LUMINARY MEMO #247

To: Distribution
From: D. Millard
Date: 1 September 1972
Subject: Level 5 Test Description for Mission 17 (PRELIMINARY)

This memo provides a description of the LUMINARY Level 5 Digital Performance Testing currently planned for Mission 16. Included are comments on test initialization and a detailed description of the digital simulation tests which fall into the following general categories.

6.1.0 ASCENT AND RENDEZVOUS
6.2.0 ABORT FROM DESCENT
6.3.0 LUNAR SURFACE OPERATION AND ALIGNMENTS
6.4.0 LUNAR LANDING
6.5.0 ERASABLE MEMORY PROGRAMS
6.6.0 SPECIAL TESTS

The test initialization listed below applies to all the tests and any special initial conditions will be specified in the detailed test description.

1) 1\sigma  IMU, Radar, State Vector Errors
2) Normal Astronaut Interface from Apollo 17 Data File
3) Apollo 17 Operational Trajectory
4) Apollo 17 Erasable Load
5) 71/72 Ephemeris
6) 10\% TLOSS
7) LM12 Vehicle

Typical 1\sigma  initialization errors are given on page 2.
## Typical 1 Sigma Initialization Errors

### IMU Errors

<table>
<thead>
<tr>
<th>Source</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Misalignment (milliradians)</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Bias Drift (MERU)</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
</tr>
<tr>
<td>Input Axis Drift (MERU/G)</td>
<td>8.00</td>
<td>-8.00</td>
<td>8.00</td>
</tr>
<tr>
<td>Spin Axis Drift (MERU/G)</td>
<td>-5.00</td>
<td>5.00</td>
<td>-5.00</td>
</tr>
<tr>
<td>PIPA Bias (CM/SEC&lt;sup&gt;2&lt;/sup&gt;)</td>
<td>.20</td>
<td>.20</td>
<td>.20</td>
</tr>
<tr>
<td>PIPA Scale Factor (PPM)</td>
<td>-116</td>
<td>-116</td>
<td>-116</td>
</tr>
</tbody>
</table>

### State Vector Errors at PDI Ignition

<table>
<thead>
<tr>
<th>Source</th>
<th>Altitude</th>
<th>Cross-Range</th>
<th>Down-Track</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position (ft.)</td>
<td>-1410</td>
<td>1080</td>
<td>-4220</td>
</tr>
<tr>
<td>Velocity (fps.)</td>
<td>4.3</td>
<td>1.28</td>
<td>-1.38</td>
</tr>
</tbody>
</table>

### Rendezvous Radar Errors

<table>
<thead>
<tr>
<th>Source</th>
<th>Bias</th>
<th>Range (ft.)</th>
<th>Range-Rate (fps)</th>
<th>Shaft/Trunnion (Mr.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Random</td>
<td>800 if R &gt; 50.8 N.M.</td>
<td>80 if R &lt; 50.8 N.M.</td>
<td>15.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.3% R</td>
<td>.4% R (Minimum .0044 fps)</td>
<td></td>
</tr>
</tbody>
</table>

### Landing Radar Errors

<table>
<thead>
<tr>
<th>Source</th>
<th>Random</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altitude (ft.)</td>
<td>.5%</td>
<td>5</td>
</tr>
<tr>
<td>VX (fps)</td>
<td>.5%</td>
<td>.8</td>
</tr>
<tr>
<td>VY (fps)</td>
<td>.7%</td>
<td>.8</td>
</tr>
<tr>
<td>VZ (fps)</td>
<td>1.0%</td>
<td>.8</td>
</tr>
</tbody>
</table>
3.1.0 ASCENT AND RENDEZVOUS

The following applies to all tests in this section unless stated otherwise in the test description.

a) The SLOSH environment is not simulated.
b) The FAST IMU environment is used.
6.1.1 ASCENT AND RENDEZVOUS

I. Test Objective

Demonstrate LM Ascent from the lunar surface and LM active short Rendezvous.

II. Test Description

The LM is tilted approximately 10° on the Lunar Surface.

Program Sequence

P57     AT-3 to Landing Site
P00
V48     DAP Data Load
V41N72  Position RR
P12     Ascent
V64     S-Band Antenna
V82     Orbital Parameter Display (R30)
P00
V48     DAP Data Load
P20     Rendezvous Navigation
V80     Enable LM State Vector Update
P34     Transfer Phase Initiation (TPI)
V83     Rendezvous Parameter Display (R31)
N52     Display LM Central Angle
N59     Display Delta LOS Vel.
V48     DAP Data Load
P42     APS
V82     Orbital Parameter Display (R30)
P35     Transfer Phase Midcourse (TPM)
V67     W-Matrix Display
V48     DAP Data Load
V83     Rendezvous Parameter Display (R31)
<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P41</td>
<td>RCS</td>
</tr>
<tr>
<td>V82</td>
<td>Orbital Parameter Display</td>
</tr>
<tr>
<td>P35</td>
<td>Transfer Phase Midcourse (TPM)</td>
</tr>
<tr>
<td>V93</td>
<td>Enable W-Matrix Initialization</td>
</tr>
<tr>
<td>P41</td>
<td>RCS</td>
</tr>
<tr>
<td>V82</td>
<td>Orbital Parameter Display</td>
</tr>
<tr>
<td>P00</td>
<td></td>
</tr>
<tr>
<td>V48</td>
<td>DAP Data Load</td>
</tr>
<tr>
<td>P47</td>
<td>Thrust Monitor</td>
</tr>
<tr>
<td>P00</td>
<td></td>
</tr>
</tbody>
</table>
6.2.0 ABORTS FROM DESCENT

The following applies to all tests in this section unless indicated differently in test description.

a) The LM is yawed left 70 degrees at PDI-3 mins. The 70° degrees yaw is removed at PDI +3 mins. This maneuver is done in the AUTO mode.

b) The AUTO throttle and ABORT back up discreetes are set.

c) The abort switch is failed ON.

d) The SLOSH environment model is not simulated.

e) The environmental FAST IMU is used.

f) Abort sequence:
   Switch to ATTHOLD
   Full Throttle
   ABORT or ABORT STAGE
   V22N46 ENTER ENTER
   Switch to AUTO

g) Terrain slope error of -1 degree.
TEST 6.2.1 ABORT AT 33 K. FT.

I. Test Objective

Demonstrate DPS Abort from descent.

II. Test Description

Program Sequence

- P00
- V48 DAP Data Load
- V64 S-Band Antenna Routine (R05)
- P63 Braking Phase Program
- V57 LR Update (R12)

ABORT sequence at 33 K ft. altitude.

- P70 DPS Abort Program
- N76 Monitor Desired HVEL, RVEL, Crossrange
- N77 Monitor TTOGO, VGY, ABVEL
- N85 Monitor VG
- P00 LGC Idle Program
- V64 S-Band Antenna Routine (R05)
- V82 Orbital Parameter Display Routine (R30)
- V83 Rendezvous Parameter Display Routine (R31)
- P20 Rendezvous Navigation Program
- P32 Coelliptic Sequence Initiation Program
I. Test Objectives

Demonstrate DPS and APS Abort from descent.

II. Test Description

The abort switch is failed OPEN requiring the astronaut to select P70 via DSKY.

Program Sequence

P00
V48   DAP data load
V64   S-Band Antenna Routine (R05)
P63   Braking Phase
V57   LR Update (R12)
P64   Approach Phase
       ATTHOLD at 7 K ft.
       Full throttle
       V22N46 EE
P70   DPS Abort select by Astronaut
       AUTO mode

ABORT STAGE at DPS depletion

P71   APS Abort
N76   Monitor Desired Horizontal, Radial Vel, Crossrange
N77   Monitor TTOGO, VGY, ABVEL
N85   Monitor VG
P00
V64   S-Band Antenna Routine (R05)
V82   Orbital Parameter Display (R30)
V83   Rendezvous Parameter Display (R31)
P20   Rendezvous Navigation
P32   Coelliptic Sequence Initiation
TEST 6.2.3 ABORT AFTER TOUCHDOWN

I. Test Objective

Demonstrate APS (T1) Abort

II. Test Description

The Auto Throttle is failed off.

Program Sequence

P00
V48 DAP Data Load
V64 S-Band Antenna Routine (R05)
P63 Braking Phase
V57 LR Update Enable
P64 Approach Phase
P66 Vertical Phase

ABORT Sequence at Lunar Surface Touchdown
P71 APS Abort
P00
V64 S-Band Antenna Routine (R05)
V82 Orbital Parameter Display (R30)
V83 Rendezvous Parameter Display (R31)
P20 Rendezvous Navigation
P32 Coelliptic Sequence Initiation
6.3.0 LUNAR SURFACE OPERATION AND ALIGNMENTS
I. Test Objective

Demonstrate LM IMU Lunar Surface alignments and operations.

II. Test Description

The LM is tilted approximately $10^\circ$ on the Lunar Surface.

Program Sequence

<table>
<thead>
<tr>
<th>Program</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P68</td>
<td>Lunar Surface Confirmation Program</td>
</tr>
<tr>
<td>P00</td>
<td>Ascent Program</td>
</tr>
<tr>
<td>P12</td>
<td>AT-3 Lunar Surface Alignment to REFSMMAT</td>
</tr>
<tr>
<td>P57</td>
<td>Recycle Gravity Determination</td>
</tr>
<tr>
<td>V47</td>
<td>AGS Initialization</td>
</tr>
<tr>
<td>V41N20</td>
<td>Park IMU</td>
</tr>
<tr>
<td></td>
<td>Coarse align IMU to parking gimbal angles</td>
</tr>
<tr>
<td>P06</td>
<td>LGC Power Down Program</td>
</tr>
<tr>
<td></td>
<td>LGC Power Up</td>
</tr>
<tr>
<td>P57</td>
<td>AT-3 Lunar Surface Alignment to Landing Site</td>
</tr>
<tr>
<td></td>
<td>4 Star sightings</td>
</tr>
<tr>
<td>V63</td>
<td>RR Self test</td>
</tr>
<tr>
<td>P22</td>
<td>Lunar Surface Navigation (No Update Mode)</td>
</tr>
<tr>
<td>P57</td>
<td>AT-3 Lunar Surface Alignment to Landing Site</td>
</tr>
<tr>
<td>V47</td>
<td>AGS Initialization</td>
</tr>
<tr>
<td>V48</td>
<td>DAP Data Load</td>
</tr>
<tr>
<td>V82</td>
<td>Orbital Parameter Display</td>
</tr>
<tr>
<td>P12</td>
<td>Ascent Program to TIG</td>
</tr>
<tr>
<td>P00</td>
<td>Ascent Program</td>
</tr>
</tbody>
</table>

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6.4.0 LUNAR LANDING

The following applies to all tests in this section unless indicated differently in test description.

a) The LM is yawed left 70 degrees at PDI -3 mins. The 70 degree yaw is removed at PDI +3 mins. This maneuver is done in the AUTO mode.

b) The AUTO throttle and ABORT back up discrete are set.

c) The abort switch is failed ON and the auto throttle failed OFF.

d) The SLOSH mode is not simulated.

e) The environmental FAST IMU is simulated.

f) Terrain slope error -1 degree
TEST 6.4.1 LUNAR LANDING - AUTO (ERROR FREE)

I. Test Objective

Demonstrate LM automatic landing.

II. Test Description

This test contains no initialization errors.

Program Sequence

P00
V48 DAP data Load
V64 S-Band Antenna Routine (R05)
P63 Braking Phase
V57 LR Update Enable
N68 Monitor Range, TGO, Velocity
N92 Monitor THROTTLE CMD, HDOT, H
P64 Approach Phase
P66 Vertical Phase
P68 Lunar Surface Confirmation
P00
I. Test Objective
   Demonstrate LM automatic landing.

II Test Description
   This is the same as TEST 6.4.1 (ERROR FREE) except that it contains a -1 degree terrain slope error.
I. Test Objection
   Demonstrate LM automatic landing.

II. Test Description
   This test exercises landing site redesignation option at PDI -10 mins. to correct propagated state vectors errors; at PDI +5 mins. to correct IMU errors and at PDI +8 mins. to correct altitude errors.

Test Sequence
P00
N69  Landing Site Redesignation at PDI -10 mins.
     Downtrack
     Crosstrack
V48  DAP Data Load
V64  S-Band Antenna Routine (R05)
P63  Braking Phase
V57  LR Update Enable
N69  Landing Site Redesignation at PDI +5 mins.
     Downtrack
     Crosstrack
N69  Landing Site Redesignation at PDI +8 mins.
     Altitude
P64  Approach Phase
     LPD ACA: AZ, EL
P66  Vertical Phase
P68  Lunar Surface Confirmation
P00
I. Test Objective

Demonstrate LM nominal landing to offset landing site.

II. Test Description

This test exercises the landing site redesignation option N69 at PDI +2 and LPD during P64. The N69 redesignation offsets the actual landing site.

Program Sequence

P00
V48 DAP Data Load
P63 Braking Phase
N69 Landing Site Redesignation at PDI +2 mins.
   Downtrack
P64 Approach Phase
   LPD ACA: AZ, EL
P66 Vertical Phase
   Entered manually at 700 ft.
P68 Lunar Surface Confirmation
6.5.0 ERASABLE MEMORY PROGRAMS

Only those EMPs specified in the flight plan for a nominal mission will be reported on.

EMP 99 LM DEORBİT TEST 6.5.1
TEST 6.5.1 LM DEORBIT

I Test Objective
Demonstrate LM deorbit using Erasable Memory Program 99.

II Test Description

Test Sequence
P00
Load EMP 99
V48  DAP Data Load
V47  AGS Initialization
P30  External Delta-V
Verify Noun 26
V62  Display Total Attitude Errors
V30  Activate EMP 99
6.6.0 SPECIAL TESTS

The following applies to all tests in this section unless otherwise indicated in the test description.

a) The SLOSH environment is not simulated.
b) The FAST IMU environment is used.
I. Test Objectives

Demonstrate the DOI2 burn with no initialization errors.

II. Test Description

The LM is yawed left 70 degrees after DOI2.
The simulation is terminated at throttle up in P63.

Program Sequence

<table>
<thead>
<tr>
<th>P00</th>
<th>V48</th>
<th>V82</th>
<th>P30</th>
<th>P41</th>
<th>V64</th>
<th>V48</th>
<th>P27</th>
<th>P63</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DAP data load</td>
<td>Orbited Parameter Display (R30)</td>
<td>External Delta V targetting</td>
<td>RCS Burn</td>
<td>S-Band Antenna Routine (R05)</td>
<td>DAP data load</td>
<td>SV Update</td>
<td>Braking Phase</td>
</tr>
</tbody>
</table>
6.6.1B DOI2

I. Test Objective
Demonstrate the DOI2 burn with $1\sigma$ errors.

II. Test Description
This is the same as TEST 6.6.1A except that it is initialized with $1\sigma$ errors.
I. Test Objective

Demonstrate the DOI2 burn with $1\sigma$ errors.

II. Test Description

This is the same as TEST 6.6.1B except that the $1\sigma$ state vector errors are reversed.
3.6.3 TEI Using DPS

I. Test Objective

Demonstrate the TEI burn using the LM DPS.

II. Test Description

Program Sequence

P00
V48 DAP Data Load
V82 Orbital Parameter Display (R30)
P30 External Delta V Targeting
P40 DPS Burn
V82 R30
6.6.4 LOI Using DPS

I. Test Objective
Demonstrate the LOI burn using the LM DPS.

II. Test Description

Program Sequence

P00  
V48  DAP Data Load  
V82  Orbital Parameter Display (R30)  
P30  External Delta V targeting  
P40  DPS Burn  
V82  R30