	OMNI	OMNI	as req
VHF AM SQLCH A tw	noise +1	noise +1	noise +1

*Identifies last momentary position switched to.

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NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 3 (CONT)			
VHF AM A	off (ctr)	off (ctr)	as req
VHF AM B	off (ctr)	DUPLEX	off (ctr)
VHF AM RCV	off (ctr)	off (ctr)	off (ctr)
VHF BCN	OFF	OFF	OFF
VHF RNG	OFF	OFF	OFF
S BD SQLCH	ENBL	ENBL	ENBL
FC REAC VLVS	NORM	LATCH	NORM
H2 PURG LINE HTR	OFF	OFF	OFF
VHF AM SQLCH B tw	noise +1	noise +1	noise +1
TAPE RCDR PCM	PCM/ANLG	PCM/ANLG	PCM/ANLG
TAPE RCDR RCD	RCD	RCD	RCD
TAPE RCDR FWD	off (ctr)	FWD	FWD
TAPE MOTION tb	bp	gray	gray
SCE PWR	NORM	NORM	NORM
PMP PWR	NORM	NORM	NORM
PCM BIT RATE	HI	HI	LO

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INV 1	MNA	MNA	MNA
INV 2	MNB	MNB	MNB
INV 3	OFF	OFF	OFF
INV 1 AC1	on (up)	on (up)	on (up)
INV 2 AC1	OFF	OFF	OFF
INV 3 AC1	OFF	OFF	OFF
AC1 RSET	ctr (RSET*)	ctr (RSET*)	ctr (RSET*)
INV 1 AC2	OFF	OFF	OFF
INV 2 AC2	on (up)	on (up)	on (up)
INV 3 AC2	OFF	OFF	OFF
AC2 RSET	ctr (RSET*)	ctr (RSET*)	ctr (RSET*)
AC IND sel	BUS 2 \emptyset C	BUS 2 \emptyset C	as desired

*Identifies last momentary position switched to.

NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 4			
SPS GAUGING	AC1	AC1	as desired
TELCOM GRP 1	AC1	AC1	AC1
TELCOM GRP 2	AC2	AC2	AC2
GLY PUMPS	OFF	1 AC1	1 AC1
SUIT COMPR 1	OFF	AC1	AC1
SUIT COMPR 2	OFF	OFF	OFF
cb SUIT COMPR AC1 ØA	close	close	close
cb SUIT COMPR AC1 ØB	close	close	close
cb SUIT COMPR AC1 ØC	close	close	close
cb SUIT COMPR AC2 ØA	close	close	close
cb SUIT COMPR AC2 ØB	close	close	close
cb SUIT COMPR AC2 ØC	close	close	close
cb GLY PUMPS AC1 ØA	close	close	close
cb GLY PUMPS AC1 ØB	close	close	close
cb GLY PUMPS AC1 ØC	close	close	close

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cb GLY PUMPS AC2 ØA
cb GLY PUMPS AC2 ØB
cb GLY PUMPS AC2 ØC

close
close
close

close
close
close

close
close
close

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NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 5			
FC 1 PUMPS	AC1	AC1	AC1
FC 2 PUMPS	AC2	AC2	AC2
FC 3 PUMPS	AC2	AC2	AC2
G/N PWR	AC1	AC1	OFF
MN BUS TIE BAT A/C	OFF	on (up)	OFF
MN BUS TIE BAT B/C	OFF	on (up)	OFF
BAT CHGR	AC1	AC1	as desired
NONESS BUS	MNA	MNA	OFF
cb SNSR SIG MNA	close	close	close
cb SNSR SIG MNB	close	close	close
cb SNSR SIG AC1	close	close	close
cb SNSR SIG AC2	close	close	close
cb C/W MNA	close	close	close
cb C/W MNB	close	close	close
cb LM PWR 1 MNB	close	close	close

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cb INV CONT 1	close	close	close
cb INV CONT 2	close	close	close
cb INV CONT 3	close	close	close
cb DC SNSR UNIT A	close	close	close
cb DC SNSR UNIT B	close	close	close
cb AC SNSR UNIT 1	close	close	close
cb AC SNSR UNIT 2	close	close	close
cb BAT RLY BUS BAT A	close	close	close
cb BAT RLY BUS BAT B	close	close	close
cb LM PWR 2 MNB	close	close	close
INTGL LTS	on	as desired	as desired
FLOOD LTS	OFF (full dim or full BRT)	OFF (full dim or full BRT)	OFF (full dim or full BRT)
FLOOD DIM	1	1	1
FLOOD FIXED	OFF	OFF	OFF
cb RAD CONTR AC1	close	close	close
cb RAD CONTR AC2	close	close	close
cb RAD CONT/HTRS MNA	close	close	close
cb RAD CONT/HTRS MNB	close	close	close

PANEL 5

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NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 5 (CONT)			
cb RAD HTRS OVLD BAT A	close	close	close
cb RAD HTRS OVLD BAT B	close	close	close
cb BAT CHGR BAT A	close	close	close
cb BAT CHGR BAT B	close	close	close
cb BAT CHGR MNA	close	close	close
cb BAT CHGR MNB	close	close	close
cb BAT CHGR AC PWR	close	close	close
cb ESS INST MNA	close	close	close
cb ESS INST MNB	close	close	close
cb NONESS INST	open	open	open
cb SCI EQUIP SEB 1	close	close	open
cb SCI EQUIP SEB 2	close	close	open
cb SCI EQUIP HATCH	open	open	open
cb POT H2O HTR MNA	close	close	close
cb POT H2O HTR MNB	close	close	close

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cb H2O ACCUM MNA	close	close	close
cb H2O ACCUM MNB	close	close	close
cb WASTE/POT H2O XDUCR MNA	close	close	close
cb WASTE/POT H2O XDUCR MNB	close	close	close
cb ECS PRESS XDUCR 1 MNA	close	close	close
cb ECS PRESS XDUCR 1 MNB	close	close	close
cb ECS PRESS XDUCR 2 MNA	close	close	close
cb ECS PRESS XDUCR 2 MNB	close	close	close
cb ECS TEMP XDUCR MNA	close	close	close
cb ECS TEMP XDUCR MNB	close	close	close
cb SEC COOL AC1	close	close	close
cb SEC COOL AC2	close	close	close
cb SEC COOL RAD HTR MNA	close	close	close
cb SEC COOL XDUCR MNA	close	close	close
cb SEC COOL XDUCR MNB	close	close	close
cb WASTE DUMP HTRS MNA	open	open	close
cb WASTE DUMP HTRS MNB	open	open	close
cb CAB FAN 1 AC1 \emptyset A	close	close	close

PANEL 5

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NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 5 (CONT)			
cb CAB FAN 1 AC1 ØB	close	close	close
cb CAB FAN 1 AC1 ØC	close	close	close
cb CAB FAN 2 AC2 ØA	close	close	close
cb CAB FAN 2 AC2 ØB	close	close	close
cb CAB FAN 2 AC2 ØC	close	close	close
cb G/N PWR AC1	close	close	close
cb G/N PWR AC2	close	close	close
cb G/N IMU MNA	close	close	close
cb G/N IMU MNB	close	close	close
cb G/N IMU HTR MNA	close	close	close
cb G/N IMU HTR MNB	close	close	close
cb G/N CMPTR MNA	close	close	close
cb G/N CMPTR MNB	close	close	close
cb G/N OPT MNA	close	close	close
cb G/N OPT MNB	close	close	close

PANEL 6

MODE	INTERCOM/PTT	as desired	as desired
VOX SENS tw	5	as req	as req
PWR	OFF	AUDIO/TONE	AUDIO/TONE
MASTER VOL tw	5	as req	as req
INTERCOM	T/R	T/R	T/R
INTERCOM VOL tw	5	as req	as req
PAD COMM	T/R	OFF	OFF
PAD COMM VOL tw	5	as desired	as desired
S BD	T/R	T/R	T/R
S BD VOL tw	5	as req	as req
VHF AM	T/R	T/R	T/R
VHF AM VOL tw	5	as req	as req
AUDIO CONT	NORM	NORM	NORM
SUIT PWR	OFF	on (up)	on (up)

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NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 7			
EDS PWR	OFF	on (up)	OFF
TVC SERVO PWR 1	OFF	AC1/MNA	OFF
TVC SERVO PWR 2	OFF	AC2/MNB	OFF
FDAI/GPI PWR	OFF	BOTH	OFF
LOGIC 2/3 PWR	on (up)	on (up)	OFF
ELEC PWR	OFF	GDC/ECA	OFF
SIG CONDR/DR BIAS PWR 1	OFF	AC1	OFF
SIG CONDR/DR BIAS PWR 2	OFF	AC2	OFF
BMAG 1 PWR	WARM UP	ON	WARM UP
BMAG 2 PWR	WARM UP	ON	WARM UP
DIRECT O2 vlv	OPEN (CCW)	partially OPEN (CCW)	N/A

PANEL 8

cb SCS TVC AC1	close	close	close
cb SCS AC1	close	close	close
cb SCS AC2	close	close	close
AUTO RCS A/C ROLL A1	OFF	OFF	OFF
AUTO RCS A/C ROLL C1	OFF	OFF	OFF
AUTO RCS A/C ROLL A2	OFF	OFF	OFF
AUTO RCS A/C ROLL C2	OFF	OFF	OFF
AUTO RCS B/D ROLL B1	OFF	MNA	OFF
AUTO RCS B/D ROLL D1	OFF	MNB	OFF
AUTO RCS B/D ROLL B2	OFF	MNA	OFF
AUTO RCS B/D ROLL D2	OFF	MNB	OFF
AUTO RCS PITCH A3	OFF	MNB	OFF
AUTO RCS PITCH C3	OFF	MNA	OFF
AUTO RCS PITCH A4	OFF	MNA	OFF
AUTO RCS PITCH C4	OFF	MNB	OFF
AUTO RCS YAW B3	OFF	MNA	OFF
AUTO RCS YAW D3	OFF	MNB	OFF

PANELS 7 AND 8

NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 8 (CONT)			
AUTO RCS YAW B4	OFF	MNB	OFF
AUTO RCS YAW D4	OFF	MNA	OFF
cb SCS ECA/TVC AC2	close	close	close
cb SCS DIR ULL MNA	close	close	close
cb SCS DIR ULL MNB	close	close	close
cb SCS CONTR 1 DIR MNA	close	close	close
cb SCS CONTR 1 DIR MNB	close	close	close
cb SCS CONTR 2 DIR MNA	close	close	close
cb SCS CONTR 2 DIR MNB	close	close	close
cb A/C ROLL MNA	close	close	as desired
cb A/C ROLL MNB	close	close	as desired
cb B/D ROLL MNA	close	close	as desired
cb B/D ROLL MNB	close	close	as desired
cb SCS PITCH MNA	close	close	as desired
cb SCS PITCH MNB	close	close	as desired

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cb SCS YAW MNA

close

close

as desired

cb SCS YAW MNB

close

close

as desired

NUMERICS LTS

as desired

as desired

as desired

FLOOD LTS

OFF (full dim or
full BRT)OFF (full dim or
full BRT)OFF (full dim or
full BRT)

INTGL LTS

as desired

as desired

as desired

cb ORDEAL AC2

close

close

close

cb ORDEAL MNB

close

close

close

cb SCS CONTR AUTO MNA

close

close

close

cb SCS CONTR AUTO MNB

close

close

close

cb SCS LOGIC 1/2 MNA

close

close

close

cb SCS LOGIC 3/4 MNA

close

close

close

cb SCS LOGIC 1/4 MNB

close

close

close

cb SCS LOGIC 2/3 MNB

close

close

close

cb SCS SYS MNA

close

close

close

cb SCS SYS MNB

close

close

close

FLOOD DIM

1

1

1

FLOOD FIXED

OFF

OFF

OFF

FLOAT BAG 1 L

VENT (locked)

VENT (locked)

OFF

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NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 8 (CONT)			
FLOAT BAG 2 R	VENT (locked)	VENT (locked)	OFF
FLOAT BAG 3 CTR	VENT (locked)	VENT (locked)	OFF
SECS LOGIC 1	OFF (locked)	on (up) (locked)	OFF (locked)
SECS LOGIC 2	OFF (locked)	on (up) (locked)	OFF (locked)
SECS PYRO A ARM	SAFE (locked)	on (up) (locked)	SAFE (locked)
SECS PYRO B ARM	SAFE (locked)	on (up) (locked)	SAFE (locked)
cb CM RCS 1 HTR MNA	open	open	open
cb CM RCS 2 HTR MNB	open	open	open
cb SM RCS A HTR MNB	close	close	close
cb SM RCS C HTR MNB	close	close	close
cb SM RCS B HTR MNA	close	close	close
cb SM RCS D HTR MNA	close	close	close
cb RCS PRPLNT ISOL MNA	close	close	close
cb RCS PRPLNT ISOL MNB	close	close	close
cb RCS LOGIC MNA	close	close	close

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cb RCS LOGIC MNB	close	close	close
cb EMS MNA	close	close	close
cb EMS MNB	close	close	close
cb DOCK PROBE MNA	close	close	close
cb DOCK PROBE MNB	close	close	close
cb SPS GAUGING MNA	close	close	close
cb SPS GAUGING MNB	close	close	close
cb SPS GAUGING AC1	close	close	close
cb SPS GAUGING AC2	close	close	close
cb SPS He VLV MNA	close	close	close
cb SPS He VLV MNB	close	close	close
cb SPS PITCH 1 BAT A	open	close	open
cb SPS PITCH 2 BAT B	close	close	close
cb SPS YAW 1 BAT A	open	close	open
cb SPS YAW 2 BAT B	close	close	close
cb SPS PILOT VLV A MNA	close	close	close
cb SPS PILOT VLV B MNB	close	close	close
cb FLOAT BAG 1 BAT A	open	open	open

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NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 8 (CONT)			
cb FLOAT BAG 2 BAT B	open	open	open
cb FLOAT BAG 3 FLT/PL	open	open	open
cb SECS LOGIC A BAT A	open	close	close
cb SECS LOGIC B BAT B	open	close	close
cb SECS ARM A BAT A	open	close	open
cb SECS ARM B BAT B	open	close	open
cb EDS 1 BAT A	close	close	open
cb EDS 2 BAT C	close	close	open
cb EDS 3 BAT B	close	close	open
cb ELS/CM SM SEP BAT A	close	close	open
cb ELS/CM SM SEP BAT B	close	close	open
cb PL VENT FLT/PL	close	close	open

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PANEL 9			
MODE	INTERCOM/PTT	as desired	as desired
VOX SENS tw	5	as req	as req
PWR	OFF	AUDIO/TONE	AUDIO/TONE
MASTER VOL tw	5	as req	as req
INTERCOM	T/R	T/R	T/R
INTERCOM VOL tw	5	as req	as req
PAD COMM	T/R	OFF	OFF
PAD COMM VOL tw	5	as desired	as desired
S BD	T/R	T/R	T/R
S BD VOL tw	5	as req	as req
VHF AM	T/R	T/R	T/R
VHF AM VOL tw	5	as req	as req
AUDIO CONT	NORM	NORM	NORM
SUIT PWR	OFF	on (up)	on (up)
VHF RNG	NORM	NORM	NORM

PANELS 8 AND 9

NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 10			
MODE	INTERCOM/PTT	as desired	as desired
VOX SENS tw	5	as req	as req
PWR	OFF	AUDIO/TONE	AUDIO/TONE
MASTER VOL tw	5	as req	as req
PAD COMM	T/R	OFF	OFF
PAD COMM VOL tw	5	as desired	as desired
INTERCOM	T/R	T/R	T/R
INTERCOM VOL tw	5	as req	as req
S BD	T/R	T/R	T/R
S BD VOL tw	5	as req	as req
VHF AM	T/R	T/R	T/R
VHF AM VOL tw	5	as req	as req
AUDIO CONT	NORM	NORM	NORM
SUIT PWR	OFF	on (up)	on (up)

PANEL 12			
TUNL VENT vlv	OFF	LM/CM ΔP	N/A
PANEL 13			
FDAI 1 sw	INRTL	INRTL	INRTL
FDAI 2 sw	INRTL	INRTL	INRTL
EARTH/LUNAR	PWR OFF	PWR OFF	PWR OFF
ALT SET cont	100 NM	100 NM	N/A
LTG	OFF	OFF	OFF
MODE	HOLD/FAST	HOLD/FAST	N/A
SLEW	off (ctr)	off (ctr)	off (ctr)
PANEL 15			
COAS PWR	OFF	OFF	OFF
UTIL PWR	OFF	OFF	OFF
PL BCN LT	off (ctr)	off (ctr)	off (ctr)
PL DYE MARKER	off (down) (guarded)	off (down) (guarded)	off (down) (guarded)
PL VENT	OFF	OFF	OFF

PANELS 10 THRU 15

NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 16			
DOCK TRGT	OFF	OFF	OFF
UTIL PWR	OFF	OFF	OFF
COAS PWR	OFF	OFF	OFF
PANEL 100			
UTIL PWR	OFF	OFF	OFF
FLOOD DIM	1	1	1
FLOOD FIXED	OFF	OFF	OFF
G/N OPT PWR	OFF	OFF	OFF
G/N IMU PWR	on (up) (guarded)	on (up) (guarded)	OFF (guarded)
RNDZ XPNDR PWR	OFF	OFF	OFF
NUMERICS LTS	as desired	as desired	OFF
FLOOD LTS	OFF (full dim or full BRT)	OFF (full dim or full BRT)	OFF (full dim or full BRT)
INTGL LTS	as desired	as desired	OFF

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PANEL 101			
SYS TEST (LH)	4	4	OFF
SYS TEST (RH)	B	B	as desired
CM RCS HTRS	OFF	OFF	OFF
WASTE H2O DUMP	OFF	HTR A	HTR A
URINE DUMP	OFF	HTR A	HTR A
RNDZ XPNDR TEST	OPR	OPR	OPR
PANEL 122			
OPT ZERO	ZERO	ZERO	ZERO
OPT TELTRUN	SLAVE TO SXT	SLAVE TO SXT	SLAVE TO SXT
OPT COUPLING	DIRECT	DIRECT	DIRECT
OPT MODE	MAN	MAN	MAN
OPT SPEED	LO	LO	LO
COND LAMPS	ON	ON	as desired
UP TLM	ACPT	ACPT	as desired
PANEL 162			
SCI PWR (Located behind closeout panel and will be set at panel closeout)	OFF	OFF	OFF

PANELS 16 THRU 162

NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 163			
SCI/UTIL PWR (Located behind closeout panel and will be set at panel closeout)	OFF	OFF	OFF
PANEL 164			
S1 (Located behind closeout panel and will be set at panel closeout)	OFF	OFF	OFF
PANEL 181			
CRYO AC PWR	on (up)	on (up)	OFF
H2 FAN	AUTO	AUTO	OFF
O2 FAN	AUTO	AUTO	OFF
cb SM SECTOR 1 AC2 ØA	close	close	open
cb SM SECTOR 1 AC2 ØB	close	close	open
cb SM SECTOR 1 AC2 ØC	close	close	open
SM/AC PWR	on (up)	on (up)	OFF
DOOR JETT	off (down) (guarded)	off (down) (guarded)	off (down) (guarded)
LOGIC PWR	OFF	OFF	OFF

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cb LOGIC PWR MNA	close	close	open
cb LOGIC PWR MNB	close	close	open
PANEL 201			
AC UTIL PWR	OFF	OFF	OFF
PANEL 225			
cb PCM TLM ac GRP 1	close	close	close
cb PCM TLM ac GRP 2	close	close	close
cb FLT BUS MNA	close	close	close
cb FLT BUS MNB	close	close	close
cb PMP PRIM FLT BUS	close	close	close
cb PMP AUX FLT BUS	close	close	close
cb VHF/CREW AUDIO L FLT/PL	close	close	close
cb VHF/CREW AUDIO CTR FLT/PL	close	close	close
cb VHF/CREW AUDIO R FLT/PL	close	close	close
cb UDL FLT BUS	close	close	close
cb HI GAIN ANT FLT BUS	open	open	close
cb HI GAIN ANT ac GRP 2	open	open	close
cb S BD XMTR/DSE FLT BUS	close	close	close
cb S BD XMTR/DSE ac GRP 1	close	close	close

PANELS 163 THRU 225

NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 225 (CONT)			
cb CTE MNA	close	close	close
cb CTE MNB	close	close	close
cb RNDZ XPNDR FLT BUS	close	close	close
cb SIG CONDR FLT BUS	close	close	close
cb S BD PWR AMPL 1 FLT BUS	close	close	close
cb S BD PWR AMPL 1 ac GRP 1	close	close	close
cb S BD PWR AMPL 2 FLT BUS	close	close	close
cb S BD PWR AMPL 2 ac GRP 2	close	close	close

PANEL 226

cb FC 1 PUMPS AC	close	close	close
cb FC 1 REACS	open	open	open
cb FC 1 BUS CONT	close	close	close
cb FC 1 PURG	close	close	close
cb FC 1 RAD	close	open	open
cb CRYO H2 HTR 1 MNA	close	close	close
cb CRYO H2 HTR 2 MNB	close	close	close
cb FC 2 PUMPS AC	close	close	close
cb FC 2 REACS	open	open	open
cb FC 2 BUS CONT	close	close	close
cb FC 2 PURG	close	close	close
cb FC 2 RAD	close	open	open
cb CRYO O2 HTR 1 MNA	close	close	close
cb CRYO O2 HTR 2 MNB	close	close	close
cb FC 3 PUMPS AC	close	close	close
cb FC 3 REACS	open	open	open
cb FC 3 BUS CONT	close	close	close
cb FC 3 PURG	close	close	close

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NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 226 (CONT)			
cb FC 3 RAD	close	open	open
cb QTY AMPL AC1	close	close	close
cb QTY AMPL AC2	close	close	close
cb CRYO FAN TK1 AC1 ØA	close	close	close
cb CRYO FAN TK1 AC1 ØB	close	close	close
cb CRYO FAN TK1 AC1 ØC	close	close	close
cb CRYO FAN TK2 AC2 ØA	close	close	close
cb CRYO FAN TK2 AC2 ØB	close	close	close
cb CRYO FAN TK2 AC2 ØC	close	close	close
cb COAS/TUNL LTG MNA	close	close	close
cb COAS/TUNL LTG MNB	close	open	close
cb FLOOD LTG MNA	close	close	close
cb FLOOD LTG MNB	close	close	close
cb FLOOD LTG FLT/PL	close	close	close
cb NUM/INTGL LTG LEB AC2	close	close	close

cb NUM/INTGL LTG L MDC AC1	close	close	close
cb NUM/INTGL LTG R MDC AC1	close	close	close
cb RUN/EVA/TRGT LTG AC1	close	close	close
cb RUN/EVA/TRGT LTG AC2	close	close	close
PANEL 227			
SCI PWR	OFF	OFF	OFF
PANEL 229			
cb EPS GRP 1 MNA	close	close	close
cb EPS GRP 1 MNB	close	close	close
cb EPS GRP 2 MNA	close	close	close
cb EPS GRP 2 MNB	close	close	close
cb EPS GRP 3 MNA	close	close	close
cb EPS GRP 3 MNB	close	close	close
cb EPS GRP 4 MNA	close	close	close
cb EPS GRP 4 MNB	close	close	close
cb EPS GRP 5 MNA	close	close	close
cb EPS GRP 5 MNB	close	close	close
cb UTIL R/L STA MNA	close	close	close

PANELS 226 THRU 229

NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 229 (CONT)			
cb UTIL LEB MNB	close	close	close
cb EPS BAT BUS A	close	close	close
cb EPS BAT BUS B	close	close	close
cb TMRS MNA	close	close	close
cb TMRS MNB	close	close	close
cb SPS LINE HTRS MNA	close	close	close
cb SPS LINE HTRS MNB	close	close	close
cb O2 VAC ION PUMPS MNA	open	open	open
cb O2 VAC ION PUMPS MNB	open	open	open
cb MN REL PYRO A	open	open	open
cb MN REL PYRO B	open	open	open

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PANEL 230			
MAP CAMR ON tb	gray	gray	TBD
MAP CAMR TRACK tb	gray	gray	TBD
MAP CAMR ON	OFF	STBY	OFF
MAP CAMR TRACK	OFF	OFF	OFF
MAP CAMR IMAGE MTN	OFF	OFF	OFF
GAMMA RAY BOOM DPLY tb	gray	gray	TBD
GAMMA RAY BOOM JETT tb	gray	gray	TBD
GAMMA RAY BOOM DPLY	off (ctr)	off (ctr)	off (ctr)
GAMMA RAY BOOM JETT	off (down)	off (down)	off (down)
GAMMA RAY EXP	OFF	OFF	OFF
GAMMA RAY GAIN	SHLD OFF	SHLD OFF	SHLD OFF
MASS SPECT BOOM DPLY tb	gray	gray	TBD
MASS SPECT BOOM JETT tb	gray	gray	TBD
MASS SPECT BOOM JETT	off (down)	off (down)	off (down)
MASS SPECT BOOM DPLY	off (ctr)	off (ctr)	off (ctr)
MASS SPECT EXP	OFF	OFF	OFF
MASS SPECT ION SOURCE	OFF	OFF	OFF

PANELS 229 AND 230

NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 230 (CONT)			
MASS SPECT MULT	LO	LO	LO
MASS SPECT DSCRM	LO	LO	LO
LASER ALTM	OFF	OFF	OFF
PAM CAMR OPR tb	gray	gray	TBD
PAN CAMR SELF TEST	off (ctr)	off (ctr)	off (ctr)
PAN CAMR MODE	STBY	STBY	STBY
PAN CAMP PWR	BOOST	BOOST	off (ctr)
DATA SYS CAL	off (down)	off (down)	off (down)
DATA SYS ON	OFF	OFF	OFF
ALPHA RAY	OFF	OFF	OFF
X RAY DR DPLY	off (down)	off (down)	off (down)
X RAY EXP	OFF	OFF	OFF
SUB SAT	off (ctr)	off (ctr)	off (ctr)
SUB SAT tb	gray	gray	gray

NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 275			
cb MNA BAT BUS A	close	close	close
cb MNA BAT C	open	open	open
cb MNB BAT C	open	open	open
cb MNB BAT BUS B	close	close	close
cb FLT/PL BAT BUS A	open	open	open
cb FLT/PL BAT BUS B	open	open	open
cb FLT/PL BAT C	open	open	open
cb FLT/PL MNA	close	close	close
cb FLT/PL MNB	close	close	close
cb INV 1 MNA	close	close	close
cb INV 2 MNB	close	close	close
cb INV 3 MNA	close	close	close
cb INV 3 MNB	close	close	close

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PANEL 276			
cb1 INST PWR CONT	close	close	close
cb2 INST PWR CONT	close	close	close
cb3 INST PWR CONT	close	close	close
cb4 INST PWR CONT	close	close	close
PANEL 278			
cb UPR SYS COMPR 1	open	open	open
cb UPR SYS COMPR 2	open	open	open
cb SIVB/LM SEP PYRO A	close	close	
cb SIVB/LM SEP PYRO B	close	close	
PANEL 300			
rh SUIT FLOW vlv	FULL FLOW	FULL FLOW	N/A
PANEL 301			
lh SUIT FLOW vlv	FULL FLOW	FULL FLOW	N/A
PANEL 302			
ctr SUIT FLOW vlv	FULL FLOW	FULL FLOW	N/A
PANEL 303			
PRIM CAB TEMP vlv	COLD (CW)	COLD (CW)	N/A
SEC CAB TEMP vlv	MAX COOL (CW)	MAX COOL (CW)	N/A

PANELS 275 THRU 303

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NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 304			
DRINK H2O SUP vlv	OFF (CW)	OFF (CW)	N/A
PANEL 305			
FOOD PREP COLD H2O vlv	rel	rel	N/A
FOOD PREP HOT H2O vlv	rel	rel	N/A
PANEL 306			
MSN TMR	START	START	START
EVNT TMR RSET	UP (ctr)	UP (ctr)	UP (ctr)
EVNT TMR START	ctr	ctr	STOP
EVNT TMR MIN	ctr	ctr	ctr
EVNT TMR SEC	ctr	ctr	ctr
MSN TMR HRS	ctr	ctr	ctr
MSN TMR MIN	ctr	ctr	ctr
MSN TMR SEC	ctr	ctr	ctr

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PANEL 325			
rh CAB PRESS RELF vlv	BOOST/ENTR	BOOST/ENTR	N/A
lh CAB PRESS RELF vlv	BOOST/ENTR	BOOST/ENTR	N/A
PRIM GLY TO RAD	NORM	BYP	N/A
PANEL 326			
REPRESS PKG vlv	OFF	ON	N/A
SM O2 SUP vlv	ON	ON	N/A
SRG TK O2 vlv	ON	ON	N/A
GLY RSVR IN vlv	OPEN	OPEN	N/A
GLY RSVR BYP vlv	CLOSE	CLOSE	N/A
GLY RSVR OUT vlv	OPEN	OPEN	N/A
PANEL 350			
CO2 CSTR DIVERT vlv	ctr	ctr	N/A
PANEL 351			
MN REG A vlv	open	open	N/A
MN REG B vlv	open	open	N/A
H2O/GLY TK REG sel	BOTH	BOTH	N/A
H2O/GLY TK RELF sel	BOTH	BOTH	N/A

PANELS 304 THRU 351

NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 351 (CONT)			
EMER CAB PRESS sel	OFF	OFF	N/A
CAB REPRESS vlv	OFF (CCW)	OFF (CCW)	N/A
PANEL 352			
WASTE TK SERV vlv	CLOSE	CLOSE	N/A
PRESS RELF sel	2	2	N/A
POT TK IN vlv	CLOSE	OPEN	N/A
WASTE TK IN vlv	AUTO	AUTO	N/A
PANEL 375			
SRG TK RELF vlv	open (CW)	open (CW)	N/A
PANEL 376			
PLVC sw	NORM	NORM	N/A
PANEL 377			
GLY TO RAD SEC vlv	BYP	BYP	N/A
PANEL 378			
PRIM GLY ACCUM vlv	open (CCW)	open (CCW)	N/A

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PANEL 379			
PRIM ACCUM FILL vlv	OFF	OFF	N/A
PANEL 380			
DEMAND REG sel	BOTH	BOTH	N/A
SUIT TEST vlv	OFF	OFF	N/A
SUIT RETURN vlv	close (push)	close (push)	N/A
PANEL 382			
SUIT HT EXCH PRIM GLY	FLOW (CCW)	FLOW (CCW)	FLOW
SUIT FLOW RELF	OFF	OFF	N/A
GLY EVAP IN TEMP vlv	MIN (CCW)	MIN (CCW)	N/A
SUIT HT EXCH SEC GLY	FLOW	FLOW	N/A
SEC EVAP H2O CONT	AUTO	AUTO	OFF
PRIM EVAP H2O CONT	AUTO	AUTO	AUTO
H2O ACCUM 1	RMTE	RMTE	RMTE
H2O ACCUM 2	RMTE	RMTE	RMTE
PANEL 600			
EMER O2	CLOSE	CLOSE	N/A
PANEL 601			
REPRESS O2	CLOSE	CLOSE	N/A

PANELS 351 THRU 601

NOMENCLATURE	CSM CONTROL/INDICATOR CONFIGURATION		
	PRIOR TO BACKUP CREW CABIN INGRESS	AT LIFTOFF	POWER DOWN
PANEL 602			
REPRESS O2 RELF	open (CW)	open (CW)	N/A
PANEL 603			
EVA STA O2 SUP	OFF	OFF	OFF
PANEL 604			
SUIT PRESS ALARM	OFF	OFF	OFF
FWD HATCH			
PRESS EQUAL vlv	CLOSE	CLOSE	N/A
Actr handle sel	stowed	stowed	N/A
Actr handle rel	locked	locked	N/A
SIDE HATCH			
CAB PRESS DUMP vlv	close (CW)	close (CW)	close (CW)
Gearbox sel	LATCH	LATCH	N/A
Actr handle sel	L (latch)	U (unlatch)	N/A
BPC jett knob	180° from BPC JETT decal	Arrow on knob pointing to BPC JETT decal	N/A

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Lock pin rel knob	UNLOCK	LOCK	N/A
GN2 vlv handle	neutral	push (outboard)	N/A
Lock pin ind	flush	flush	N/A

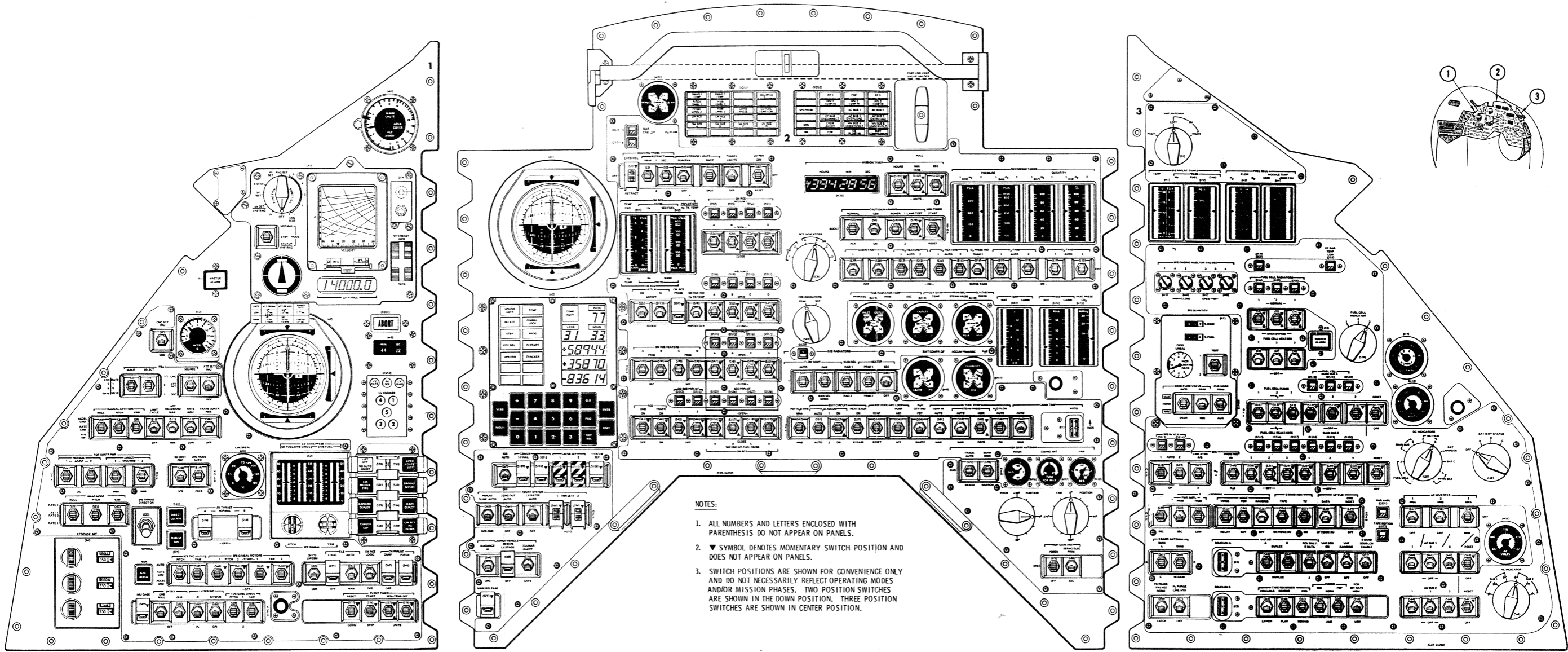
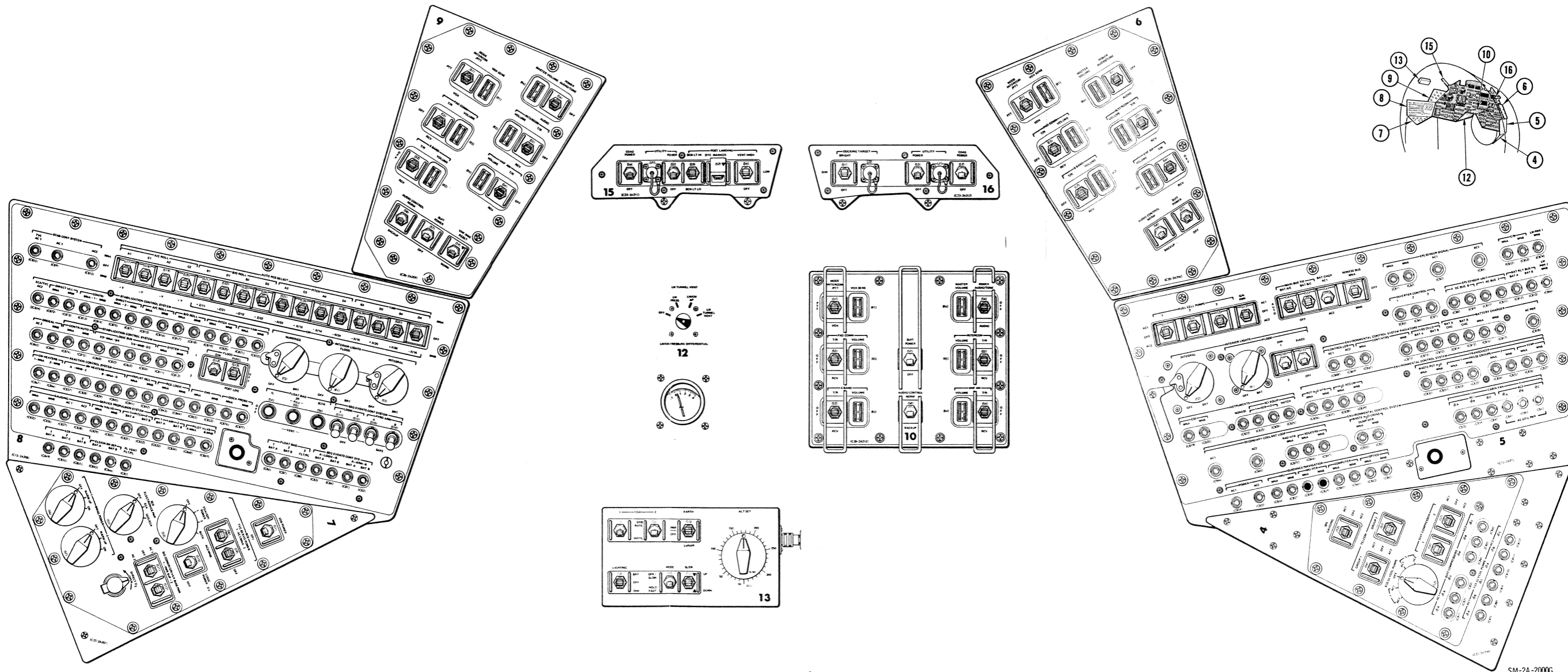


Figure B-1. Crew Displays and Controls (Sheet 1 of 5)



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Figure B-1. Crew Displays and Controls (Sheet 2 of 5)

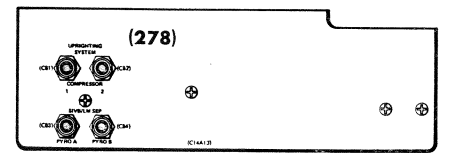
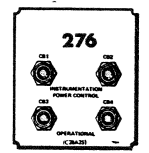
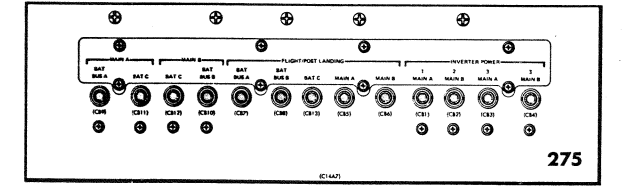
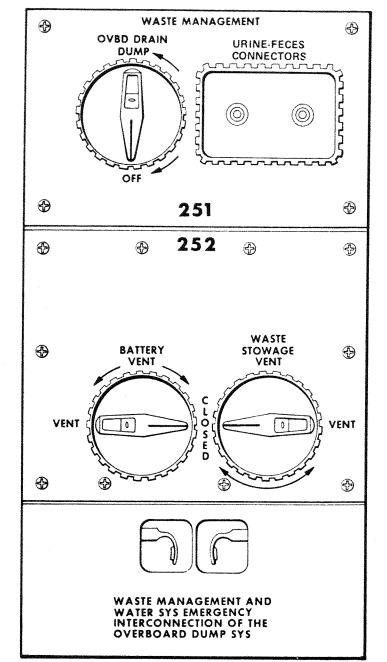
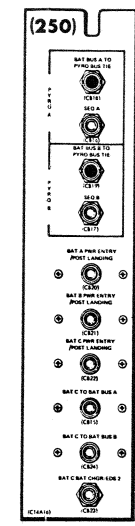
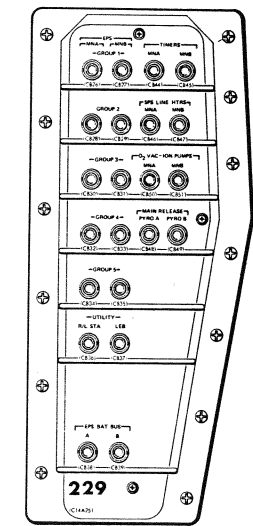
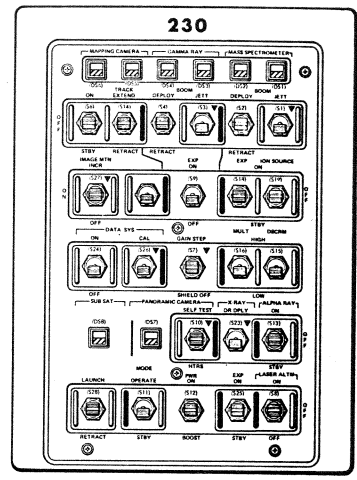
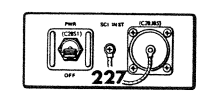
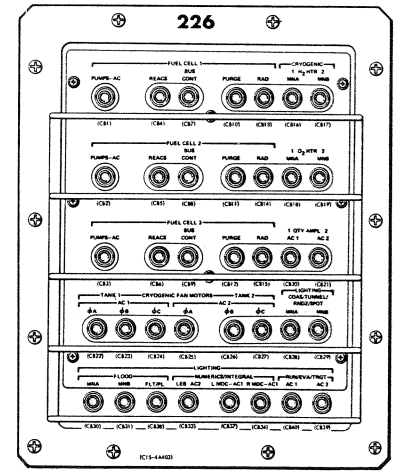
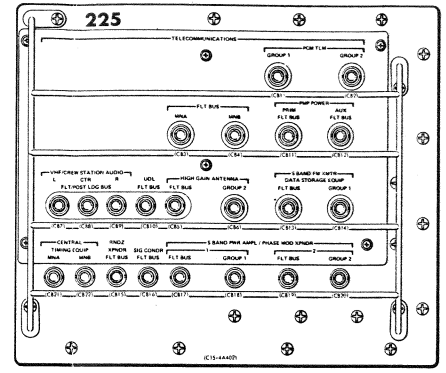
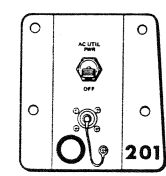
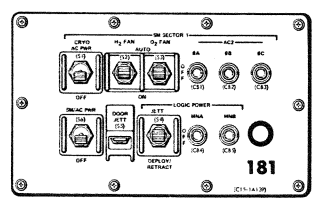
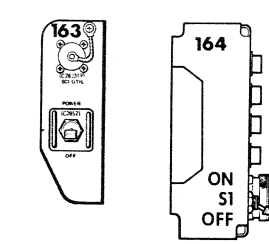
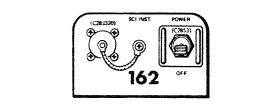
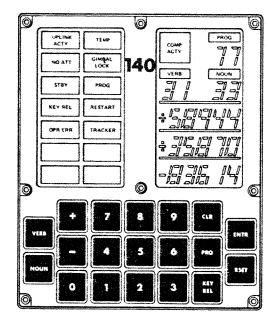
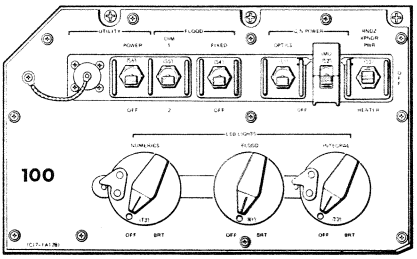
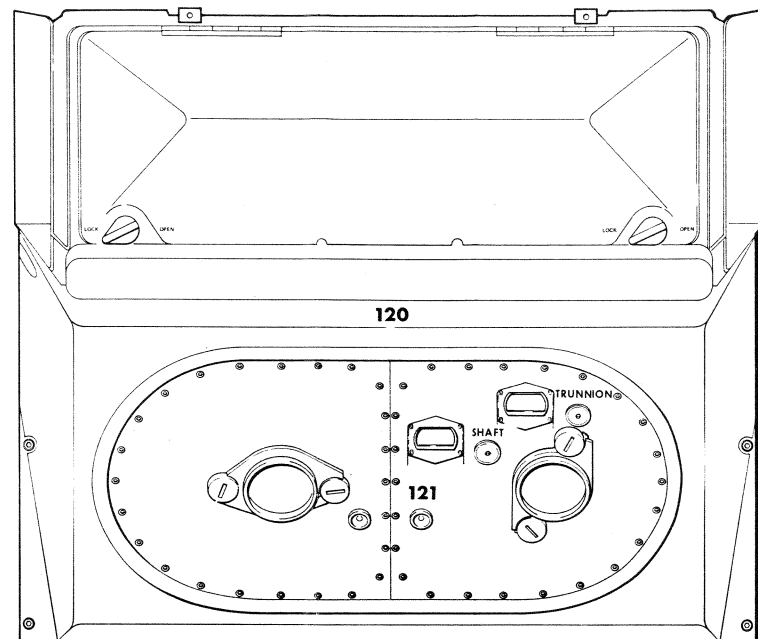
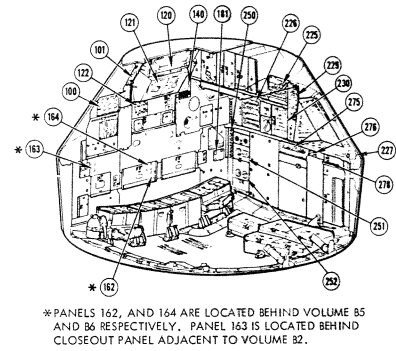


Figure B-1. Crew Displays and Controls (Sheet 3 of 5)

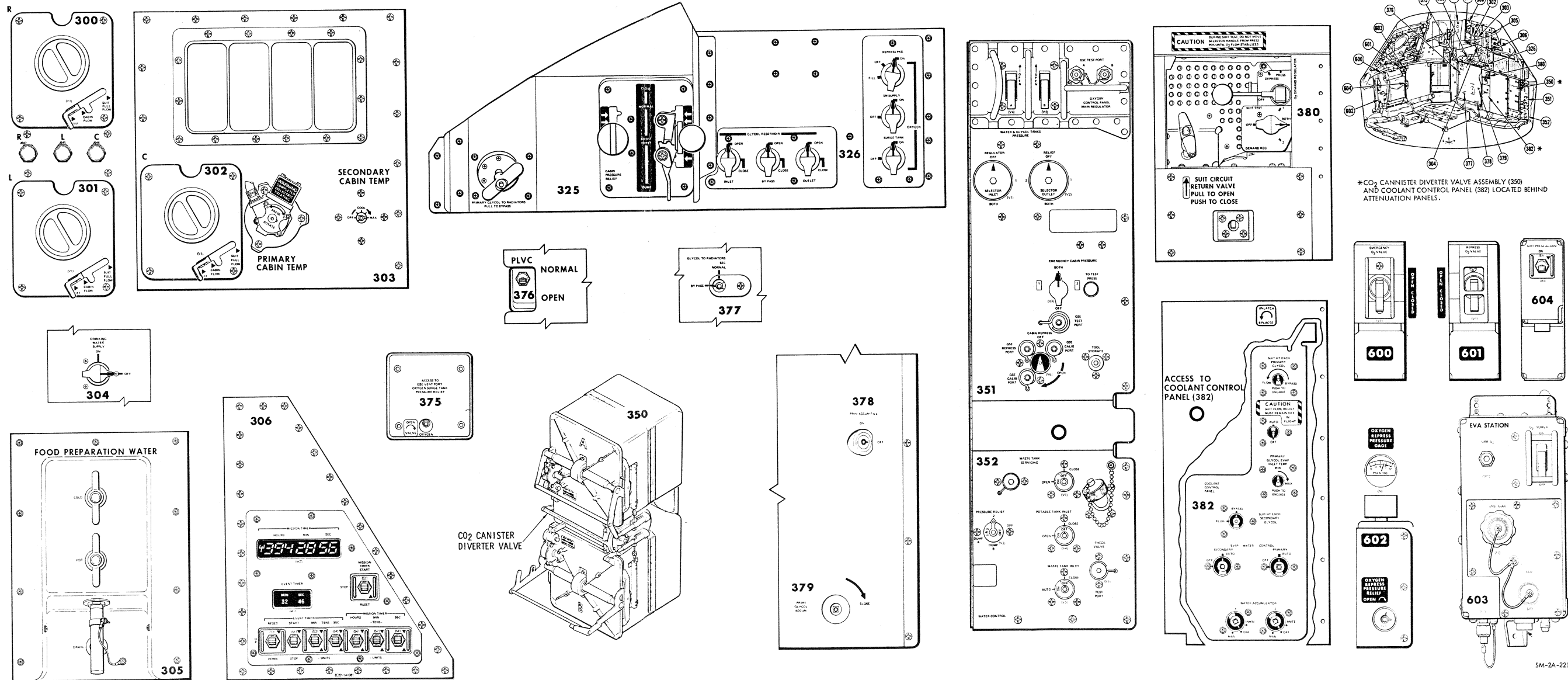


Figure B-1. Crew Displays and Controls (Sheet 4 of 5)

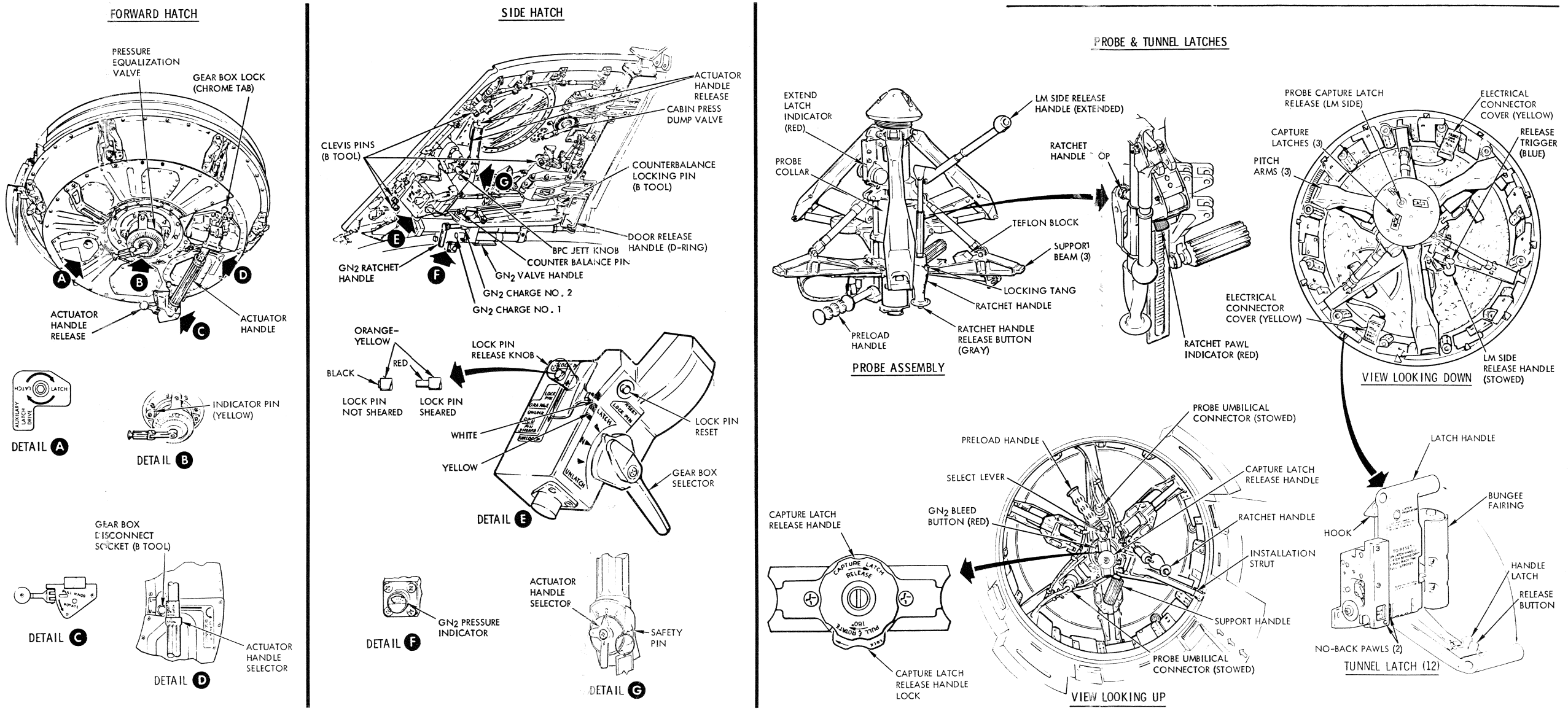


Figure B-1. Crew Displays and Controls (Sheet 5 of 5)

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APOLLO OPERATIONS HANDBOOK

APPENDIX C

FLIGHT OPERATIONAL CHECKLIST DEVELOPMENT

The CSM Apollo Operations Handbook Procedures are formatted so as to make possible direct development of flight operational checklist material.

Figures C-1 through C-3 indicate a method of arranging material from the procedures column of the normal/backup and contingency sections of the AOH to provide three relatively compact and convenient checklists ordered and oriented to specific Apollo mission phases. Material is arranged to provide a minimum of redundancy and cross referencing, while at the same time allowing optimum procedure sequencing for each phase.

The LAUNCH CHECKLIST, figure C-1, contains flight crew procedures from prime crew ingress through translunar injection, including aborts and applicable pad and flight emergency procedures.

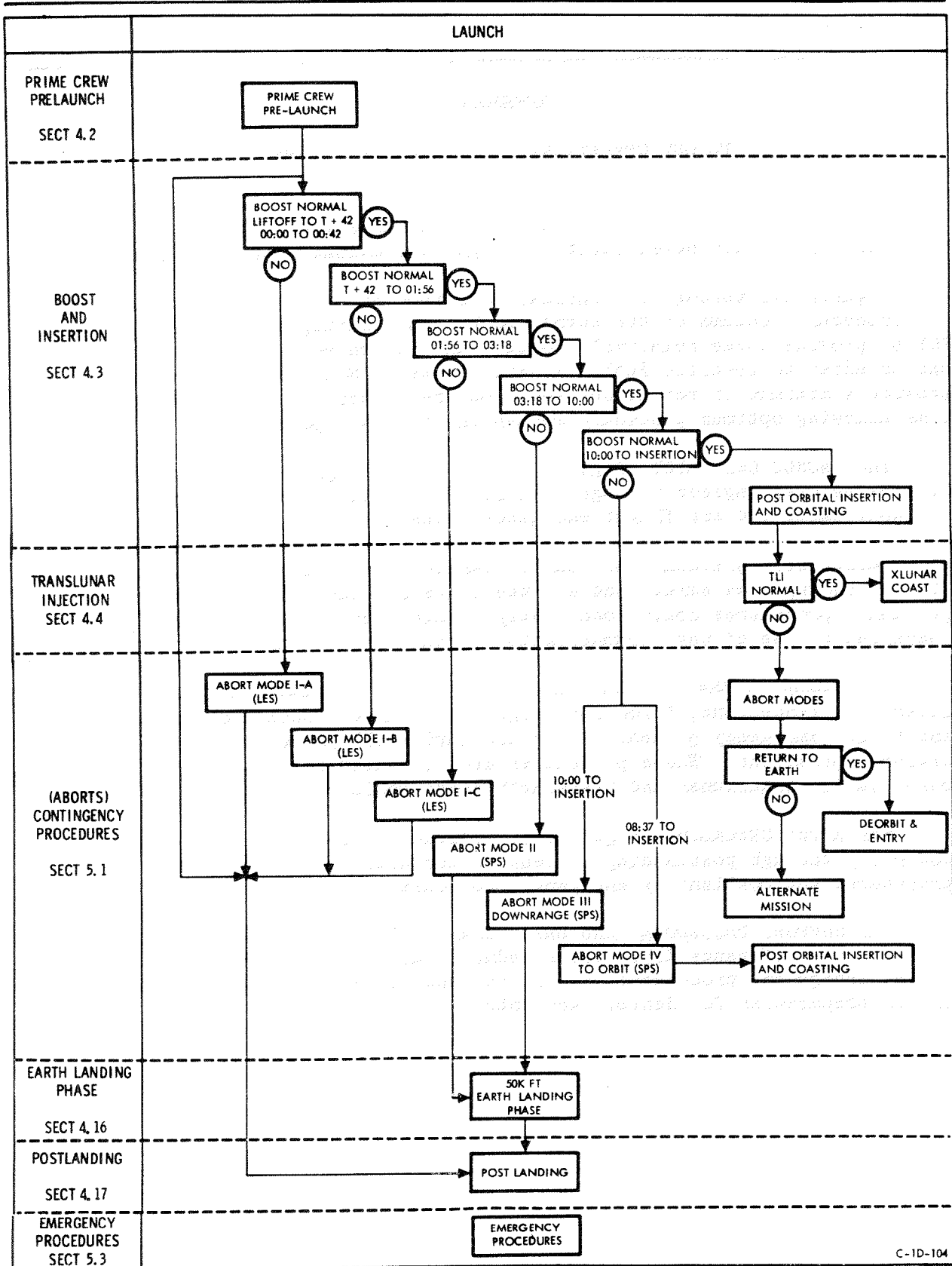
Backup crew prelaunch procedures can be made a carry-off item at the time of backup crew egress and are therefore not included. Prime crew prelaunch procedures could conceivably be excluded as well from the launch checklist by use of task communication to the crew via hardline.

The FLIGHT OPERATIONS CHECKLIST, figure C-2, includes CSM/LM/SIVB interface, rendezvous, formation flight, docking and docked operations, and flight emergency procedures for use during all phases of Earth-Lunar orbital operations. These procedures are also used for TEI and for MCC burns during translunar and transearth coast periods.

The ENTRY CHECKLIST, figure C-3, includes preparation for deorbit and entry through postlanding procedures including flight emergency procedures and postlanding emergency procedures, if any.

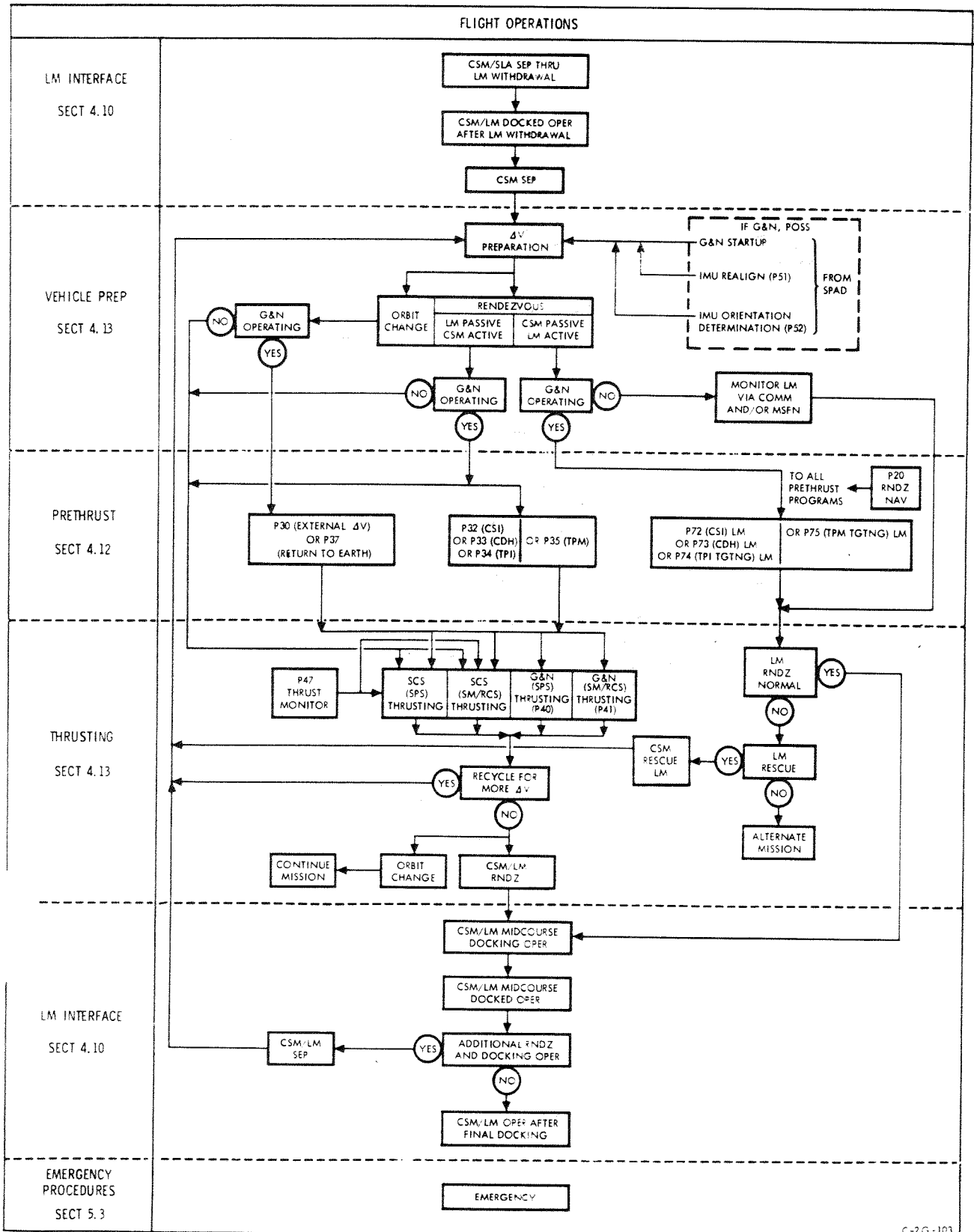
The SUPPORT PROCEDURES AND DATA (SPAD), detailed in figure C-4, includes G&C reference data, subprocedures, mode selection, and vehicle system management procedures used in conjunction with orbital operations and in preparation for deorbit and entry.

SM2A-03-BLOCK II-J-(2)
 APOLLO OPERATIONS HANDBOOK



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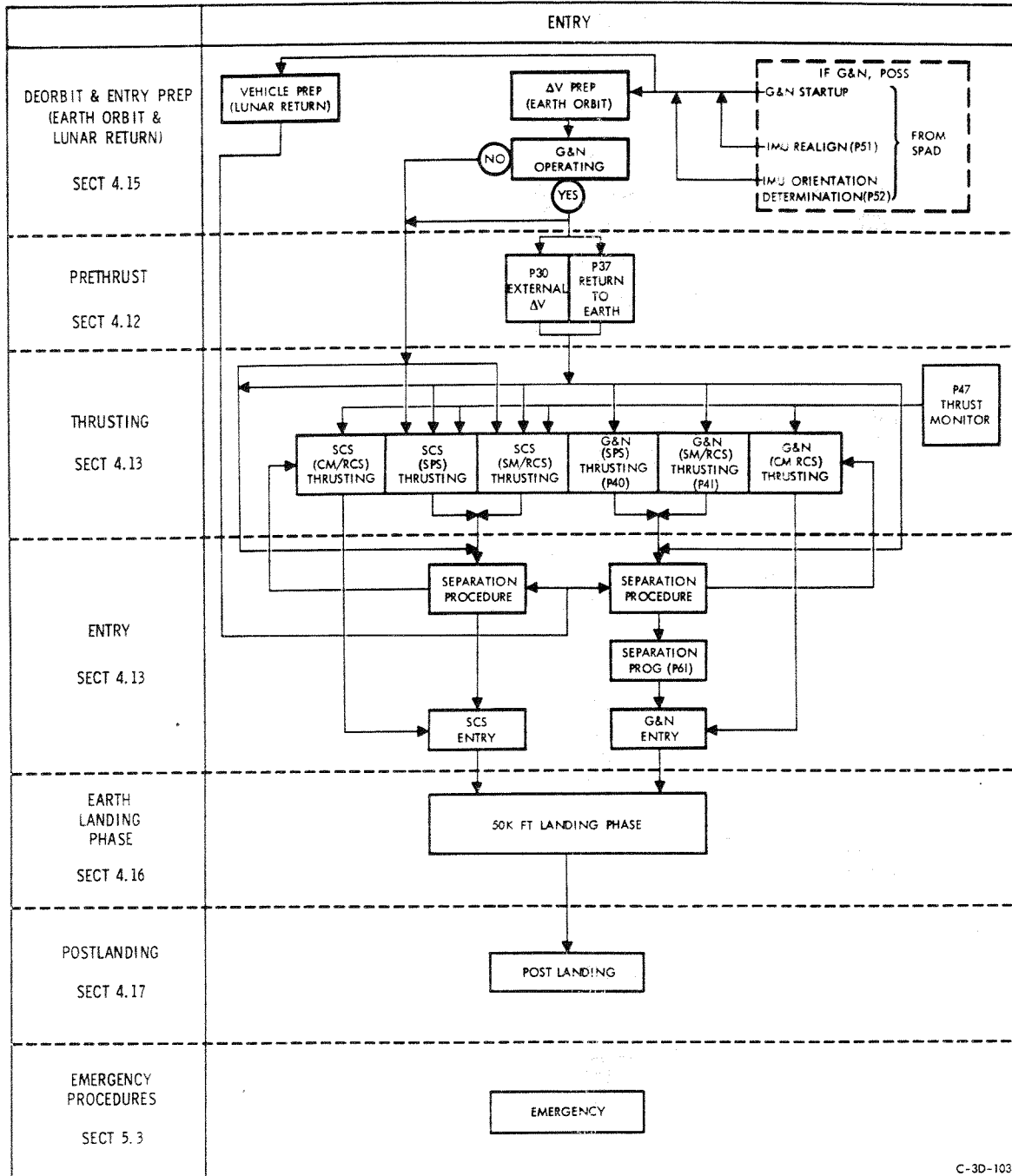
Figure C-1. Launch



C-2 G-103

Figure C-2. Flight Operations

SM2A-03-BLOCK II-J-(2)
 APOLLO OPERATIONS HANDBOOK



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Figure C-3. Entry

SM2A-03-BLOCK II-J-(2)
APOLLO OPERATIONS HANDBOOK

SUPPORT PROCEDURES AND DATA				
REFERENCE DATA SECT 4.8	G&C GENERAL INSTRUCTIONS G&C OPERATING NOTES G&C OPERATIONS SCS OPERATIONS	G&N OPERATIONS OPTICS MECHANIZATION VERB LIST NOUN LIST	STAR LIST CHECKLIST CODES OPTION CODES ALARM CODES	CMC PROGRAM-ROUTINE CHECK • PROGRAMS • ROUTINES • CMC FLAG LISTINGS
G&C REFERENCE MODES SECT 4.7	ATTITUDE CONTROL MODES • CHANNEL SELECTION • SCS MINIMUM IMPULSE • SCS ACCELERATION COMMAND • SCS ATTITUDE HOLD/RATE COMMAND • CMC ACCEL CMD/MIN IMP • CMC ATT CONTR-AUTO/HOLD • SIVB ATT CONTR DISPLAY MODES • DYNAMIC DISPLAY MONITOR	• RATE DISPLAY • ERROR DISPLAY (BMAG, CMC, ATT SET SOURCE) • TOTAL ATTITUDE DISPLAY • ORDEAL-LCL HORIZ ATT GDC ALIGN TVC MODES • SPS THRUSTING • TVC INITIALIZATION • SPS GMBL CONTR • THRUST ON-OFF CONTR		OPTICS CONTROL • AUTO OPT POSITIONING • MAN OPT CONTR • MAN OPT DRIVE ENTRY MONITOR SYSTEM (EMS) • ΔV TEST AND NULL BIAS CHECK • ΔV SETUP
G&C GENERAL PROCEDURES SECT 4.8	G&N GENERAL • (P00) CMC IDLING PROGRAM • (P06) CMC/IMU POWER DOWN PROCEDURES • STARTUP PROCEDURE • OPTICS POWER CONTROL • (P27) CMC UPDATE • (P47) G&N THRUSTING MONITOR PROGRAM • CMC SELF-CHECK PROCEDURE • MEASUREMENT AND LOADING OF PIPA BIAS • (R33) CMC/LGC CLOCK SYNC ROUTINE • ΔR AND ΔV THRESHOLD CHANGE PROCEDURE • A OR B ERASABLE VALUE CHANGE PROCEDURE • FLAGWORD MONITOR AND CHANGE PROCEDURE • (V79) ORBRATE/PTC (BBQ MODE - R64) • G&N PASSIVE THERMAL CONTROL PROCEDURE • G&N +X LANDMARK TRACKING • SATURN RATE CHANGE • (R02) IMU STATUS CHECK • (R05) S BAND ANTENNA ROUTINE • DSKY 88888 CLEAR PROCEDURE DIGITAL AUTO PILOT (DAP) • (V48) DAP DATA LOAD ACTIVATION (R03) • RCS DAP ATTITUDE DEADBAND CHANGE PROCEDURE • RCS DAP ORBITAL RATE PROCEDURE		EXTENDED VERBS • (V35) DSKY CONDITION LIGHT CHECK • (V42) TORQUE GYROS • (V43) LOAD FDAI ERROR NEEDLES • (V49) CSM CREW DEFINED MANUEVER (R62) • (V67) START W-MATRIX RSS ERROR DISPLAY • (V74) INITIALIZE ERASABLE DUMP VIA DOWNLINK • (V91) DISPLAY BANKSUM SCS GENERAL • SCS POWER DOWN • SCS POWER UP • DRIFT RATE ADJUST • MINIMUM POWER SCS ATTITUDE HOLD (THREE OR TWO AXES) • SCS ATTITUDE MANUEVER • GDC ALIGNMENT TO IMU GIMBAL ANGLES • ATTITUDE REFERENCE SYSTEM COMPARISON • ORDEAL INITIALIZATION • SCS PASSIVE THERMAL CONTROL USING WOBBLE MODE • SCS PASSIVE THERMAL CONTROL USING BAR-B-Q MINIMUM POWER MODE	
NAVIGATION SECT 4.11	ORBITAL NAV • (P21) GROUND TRACK DETERMINATION • (P22) ORBITAL NAVIGATION • (P23) Cislunar MIDCOURSE NAV • (P24) RATE AIDED OPTICS • (R30) ORBIT PARAMETER DISPLAY		RENDEZVOUS NAV • (P20) CSM RENDEZVOUS NAV • (V83) RENDEZVOUS PARAMETER DISPLAY NO. 1 (R31) • (V85) RENDEZVOUS PARAMETER DISPLAY NO. 2 (R34) • (V90) RENDEZVOUS OUT OF PLANE DISPLAY (R36) • (V89) RENDEZVOUS FINAL ATTITUDE (R63) • (P76) TARGET DELTA V	
ALIGNMENTS SECT 4.14	G&N ALIGNMENTS • (P51) IMU ORIENTATION DETERMINATION • (P52) IMU REALIGN • (P53) ALTERNATE LOS IMU ORIENTATIONS DETERMINATION	• (P54) ALTERNATE LOS IMU REALIGN • (V40 N20) ZERO ICDOU EXTENDED VERB • (V41 N20) COARSE ALIGN ICDOU EXTENDED VERB • (V41 N91) COARSE ALIGN OCDOU EXTENDED VERB • INFLIGHT COAS CALIBRATION		SCS ALIGNMENTS • ALTERNATE SC INERTIAL ATTITUDE DETERMINATION AND GDC ALIGNMENT • INPLANE GDC ALIGNMENT • BACKUP GDC ALIGNMENT WITH COAS BACKUP GDC AND/OR IMU ALIGNMENT
EXPERIMENTS SECT 4.19	① S160-GAMMA RAY SPECTROMETER ① S161-X-RAY FLUORESCENCE ① S162-ALPHA-PARTICLE SPECTROMETER ① S163-OPTICAL BAR PANARAMIC CAMERA ② S164-S-BAND TRANSPONDER ① CSM 112-114 ② CSM 112-115A ③ CSM 115-115A	① S165-MASS SPECTROMETER (SMOG) ② S166-3-IN. MAPPING CAMERA ③ S167-SOUNDING RADAR ④ S168-EM SOUNDER "A" ③ S169-FAR ULTRA-VIOLET SPECTROMETER		③ S170-BISTATIC RADAR ③ S171-IR SCANNING RADIOMETER ③ S173-SUBSATELLITE-PARTICLE MEAS ③ S174-SUBSATELLITE-MAGNETOMETER ② S175-LASER ALTIMETER
SYSTEMS MANAGEMENT SECT 4.5	PROPULSION • SPS • RCS EPS	ECS C&WS TELECOM	MECH SYS FLOODLIGHT OPERATING MODES GEN DATA	

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Figure C-4. Support Procedures and Data