MSC INTERNAL NOTE
MSC-CF-P-69-5
IM DESCENT/PHASING SUMMARY DOCUMENT
MISSION F
PRELIMINARY

PREPARED BY:
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HOUSTON, TEXAS
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IM DESCENT/PHASING SUMMARY DOCUMENT

MISSION F

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<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACA</td>
<td>Attitude Control Assembly (Hand Controller)</td>
</tr>
<tr>
<td>AGC</td>
<td>Abort Guidance Computer</td>
</tr>
<tr>
<td>AGS</td>
<td>Abort Guidance System</td>
</tr>
<tr>
<td>ACT</td>
<td>Alignment Optical Telescope</td>
</tr>
<tr>
<td>APS</td>
<td>Ascent Propulsion System</td>
</tr>
<tr>
<td>ASC</td>
<td>Ascent</td>
</tr>
<tr>
<td>BP</td>
<td>Barber Pole</td>
</tr>
<tr>
<td>CB</td>
<td>Circuit Breaker</td>
</tr>
<tr>
<td>CDR</td>
<td>Commander</td>
</tr>
<tr>
<td>COAS</td>
<td>Crewman Optical Alignment Sight</td>
</tr>
<tr>
<td>C&amp;W</td>
<td>Caution and Warning</td>
</tr>
<tr>
<td>DAP</td>
<td>Digital Autopilot</td>
</tr>
<tr>
<td>DB</td>
<td>Deadband</td>
</tr>
<tr>
<td>DEDA</td>
<td>Data Entry and Display Assembly</td>
</tr>
<tr>
<td>DES</td>
<td>Descent</td>
</tr>
<tr>
<td>DOI</td>
<td>Descent Orbit Injection</td>
</tr>
<tr>
<td>DPS</td>
<td>Descent Propulsion System</td>
</tr>
<tr>
<td>DSKY</td>
<td>Display and Keyboard</td>
</tr>
<tr>
<td>EPS</td>
<td>Electrical Power System</td>
</tr>
<tr>
<td>ET</td>
<td>Event Timer</td>
</tr>
<tr>
<td>FDAI</td>
<td>Flight Director Attitude Indicator</td>
</tr>
<tr>
<td>FOV</td>
<td>Field of View</td>
</tr>
<tr>
<td>FPS</td>
<td>Feet Per Second</td>
</tr>
<tr>
<td>GET</td>
<td>Ground Elapsed Time</td>
</tr>
<tr>
<td>IMU</td>
<td>Inertial Measurement Unit</td>
</tr>
<tr>
<td>LGC</td>
<td>IM Guidance Computer</td>
</tr>
<tr>
<td>LMP</td>
<td>IM Pilot</td>
</tr>
<tr>
<td>LOS</td>
<td>Line of Sight</td>
</tr>
<tr>
<td>LR</td>
<td>Landing Radar</td>
</tr>
<tr>
<td>LS</td>
<td>Landing Site</td>
</tr>
<tr>
<td>MSFN</td>
<td>Manned Spaceflight Network</td>
</tr>
<tr>
<td>NM</td>
<td>Nautical Miles</td>
</tr>
<tr>
<td>NOR</td>
<td>Normal Operating Range</td>
</tr>
<tr>
<td>OHW</td>
<td>Overhead Window</td>
</tr>
<tr>
<td>PB</td>
<td>Pushbutton</td>
</tr>
<tr>
<td>PGNS</td>
<td>Primary Guidance and Navigation System</td>
</tr>
<tr>
<td>PDI</td>
<td>Powered Descent Initiation</td>
</tr>
<tr>
<td>RCB</td>
<td>Reaction Control System</td>
</tr>
<tr>
<td>ROD</td>
<td>Rate of Descent</td>
</tr>
<tr>
<td>RR</td>
<td>Rendezvous Radar</td>
</tr>
<tr>
<td>SCHE</td>
<td>Supercritical Helium</td>
</tr>
<tr>
<td>SOV</td>
<td>Solenoid Operated Valve</td>
</tr>
<tr>
<td>SV</td>
<td>State Vector</td>
</tr>
<tr>
<td>SW</td>
<td>Switch</td>
</tr>
<tr>
<td>TB</td>
<td>Talkback</td>
</tr>
<tr>
<td>TFC</td>
<td>Time From Cutoff</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>TFI</td>
<td>Time From Ignition</td>
</tr>
<tr>
<td>TG</td>
<td>Time to Go</td>
</tr>
<tr>
<td>TIG</td>
<td>Time of Ignition</td>
</tr>
<tr>
<td>TIM</td>
<td>Telemetry</td>
</tr>
<tr>
<td>TM</td>
<td>Tape Meter</td>
</tr>
<tr>
<td>TRUN</td>
<td>Trunnion</td>
</tr>
<tr>
<td>TTCA</td>
<td>Thrust and Translation Control Assembly</td>
</tr>
<tr>
<td>VHF</td>
<td>Very High Frequency</td>
</tr>
<tr>
<td>XMTR</td>
<td>Transmitter</td>
</tr>
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</table>
1.0 INTRODUCTION

The Descent/Phasing Summary Document has been prepared to document in detail the crew procedures and supporting information to be used in training for the F Mission. The document covers the mission phase from CSM-LM undocking to completion of the phasing burn. The procedures contained herein will become controlled procedures upon final issue.

Comments or questions concerning this document should be directed to C. O. Lewis, Flight Procedures Branch, CF24.
2.0 MISSION SUMMARY

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 lock-on 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 (S/V and DOI targeting) and pad data for DOI and the Phasing Burn 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. The LM uses the target AV Program to change the CSM S/V in the LGC. After separation, the DOI pre-thrust program is run to verify it is loaded correctly, and a Rendezvous Radar and 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 AGS is updated, configured to follow the DOI PGNS burn, and aligned to the IMU. The DFS 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 AV 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 AGS is re-calibrated, Landing Radar turned on and checked out, MSFN reacquired, and pre-burn systems and controls checks made. The powered descent braking program is entered to check the operation of that program in making pre-ignition calculations. It is then exited.

Up to this time, the F Mission has been almost identical to the G Mission profile, but at PDI-10 minutes, the G profile is abandoned and the Phasing Burn targeting is loaded in the LGC. At 3 minutes prior to pericynthian, a pitch rate is established which will have the vehicle 0.0.0 (LV) at pericynthian. Landing
radar readings are taken to assess the radar's high altitude capability, and observations of the landing site are made during the pass.

At 10 minutes prior to the Phasing Burn, the AGS is updated, configured, and aligned to follow-up the burn. The thrust program is entered and final preparations are made. The Phasing Burn occurs 14 minutes past pericynthian and is a posigrade External ΔV burn of approximately 190 fps. The resulting high apogee orbit will put the IM below and behind the CSM on the succeeding revolution so that a lunar landing mission rendezvous can be simulated.
# Maneuver Summary

<table>
<thead>
<tr>
<th></th>
<th>Undock</th>
<th>Separation</th>
<th>DOI</th>
<th>Phasing</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIG</td>
<td>98:30</td>
<td>98:55</td>
<td>99:54:12.1</td>
<td>101:06:34.9</td>
</tr>
<tr>
<td>Prop Sys</td>
<td>CSM RCS</td>
<td>CSM RCS</td>
<td>IM DPS</td>
<td>IM DPS</td>
</tr>
<tr>
<td>Control</td>
<td>Manual</td>
<td>PGNS (P41)</td>
<td>PGNS (P40)</td>
<td>PGNS (P40)</td>
</tr>
<tr>
<td>Attitude (LV)</td>
<td>POS, Heads DN</td>
<td>PITCH UP 90°</td>
<td>RET, FACE UP</td>
<td>POS, FACE DN</td>
</tr>
<tr>
<td>ΔVx (LV)</td>
<td>0</td>
<td>72.8 AFT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔVy</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔVz</td>
<td>2.5 FPS DN</td>
<td>2.2 DN</td>
<td>86.6 UP</td>
<td></td>
</tr>
<tr>
<td>TB</td>
<td>12.5 SEC</td>
<td>27.5 SEC*</td>
<td>42.0 SEC</td>
<td></td>
</tr>
</tbody>
</table>

*Assumes throttle up to 40% at +15 sec
MISSION F

DESCENT/PHASING ATTITUDE PROFILE

PHASING BURN

EARTH

PHASING BURN

HORIZ TRACK

SUN

PDI ATTITUDE

START LR
FITCH
PROFILE

LR TEST
MISSION F
UNDOCKING - PHASING BURN

1. CSM UNDOCK AND STATION KEEP
2. IM YAW RIGHT 120°, PITCH UP 90°, YAW 360° FOR INSPECTION
3. ACQUIRE S-BAND WITH MSFN
4. IM STATION KEEP UNTIL CSM SEP
5. STATE VECTOR AND DOI TARGETING UPDATE (P27)
6. COPY DOI AND PHASING BURN PADS
7. CSM SEP BURN
8. UPDATE CSM STATE VECTOR IN LGC (P76)
9. VERIFY DOI TARGETING (P30)
10. RR/VHF CHECK
11. DESIGNATE RR ANTENNA TO CLEAR AOT
12. ALIGN IMU TO LANDING SITE REF (P52)
13. CHECK ALIGNMENT
14. PERFORM PRE-BURN SYSTEMS CHECK
15. SECURE CABIN AND CREW
16. CONFIGURE CONTROLS AND DISPLAYS
17. UPDATE AGS
18. CONFIGURE AGS TO FOLLOW DOI BURN
19. ALIGN AGS TO IMU
20. SWITCH FROM S-BAND TO VHF
21. CHECK DAP
22. ENTER THRUSTING PROGRAM (P40)
23. PERFORM DOI BURN
24. TRIM RESIDUALS
25. POST-BURN SYSTEMS CHECK
26. MODE II RR LOCKON (MANUAL)
27. VERIFY TRAJECTORY WITH RR, VHF
28. CALIBRATE AGSgyros and accelerometers
29. POWER UP AND CHECK LANDING RADAR
30. YAW TO PDI ATTITUDE
31. ACQUIRE S-BAND WITH MSFN
32. PERFORM PRE-BURN SYSTEMS CHECK
33. SECURE CABIN AND CREW
34. ENTER BRAKING PROGRAM (P63)
35. CHECK P63 CALCULATIONS AND EXIT PROGRAM
36. CONFIGURE CONTROLS AND DISPLAYS
37. YAW TO FACE UP
38. LOAD PHASING BURN TARGETING (P30)
39. START PITCH DOWN PROFILE FOR LR TEST
40. LR TEST AND LANDING SITE OBSERVATIONS
41. UPDATE AGS
42. CONFIGURE AGS TO FOLLOW PHASING BURN
43. ALIGN AGS TO IMU
44. CHECK DAP
45. ENTER THRUSTING PROGRAM (P40)
46. PERFORM PHASING BURN
47. TRIM RESIDUALS
48. POST-BURN SYSTEMS CHECK
DESCRIPTIVE PROCEDURES

MISSION FL PROCEEDURES (UNDOKING-PHASING BURN)

ASSUMPTIONS:

A. SYSTEMS CHECKOUT COMPLETE
B. GEAR DOWN
C. LGC IN POO
D. IMU ALIGNED TO L.S. REFSSMAT
E. AGS INITIALIZED, CALIBRATED, ALIGNED TO PGNS
F. RR SELF TESTED
G. LL SELF TESTED, ANTENNA-DESCENT
H. DAP - 21002 GIMBALS TRIMMED
I. CREW SUITED AND RESTRAINED
J. CSM POSIGRADE, Z VERTICAL DOWN
K. DPS, RCS PRESSURIZED, RCS HOT FIRED
L. CHECKLIST PERFORMED:

- MODE CONTROL (PGNS) - ATT HOLD
- MODE CONTROL (AGS) - ATT HOLD
- ATTITUDE CONTROL (R,P,Y) - PULSE
- KEY V77E
- DEADBAND - MAX
- GUID CONT - AGS
- RATE/ERR MON - LDG RDR/CMPTR
- RATE SCALE - 5°/SEC
- X-TRANSL - 2' JET
- BAL CPL - ON
- ACA/4 JET (BOTH) - ENABLE
- THROTTLE/JETS (BOTH) - JETS
- TTCA/TRANSL (BOTH) - ENABLE
- CB/HEATERS: AOT - CLOSE

98:45   CSM UNDOCKS

YAW RIGHT 120°
PITCH UP 90° (CSM IN FWD WID)
YAW 360° FOR INSPECTION
ACA OUT OF DETENT ALL AXIS
ATTITUDE CONTROL (R,P,Y) - MODE CONT

KEY V64E (S-BAND ANT ANGLES)

F 16 51   XXX.XX P XXX.XX Y
ACQUIRE S-BAND LOCK-ON
VERIFY VOICE, TLM

99:10   CSM SEP (2.5 FPS DOWN)
F 06 84  \( \Delta V_x \Delta V_y \Delta V_z \) (SEP \( \Delta V \))
F 06 33 HRS, MIN, SEC (TIG OF SEP)
F 06 33 TIG (HR,MIN,.01 SEC)
F 06 33 \((-)\Delta V_x \Delta V_y \Delta V_z (.1 \text{ fps})\)
F 06 42 60.0 \( \text{nm} \) APO, 8.3 \( \text{nm} \) PER, XXXX.X \( \text{fps} \) \( \Delta V_t \)
F 16 45 RR MARKS, TFI, MGA
F 04 06 00001 00003 (REFSMAT)
F 01 70 002XX LOAD STAR #1
F 01 71 002XX
F 54 71 MARK X OR Y
F 01 70 002XX LOAD STAR #2
F 01 71 002XX
F 50 18 R,P,Y ANGLES (0.01\(^\circ\)) MODE CONTROL - AUTO
F 06 18 PLEASE TRIM MODE CONTROL - ATT HOLD ENTR (TRIM NOT REQ'D)
F 01 71 002XX
F 54 71 MARK X OR Y KEY V76E (PULSE)
F 01 70 002XX LOAD STAR #2
F 50 18 R,P,Y ANGLES MODE CONTROL - AUTO
F 06 18 PLEASE TRIM MODE CONTROL - ATT HOLD ENTR (TRIM NOT REQ'D)
F 01 71 002XX
F 54 71 MARK X OR Y MARK 5 PAIR X,Y
F 01 71 002XX
F 06 05  STAR ANGLE DIFF ("0.01")
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
PRO
F 01 70  002XX LOAD CHECK STAR
PRO
F 50 18  R, P, Y FDAL ANGLES
MODE CONTROL-AUTO
PRO
F 06 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
CRSF/D: TB - BP
ASC FEED: TB's (4) - BP
ECS SYS: TEMPS/PRESS - NOR
ASC BATS: NORMAL sw (2) - ON
CB/EPS: BAL LOADS (2) - OPEN
CB/INST: CWEA - OPEN THEN CLOSE
ECS SYS: VOLTS/AMPS - NOR

SECURE CABIN AND CREW
CONTROLS CHECK:
ATT MON - PGNS (CDR) AGS (LMP)
HEL MON - SUPCRIT PRESS
THR CONT - AUTO
MAN THROT - CDR
DEAD BAND - MIN
ACA/4 JET (CDR) - ENABLE
THROTTLE/JETS (CDR) - THROTTLE (10%)
TTCU/TRANSL (BOTH) - ENABLE
DES ENG CMD QVRD - OFF
ENG STOP PB (BOTH) - RESET
ABORT/ABORT STAGE PB's - RESET
RCS TEMP/PRESS MON-HE
POWER/TEMP MON - CDR BUS
BAL CPS - ON
-10
KEY V47E (AGS UPDATE)
F 06 16  90:00:00 AGS CLOCKZERO
*414+1E
PRO
*414 R (00000)
F 50 16  UPDATE COMPLETE
PRO
KEY V83E
F 06 54  R/R DOT/THETA (.01nm,.lfps,.01°)
*317 R (RANGE .1 nm) COMPARE
PRO
*623+0 E  X-AXIS
*410+5 E  EXT ΔV
*411+0 E  ΔPS
*407+0 E
*450-00XX.X E  ΔVX
*451+00000 E  ΔVY
*452+00000 E  ΔVZ
*400+3 E  ALIGN
*400 R (00000)
*400+1 E  GUID STEER
*500 R  VG
OBSERVE CHECK STAR
AGS ATTITUDE ERRORS ZERO
ENTR (NO FURTHER TRIM)

06 40
TFI, VG, ΔVM

-35 DSKY B

MASTER ARM - ON
PRPLNT QTY MON - DES 1
ENG GMBL - ENABLE
THROTTLE - MIN
ENG ARM - DES

-07
ULLAGE START (AUTO)
F 99 40
ENABLE IGNITION
PRO

06 40
ENGINE START, START ET COUNTING UP

+15
THROTTLE (CDR) - SET TO 40%

F 16 40
ENG ARM - OFF
ENG GMBL - OFF
MASTER ARM - OFF
PRPLNT QTY MON - OFF
PRO

F 16 85
VGX VGY VGZ (.1 fps)
NULL VGX
PGNS: _______ VGX _______ VGY _______ VHZ
*AGS: _______ VGX _______ VGY _______ VHZ
500 501 502

TRANSMIT ΔV INFORMATION TO CSM
KEY V82E

F 16 44
APO ALT ______ PER ALT ______ TFF ______
*403 R ______ PER ALT ______
PRO
POO
*400+0 E (ATT HOLD)
MODE CONTROL (BOTH) - ATT HOLD

SYSTEMS CHECK:
PROPULSION SYS: TEMPS/PRESS-NOR
ASC BATS: NORMAL (2)-OFF/RESET
CB/EPS: CROSS TIE BAL LOADS (2) - CLOSE

EXTERIOR LTG - TRACK (OFF AFTER PITCH)
CSM TRANSPONDER ON, TRACK ATT & LITE
KEY V89E (RNDZ FINAL ATT)

F 04 12
00003 00002 (X-AXIS)
PRO

F 06 18
R,P,Y ANGLES (.01°)
PRO

F 50 18
R,P,Y ANGLES
MODE CONTROL (PGNS) - AUTO
PRO

06 18
ENTR
MODE CONTROL–ATT HOLD
CB/AC BUS A: RNDZ RDR – CLOSE
CB/PGNS: RNDZ RDR – CLOSE
RR MODE – LGC
KEY V41 N72E

RNDZ
RDR – CLOSE
CB/PGNS:

RR MODE – LGC
KEY V41 N72E

41
KEY V16 N72E, MONITOR DRIVE
KEY V44E (TERMINATE DESIG)
PERFORM MANUAL LOCK-ON

+10
TAKE RANGE READINGS:

<table>
<thead>
<tr>
<th>RR</th>
<th>CSM</th>
<th>NOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOI</td>
<td>+10</td>
<td>______</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>______</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>______</td>
</tr>
<tr>
<td>25</td>
<td></td>
<td>______</td>
</tr>
</tbody>
</table>

+13
GUID CONT – PGNS/PULSE
(MAINTAIN ZERO RATES DURING CALIB)
*400+6 E
*400 R (00000)
GUID CONT – AGS
*540 ______ 544 ______
541 ______ 545 ______
542 ______ 546 ______

+25
CB/PGNS: LDG RDR – CLOSE
TEST MON – VEL XMTR (>2.9v)
TEST MON – ALT XMTR (>2.9v)
RNG ALT MON – ALT/ALT RT
X-POINTER SCALE – HI MULT
MODE SEL – LDG RADAR
RADAR TEST – LDG
H = ______ to ______ FT
HDOT= ______ to ______ FPS

TEST MON – VEL XMTR (X-POINTER UP/RT)
KEY V16 N66E

F 16 66
08300 FT RANGE 00002 ANT POS
REJECT: LDG ANT – AUTO, KEY V61E,
WAIT 22 SEC, KEY V16 N66
ACCEPT: KEY POO
RADAR TEST – OFF

+30
YAW 180° (FACE DOWN)
MAIN RR LOCK
KEY V78E (LR READ)

KEY V64E

F 16 51
S–BAND PITCH, YAW (.01°)
ACQUIRE S–BAND LOCK-ON
VERIFY VOICE, TLM
VHF B/XMTR – OFF
TELEMETRY PCM – HI
PRO

DSKY B

SYSTEMS CHECK:

PROPULSION SYS: TEMPS/PRESS – NOR
DES REG: TB’s – 1/3P 2/GREY
ASC REG: TB’s (2) – GREY
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
CB/EPS: BAL LOADS (2) – OPEN
CB/INST: CWEA – OPEN THEN CLOSE
EPS SYS: VOLTS/AMPS – NOR
SECURE CABIN AND CREW

+40
KEY V37E 63E (BRAKING)

F 06 61
TGO ______, TFI, CR ______ NM
RESET ET
PRO

F 50 25
00114 FINE ALIGN
ENTR (BYPASS ALIGNMENT)

F 50 18
R ______ P ______ Y
MANUAL TRIM TO PDI ATTITUDE
KEY V34E
KEY V25 N07E
CONTROLS CHECK:
ATT MON - PGNS (CDR) AGS (LMP)
HEL MON - SUPCRIT PRESS
THR CONT - AUTO
MAN THROT - CDR
DEAD BAND -MIN
THROTTLE/JETS (CDR) - THROTTLE (10%)
DES ENG CMD OVRD - OFF
ENG STOP PB (BOTH) - RESET
ABORT/ABORT STAGE PB's - RESET
RCPS TEMP/PRESS MON - HE
POWER/TEMP MON - CDR BUS
BAL CPL - ON

PB-10
YAW RIGHT 180° (FACE UP)
(PB-24)

KEY V37E 30E (PHASING BURN)
F 06 33 : : TIC PRO
F 06 81 ΔVX ΔVY ΔVZ PRO
F 06 42 XXX.XHA XXX.XHP ΔVT ( ) ( ) PRO
F 16 45 RR MARKS, TFI, MCA PRO
RESET ET
CB/AC BUS A: RNDZ RDR - OPEN
CB/PGNS: RNDZ RDR - OPEN

GUID CONT - PGNS
KEY V76E

PB-17
BEGIN 0.5°/SEC PITCH DOWN

PB-10
KEY V77E (STOP PITCH RATE)
-:35 DSKY B

PRPLNT QTY MON - DES 1
ENG GMBL - ENABLE
THROTTLE - MIN
ENG ARM - DES

-:07
ULLAGE START (AUTO)
F 99 40 ENABLE IGNITION
PRO

-:00
ENGINE START, START ET COUNTING UP
ENGINE CUTOFF, ENG STOP PB - PUSH

F 16 40
ENG ARM - OFF
ENG GMBL - OFF
PRPLNT QTY MON - OFF
PRO

F 16 85 VGX VGY VGZ (.1 fps)
NULL RESIDUALS
*500 R ________ VGX
*501 R ________ VGY
*502 R ________ VGZ

TRANSMIT AV's To CSM
KEY V82E

F 16 44 APO ALT _____ PER ALT _____ TFF ______
PRO
POO
*400+0 E (ATT HOLD)
MODE CONTROL (BOTH) - ATT HOLD

SYSTEMS CHECK:
PROPUSSION SYS: TEMPS/PRESS -NOR
ASC BATS: NORMAL (2)- OFF/RESET
CB/EPS: CROSS TIE BAL LOADS (2) - CLOSE
CB/PDNS: LDG RDR - OFF

RENEZVOUS
PROCEDURES
APENDIX A - 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 tape meter and FWD and LAT velocity is displayed on the X-POINTER.

PGNS - LGC computed altitude and altitude rate are displayed on the tape meter 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 tape meter.

ALT/ALT RT - Altitude and altitude rate data, from the system selected by the MODE SEL sw, is displayed on the tape meter.
RATE/ERR MON sw

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

RNDZ RADAR - 
shaft and trunnion angles are displayed on the error needles and LOS rates are displayed on the X-POINTER.

LDG RDR/CMPTR - 
Attitude errors (PCNS/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 3 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.
<table>
<thead>
<tr>
<th>Switch</th>
<th>Position</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF</td>
<td>-</td>
<td>The arming signals are removed; therefore, this position can be used as a backup means to engine shutdown.</td>
</tr>
<tr>
<td>DES</td>
<td>-</td>
<td>The DES engine is armed.</td>
</tr>
</tbody>
</table>

**X-TRANSL sw**

<table>
<thead>
<tr>
<th>JETS</th>
<th>-</th>
<th>Provides four jets for AGS X-axis translation maneuvers.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 JETS</td>
<td>-</td>
<td>Provides two jets for AGS X-axis translation maneuvers.</td>
</tr>
</tbody>
</table>

**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.

<table>
<thead>
<tr>
<th>Switch</th>
<th>Position</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON</td>
<td>-</td>
<td>Enables the four up-firing jets for AGS controlled maneuvers. The switch should be in this position when maximum stabilization and control is required.</td>
</tr>
<tr>
<td>OFF</td>
<td>-</td>
<td>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.</td>
</tr>
</tbody>
</table>

**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.

<table>
<thead>
<tr>
<th>Switch</th>
<th>Position</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENABLE</td>
<td>-</td>
<td>Pitch and roll gimbal trim commands are enabled.</td>
</tr>
</tbody>
</table>
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 ± 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

<table>
<thead>
<tr>
<th>GUID CONT</th>
<th>MODE sw</th>
<th>ATT CONT (selectable per axis)</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PGNS AUTO</td>
<td>MODE CONT</td>
<td>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</td>
<td></td>
</tr>
</tbody>
</table>
### CONTROL MODES/SWITCHES

<table>
<thead>
<tr>
<th>GUID CONT</th>
<th>MODE CONT</th>
<th>ATT CONT (selectable per sw's axis)</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>control vehicle yaw attitude in a proportional rate command - attitude hold mode unless there is a program inhibit present.</td>
<td></td>
</tr>
<tr>
<td>PGNS</td>
<td>AUTO</td>
<td>PULSE</td>
<td>This position is inoperative. Vehicle control remains automatic.</td>
</tr>
<tr>
<td>PGNS</td>
<td>AUTO</td>
<td>DIRECT</td>
<td>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.</td>
</tr>
<tr>
<td>PGNS</td>
<td>ATT HOLD</td>
<td>MODE CONT</td>
<td>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.</td>
</tr>
<tr>
<td>PGNS</td>
<td>ATT HOLD</td>
<td>PULSE</td>
<td>Same as AUTO-PULSE.</td>
</tr>
<tr>
<td>PGNS</td>
<td>ATT HOLD</td>
<td>DIRECT</td>
<td>Same as AUTO-DIRECT.</td>
</tr>
<tr>
<td>PGNS</td>
<td>OFF</td>
<td>MODE CONT, PULSE OR DIRECT</td>
<td>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</td>
</tr>
</tbody>
</table>
### CONTROL MODES/SWITCHES

<table>
<thead>
<tr>
<th>AGS</th>
<th>MODE</th>
<th>ATT CONT</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AUTO</td>
<td>MODE CONT</td>
<td>&quot;hardover&quot; position (If DIRECT is selected, 2 jet firing is available in that axis). Automatic engine ON/OFF commands and the TTCA's are disabled.</td>
</tr>
<tr>
<td>AGS</td>
<td>AUTO</td>
<td>PULSE</td>
<td>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.</td>
</tr>
<tr>
<td>AGS</td>
<td>AUTO</td>
<td>DIRECT</td>
<td>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.</td>
</tr>
<tr>
<td>AGS</td>
<td>ATT HOLD</td>
<td>MODE CONT</td>
<td>This is a manual proportional rate command mode. The control loop maintains the vehicle attitude when the ACA is returned to detent.</td>
</tr>
<tr>
<td>AGS</td>
<td>ATT HOLD</td>
<td>PULSE</td>
<td>Same as AUTO-PULSE.</td>
</tr>
<tr>
<td>AGS</td>
<td>ATT HOLD</td>
<td>DIRECT</td>
<td>Same as AUTO-DIRECT.</td>
</tr>
<tr>
<td>AGS</td>
<td>OFF</td>
<td>MODE CONT</td>
<td>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.</td>
</tr>
</tbody>
</table>
Figure F-1. LM-4 Cabin Controls & Displays.
REFERENCES


