NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MSC INTERNAL NOTE

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IM DESCENT/ASCENT SUMMARY DOCUMENT

MISSION G

PRELIMINARY

PREPARED BY:

LAUNCH AND ENTRY PROCEDURES SECTION

FLIGHT PROCEDURES BRANCH

FLIGHT CREW SUPPORT DIVISION

MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

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DESCENT/ASCENT SUMMARY DOCUMENT

MISSION G

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1.0 INTRODUCTION

The Descent/Ascent Summary Document has been prepared to document in detail the crew procedures and supporting information to be used in training for the G Mission. This document covers the mission phase from CSM-LM undocking to touchdown plus two hours, and from preparation for ascent to insertion.

Comments should be directed to C. O. Lewis, Flight Procedures Branch, CF24, extension 3436.

2.1 MISSION SUMMARY

Descent

The mission phase within the scope of this document begins with undocking of the LM and CSM approximately three-quarters of a revolution prior to DOI. At the time of undocking, the vehicles are in a 58 nm circular orbit, and LM activation and checkout has been completed except for items which could not be performed while in the docked configuration.

The CSM undocks from the LM and station keeps in close proximity while the LM rotates for a visual inspection by the CSM. Upon completion of the inspection, the LM acquires S-BAND lockon with MSFN and takes over the station keeping while the CSM prepares for the separation burn. During this period the LGC is updated by MSFN (LM state vector) and pad data for DOI, powered descent, and aborts is read up.

The CSM performs the separation burn 180° prior to DOI. The burn is 2.5 fps radially down. This burn will put the CSM 11,400 ft in front of the LM at DOI. MSFN updates the new CSM S/V into the LGC, and the crew updates and aligns the AGS. The DOI thrusting parameters are loaded into the LGC and a rendezvous radar/VHF ranging test is run.

After the LM passes into darkness, the IMU is fine aligned to a landing site REFSMAT. Systems and controls checklists are performed, and the landing radar is checked out. The AGS is updated, configured to follow the DOI PGNS burn, and aligned to the IMU. The DPS thrust program is called and final preparations for the DOI burn are made.

The DOI burn is a retrograde burn of approximately 70 fps which reduces pericynthian to 50,000 ft. The burn is PGNS controlled, using the external ΔV program. Timing is such that pericynthian will occur 15° prior to reaching the target landing site. The AGS, rendezvous radar, and VHF ranging are used to verify that the burn was performed correctly.

The LM is oriented to PDI attitude and MSFN acquired. Mode II rendezvous radar lockon is then performed manually, so that rendezvous radar will be available at PDI if required. The braking program is then entered and the solutions verified. LM systems are checked and configured for powered descent.

An LPD altitude determination is made to verify a safe altitude and attitude and position checks are run using out-the-window

sightings and lunar charts. These independent checks verify LGC and MSFN trajectory and guidance calculations.

At 7 minutes prior to PDI, the AGS is updated, aligned, and configured for abort. Final preparations are made, including another altitude, attitude, and position check.

At about 15° central angle from the landing site, the DPS engine is started to begin powered descent. Throughout the powered descent, the crew monitors guidance and systems performance. The CDR primarily monitors attitudes and thrust levels, using out-the-window checks extensively for verification. The LMP monitors systems and makes AGS/PGNS comparisons to quickly identify guidance failures.

After a couple of out-the-window checks verify a nominal trajectory, the CDR yaws the vehicle face up so that landing radar can update PGNS altitude and velocity. When the visability phase is reached, the CDR redesignates as required to fly to an acceptable landing site. During this period, the LMP also updates the AGS altitude. Near the end of powered descent (currently 500 ft) the CDR takes over and manually controls the attitude until touchdown. He may also control the throttle, either completely manually, or through the LGC (ROD made). At lunar contact, the crew stops the engine. At touchdown, the crew verifies that the vehicle is stable, and that no systems problem is cause for immediate abort. A stay/no stay decision is made and if it is stay, the crew prepares for the next stay/no stay decision which occurs 10 minutes later. If this decision is stay, a launch countdown is performed which would prepare the vehicle for liftoff approximately 2 hours later. If a liftoff at that time is not required, then the vehicle is powered down and lunar surface operations are begun.

2.3 MISSION G LM PROCEDURES (UNDOCKING - LUNAR STAY)

ASUMPTION:

A. SYSTEMS ACTIVATION COMPLETE (PER CHKLST)
B. VEHICLES IN UNDOCKING ATTITUDE (PER ATT PROFILE)
C. PREP FOR UNDOCKING (PER CHKLST) AS FOLLOWS:
  - BASIC COMM WITH VHF B BACKUP
  - MISSION TIMER - SET
  - EVENT TIMER - SET
  - OVHD HATCH - LOCKED
  - OVHD CABIN RELIEF & DUMP VLV - AUTO
  - REGS A&B - CABIN
  - GUID CONT - AGS
  - RNG/ALT MON - RNG/RNG RT
  - RATE ERR MON (LMP) - RNDZ RDR
  -   (CDR) - LDG RDR/CMPTR
  - ATTITUDE MON (CDR) - PGNS
  -   (LMP) - AGS
  - RATE SCALE - 5°/SEC
  - X-TRANSL - 2 JET
  - BAL CPL - ON
  - DEADBAND - MAX
  - ATTITUDE CONTROL (3) - PULSE
  - MODE CONT (BOTH) - ATT HOLD
  - TTCA (BOTH) - JET
  - RNDZ RDR - SLEW
  - ACA/4 JET (BOTH) - ENABLE
  - TTCA/TRANSL (BOTH) - ENABLE
  - CB(11) HTRS: AOT - CLOSE

D. CREW SUITED AND RESTRAINED

CONFIGURE PGNS FOR UNDOCKING

	KEY V77E (RATE CMD)		
	KEY V62E (TOTAL ATT ERROR)		
	KEY V48E (DAP)		
F 01 46	21002		
	PRO		
F 06 47	LM WT ____________	CSM WT ____________	
	PRO		
F 06 48	PITCH ____________	ROLL ____________	
	KEY V34E (DO NOT TRIM)		
	KEY V37E 47E		
F 16 83	ΔVX,ΔVY,ΔVZ		(0.1 FPS)

98:30:00	CSM UNDOCK	
	CABIN PRESSURE HOLDING	
	VEHICLE STABLE	
	NULL UNDOCKING ΔV's	
	YAW RIGHT 120°	
	PITCH UP 90° (CSM IN FWD WDW)	
	YAW 360° FOR INSPECTION	
	ACA OUT OF DETENT ALL AXIS	
	ATTITUDE CONTROL (R,P,Y)-MODE CONT	
	PRO	
	ACQUIRE S-BAND	
	KEY V64E	
F 16 51	PITCH, YAW ANGLES	(0.01°)
	ACQUIRE LOCK-ON	
	VERIFY VOICE, TLM	
	VHF B/XMTR-OFF	
	PCM-HI	
	PRO	
	LM STA KEEP UNTIL SEP	
	MSFN UPDATE	
	P00	
	UPDATA LINK - DATA	
	MSFN UPDATE LM S.V. IN LGC (P 27)	
	UPDATA LINK - OFF	
	COPY PAD DATA FOR DOI,POWERED DESCENT	
98:55:59	CSM SEP (2.5 FPS RADIAL DN)	
	MSFN UPDATE	
	UPDATA LINK - DATA	
	MSFN UPDATE CSM S.V. IN LGC (P 27)	
	UPDATA LINK - OFF	
	SET ORB RT BALL	

AGS UPDATE AND ALIGN

KEY V47E
F 06 16 90:00:00 AGS CLOCK ZERO TIME
*414 + 1E
PRO
*414 R (00000)
F 50 16 UPDATE COMPLETE
PRO
*400 + 3E
*400 R (00000)
FDAI AGS = FDAI PGNS

LOAD DOI TARGETING

KEY V37E 30E
F 06 33 ____:___:_____ TIG
(99: 54:12.10)
PRO
F 06 81 _____ ΔVX _____ ΔVY _____ ΔVZ
(-72.8) (0) (+2.2)
PRO
F 06 42 HA,HP,ΔVT (58.2,8.2nm,72.8 fps)
PRO
F 16 45 M,TFI,MGA
RESET ET
PRO
POO

R/VHF RANGING CHECK

:SM TRANSPONDER ON, TRACKING ATT
:NDZ RADAR TEMP 10-150°F
:ADAR TEST-OFF
:B/PGNS: SIG STR DISP - CLOSE
:EST MON - AGC
:R MODE - SLEW
:ATE/ERR MON - RNDZ RADAR
:NG/ALT MON - RNG/RNG RT

-50 CB/AC BUS A: RNDZ RDR - CLOSE
WAIT 30 SEC
CB/PGNS: RNDZ RDR - CLOSE
GUID CONT - PGNS
KEY V37E 20E
F 50 18 R,P,Y ANGLES (.01°)
KEY V95E (NO UPDATE)
MODE CONTROL (PGNS) - AUTO
PRO
06 18
F 50 18 PLEASE TRIM
ENTR (TRIM NOT REQ'D)
F 50 25 00201 REQUEST LGC MODE
ENTR
00205
SLEW ANTENNA TO 0,0 AND PEAK AGC
RR MODE - AUTO TRACK
NO TRACK LITE - OUT
MODE CONTROL (PGNS) - ATT HOLD
ZERO RR ERROR NEEDLES
RR MODE - LGC
NO TRACK LITE - ON, THEN OFF
PRO
MODE CONTROL (PGNS) - AUTO

*507 + 0E +Z LOS
*400 + 2 E ACQ STEER
MODE CONTROL (AGS) - AUTO
DEADBAND - MIN
AGS ATTITUDE ERRORS ZERO
GUID CONT - AGS
POO
KEY V63E RADAR SELF TEST
F 04 12 00004 00001 1=RR
PRO
F 16 72 TRUN, SHFT ANGLES (.01°)
PRO
F 16 78 RNG,RNG RT (.01nm, FPS)

VHF A XMTR - VOICE/RNG (AT CSM REQUEST)
VHF A RCVR - OFF
VHF B XMTR - OFF
VHF B RCVR - ON

RR DATA ON DSKY SAME AS CSM VHF

KEY V34E
VHF A XMTR - VOICE
VHF A RCVR - ON
VHF B XMTR - DATA
VHF B RCVR - OFF
PCM - LO
WAIT 30 SEC
VHF B XMTR - OFF
PCM - HI

MODE CONTROL (AGS) - ATT HOLD
*400 + 0E ATT HOLD
DEADBAND - MAX

DESIGNATE RR ANT TO CLEAR AOT

KEY V41 N72E
F 21 73 +00000 TRUN +283.00 SHFT
PRO
04 06 00006 00002 (CONT DESIGNATE)
PRO
41 KEY V16 N72E
16 72 MONITOR TRUN AND SHFT ANGLES
KEY V44E (TERMINATE)
--/PGNS: RNDZ RDR - OPEN

IGN IMU

-40 CB/AC BUS A: AOT LAMP - CLOSE
AOT DETENT -F
KEY V37E 52E
F 04 06 00001 00003 (REFSMMAT)
PRO

F 50 25 00015 (ACQUIRE STAR #1)
GUID CONT - PGNS
ENTR
F 01 70 002XX LOAD STAR #1
PRO
F 50 18 R,P,Y ANGLES (.01°)
MODE CONTROL - AUTO
PRO
06 18
F 50 18 PLEASE TRIM
MODE CONTROL - ATT HOLD
ENTR (TRIM NOT REQ'D)
F 01 71 002XX
PRO
F 54 71 MARK X OR Y
KEY V76E (PULSE)
MARK 4 PAIR X,Y
PRO
F 01 70 002XX LOAD STAR #2
PRO
F 50 18 R,P,Y ANGLES
MODE CONTROL - AUTO
PRO
06 18
50 18 PLEASE TRIM
MODE CONTROL - ATT HOLD
ENTR (TRIM NOT REQ'D)
F 01 71 002XX
PRO
F 54 71 MARK X OR Y
MARK 4 PAIR X,Y
PRO
F 06 05 STAR ANGLE DIFF (.01°)
REJECT: KEY V32E (RECYCLE TO R51)
ACCEPT: PRO
F 06 93 X,Y,Z GYRO TORQUING ANGLES (.001°)
PRO
F 50 25 00014 PLEASE FINE ALIGN
PRO (CHECK ALIGNMENT)

F 50 25 00015 ACQUIRE STAR
ENTR
F 01 70 002XX LOAD CHECK STAR
PRO
F 50 18 R,P,Y FDAI ANGLES
MODE CONTROL - AUTO
PRO
06 18
F 50 18
ENTR
OBSERVE CHECK STAR IN AOT
REJECT: REPEAT ALIGNMENT
ACCEPT: KEY V34E
MODE CONTROL - ATT HOLD
POO
KEY V77E
GUID CONT - AGS
CB/AC BUS A: AOT LAMP - OPEN
AOT DETENT - CL

-20 SYSTEM CHECK:
PROPULSION SYS: TEMPS/PRESS -NOR
DES REG: TB's -1/BP 2/GRAY
ASC REG: TB's (2)-GRAY
RCS QUADS: TB's (8)-GRAY
MAIN SOV: TB's (2)-GRAY
CRSFD: TB-BP
ASC FEED: TB's (4)-BP
ECS SYS: TEMPS/PRESS-NOR
ASC BATS: NORMAL sw (2)-ON
EPS SYS: VOLTS/AMPS-NOR

SECURE CABIN AND CREW

-15 LR TEST

CB/PGNS: LDG RDR - CLOSE
X-POINTER (BOTH)- HI MULT
TEMP MON - LDG RDR (10-50°F)
RNG/ALT MON - ALT/ALT RT
LDG ANT - DES
MODE SEL - LDG RDR
RADAR TEST - LDG
X-POINTERS UP AND LEFT .
TM TAPES DRIVE
TEST MONITOR - ALT XMTR (2.1-5.0)
- VEL XMTR (2.1-5.0)
TM ALT - +7913 to +8050 ft
ALT RT - -237 to -243 fps
LDG ANT - HOVER (10 sec)
TM ALT/ALT RT - SAME AS ABOVE
LDG ANT - DES (10 sec)
POO
KEY V63E
F 04 12 00004 00002
PRO
F 16 66 +08195 to +08357 RNG, 00001 ANT POS
PRO
F 16 67 -00244 to -00250 VX
-00918 to -00940 VY
+00658 to +00672 VZ
KEY V34E
LDG ANT - AUTO
KEY V60E (22 sec)
TM ALT - +7913 to 8050 ft
ALT RT - -237 to - 243 fps
KEY V63E
F 04 12 00004 00002
PRO
F 16 66 +08195 to +08357 RANGE
00002 ANT POS
LDG ANT - DES (10 sec)
R2 - 00001
F 05 09 PROG LT ON 00522 LR POS CHANGE
LDG ANT - AUTO
R2 - 00001
PRO
KEY V34E
RADAR TEST - OFF

-7 UPDATE, ALIGN, CONFIGURE AGS

KEY V47E
F 06 16 90:00:00 AGS ZERO TIME
*414 + 1E UPDATE
PRO
*414 R (00000)
F 50 16 UPDATE COMPLETE
PRO
*400 + 3E ALIGN
*400 R (00000)
FDAI PGNS = FDAI AGS
*411 + 0E DPS
*410 + 5E EXT ΔV
(AT LOS)
PCM-LO
VHF B/XMTR-DATA

-6 ENTER THRUSTING PROGRAM

KEY V37E 40E
F 50 18 R,P,Y BURN ATTITUDE (.01°) (0,285,0)
KEY V06N 86E
F 06 86 _____ ΔVX _____ ΔVY _____ ΔVZ
KEY RLSE
GUID CONT - PGNS
MODE CONTROL (PGNS,AGS) - AUTO
PRO
06 18
F 50 18 TRIM
AGS ATTITUDE ERRORS NOMINAL
ENTR (TRIM NOT REQ'D)
F 06 40 TFI,VG,ΔVM
*450 LOAD
*451 LOAD
*452 LOAD
*400 + 1E GUID STEER
*407 + 0E REF FRAME
*500 R VGX

CB/ EPS: CROSS TIE BAL LOADS - OPEN
CB/INST: CWEA - OPEN THEN CLOSE
KEY V78E LR SPURIUS TEST
-4 ENG GIMBAL - ENABLE
THROTTLE - MIN
THR CONT - AUTO
MAN THROT - CDR
BAL CPL - ON
DES ENG CMD OVRD - OFF
ENG STOP PB (BOTH) - RESET
ABORT/ABORT STAGE - RESET
TEMP LDG RDR _____°F
-1 CB/STAB/CONT: DECA PWR - CLOSE
CB/STAB/CONT: DES ENG OVRD - CLOSE
MASTER ARM - ON

-:35 ENG ARM - DES
PRPLNT QTY MON - DES 1
MODE CONTROL (AGS) - ATT HOLD

-:07 ULLAGE (AUTO)
F 99 40 ENABLE IGNITION
PRO
06 40
00:00 ENGINE START, START ET COUNTING UP
06 40 TFC,VG,ΔVM
THRUST = 10%
RATES/ERRORS ZERO
+ :15 THROTTLE UP TO 40%
+ :27.5 ENGINE CUTOFF
ENG STOP PB - PUSH
PRO
F 16 85 ΔVX ΔVY ΔVZ RESIDUALS
BURN RESIDUALS
*500 (VGX) _____
*501 (VGY) _____
*502 (VGZ) _____
PITCH DOWN 90°
KEY V82E

F 16 44 APO ALT, PER ALT, TFF (58.2,8.2,59B59)
PRO
ENG ARM - OFF
ENG GMBL - OFF
MASTER ARM - OFF
PRPLNT QTY MON - OFF
KEY V79E (stop LR Spurius test)
LR TEMP _____°F

VERIFY ΔVX WITH RR

CB/PGNS: RNDZ RDR - CLOSE
RR MODE - LGC
KEY V37E 20E
F 50 18 R,P,Y ANGLES (.01°)
KEY V95E
PRO
06 18
F 50 18 PLEASE TRIM
ENTR
NO TRACK LITE - OUT
*400 + 2 ACQ STEER
MODE CONTROL (AGS) - AUTO
AGS ATTITUDE ERRORS ZERO
GUID CONT - AGS
POO
KEY V63E
F 04 12 00004 00001 1=RR
PRO
F 16 72 TRUN, SHFT ANGLES
PRO
F 16 78 RNG, RNG RT (.01nm, FPS)
VERIFY RANGE RATE NOMINAL
CONFIRM ΔV WITH CSM
MAKE ABORT OR CONTINUE DECISION
(CONTINUE)
KEY V34E

SYSTEMS CLEANUP

CB/PGNS: LDG RDR - OPEN
CB/PGNS: RNDZ RDR - OPEN
CB/STAB/CONT: DECA PWR - OPEN
CB/STAB/CONT: DES ENG OVRD - OPEN
CB/EPS: CROSS TIE BAL LOADS - CLOSE
*400 + 0E (ATT HOLD)
MODE CONTROL (BOTH) - ATT HOLD
ASC BATS: NORMAL (2) - OFF/RESET
PROPULSION SYSTEM TEMPS/PRESS - NOR

GO TO PDI ATTITUDE, ACQUIRE S-BAND

PITCH DOWN TO 105°
YAW 180° (P=285 USD)
(AT AOS)
KEY V64E
F 16 51 S-BAND PITCH YAW (.01°)
ACQUIRE LOCK-ON
VERIFY VOICE, TLM
VHF B/XMTR - OFF
PCM-HI
PRO
TRANSMIT DOI RESULTS

OBTAIN MODE II RR LOCK-ON

CB/PGNS: RNDZ RDR - CLOSE
KEY V41 N72E
F 21 73 +180.00 TRUN +090.00 SHFT
PRO
F 04 06 00006 00002
PRO

KEY V16 N72E MONITOR DRIVE
KEY V44E (TERMINATE DESIG)
RR MODE - SLEW
PERFORM MANUAL LOCK-ON
RR MODE - AUTO TRACK
NO TRACK LITE - OUT

DOI + 35 (PDI - 25) — ENTER BRAKING PROGRAM

KEY V37E 63E
F 06 61 — TGO _____, TFI, CR _____ (.1nm)
RESET ET
PRO
F 50 25 — 00014 FINE ALIGN
ENTR (BYPASS ALIGNMENT)
F 50 18 — R,P,Y ANGLES (.01°) P=285 USD
GUID CONT - PGNS
MODE CONTROL (PGNS) - AUTO
PRO

06 18
F 50 18 — PLEASE TRIM
ENTR
06 62 — VI, TFI, ΔVM

-20 — SYSTEMS CHECK

PROPULSION SYS: TEMPS/PRESS - NOR
DES REG: TB's - 1/BP 2/GRAY
ASC REG: TB's (2)-GRAY
MAIN SOV: TB's (2)-GRAY
CRSFD: TB-BP
ASC FEED: TB's (4)-BP
ECS SYS: TEMPS/PRESS - NOR
ASC BATS: NORMAL (2)-ON
EPS SYS: VOLT/AMPS - NOR
SECURE CABIN AND CREW

-15 — ALTITUDE, ATTITUDE, POSITION CHECKS

-7 — UPDATE, ALIGN, CONFIGURE AGS

KEY V47E
F 06 16 — 90:00:00 AGS ZERO TIME
*414 + 1E UPDATE
PRO
*414 R (00000)
F 50 16 — UPDATE COMPLETE
PRO
KEY V83E
F 16 54 — R/R DOT/THETA (R-.01nm)
*317 R (R-.1nm)
AGS RANGE = PGNS RANGE
PRO
*400 + 3E ALIGN
*400 R (00000)
FDAI PGNS = FDAI AGS
*400 + 1E GUID STEER
*232 LOAD (+00600 INJ ALT)
*465 LOAD (+00180 ALT RT)
*411 + 0 DPS
*623 + 0 YAW STEER SELECT
*433 R VI

-4 — CB/ EPS: CROSS TIE BAL LOADS - OPEN
CB/INST: CWEA - OPEN THEN CLOSE
ENG GIMBAL - ENABLE
THROTTLE - MIN
THR CONT - AUTO
MAN THROT - CDR
BAL CPL - ON
DES ENG CMD OVRD - OFF
ENG STOP PB (BOTH) - RESET
ABORT/ABORT STAGE - RESET
CB/PGNS: LDG RDR - CLOSE

-3	ALTITUDE, ATTITUDE, POSITION CHECK
-1	CB/STAB/CONT: DECA PWR - CLOSE CB/STAB/CONT: DES ENG OVRD - CLOSE
-:35	ENG ARM - DES PRPLNT QTY MON - DES 1 DEADBAND - MIN MODE CONTROL (AGS) - ATT HOLD
-:07 F 99 62	ULLAGE (AUTO) ENABLE IGNITION PRO
00:00	ENGINE START, START ET COUNTING UP

POWERED DESCENT MONITORING

	CDR	LMP	VI	H	H DOT	FDAI P	OHW <	DPS PROP
00:00	ENG START	RESET ET TO COUNT UP		50.0	0			
	THRUST = 10%	VI COUNTING DN (PGNS,AGS)						
	RATES/ERRORS-ZERO	H DKSY = H TM						
		H DOT DSKY = H DOT TM						
00:26	THRUST = 97%							
		LR ALT LT-ON (50 K)						
	RATES/ERRORS-ZERO	SUPRCRIT HE < PSI						
	DES ENG CMD OVRD-ON							
01:00	FDAI P	VI PGNS = VI AGS		49.8	-14			
	OHW <	H PGNS = H AGS (TM)						
	R,Y - ZERO	H DOT PGNS = H DOT AGS (TM)						
	GROUND TRACK IN PLANE	R DOT AGS (440)=R DOT RR(TM)						
	AGS BALL = PGNS BALL	VLAT PGNS = VLAT AGS						
02:00	LPD ALT CHECK	DPS PROP		48.5	-35			
		SUPRCRIT HE < PSI						
		DPS TEMP/PRESS - NOR						
	CB/PGNS: RNDZ RDR - OPEN	RCS QUAN < %						
		RCS TEMP/PRESS - NOR						
		SUIT/CABIN PRESS - NOR						
		PP C02 - NOR						
		GLYCOL TEMP/PRESS - NOR						
		02/H20 QUAN - NOMINAL						
		CDR BUS - VDC						
03:00	FDAI P	VI PGNS - VI AGS		45.7	-60			
	OHW <	H PGNS = H AGS (TM)						
	R,Y - ZERO	H DOT PGNS = H DOT AGS (TM)						
	GROUND TRACK IN PLANE	VLAT PGNS = VLAT AGS						
	AGS BALL = PGNS BALL							

			VI	H	H DOT	FDAI P	OHW <	DPS PROP
04:00	YAW RIGHT 180° (>35 K)	DPS PROP		41.0	-92			
		SUPRCRIT HE						
		DPS TEMP/PRESS - NOR						
		RCS QUAN > %						
		RCS TEMP/PRESS - NOR						
		SUIT/CABIN PRESS - NOR						
		PP C02 - NOR						
		GLYCOL TEMP/PRESS - NOR						
		02/H20 QUAN - NOMINAL						
		CDR BUS - VDC						
		MAINTAIN S-BAND LOCK						
05:00	FDAI P	LR ALT LITE - OFF		34.5	-123			
	R,Y - ZERO	KEY V16 N68 E						
	PGNS BALL = AGS BALL	RANGE, TGO, ΔH						
		ΔH WITHIN LIMITS						
		KEY V57 E						
		ΔH DECREASING						
		KEY RLSE						
		VI , H , H DOT						
06:00		DPS PROP		26.5	-131			
		RCS QUAN						
	THRUST = 57% (06:20)	VI PGNS = VI AGS						
	MODE CONTROL (PGNS)-ATT HOLD	H PGNS = H LR (TM)						
	EVALUATE MANUAL CONTROL	H DOT PGNS = H DOT AGS (TM)						
	MODE CONTROL (PGNS) - AUTO	VLAT PGNS = VLAT AGS						
		NO LR VEL LT AT VI = 2000						
07:00	FDAI P	DPS PROP						
	R,Y - ZERO	DPS TEMP/PRESS - NOR		19.0	-150			
	PGNS BALL = AGS BALL	RCS QUAN > %						
	HORIZON IN FWD WDW	RCS TEMP/PRESS - NOR						
		SUIT/CABIN PRESS - NOR						
	THRUST = 59%	PP C02 - NOR						
		GLYCOL TEMP/PRESS - NOR						
		02/H20 QUAN - NOMINAL						
		CDR BUS - VDC						

			VI	H	H DOT	FDAI P	OHW <	DPS PROP
08:00	THRUST = 59%	VI PGNS = VI AGS KEY V16 N68 E RANGE, TGO, ΔH *223 + 00020 (DO NOT ENTER)		9.5	-144			
	PITCHOVER AT P64 THRUST DECREASES LANDING SITE VISABLE LDG ANT - HOVER	P64 AT TGO = 60 SEC TGO/LPD, H DOT, H H DOT DECREASING____FPS/SEC						
09:00	PRO AND REDSGNTE IF REQ	CALL OUT LPD ANGLES AT H = 2000 FT, KEY ENTER ON DEDA		3.0	-73			
10:00	MODE CONTROL (PGNS) - ATT HOLD CONTROL ATTITUDE MANUALLY NULL VH OVER LANDING SITE ACTIVATE ROD FOR LANDING	CALL OUT H, HDOT, DPS PROP UNTIL TOUCHDOWN P 65 VH, H DOT, H P 66		.5	-17 -3 LAST 150' FT			
12:00	LUNAR CONTACT LIGHT	LUNAR CONTACT LIGHT						
	ENGINE STOP - PUSH							
	TOUCHDOWN	TOUCHDOWN						
	VEHICLE STABLE ACA OUT OF DETENT (STOPS RCS) DES ENG CMD OVRD - OFF ENG ARM - OFF	SYSTEMS SAFE						
	REPORT STATUS TO MSFN 2 MIN ABORT NOT REQUIRED	*223 + 00000 E (ZERO AGS ALT) *413 + 1 E (STORE AZIMUTH)						
	CB/PGNS: LDG RDR - OFF MASTER ARM - ON DES VENT - FIRE MASTER ARM - OFF OXID VENT - OPEN							

PREP FOR 12 MIN ABORT

+02:00 KEY V37E 68 E
F 06 43 LAT _____ LONG _____ ALT _____(.01°,.1nm)
PRO

KEY V37E 12 E
F 06 33 _____:_____:_____ TIG
(POI + 23 MIN)
F 06 76 CR _____ APO ALT _____ (.1nm)
(<) (45.0)
PRO
F 06 74 TFI, YAW _____ PITCH _____

*400 + 3 (ALIGN)
*400 R (00000)
*400 + 1 GUID STEER

DETERMINE GO FOR 1 REV

OXID VENT - CLOSE (AT DPS PRESS <)
WAIT 30 SEC
FUEL VENT - OPEN (CLOSE AT PRESS <)
KEY V34 E (TERMINATE P12)

SYSTEMS CLEANUP

PRPLNT QTY MON - OFF
ENG GMBL - OFF
CB/AC BUS A: RNDZ RDR - OPEN
CB/STAB/CONT: DECA PWR - OPEN
CB/STAB/CONT: DES ENG OVRD - OPEN
CB/EPS: CROSS TIE BAL LOAD - CLOSE
ASC BATS: NORMAL (2) - OFF/RESET
MODE CONTROL (PGNS,AGS) - OFF
ACA/4 JET (BOTH) - DISABLE
TTCA/TRANSL (BOTH) - DISABLE
ACA PROP (BOTH) - DISABLE

SIMULATED COUNTDOWN
TBD

3.1 POWERED DESCENT ABORTS

Aborts from powered descent will be controlled by the PGNS, AGS or manually by the crew. The PGNS and AGS are targeted to guide the IM to a safe orbit with variable insertion velocities to improve rendezvous phasing. Aborts will be controlled by PGNS, if operational, or by AGS if the PGNS has failed. The abort action will occur only if the lunar landing phase cannot be continued or completed safely.

These abort procedures assume that the abort decision has been made and the abort mode has been selected. The recent changes in the abort targeting have simplified the abort procedures. The procedures for an abort, with a particular guidance system/engine combination, are fairly consistent throughout the powered descent phase. Of course, high altitude and low altitude aborts differ procedurally, since a staging will be required in the low altitude case. Aborts from around 300 seconds into powered descent should be avoided since DPS propellant depletion and a subsequent staging sequence will occur near insertion. During an abort, the crew must assess guidance, engine and general system performance onboard, with help from MSFN if S-BAND lock is not broken. If PGNS and AGS parameters are diverging during an abort, it is possible that a third vote will be required to determine which system has failed. This third vote may come from the rendezvous radar data (assuming R29 has performed its function), visual sightings on the horizon, nominal trajectory data, or MSFN. If the AGS fails during an AGS abort, a manual insertion will be performed. These procedures are dependent upon the control modes available and will be developed in the near future. A redundant "engine on" command and APS/RCS fuel interconnection should be established on APS aborts, if time permits. The redundant path is established by arming the engine and depressing the start pushbutton. The engine must be dearmed prior to insertion to get a guidance commanded cutoff.

3.2 PGNS - DPS ABORT (AGS OPERATIVE)

TIME	STA	PROCEDURE
TAB	C	MOVE TTCA TO MAX POSITION
		VERIFY FULL THRUST
	P	RECORD TAB
		Perform following 5 steps if aborting from P66/67
	06 60	VI, HDOT, H
	C	1. MANEUVER +X TO LOCAL VERTICAL
		2. HOLD ATTITUDE
	P	3. REPORT DPS PRPLNT QTY
		4. AT PRPLNT QTY = ___%: ABORT STG PB-PUSH
		5. GO TO PGNS - APS PROCEDURE
	C	ABORT PB - PUSH
	06 63	VI, HDOT, H
	P	VERIFY P70/+HDOT
		H<25K
	C	MONITOR MANEUVER TO LOCAL VERTICAL - +Z DOWN RANGE
		H>25K or HDOT >+40FPS
		VERIFY PITCH INITIATE
		MODE SEL - PGNS
	P	ATT MON - AGS
		MODE CONT (AGS) - AUTO
		VERIFY SYSTEMS STATUS
		MONITOR DPS PRPLNT QTY
		NOTE: WHEN PRPLNT QTY = ___% ABORT STG PB-PUSH, GO TO PGNS - APS PROCEDURE
		GUIDANCE CHECK
	P	RECORD TARGETED VI (PAD/DSKY**)
	C,P	VERIFY RATES/ATT ERR'S IN LIMITS - PGNS/AGS
	P	*433R (VI)
		COMPARE PGNS/AGS VI
		COMPARE PGNS/AGS TOTAL ATTITUDE (FDAI)
	C	COMPARE PGNS/AGS H/HDOT (TM)
		MAKE ATTITUDE CHECK ON HORIZON/STAR
		NOTE: ABORTS ABOVE 35K WILL BE FACE UP AND HORIZON WILL NOT BE VISIBLE

**PCR 708: N76 - Targeted horizontal forward velocity (Vhf).

TIME	STA	PROCEDURE
	P	KEY V16 N77E
	16 77	(TG, VY)
		VERIFY TGO NOMINAL
		SET EVENT TIMER
		KEY REL
	06 63	(VI, HDOT, H)
		ENGINE CHECK
	C	THRUST CMD/ENG = ___%
		PROPULSION SYS: TEMP/PRESS - NOR
		T/W - NOMINAL
	C,P	PERFORM SYSTEMS/GUIDANCE/ENGINE
		CHECKS PERIODICALLY UNTIL INSERTION
		INSERTION
	P	VERIFY VI APPROACHING TARGETED VALVE
		MONITOR TG/DPS PRPLNT QTY
		KEY V16 N85
	16 85	VGX, VGY, VGZ
	C	MONITOR VGX
		MONITOR H/HDOT (TM)
		MONITOR SHUTDOWN
		NOTE: IF VGX BECOMES NEGATIVE:
		ENG STOP PB - PUSH
		*500R (VGX)
		VGX >30FPS
	F 97 XX	(ENG FAIL) - PRPLNT DEPLETION
		ABORT STG PB - PUSH
	06 63	VI, HDOT, H
		MONITOR APS IGNITION AND SHUTDOWN
		ABORT STG - RESET
	F 06 63	
		ENG ARM - OFF
		DES ENG CMD OVRD - OFF
		PRO
	F 16 85	VGX, VGY, VGZ
		MODE CONT (PGNS) - ATT HOLD
		NULL RESIDUALS (TTCA)
		5 FPS < VGX < 30 FPS
		GUID CONT - AGS
		ENG STOP PB - PUSH
		TRANSL +X (TTCA)
		STAGE sw - FIRE
		NULL RESIDUALS (TTCA)
		ENG ARM - OFF
		DES ENG CMD OVRD - OFF
		ENG STOP PB - RESET

TIME	STA	PROCEDURE
		VGX <5FPS
16	85	VGX, VGY, VGZ ENG ARM - OFF DES ENG CMD OVRD - OFF MODE CONT (PGNS) - ATT HOLD NULL RESIDUALS CONTINUE WITH POST INSERTION PROCEDURES (TBD)

3.3 PGNS - APS ABORT (AGS OPERATIVE)

TIME	STA	PROCEDURE
	C	ABORT STG PB - PUSH
		VERIFY APS THRUST (T/W IND)
	P	RECORD TAB (IF NOT DONE)
		VERIFY P71
		Perform following 3 steps if aborting from P66/67
	F 50 25	00203
		1. MODE CONT (PGNS) - AUTO
		2. PRO
		3. ENT
	06 63	(VI, HDOT, H)
		VERIFY + HDOT
		H <25K:
	C	MONITOR PITCH TO LOCAL VERTICAL - +Z
		DOWN RANGE
		H >25K or HDOT >+40FPS:
		VERIFY PITCH INITIATE
		MODE SEL - PGNS
		ATT MON - AGS
		MODE CONT (AGS) - AUTO
		VERIFY SYSTEMS STATUS
		(IF TAB > ___ SEC)
	C	ENG ARM - ASC
		ENG START PB - PUSH
	P	SYSTEM A: ASC FEED - OPEN
		SYSTEM B: ASC FEED - OPEN
		VERIFY ASC FUEL/OXID TB'S - GRAY
		GUIDANCE CHECK
	P	RECORD TARGETED VI (PAD/DSKY)
	C,P	VERIFY RATES/ATT ERR'S IN LIMITS (PGNS/AGS)
	P	*433R (VI)
		COMPARE PGNS/AGS VI
		COMPARE PGNS/AGS TOTAL ATTITUDE (FDAI)
		COMPARE PGNS/AGS H/HDOT (TM)
		MAKE ATTITUDE CHECK ON HORIZON/STAR
		NOTE: ABORTS ABOVE 35K WILL BE FACE UP AND HORIZON WILL NOT BE VISIBLE

3.4 AGS - DPS ABORT (PGNS FAILED)

TIME	STA	PROCEDURE
	C	MOVE TTCA TO MAX POSITION GUID CONT - AGS ATT MON - AGS NOTE: IF VEHICLE ATTITUDE UNSTABLE: 1 GUID CONT - AGS 2 MANEUVER TO APPROXIMATE ABORT ATTITUDE 3 THROTTLE UP ABORT PB - PUSH
	P	RECORD TAB
	C	MODE CONT (AGS) - AUTO MODE SEL - AGS MONITOR ATT ERR'S/RATES VERIFY FULL THRUST H < 25K MONITOR MANEUVER TO LOCAL VERTICAL H > 25K or HDOT > 50FPS VERIFY PITCH INITIATE BAL CPL - OFF
	P	VERIFY SYSTEMS STATUS MONITOR DPS PRPLNT QTY NOTE: WHEN PRPLNT QTY = ___% GO TO AGS - APS PROCEDURE
		GUIDANCE CHECK
	P	COPY VI/TG FROM PAD SET EVENT TIMER *433R (VI)
	C,P	VERIFY H/HDOT/VI NOMINAL MONITOR ATT ERR'S/RATES
	P	*347R (B.O. RADIUS) _____FT *433R MAKE ATTITUDE CHECK ON HORIZON/STAR NOTE: ABORTS ABOVE 35K WILL BE FACE UP - IF HORIZON VISIBILITY REQ'D: ATT CONT: YAW - DIRECT MANEUVER (ACA) IN YAW MAINTAIN S-BAND LOCK
		ENGINE CHECK
		THRUST ENG = ___% PROPULSION SYS: TEMP/PRESS - NOR T/W - NOMINAL

TIME	STA	PROCEDURE
		PERFORM SYSTEMS/GUIDANCE/ENGINE CHECKS PERIODICALLY UNTIL INSERTION
		INSERTION
		VERIFY VI APPROACHING TARGETED VALVE MONITOR TG/DPS PRPLNT QTY *500R (VGX) MONITOR VGX UNTIL CUTOFF NOTE: IF VGX BECOMES NEGATIVE: ENG STOP PB - PUSH
		VGX > 30FPS (THRUST FAIL - PRPLNT DEPLETION)
		ABORT STG PB - PUSH MONITOR APS IGNITION AND SHUTDOWN ABORT STG PB - RESET MODE CONT (AGS) - ATT HOLD NULL RESIDUALS
		5 FPS < VGX < 30 FPS
		ENG STOP PB - PUSH TRANSL +X (TTCA) STAGE sw - FIRE NULL RESIDUALS (TTCA) ENG ARM - OFF DES ENG CMD OVRD - OFF ENG STOP PB - RESET
		VGX < 5 FPS
		ABORT STG - RESET MODE CONT (AGS) - ATT HOLD NULL RESIDUALS
		CONTINUE WITH POST INSERTION PROCEDURES (TBD)

3.5 AGS - APS (PGNS FAILED)

TIME	STA	PROCEDURE
	C	GUID CONT - AGS
TAB		ABORT STG PB - PUSH
		MODE CONT (AGS) - AUTO
		VERIFY APS THRUST (T/W IND)
	P	RECORD TAB
	C	ATT MON - AGS
		MODE SEL - AGS
		MONITOR ATT ERR'S/RATES
		H < 25K
		MONITOR MANEUVER TO LOCAL VERT - +Z
		DOWN RANGE
		H > 25K or HDOT > 50FPS
		VERIFY PITCH INITIATION
	P	VERIFY SYSTEMS STATUS
		BAL CPL - OFF
		(IF TAB > ___ SEC)
		ENG ARM - ASC
		ENG START PB - PUSH
		SYSTEM A: ASC FEED - OPEN
		SYSTEM B: ASC FEED - OPEN
		VERIFY TB'S - GRAY
		GUIDANCE CHECK
	P	COPY VI/TG FROM PAD
		SET EVENT TIMER
		*433R (VI)
	C,P	VERIFY H/HDOT/VI NOMINAL
		MONITOR ATT ERR'S/RATES
	P	*347R (B.O. RADIUS) _____ FT
		*433R
	C	MAKE ATTITUDE CHECK ON HORIZON/STAR
		NOTE: ABORTS ABOVE 35K WILL BE FACE UP
		IF HORIZON VISIBILITY REQ'D:
		ATT CONT: YAW - DIRECT
		MANEUVER (ACA) IN YAW
		MAINTAIN S-BAND LOCK
		ENG CHECK
	C	T/W - NOMINAL
		PROPULSION SYS: TEMP/PRESS - NOR
		THROTTLE/JETS - JETS
	P	DES O2 vlv - CLOSE
		#1 ASC O2 - OPEN
		WATER TANK SEL - ASC
		PERFORM ENG/GUIDANCE/SYSTEMS CHECKS
		PERIODICALLY UNTIL INSERTION

TIME	STA	PROCEDURES
		INSERTION
		VERIFY VI APPROACHING TARGETED VALVE
		*500R (VGX)
		SYSTEM A: ASC FEED - CLOSE
		SYSTEM B: ASC FEED - CLOSE
		VERIFY TB'S - BP
		ENG ARM - OFF
		MONITOR AUTO SHUTDOWN
		NOTE: IF VGX BECOMES NEGATIVE:
		ABORT STG - RESET
		MODE CONT (AGS) - ATT HOLD
		ABORT STG - RESET
		NULL RESIDUALS (TTCA)
		ENG STOP PB - PUSH
		VERIFY START PB - RESET
		ENG STOP PB - RESET
		CONTINUE WITH POST INSERTION PROCEDURES (TBD)

3.6 TILT - OVER ABORT

TIME	STA		PROCEDURE
			ASSUMPTIONS: GUID CONT - PGNS MODE CONT (PGNS) - ATT HOLD P66/67
			LUNAR CONTACT LIGHT
	C		ENG STOP PB - PUSH
TOUCHDOWN			MONITOR RATES/TOTAL ATTITUDE
			NOTE: ABORT DECISION WILL BE BASED ON RATES, TILT ANGLE (FDAI), PHYSIOLOGICAL CUES, AND OUT THE WINDOW VIEW. (LIMITS TBD)
			ABORT STG PB - PUSH
			ROTATE TO LOCAL VERTICAL (ACA - HARDOVER)
			HOLD ATTITUDE
		F 50 25	00203
	P		MODE CONT (PGNS) - AUTO
			PRO
			ENT
		06 63	VI,HDOT,H
	C		VERIFY PITCH INITIATION
	P		VERIFY SYSTEMS STATUS
	C		ENG ARM - ASC
			ENG START PB - PUSH
	P		SYSTEM A: ASC FEED - OPEN
			SYSTEM B: ASC FEED - OPEN
			VERIFY ASC FUEL/OX TB'S - GRAY
	C		ENG STOP PB - RESET
			CONTINUE WITH GUIDANCE CHECK IN PGNS - APS PROCEDURE.

4.1 LUNAR ASCENT SUMMARY

The lunar ascent phase begins 3 hours prior to ignition for powered ascent and ends at orbit insertion, after powered ascent. It is assumed that the flight crew has performed a simulated countdown immediately after touchdown, and that the IMU was aligned and has remained powered-up throughout lunar stay. MSFN will have obtained enough data to determine gyro drift rates and alignment accuracies in both PGNS and AGS and will be able to recommend which system should be used for powered ascent. Nominally, the PGNS will be the prime system with the AGS in the follow-up mode. It is also assumed that the CSM has made a plane change such that it will pass over the landing site immediately prior to liftoff. The LM can take out a maximum of 0.5 degrees of out-of-plane error during powered ascent.

At TIG -3 hours the crew turns on the LGC and AEA and performs self tests of both systems. The LGC is updated by MSFN with, among other things, the radius of the landing site and the time of ignition. The rendezvous radar is then self tested in preparation for use (P22) in tracking the CSM on its last pass. An option 1 alignment (REFSMMAT/ gravity) is performed and the RR antenna is designated by P22 to acquire the CSM.* The crew uses the RR data onboard as a backup means of determining liftoff time. The antenna is then designated for CSM acquisition during powered ascent. An option 3 alignment (Celestial body/gravity) is performed assuming there is a visible body (star/ planet) at least 20 degrees from the gravity vector. If there are no visible celestial bodies, the option 1 alignment will be primary for liftoff. The AGS is then aligned (lunar align) and the PGNS/AGS gravity vectors can be compared. The crew then receives and records data from MSFN and another option 3 alignment is performed. The AGS is then updated, aligned to the PGNS, and calibrated. The DAP is configured for powered ascent and the crew prepares the vehicle for staging. The ascent batteries are put on the line, but the descent batteries are not removed until 5 to 15 minutes later (2 at a time). The ascent engine is pressurized and the RR is turned on. P12, the ascent program is entered at TIG -20 minutes and a prelaunch system's and switch configuration check is made. The transfer to ascent power is completed and at TIG -5 minutes the AGS is again aligned to PGNS and configured for powered ascent. At TIG -20 seconds the abort stage pushbutton is activated enabling the LGC to send the "Engine On" command at TIG. The actual staging command, which is interlocked with the "On" command, is also issued at this time. The CDR activates

*The most optimum alignment sequence has not been determined, but the sequence presented should be representative and adequate for timeline development.

the engine start switch immediately after the engine starts, to establish a redundant engine on command. The LGC yaws the vehicle +Z axis downrange and initiates pitchover when HDOT is equal to 40 fps. The crew monitors guidance performance (PGNS and AGS) and will switch to AGS should the PGNS performance degrade. The crew will use visual references and RR data to help monitor the trajectory. These procedures will be further developed and refined on simulators. The ascent phase terminates a short time after LM insertion and residual nulling.

4.2 SEQUENCE OF EVENTS.

TIG -03:00:00	1.	LGC/AGS TURN ON
	2.	LGC SELF TEST
	3.	LGC UPDATE (P27)
	4.	RR SELF TEST
	5.	AGS SELF TEST
	6.	OPTION 1 ALIGN
-02:30:00	7.	RR TRACKING (P22)
	8.	OPTION 3 ALIGN
	9.	AGS LUNAR ALIGN
	10.	PAD DATA TRANSMISSION
-01:30:00	12.	OPTION 3 ALIGN
	13.	AGS UPDATE/ALIGNMENT/CALIBRATION
	14.	DAP LOAD
	15.	PREPARATION FOR STAGING
		a. APS PRESSURIZATION b. ASCENT BATTERIES ON c. RR ON d. INTERCONNECTS - OPEN e. ASC CONSUMABLES
-00:20:00	16.	ENTER P12
	17.	PRELAUNCH SYSTEMS CHECK
	18.	PRELAUNCH SWITCH CHECK/ASC POWER
-00:07:00	19.	AGS INITIALIZATION/CONFIG. FOR ORBIT INS.
-00:00:00	20.	POWERED ASCENT
+00:07:00	21.	INSERTION

4.3 ASCENT PROCEDURES

ASSUMPTIONS:

a. IMU POWERED UP
b. SYSTEM ACTIVATION AND C/O COMPLETE
c. RR OPERATE BREAKER CLOSED -2 HOURS

TIME		PROCEDURE
-03:00:00		BEGIN COUNTDOWN TO LIFT-OFF
		IF STBY LT ON - PRO
		KEY RESET WHEN LT - OFF
		GUID CONT - PGNS
		(VERIFY AEA AND AGS CB'S CLOSED - 15 MIN)
		AGS STATUS sw - STANDBY
		MASTER ALARM - RESET
		LGC SELF TEST
		KEY V96E (S/V UPDATE INHIBIT)
		VERIFY POO SELECTED
		KEY V35E
	F 88 88	DSKY LT CHECK
		VERIFY LTS ON: MASTER ALARM, LGC, ISS, ALL DSKY LTS
		VERIFY ALL 8'S IN REGISTERS
		KEY V25 N01E 1365E (ZERO COUNTERS)
	F 21 01	E, E, E
		KEY V15 N01 1365E
	15 01	(ALL ZERO)
		KEY V21 N27E 10E (TEST FIXED/ERASABLE MEMORY)
		KEY REL
		MONITOR R1 NO. OF ERRORS R2 NO. OF TESTS R3 NO. OF SUCCESSFUL TESTS
		VERIFY R2 $\geq$ 3 WITHIN 78 SEC
		KEY V21 N27E 0E (TERMINATE SELF TEST)
		KEY V37E 00E
		LGC UPDATE
		COORDINATE UPLINK WITH MSFN (RECEIVE TIG-VOICE)
		CB/COMM: UP DATA LINK - CLOSE
		UP DATA LINK - DATA
		KEY V21 N01E, 00045E, 00000E
		VERIFY UPLINK ACTY LT - ON
		VERIFY UPLINK ACTY LT - OFF
		UP DATA LINK - OFF
		KEY RESET, CLR
		PRO
		KEY V96E

TIME	PROCEDURE
	RR SELF TEST
	TEMP MON sel - RNDZ RDR
	VERIFY TEMP $\geq$ 10° F
	ATT MON (BOTH) - PGNS
	SHFT/TRUN - $\pm$50°
	RNG/ALT MON - RNG/RNG RT
	RATE/ERR MON (BOTH) - RNDZ RADAR
	RNDZ RADAR sel - SLEW
	X-POINTER SCALE (BOTH) - HI MULT
	CB/AC BUS A: RNDZ RDR - CLOSE (WAIT 30 SEC)
	CB/PGNS: RNDZ RDR - CLOSE (NO TRACK LT - ON)
	SLEW RATE - HI
	KEY V16 N72
F 16 72	RR TRUN, SHFT (.01)
	SLEW ANTENNA RIGHT-UP/RIGHT-DOWN
	VERIFY FDAI NEEDLE DEFLECTIONS
	VERIFY DSKY ANGLES (+)
	RNDZ RDR - AUTO TRACK (CAUTION LT/M.A.)
	RESET MASTER ALARM
	RADAR TEST - RNDZ RDR
	(12 SEC, NO TRACK/CAUTION LT - OUT)
	TEST MONITOR - AGC (___ to ___)
	XMTR PWR (___ to ___)
	SHFT ERR (___ to ___)
	TRUN ERR (___ to ___)
	AGC
	RNDZ RDR - LGC (NO TRACK LT - ON)
	KEY V63E (SELF TEST)
F 04 12	(00004, 00001)
	PRO
	NO TRACK LT - OUT (12 SECONDS)
F 16 72	TRUN, SHFT (.01)
	PRO
F 16 72	R1 RANGE 200 NM
	R2 R DOT 459-541 FPS
	VERIFY R/RDOT ON TAPEMETER
	KEY V34E
	KEY V40 N72E - RR CDU ZERO (10 SEC)
	KEY V41 N72E - COARSE ALIGN RR CDU
F 21 73	TRUN, SHFT (.01°)
	LOAD: TRUN _____° (ANGLES FOR CSM ACQUISITION-P22)
	SHFT _____°
	PRO
F 04 12	00006, 00002
	PRO
41	COARSE ALIGN VERB
	KEY V16 N72E
16 72	SHFT, TRUN (.01) - MONITOR ANGLES
	KEY V44E

TIME	PROCEDURE

AGS SELF TEST

AGS STATUS sw - OPERATE
RESET MASTER ALARM
*6666 (OPR ERR)
*000 + 88888
*123 + 45679
*412R (+X0000) (VERIFY 10000)
+0 TEST NOT EXECUTED
+3 LOGIC FAIL
+4 MEMORY FAIL
+7 LOGIC/MEMORY FAIL
*412 + 70000E (AGS WARN LT)
RESET MASTER ALARM
*574R (STAGING FLAG) (+0)
*604R (LUNAR SURFACE FLG.) (-0)
*612R (STAGING SEQ COUNTER) (+0)

OPT 1 ALIGN

	KEY V37 N57E
F 06 34	T ALIGN (.01 SEC)
	LOAD/VERIFY T ALIGN
	PRO
F 05 06	00010, 00001 (OPT 1)
	PRO
	KEY V16 N20E (MONITOR COARSE ALIGN)
16 20	OG, IG, MG (.01)
	NO ATT LT (1ST POS. GRAV. DETERM)
	2ND NO ATT LT (2ND POS.)
	KEY REL
F 06 04	GRAV. ERR ANGLE (.01°)
	VERIFY ACCEPTABLE
	PRO
	KEY V16 N93 (MONITOR GYRO TORQUING)
	KEY REL
F 50 25	EXIT OR RECHECK ALIGN
	KEY V34E (EXIT), PRO (RECHECK)
F 37	22E

TIME		PROCEDURE
-02:30:00		RR TRACK
	F 04 06	00012, 00001
		RADAR TEST - OFF
		RNDZ RADAR sel - LGC
		RNG/ALT MON - RNG/RNG RT
		KEY V95E (INHIBIT UPDATE)
		PRO
	F 06 33	(TIG) HRS,MIN,SEC (.01)
		LOAD TIG
		CONFIRM CSM GO FOR TRACKING
		PRO (RR DESIGNATE)
		MONITOR R/RDOT ON TM
		(IF NO ACQUISITION PRO FOR RR SEARCH)
		RECORD TIME OF CLOSEST APPROACH (RDOT=0)
		COORDINATE WITH MSFN BEFORE TERMINATING
		KEY V56E (TERM)
	F 37	00E
		KEY V41 N72E
	F 21 73	TRUN, SHFT (.01)
		LOAD χ'S FOR POWERED ASCENT ACQUISITION
	F 04 12	00006, 00002
		PRO
	41	COARSE ALIGN
		KEY V16 N72E
	16 72	MONITOR ANGLES
		KEY V44E (TERM.)
		CB/PGNS: RNDZ RDR - OPEN
		CB/AC BUS A: RNDZ RDR - OPEN
		OPT 3 ALIGNMENT
		KEY V37E 57E
		CB/AC BUS A: AOT LAMP - CLOSE
		ZERO RETICLE
	F 06 34	T ALIGN (HRS,MIN,SEC) (.01)
		PRO
	F 05 06	00010, 00003
		PRO
		KEY V16 N20E
	16 20	OG,IG,MG (.01)
		NO ATT LT (1ST POS. GRAV. DETERM.)
		2ND NO ATT LT (2ND POSITION)
		KEY REL
	F 06 04	**GRAV ERR ANGLE (.01°)
		PRO (R59)

TIME	PROCEDURE
F 01 70	ABCDE C-DETENT,D,E - STAR CODE
	LOAD AND PRO
	(Next display - STAR only)
F 06 79	CURSOR (.01), SPIRAL (.01), DETENT
	PRO
F 01 71	DETENT, STAR CODE
	PRO
	(Next display - REAR DETENTS only)
F 06 87	OPT AZ,OPT EL (.01)
	PRO
F 54 71	MARK X OR Y
	CENTER TARGET - SPIRAL LINES
	MARK PB - PUSH
	RECORD SPIRAL ✕
F 06 79	CURSOR, SPIRAL, DETENT
	CENTER TARGET - CURSOR LINES
	LOAD SPIRAL/CURSOR ✕'S
	CONTINUE MARKING (5 MARKS)
	PRO
	(Next display - SUN/PLANET only)
F 06 88	PLANET VECTOR (X,Y,Z) (.00001)
	PRO
F 06 05	SIGHTING ✕ DIFF (.01)
	PRO
F 06 93	TORQUING ✕'S (.001)
	PRO (GYRO TORQUING)
F 50 25	00014
	ENT (PRO TO CHECK ALIGNMENT - RETURN TO **)
F 37	KEY 57E

AGS LUNAR ALIGN

RECEIVE/RECORD AZIMUTH CORRECTION (MSFN)
(MAY REQUIRE ONE STAR SIGHTING AND ANGLE TRANSMISSION TO MSFN)
$\Delta\delta \leq 5$ DEG:
*547 + XXXXXE (OCTAL)
$\Delta\delta > 5$ DEG:
*053 + XXXXXE (OCTAL, COS δ_L)
*047 + XXXXXE (OCTAL, SIN δ_L)
*400 + 4E (REQ. 3 MINUTES)

*400 + 0E (TERMINATES LUNAR ALIGN)

TIME	PROCEDURE

RECEIVE PAD DATA

1	TIG	_____	
2	CROSS RANGE	_____	
3	PITCH	_____	(FDAI ANGLES AFTER
	YAW	_____	YAW/PITCH MANUEVER)
	ROLL	_____	
4	TIG (CSI)	_____	
5	TIG (TPI)	_____	

00:01:30 OPT 3 ALIGN

```
                ZERO RETICLE
        F 06 34 T ALIGN (HRS,MIN,SEC)(.01)
                PRO
        F 05 06 00010, 00003
                PRO
                KEY V16 N20E
          16 20 OG,IG,MG  (.01)
                NO ATT LT (1ST POS. GRAV. DETERM.)
                2ND NO ATT LT (2ND POSITION)
                KEY REL
        F 06 04 **GRAV. ERR. ANGLE (.01°)
                PRO (R59)
        F 01 70 ABCDE   C-DETENT, D,E - STAR CODE
                LOAD AND PRO
                  (Next display - STAR only)
        F 06 79 CURSOR  (.01), SPIRAL (.01), DETENT
                PRO
        F 01 71 DETENT, STAR CODE
                PRO
                  (Next display - REAR DETENTS Only)
        F 06 81 OPT AZ, OPT EL  (.01)
                PRO
        F 54 71 MARK X OR Y
                CENTER TARGET - SPIRAL LINES
                MARK PB - PUSH
                RECORD SPIRAL ⨯
        F 06 79 CURSOR, SPIRAL, DETENT
                CENTER TARGET - CURSOR LINES
                LOAD SPIRAL/CURSOR ⨯'S
                CONTINUE MARKING (5 MARKS)
                PRO
                  (Next display - SUN/PLANET only)
        F 06 88 PLANET VECTOR (X,Y,Z)  (.00001)
                PRO
```

TIME	PROCEDURE
F 06 05	SIGHTING χ DIFF (.01)
	PRO
F 06 93	TORQUING χ'S (.001)
	PRO (GYRO TORQUING)
F 50 25	00014
	ENT (PRO TO CHECK ALIGNMENT - RETURN TO **)
F 37	KEY 47E
	CB/AC BUS A: AOT LAMP - CLOSE

AGS UPDATE/ALIGN/CALIBRATION

	(R47)
F 06 16	AGS ZERO TIME
	VERIFY OR LOAD MORE PRECISE TIME
	*414 + 1E
	TLM - HI
	PRO
	*414R (0)
F 50 16	UPDATE COMPLETE
	PRO
	KEY V83E
F 16 54	R, RDOT, THETA (RDOT - 0.1 FPS)
	*440R (RDOT - 0.1 FPS)
	COMPARE PGNS/AGS RDOT
	PRO
	*400 + 3E ALIGN
	*400R (+0)
	COMPARE PGNS/AGS FDAI
	*413R (+1)
	*544R (.01 DEG/HR)
	*545R
	*546R
	RECORD
	*400 + 6E (GYRO CALIBRATION)
	*400R (+0) (302 SECONDS)
	*544R (.01 DEG/HR)
	*545R
	*546R
	RECORD NEW VALUES

DAP LOAD

	KEY V48E
F 01 46	12103
	PRO
F 06 47	LM WT, CSM WT
	PRO

TIME	PROCEDURE

PREPARATION FOR STAGING

BAT 5 NORMAL SE FEED - ON
BAT 6 NORMAL CDR FEED - ON
ASC HELIUM (1/2) TEMP - 30° to 140°
ASC HELIUM (1/2) PRESS - 2720 to 3500 PSI
ASC HELIUM REG 1 - CLOSE TB-BP
ASC He SEL - BOTH
MASTER ARM - ON
ASC He PRESS - FIRE
MASTER ARM - OFF
WAIT FOR PRESSURE STABILIZATION
ASC PRPLNT PRESS - ___ - ___ PSI
ASC HELIUM REG 1 - OPEN
ASC PRPLNT PRESS - ___ - ___ PSI
CB/PGNS: RNDZ RDR - CLOSE
CB/AC BUS A: RNDZ RDR - CLOSE
SYSTEM A: ASC FEED - OPEN
SYSTEM B: ASC FEED - OPEN
VERIFY FUEL/OXID TB'S - GRAY
VERIFY PRESS EQUALIZED (APS/RCS)
DES O2 vlv - CLOSE
#1 ASC O2 vlv - OPEN
DES H2O vlv - CLOSE
ASC H2O vlv - OPEN
WATER TANK SEL - ASC

-00:20:00

ENTER P12

KEY V37E 12E
MODE CONT - PGNS
F 06 33 (TIG)
VERIFY/LOAD TIG
PRO
F 06 76 CROSSRANGE $^{+N}_{-S}$, APO ALT (0.1 NM)
VERIFY/LOAD
PRO
F 06 74 TFI, YAW ☒, PITCH ☒ (FDAI ANGLES AFTER PITCH, YAW)
SET E.T. WITH TFI (COUNTDOWN)
COMP ACTY LT - ON

TIME | PROCEDURE

PRELAUNCH SYSTEMS CHECK

SE BAT 1: HI VOLT - OFF/RESET
SE BAT 3: HI VOLT - OFF/RESET

EPS BAT 5: VOLTS/AMPS - NOR
EPS BAT 6: VOLTS/AMPS - NOR
ED VOLTS: BAT A/B - 35.0 - 37.8 vdc
ASC HELIUM (1/2): TEMP/PRESS - NOR
ASC PRPLNT: TEMP/PRESS - NOR
RCS PRPLNT: TEMP/PRESS - NOR
RCS PRPLNT QTY - _____%
ECS SUIT/CABIN: TEMP/PRESS - NOR
ECS GLYCOL: TEMP/PRESS - NOR
ECS O2 QTY - _____%
ECS H2O QTY (1/2) _____%
ECS PP CO2 - NOR
CAUTION AND WARNING - GO
PERFORM COMM CHECK - MSFN

PRELAUNCH SWITCH CHECK/ASC POWER

PANEL 1:
X POINTER SCALE - HI MULT
RATE/ERR MON - LDG RDR/CMPTR
ATT MON sw - PGNS
GUID CONT - PGNS
MODE SEL - PGNS
RNG/ALT MON - ALT/ALT RT
RATE SCALE - 5°/SEC
ACA PROP - ENABLE
ENG ARM - OFF
X-TRANL - 4 JETS
BAL CPL - ON
ASC He REG 1 - OPEN, TB-GRAY
ASC He REG 2 - OPEN, TB-GRAY
PANEL 2:
PRPLNT TEMP/PRESS - ASC
HELIUM MON - ASC PRESS 1
ALL THRUSTER PAIR QUAD sw's - OPEN, TB'S-GRAY
ALL INTERCONNECT vlv's - OPEN, TB'S-GRAY
MAIN SOV (A/B) - OPEN, TB'S-GRAY
CRSFD - CLOSE, TB-BP
TEMP/PRESS MON - PRPLNT
GLYCOL sw - PUMP 1
SUIT FAN - 1
O2/H2O QTY MON - ASC 1
ACA PROP - ENABLE
ATTITUDE MON - AGS

TIME		PROCEDURE
		RATE/ERR MON - LDG RDR/CMPTR
		PANEL 3:
		RADAR TEST - OFF
		RENDEZVOUS RADAR sel - LGC
		DEADBAND - MIN
		ATTITUDE CONTROL (ALL) - MODE CONT
		MODE CONTROL (PGNS) - AUTO
		MODE CONTROL (AGS) - AUTO
		TEMP MONITOR - QUAD 1
		RCS SYS A/B-2 (ALL QUADS) - AUTO
		X-POINTER SCALE - HI MULT
		PANEL 4:
		ACA/4 JET (2) - ENABLE
		TTCA/TRANSL (2) - ENABLE
		PANEL 8:
		MASTER ARM - OFF
		STAGE RELAY - OFF
		STAGE - SAFE
		CIRCUIT BREAKER CHECKLIST (TBD)
		SE BAT 2: HI VOLT - OFF/RESET
		SE BAT 4: HI VOLT - OFF/RESET
		EPS CDR BUS: VOLTS/AMPS - NOR
		EPS SE BUS: VOLTS/AMPS - NOR
		EPS AC BUS: VOLTS/AMPS - NOR
		DES BATS - DEADFACE
-00:07:00		AGS INITIALIZATION/CONFIG
		KEY V47E
	F 06 16	AGS ZERO TIME (90:00:00)
		*414 + 1E
		TLM - HI
		PRO
		*414R (0)
	F 50 16	UPDATE COMPLETE
		PRO
		KEY V83E
	F 16 54	R,RDOT,THETA (RDOT - 0.1 FPS)
		*440R (RDOT - 0.1 FPS)
		COMPARE RDOT
		PRO
-00:05:00		*400 + 3E ALIGN
		*400R (0)
		COMPARE PGNS/AGS - FDAI
		*400 + 1E
		*410 + 0E (ORBIT INS.)
		*232R (00600)
		*465R (00320)
		*411 + 1E
		*233R (00250)
		*464R (00500)
		*623R (+0)
		*433R (VI)

TIME		PROCEDURE
		POWERED ASCENT
-00:00:35		DSKY BLANKS
-00:00:29	06 74	TFI, YAW ⅋,PITCH ⅋
		ABORT STG PB - PUSH
		MASTER ARM - ON
		ENG ARM - ASC
-00:00:05	F 99 74	ENG ON ENABLE
		PRO
00:00:00		ENG START, START E.T. COUNTING UP
		ENG START PB - PUSH
	06 63	VI, HDOT, H
		MONITOR YAW MANEUVER (+Z DOWNRANGE)
		VERIFY PGNS/AGS RATES/ERRS IN LIMITS (TBD)
00:00:12		PITCH INITIATE
		VERIFY FDAI ANGLES AT PITCH COMPLETION
		VERIFY T/W - NOMINAL
		BAL CPL - OFF
		DEDA/DSKY: VI COUNTING UP
		MONITOR SYSTEMS STATUS
+00:01:00		**GUIDANCE CHECK**
		MONITOR RATES/ATT ERR'S (PGNS/AGS)
		COMPARE PGNS/AGS VI
		COMPARE PGNS/AGS ATTITUDE (FDAI)
		COMPARE PGNS/AGS H/HDOT (TM)
		MAKE ATTITUDE CHECK ON HORIZON/STAR
		NOTE: HORIZON WILL BE VISIBLE IN OVHD WINDOW AFTER PITCHOVER
		RNG/ALT MON - RNG/RNG RT
		VERIFY RR DATA
		RNG/ALT MON - ALT/ALT RT
		NOTE: MSFN SHOULD GIVE "GO" EVERY MINUTE
		ENGINE CHECK
		T/W - NOMINAL
		PROPULSION SYSTEM: TEMP/PRESS - NOR
		ASC PRPLNT PRESS = RCS PRPLNT PRESS
		PERFORM SYSTEMS/GUIDANCE/ENGINE CHECKS PERIODICALLY (ONE PER MIN.)

TIME		PROCEDURE
		INSERTION
		KEY V16 N77
	16 77	TG, VY (.1)
		DETERMINE CUT-OFF TIME (E.T.) FROM TG
		KEY V16 N85
	16 85	(VGX,VGY,VGZ)
		MONITOR VGX
		MONITOR H/HDOT ON TM
		SYSTEM A: ASC FEED - CLOSE
		SYSTEM B: ASC FEED - CLOSE
		VERIFY TB'S - BP
		ENG ARM - OFF
		MONITOR AUTO SHUTDOWN
		ABORT STG - RESET
		*500R (VGX)
		MODE CONT (PGNS) - ATT HOLD
		NULL RESIDUALS
		ENG STOP PB - PUSH
		VERIFY START PB - RESET
+00:07:00		ENG STOP PB - RESET
		CONTINUE WITH POST INSERTION PROCEDURES (TBD)

APPENDIX A - TRAJECTORY AND PERFORMANCE PARAMETERS

To be supplied when operational trajectory becomes available.

APPENDIX B - VEHICLE OPERATIONS

A. SWITCH DESCRIPTIONS

GUID CONT sw

This switch selects either PGNS or AGS for guidance and control of the LM.

PGNS – Enables the ACA and TTCA, proportional rate command inputs to the LGC, engine ON-OFF signals and gimbal trim commands, translation ON-OFF commands, the primary preamps of the ATCA, and sends the follow-up signal to the AEA.

AGS – Enables the ACA and TTCA, proportional rate commands to the ATCA, gimbal trim commands, the abort preamps of the ATCA, and removes the follow up signal.

MODE SEL sw

LDG RADAR – Landing radar altitude and altitude rate are displayed on the tapemeter and FWD and LAT velocity is displayed on the X-POINTER.

PGNS – LGC computed altitude and altitude rate are displayed on the tapemeter and FWD and LAT velocity is displayed on the X-POINTER.

AGS – AEA computed altitude, altitude rate, and LAT velocity are displayed.

RNG/ALT MON sw

RNG/RNG RT – RR range and range rate data is displayed on the tapemeter.

ALT/ALT RT – Altitude and altitude rate data, from the system selected by the MODE SEL sw, is displayed on the tapemeter.

RATE/ERR MON sw

This switch selects the input for the X-POINTER and FDAI error needle displays.

RNDZ RADAR –	RR shaft and trunnion angles are displayed on the error needles and LOS rates are displayed on the X-POINTER.
LDG RDR/CMPTR –	Attitude errors (PGNS/AGS) are displayed on the error needles and FWD and LAT velocity (PGNS/LR) on the X-POINTER. (When AGS is selected only LAT velocity is displayed).

ATTITUDE MON sw

PGNS –	PGNS total attitude and attitude errors are displayed on the FDAI.
AGS –	AGS total attitude and attitude errors are displayed on the FDAI.

SHFT/TRUN ⅀ sw

This switch selects the scaling for the FDAI error needles when RR shaft and trunnion angles are displayed.

50 DEG –	Full deflection of the error needles indicates shaft and trunnion angles of 50 DEG.
5 DEG –	Full deflection indicates angles of 5 DEG.

RATE SCALE sw

25 DEG/SEC –	Full deflection of the rate needles is 25 DEG/SEC.
5 DEG/SEC –	Full deflection of the rate needles is 5 DEG/SEC.

ACA PROP sw

This switch allows the crewman to remove power from the ACA transducer primary coils, disabling proportional rate commands. The switch will be used to isolate ACA malfunctions. The direct and hardover modes are still available when disabled.

ENABLE	-	ACA operates normally.
DISABLE	-	Removes 28-volt, 800-cps power from the transducer primary coils.

THR CONT sw

AUTO	-	LGC thrust commands are summed with manual commands from the TTCA for DPS throttle control. Normally the TTCA is in the minimum position (10%) in this mode. LGC commands, plus a 10% bias, are displayed on the CMD side of the thrust indicator.
MAN	-	Manual commands control the DPS throttle and are displayed on the thrust indicator.

MAN THROT sw

This switch selects the TTCA (CDR/SE) which controls the DPS thrust level. (Assuming the THROTTLE-JETS lever is set to THROTTLE)

CDR	-	Enables the CDR's TTCA.
SE	-	Enables the pilots TTCA.

ENG ARM sw

This switch provides arming signals to the APS or DPS while signaling the LGC that the engine is armed. Without the engine arm signal neither engine will fire. The appropriate engine will be armed when the ABORT or ABORT STAGE switches are depressed, regardless of the position of this switch.

ASC	The ASC engine is armed.

OFF	-	The arming signals are removed; therefore, this position can be used as a backup means to engine shutdown.
DES	-	The DES engine is armed.

X-TRANSL sw

4 JETS	-	Provides four jets for AGS X-axis translation maneuvers.
2 JETS	-	Provides two jets for AGS X-axis translation maneuvers.

BAL CPL sw

This switch, effective only with AGS, selects either balanced pairs of x-axis RCS jets in a couple or unbalanced x-axis RCS jets for use in maintaining pitch and roll attitude during thrust phases.

ON	-	Enables the four up-firing jets for AGS controlled maneuvers. The switch should be in this position when maximum stabilization and control is required.
OFF	-	Disables the up-firing x-axis jets. The switch will be positioned to OFF to prevent RCS jet firings opposing the direction of motion during powered phases - assuming adequate stability and control can be maintained by the down-firing jets.

ENG GMBL sw

This switch enables or disables pitch and roll DPS gimbal trim commands from the LGC or ATCA. The switch must be placed to ENABLE and the engine must be armed to accomplish the trim function prior to and during a burn. If the ENG GMBL light illuminates during a burn and/or the RCS fuel consumption is excessive the switch should be thrown to OFF.

ENABLE	Pitch and roll gimbal trim commands are enabled.

OFF		Power is removed from the actuators and the gimbal malfunction logic is reset. The actuators "lock up" in the last commanded position.

DES ENG CMD OVRD sw

The switch applies redundant power to the descent engine bi-propellant valves to prevent inadvertent engine shutdown during a critical mission phase. During powered descent, the switch will be ON immediately after ignition and will remain ON until after the landing. The circuit is interrupted by the ABORT STAGE button and the engine STOP button.

ON	-	Redundant 28 vdc power is applied to the descent engine valves.
OFF	-	Removes 28 vdc from the bi-prop valves.

LDG ANT sw

The switch controls the position of the landing radar antenna.

AUTO	-	The LGC automatically positions the LR antenna as a function of mission phase.
DES	-	The antenna x-axis is driven to a position 24 DEG from the LM body x-axis. The Y and Z antenna axes are 6 DEG from the respective body axes. This is the antenna position during the braking phase of powered descent.
HOVER	-	The antenna x-axis is aligned with the body x-axis and the Y and Z axes are 6 DEG from the respective body axes. This is the antenna position during the approach and landing phases.

DEADBAND sw

MAX	A 5 DEG attitude deadband is provided under AGS control. FDAI attitude error needle scaling is 14.4 DEG.
MIN	A 0.3 DEG attitude deadband is provided under AGS control. FDAI error needle scaling is 1.7 DEG.

ACA/4 JET sw

The switches allow the crew to disable the hardover mode of the ACA in the event of a short or jammed hand controller. All other ACA modes remain operative.

ENABLE	-	Normal ACA operation.
DISABLE	-	Interrupts the 28 vdc to the secondary RCS coils.

TTCA/TRANSL sw

The switches allow the crew to disable the translation control function of the TTCA in the event of a short or jammed controller. The throttling function of the controller remains operative.

ENABLE	-	Normal TTCA operation.
DISABLE	-	Interrupts $\pm$ 15 vdc to the primary RCS coils.

LUNAR CONTACT LIGHT

The lights are illuminated when the lunar surface sensing probes touch the surface, actuating mechanical switches. If serves as the signal for manual engine shutdown prior to lunar impact. The light is blue and extinguishes when the STOP PB is depressed.

T/W INDICATOR

The indicator displays instantaneous x-axis acceleration in lunar g units. It provides a gross check on engine (APS/DPS) performance.

MASTER ALARM LIGHTS

The lights alert the flight crew to critical subsystem malfunctions. Upon receipt of the signal, the crew should reset the light and refer to the caution and warning panel. Depression of either switch will extinguish both lights and terminate the audible tone.

ABORT PUSH BUTTON sw

The switch should be actuated when an abort from powered descent, using the descent engine is desired. The switch activation arms the descent engine and signals the LGC and AEA to compute and execute the abort trajectory. The AGS will not issue automatic engine ON/OFF commands unless this switch is depressed. It is reset by depressing it a second time.

ABORT STAGE PB sw

The switch should be actuated when an abort staging sequence, with ascent engine ignition is desired. The switch activation will cause the following events to occur:

1. The "Abort Stage" discrete is sent to the LGC and AEA.
2. The "Abort Stage" delay is initiated (500 ms).
3. The DPS is shutdown.
4. The APS is pressurized - should be completed in 400 ms.
5. Power is transferred from descent to ascent batteries.
6. At the termination of the delay, the selected guidance system issues an engine ON command.
7. A "stage" command is sent to the electro-explosive devices.

If the Abort Stage sequence is initiated in coasting flight an ullage burn will be required. This switch interrupts the redundant 28 vdc to the DPS engine valves.

ENGINE STOP sw (2)

The pushbutton switches separately interrupt the "ON" signal to the ascent and descent engines independent of the position of the ENG ARM switch. The STOP PB is the primary means of terminating thrust at lunar landing and should be used to back-up engine shutdown for automatic thrusting maneuvers. When actuated the latching PB illuminates red and is reset

by a second depression. If it cannot be reset the APS can still be started and the Abort Stage function can be utilized with a manual engine start. The switch activation interrupts the redundant 28 vdc to the DPS engine valves.

ENGINE START sw

This PB momentary contact switch provides the crew with the capability to immediately fire the DPS or APS, depending on the position of the ENG ARM sw. The START sw energizes a latching relay which provides a continuous engine ON command and a RED light to indicate the relay is energized. Activation of either STOP sw resets the latching relay, interrupts the ON signal and extinguishes the light.

+ X TRANSL sw

This PB switch applies 28 vdc to the secondary RCS coils providing 4-jet translation in +X direction. It is the primary means of providing ullage for manual APS/DPS burns. The switch is momentary contact and the signal is removed from the coils when the button is released. If the switch fails closed the ATT DIR CONT cb must be opened.

DES RATE sw

This switch can be used to control the rate of descent of the LM, in a semi-manual mode during powered descent. The vehicle must be under PGNS control in the attitude hold mode. Vehicle attitude is controlled by the crewman and the DPS throttle by the LGC. Each switch actuation provides a discrete pulse, changing the rate of descent by 1 fps. Upward deflections of the switch decrease the descent rate and downward deflections increase it.

B. CONTROL MODES/SWITCHES

GUID CONT sw	MODE CONT sw's	ATT CONT (selectable per axis)	REMARKS
PGNS	AUTO	MODE CONT	This is the switch configuration for all automatic PGNS maneuvers. Rate compensated steering errors are generated in the DAP and ON/OFF commands are sent to the jet drivers for vehicle control. The crew can

CONTROL MODES/SWITCHES

GUID CONT sw	MODE CONT sw's	ATT CONT (selectable per axis)	REMARKS
			control vehicle yaw attitude in a proportional rate command - attitude hold mode unless there is a program inhibit present.
PGNS	AUTO	PULSE	This position is inoperative. Vehicle control remains automatic.
PGNS	AUTO	DIRECT	A displaced ACA will fire pairs of jets, but since vehicle control is still automatic, the jet firing will conflict with the automatic steering commands.
PGNS	ATT HOLD	MODE CONT	If the extended verb V77 is selected, this is a manual proportional rate command mode. When the hand controller is returned to detent the DAP removes the vehicle rates and reverts to attitude hold. If V76 is selected, this is a minimum impulse mode with a single 14ms jet firing each time the hand controller is moved beyond the pulse/direct switches of the ACA. If no commands, are present the vehicle will drift freely.
PGNS	ATT HOLD	PULSE	Same as AUTO-PULSE.
PGNS	ATT HOLD	DIRECT	Same as AUTO-DIRECT.
PGNS	OFF	MODE CONT, PULSE OR DIRECT	Power is removed from the primary and abort preamps, disabling PGNS control of the RCS jets. The DAP will revert to an idle mode, in which it will not respond to any inputs. The ACA will be operative only in the

CONTROL MODES/SWITCHES

GUID CONT sw	MODE CONT sw's	ATT CONT (selectable per axis)	REMARKS
			"hardover" position (If DIRECT is selected, 2 jet firing is available in that axis). Automatic engine ON/OFF commands and the TTCA's are disabled.
AGS	AUTO	MODE CONT	This is the switch configuration for automatic AGS maneuvers. Steering signals are generated in the AEA. Rate gyro signals are summed with attitude error signals to provide vehicle rate damping.
AGS	AUTO	PULSE	The crew can command vehicle rotation through low frequency pulsing of the RCS jets (approximately 1.5 pulses/sec). Steering signals are interrupted and there is no rate damping.
AGS	AUTO	DIRECT	The crew can command vehicle rotation through 2 jet operation, direct to the secondary coils. Steering signals are interrupted and there is no rate damping.
AGS	ATT HOLD	MODE CONT	This is a manual proportional rate command mode. The control loop maintains the vehicle attitude when the ACA is returned to detent.
AGS	ATT HOLD	PULSE	Same as AUTO-PULSE.
AGS	ATT HOLD	DIRECT	Same as AUTO-DIRECT.
AGS	OFF	MODE CONT PULSE OR DIRECT	Power is removed from the primary and abort preamps disabling AGS control of the RCS jets. The ACA is operative only in the direct modes using the secondary coils. Automatic engine ON/OFF commands and the TTCA's are disabled.

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