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LUMINARY Memo #222

To: Distribution  
From: Luminary Test Group  
Date: 15 June 1971  
Subject: Summary of Level 6 Test Results for LUMINARY 1E

Reference: LUMINARY Memo #214 Rev. 1 "Level 6 Test Description  
for Luminary 1E" dated 6 April 1971

This memo summarizes the results of the Level 6 digital testing effort conducted at MIT. The tests fall into the following general categories:

- 6.1.0 RENDEZVOUS
- 6.2.0 ABORTS FROM DESCENT
- 6.3.0 LUNAR SURFACE OPERATIONS, ALIGNMENTS, ASCENT
- 6.4.0 LANDING ON LUNAR SURFACE
- 6.5.0 SPECIAL TESTS

The test initialization listed below apply to all the tests and any special initial conditions will be indicated in the particular test.

- (1)  $1\sigma$  IMU, Radar, State Vector Errors.
- (2) Normal Astronaut interface from Apollo 15 Data File.
- (3) Apollo 15 Operation Trajectory.
- (4) Apollo 15 Erasable Load.
- (5) 71/72 Ephemeris.
- (6) 0 TLOSS.
- (7) LM-10 Vehicle.

Typical values of  $1\sigma$  initialization error are given on page 2.

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## TYPICAL 1 SIGMA INITIALIZATION ERRORS

### IMU ERRORS

|                                  | X     | Y     | Z     |
|----------------------------------|-------|-------|-------|
| Misalignment (milliradians)      | 1.0   | 1.0   | 1.0   |
| Bias Drift (MERU)                | 2.00  | 2.00  | 2.00  |
| Input Axis Drift (MERU/G)        | 8.00  | -8.00 | 8.00  |
| Spin Axis Drift (MERU/G)         | -5.00 | 5.00  | -5.00 |
| PIPA Bias (CM/SEC <sup>2</sup> ) | .20   | .20   | .20   |
| PIPA Scale Factor (PPM)          | -116  | -116  | -116  |

### STATE VECTOR ERRORS AT PDI IGNITION

|                  | ALTITUDE | CROSS-RANGE | DOWN-TRACK |
|------------------|----------|-------------|------------|
| POSITION (ft. )  | -1410    | 1080        | -4220      |
| VELOCITY (fps. ) | 4.3      | 1.28        | -1.38      |

### RENDEZVOUS RADAR ERRORS

|                       | BIAS                                               | RANDOM                               |
|-----------------------|----------------------------------------------------|--------------------------------------|
| RANGE (ft. )          | 800 if $R > 50.8$ N.M.<br>80 if $R \leq 50.8$ N.M. | .3% R                                |
| RANGE-RATE (fps)      | .3                                                 | .4% $\dot{R}$<br>(MINIMUM .0044 fps) |
| SHAFT/TRUNNION (Mr. ) | 15.0                                               | 1.0                                  |

### LANDING RADAR ERRORS

|                 | RANDOM | MINIMUM |
|-----------------|--------|---------|
| ALTITUDE (ft. ) | .5%    | 5       |
| VX (fps)        | .5%    | .8      |
| VY (fps)        | .7%    | .8      |
| VZ (fps)        | 1.0%   | .8      |

## TEST 6.1.1 RENDEZVOUS

### I. Test Objective

This test is made to verify the nominal LM Active Short Rendezvous Program Sequence.

### II. Test Description

#### Timeline



See Figure 1

#### Program Sequence

|     |                                 |
|-----|---------------------------------|
| P00 | LGC Idling                      |
| P20 | Rendezvous Navigation           |
| P34 | Transfer Phase Initiation (TPI) |
| P42 | APS                             |
| P35 | Transfer Phase Midcourse (TPM)  |
| P41 | RCS                             |
| P35 | Transfer Phase Midcourse (TPM)  |
| P41 | RCS                             |
| P00 | LGC Idling                      |
| P47 | Thrust Monitor                  |
| P00 | LGC Idling                      |

#### Extended Verbs

|     |                                        |
|-----|----------------------------------------|
| V47 | Initialize AGS (R47)                   |
| V48 | Start DAP Data Load (R03)              |
| V63 | Start RR/LR Self Test Routine (R04)    |
| V64 | S-Band Antenna Routine (R05)           |
| V67 | W Matrix RMS Error Display             |
| V80 | Enable LM State Vector Update          |
| V82 | Request Orbit Param Display (R30)      |
| V83 | Request Rendezvous Param Display (R31) |
| V93 | Enable W Matrix Initialization         |
| V95 | No Update of Either State Vector       |

### III. Test Initialization

1. 10% TLOSS during powered flights.

### IV. Discussion of Results

The Navigation data from P20 is shown in Table I. The state errors before each targetting computation are as follows:

|      | Position (m) | Velocity (m/s) |
|------|--------------|----------------|
| TPI  | 334          | 0.215          |
| MCC1 | 179          | 0.256          |
| MCC2 | 88           | 0.185          |

These values are considered nominal.

The targetting data is shown in Tables II and III and is considered nominal.

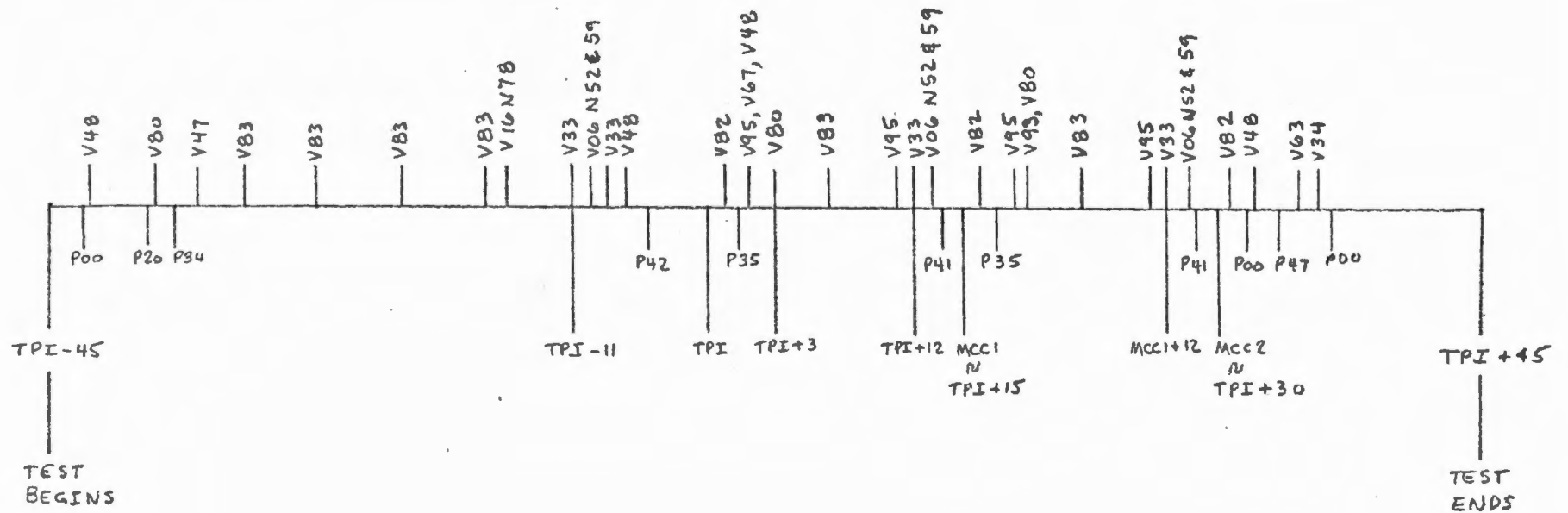
This test had no downrupts lost and had seven N49s (listed in Table IV).

### V. Conclusions and Special Comments

This test verified the nominal LM Active short rendezvous sequence with the closest point of approach computed as 82 meters and less than two FPS of burn uncertainty for each burn.

# 6.1.1 SHORT RENDEZVOUS

Figure I



# SUMMARY OF FIRST-LAST MARK DATA

| TIME(SEC.) | MARKS | POSITION(METERS) |        |       | VELOCITY(M/SEC) |        |        | ZDOT   | MAG   |
|------------|-------|------------------|--------|-------|-----------------|--------|--------|--------|-------|
|            |       | X                | Y      | Z     | MAG             | XDOT   | YDOT   |        |       |
| 619000.239 | 0     | 225              | - 2243 | - 699 | 2361            | -0.398 | -3.421 | 0.140  | 3.447 |
| 620281.449 | 19    | 224              | - .159 | - 190 | 334             | -0.037 | -0.177 | -0.116 | 0.215 |
| 621231.579 | 0     | 303              | - 205  | - 303 | 475             | 0.015  | -0.303 | -0.057 | 0.309 |
| 621606.469 | 6     | 126              | 21     | - 126 | 179             | 0.162  | 0.094  | 0.173  | 0.256 |
| 621965.189 | 0     | 209              | 122    | - 53  | 248             | 0.316  | 0.285  | 0.138  | 0.448 |
| 622488.369 | 8     | 75               | 47     | 0     | 88              | 0.175  | 0.005  | 0.059  | 0.185 |
| 0.000      | 0     | 0                | 0      | 0     | 0               | 0.000  | 0.000  | 0.000  | 0.000 |

TABLE I

| EVENT | TIG<br>SEC | TPI<br>SLIP<br>SEC | DELTA<br>ALT<br>NM | DELTA V (LOCAL VERT)-FPS |                |                      |                  | BURN RESIDUAL-FPS |       |       | ENV CPA     |            |
|-------|------------|--------------------|--------------------|--------------------------|----------------|----------------------|------------------|-------------------|-------|-------|-------------|------------|
|       |            |                    |                    | X                        | Y              | Z                    | MAG              | X                 | Y     | Z     | TIME<br>SEC | RANGE<br>M |
|       |            |                    |                    |                          |                |                      |                  |                   |       |       |             |            |
| TP1   | 620979.90  | - 0.00<br>- 0.00   |                    | + 70.7 -<br>+ 70.6 +     | 0.2 -<br>0.4 + | + 21.4 +<br>+ 21.9 + | + 73.9<br>+ 73.9 | + 0.1 -           | 0.1 - | + 0.3 | 623498.19   | 219.2      |
| MCC1  | 621887.01  |                    |                    | - 0.5 -<br>- 0.5 +       | 0.6 -<br>0.2 - | + 0.1 +<br>1.1 +     | + 0.8<br>1.2     | - 0.0 -           | 0.0 - | + 0.1 | 623421.13   | 579.3      |
| MCC2  | 622790.93  |                    |                    | + 2.5 -<br>+ 2.4 -       | 1.1 -<br>0.7 + | + 5.4 +<br>4.1 +     | + 6.1<br>4.8     | + 0.1 +           | 0.2 + | + 0.2 | 623497.00   | 82.3       |

TABLE II

# BURN PERFORMANCE

| TEST         | EVENT | BURN UNCERTAINTY (FPS) |       |         |       | DELTA<br>V MAG<br>(FPS) | MISS<br>(METERS) |
|--------------|-------|------------------------|-------|---------|-------|-------------------------|------------------|
|              |       | RANGE                  | TRACK | ALT     | MAG   |                         |                  |
|              | CSI   | + 0.0                  | + 0.0 | + 0.0   | + 0.1 | 0.0                     |                  |
|              | CDH   | + 0.0                  | + 0.0 | + 0.0   | + 0.1 | 0.0                     |                  |
|              | TPI   | - 0.1                  | + 0.7 | + 0.5   | + 0.9 | 73.9                    | 219              |
|              | MCC1  | + 0.1                  | + 1.0 | - 1.4   | + 1.7 | 1.2                     | 579              |
|              | MCC2  | - 0.1                  | + 0.4 | - 1.4   | + 1.5 | 4.8                     | 82               |
| TPI SLIPPAGE |       | -                      | 0.00  | SECONDS |       |                         |                  |

TABLE III

## SUMMARY OF EXCESSIVE STATE VECTOR UPDATE DATA

| MARKTIME<br>SECS. | RMAG<br>FEET | VMAG<br>FT/SEC |
|-------------------|--------------|----------------|
| 619000.2399       | 2047.34      | 2.497259       |
| 619000.2399       | 5689.25      | 4.590250       |
| 619000.2399       | 3504.10      | 0.000000       |
| 619085.8599       | 0.00         | 3.420002       |
| 619085.8599       | 1410.82      | 3.409990       |
| 619236.2499       | 3280.99      | 4.405952       |
| 619932.3299       | 1391.14      | 2.991016       |
| 0.0000            | 0.00         | 0.000000       |

TABLE IV

## TEST 6.2.1 ABORT AT 33 K. FT.

### I. Test Objective

Verify proper operation and ascertain performance of the DPS Abort Program P70 in Luminary revision 210.

### II. Test Description

This test is run with ABORT discrete present

#### Program Sequence

P00 Idle Program  
V48 DAP Data Load.  
Set Abort Backup  
V64 S-Band Antenna Routine (R05)  
P63 Braking Phase Program  
V57 State Vector Update Routine; LR Update (R12)

Manual Throttle to 99% and ABORT at 33K ft.

ATTITUDE HOLD

P70 DPS Abort Program  
Switch to AUTO

P00 LGC Idling Program  
V64 S-Band Antenna Routine (R05)  
V82 Orbital Parameters Display Routine (R30)  
V83 Rendezvous Parameter Display Routine (R31)  
P20 Rendezvous Navigation Program  
P32 Coelliptic Sequence Initiation Program

While in P70 the following exercises will be performed:

- I. Manual yaw maneuver to observe vehicle attitude control response to ACA when mode control is AUTO.
- II. Monitor N76, N77, N85 via V16.

### III. Test Initialization

1. Environment initialization
  - A. Terrain profile with  $+1^{\circ}$  errors.
  - B. 10% TLOSS
2. CHANBKUP abort discrete set in P00.

#### IV. Test Results

Examination of the on-line printout, guidance edits, and DAP performance edit and plots revealed that the LGC Abort Program behaved in a nominal fashion. The correct targets were selected and the TGO and the desired downrange velocities were computed correctly. The insertion parameters were as targetted, with small  $\Delta V$  residuals in N85.

Throughout the simulation, Ascent nouns 76, 77, and 85 were monitored, and it was seen that the correct data was available through these nouns.

During this test, there were 1 lost downrupts. The analysis and report of these lost downrupts is included in LUMINARY Development Note #87 dated 14 June 1971.

#### V. Conclusion

The objective has been achieved.

# Figures of Merit - 6.2.1

| Data (insertion)          | Environment Value | LGC Value | Target Value |
|---------------------------|-------------------|-----------|--------------|
| Apolune (n. mi.)          | 137.04            | 132.4     | 132.5        |
| Perilune (n. mi.)         | 10.27             | 9.8       |              |
| Out of Plane distance     | .15 n. mi.        | -1.2ft    | 0            |
| Altitude (ft.)            | 59614             | 60051     | 60000        |
| Altitude rate (fps)       | 25.6              | 19.88     | 19.5         |
| Down range Velocity (fps) | 5654              | 5651      | 5651         |
| Yaw angle (deg)           | +.19              | .53       |              |
| Pitch angle (deg)         | -11.24            | -10.52    |              |
| VGX Body (fps)            |                   | +.118     |              |
| VGY Body (fps)            |                   | +.041     |              |
| VGZ Body (fps)            |                   | +.533     |              |
| Theta [phase angle]       |                   | -15.05    |              |

Abort at 33 K Ft.  
Displays of Interest

| V/N   | R1     | R2     | R3     | Mode |
|-------|--------|--------|--------|------|
| 04/46 | 21112  | 00001  |        | 00   |
| 06/47 | +36703 | +38643 |        |      |
| 06/51 | +16243 | -04315 |        |      |
| 06/61 | -11x05 | -3x44  | -00002 | 63   |
| 50/18 | +35993 | +11006 | +00023 |      |
| 06/62 | +55639 | -01x00 | +00000 |      |
| 06/63 | +99999 | -00043 | +49849 |      |
| 06/63 | -03670 | -00768 | +35750 |      |
| 06/94 | +30179 | -00001 | +30077 | 70   |
| 16/94 | +00001 | +00201 | +60070 |      |
| 16/85 | +00004 | -00008 | +00009 |      |
| 06/51 | +17401 | +01719 |        | 00   |
| 16/44 | +01322 | +00098 |        |      |
| 16/54 | +26517 | +05350 |        |      |

Timeline of Test 6.2.1  
Abort at 33 K Ft.

| <u>Event</u>                 | <u>Time (G. E. T.)</u> |
|------------------------------|------------------------|
| Start Simulation             | 375834.8               |
| P00                          | 375849                 |
| V48 (R03) (CHANBKUP = 00001) | 375870                 |
| V64 (R05)                    | 375876                 |
| P63 initiation               | 375896                 |
| DPS engine ignition (PDI)    | 376137                 |
| Throttle up                  | 376163                 |
| LR Data acceptance           | 376456                 |
| Abort Sequence initiation    | 376470                 |
| P70 Entry                    | 376480                 |
| DPS engine cutoff            | 376727                 |
| P00                          | 376749                 |
| V64 (R05)                    | 376770                 |
| V82 (R30)                    | 376783                 |
| V83 (R31)                    | 376802                 |
| P20                          | 376825                 |
| P32                          | 376892                 |
| End Simulation               | 377818                 |

## TEST 6.2.2 ABORT AT 7K FT.

### I. Test Objective

Verify operation and ascertain performance of the APS Abort Program (after DPS depletion in the DPS Abort Program) in Luminary revision 210.

### II. Test Description

This test is run with the ABORT discrete present

#### Program Sequence

|             |                                              |
|-------------|----------------------------------------------|
| P00         | Idle Program                                 |
| V48         | DAP Data Load                                |
|             | Set Abort Backup                             |
| V64         | S-Band Antenna Routine (R05)                 |
| P63         | Braking Phase Program                        |
| V57         | State Vector Update Routine; LR Update (R12) |
| P64         | Approach Phase Program                       |
| P70         | DPS Abort Program (at 7K ft)                 |
| Abort Stage |                                              |
| P71         | APS Abort Program (at DPS depletion)         |
| P00         | LGC Idling Program                           |
| V64         | S-Band Antenna Routine (R05)                 |
| V82         | Orbital Parameters Display Routine (R30)     |
| V83         | Rendezvous Parameters Display Routine (R31)  |
| P20         | Rendezvous Navigation Program                |
| P32         | Coelliptic Sequence Initiation Program       |

While in P70, the following exercise will be performed (until DPS depletion):

I. Monitor N76, N77, N85 via V16.

While in P71, the following exercises will be performed:

I. Manual yaw maneuver to observe vehicle attitude control response to ACA when mode control is ATTHOLD.

II. Monitor N76, N77, N85 via V16.

III. Test Initialization

1. Environment Initialization

A. LM-10 Vehicle

B. Terrain profile with  $+1^{\circ}$  errors.

C. 10% TLOSS

2. CHANBKUP abort discrete set in P00.

#### IV. Test Results

Examination of the on-line printout, guidance edits, and DAP performance edit and plots revealed that the LGC Abort Program behaved in a nominal fashion. The correct targets were selected and the TGO and the desired downrange velocities were computed correctly. The insertion parameters were as targetted, with small  $\Delta V$  residuals in N85.

Throughout the simulation, Ascent nouns 76, 77, and 85 were monitored, and it was seen that the correct data was available through these nouns.

During this test, there were 19 lost downrupts. The analysis and report of these lost downrupts is included in LUMINARY Development Note #87 dated 14 June 1971.

#### V. Conclusion

The objective has been achieved.

# Figures of Merit - 6.2.2

| Data (insertion)          | Environment Value | LGC Value | Taget Value |
|---------------------------|-------------------|-----------|-------------|
| Apolune (n. mi.)          | 102.5             | 100.2     | 101         |
| Perilune (n. mi.)         | 10.54             | 10.4      |             |
| Out of Plane distance     | -.03 n. mi.       | -1.64 ft  | 0           |
| Altitude (ft.)            | 58491             | 64031     | 60000       |
| Altitude rate (fps)       | 27.0              | 20.1      | 19.5        |
| Down range Velocity (fps) | 5609              | 5607.8    | 5607        |
| Yaw angle (deg)           | +1.17             | +.91      |             |
| Pitch angle (deg)         | -3.13             | -5.5      |             |
| VGX Body (fps)            |                   | -.07      |             |
| VGY Body (fps)            |                   | +.08      |             |
| VGZ Body (fps)            |                   | +.93      |             |
| Theta [phase angle]       |                   | +1.39     |             |

Abort - Abort Stage at 7 K Ft.  
Displays of Interest

| V/N   | R1     | R2     | R3     | Mode |
|-------|--------|--------|--------|------|
| 04/46 | 21112  | 00001  |        | 00   |
| 06/47 | +36703 | +38643 |        |      |
| 06/61 | -11x05 | -03x54 | -00002 | 63   |
| 50/18 | +35993 | +11006 | +00023 |      |
| 06/62 | +55639 | -01x00 | +00000 |      |
| 06/63 | +99999 | -00043 | +49849 |      |
| 06/63 | -03874 | -00618 | +40517 |      |
| 06/64 | +99x40 | -1752  | +06978 | 64   |
| 06/94 | +07732 | +00247 | +05385 | 70   |
| 97/94 | +41154 | +02391 | +21635 |      |
| 06/94 | +42403 | +02009 | +24221 | 71   |
| 16/94 | -00004 | +00205 | +63902 |      |
| 16/85 | +00004 | -00012 | +00019 |      |
| 06/51 | +17327 | +01455 |        | 00   |
| 16/44 | +01000 | +00104 |        |      |
| 16/54 | +04587 | -02031 | +30524 |      |

# Timeline of Test 6.2.2

Abort - Abort stage at 7 K Ft.

| <u>Event</u>                  | <u>Time (G. E. T.)</u> |
|-------------------------------|------------------------|
| Start simulation              | 375834.8               |
| P00                           | 375849                 |
| V48 (R03) (CHANBKUP = 00001)  | 375869                 |
| P63 initiation                | 375885                 |
| Start attitude maneuver (R60) | 375907                 |
| End attitude maneuver         | 375993                 |
| Abort button depress          | 376135                 |
| DPS engine ignition (PDI)     | 376137                 |
| Throttle up                   | 376163                 |
| LR Data acceptance            | 376386                 |
| Throttle down                 | 376583                 |
| P64 initiation                | 376698                 |
| Abort procedure initiation    | 376702                 |
| P70 entry                     | 376712                 |
| DPS Engine fuel exhaustion    | 376803                 |
| Abort stage button depress    | 376812                 |
| P71 entry                     | 376822                 |
| APS engine cutoff             | 377160                 |
| P00                           | 377256                 |
| V64 (R05)                     | 377285                 |
| V82 (R30)                     | 377297                 |
| V83 (R31)                     | 377316                 |
| P20                           | 377339                 |
| P32                           | 377436                 |
| End simulation                | 377784                 |

### TEST 6.2.3 ABORT AFTER TOUCHDOWN

#### I. Test Objective

Verify operation and ascertain performance of the APS Abort Program (after a nominal Lunar Landing) in Luminary revision 210.

#### II. Test Description

This test is run with the ABORT present

##### Program Sequence

|     |                                              |
|-----|----------------------------------------------|
| P00 | Idle Program                                 |
| V48 | DAP Data Load Routine (R03)                  |
|     | Set abort channel backup                     |
| P63 | Braking Phase Program                        |
| V57 | State Vector Update Routine; LR Update (R12) |
| P64 | Approach Phase Program                       |
| P66 | Vertical Phase Program (R. O. D. -Auto)      |

##### Abort Stage

|     |                                             |
|-----|---------------------------------------------|
| P71 | APS Abort Program (after Touchdown)         |
| P00 | LGC Idling Program                          |
| V64 | S-Band Antenna Program (R05)                |
| V82 | Orbital Parameters Display Routine (R30)    |
| V83 | Rendezvous Parameters Display Routine (R31) |
| P20 | Rendezvous Navigation Program               |
| P32 | Coelliptic Sequence Initiation Program      |

While in P71, the following exercises will be performed:

- I. Manual yaw maneuver to observe vehicle attitude control response to ACA when mode control is ATTHOLD.
- II. Monitor N76, N77, N85 via V16.

### III. Test Initialization

#### 1. Environment Initialization

- A. LM-10 Vehicle
- B. Terrain profile with  $+1^{\circ}$  errors
- C. 10% TLOSS

#### 2. CHANBKUP abort discrete set in P00

#### IV. Test Results

Examination of the on-line printout, guidance edits, and DAP performance edit and plots revealed that the LGC Abort Program behaved in a nominal fashion. The correct targets were selected and the TGO and the desired downrange velocities were computed correctly. The insertion parameters were as targetted, with small  $\Delta V$  residuals in N85.

Throughout the simulation, Ascent nouns 76, 77, and 85 were monitored, and it was seen that the correct data was available through these nouns.

During this test, there were 12 lost downrupts. The analysis and report of these lost downrupts is included in LUMINARY Development Note #87 dated 14 June 1971.

#### V. Conclusion

The objective has been achieved.

### Figures of Merit - 6.2.3

| Data (insertion)          | Environment Value | LGC Value | Target Value |
|---------------------------|-------------------|-----------|--------------|
| Apolune (n. mi.)          | 71.9              | 69.5      | 70.5         |
| Perilune (n. mi.)         | 9.79              | 9.7       |              |
| Out of Plane distance     | -.04 n.mi.        | 9 ft      | 0            |
| Altitude (ft)             | 55750             | 60318     | 60000        |
| Altitude rate (fps)       | 27.1              | 19.5      | 19.5         |
| Down range Velocity (fps) | 5572              | 5569      | 5578         |
| Yaw angle (deg)           | -4.02             | -1.15     |              |
| Pitch angle (deg)         | -5.47             | -6.53     |              |
| VGX Body (fps)            |                   | +.25      |              |
| VGY Body (fps)            |                   | +.13      |              |
| VGZ Body (fps)            |                   | +.22      |              |
| Theta [phase angle]       |                   | +10.15    |              |

Abort Stage from Touchdown - A

Displays of Interest

| V/N   | R1     | R2     | R3     | Mode |
|-------|--------|--------|--------|------|
| 04/46 | 21112  | 00001  |        | 00   |
| 06/47 | +36703 | +38643 |        |      |
| 06/61 | -11x05 | -04x08 | -00002 | 63   |
| 50/18 | +35993 | +11006 | +00023 |      |
| 06/62 | +55639 | -01x00 |        |      |
| 06/63 | +99999 | -00045 | +49856 |      |
| 06/63 | -02008 | -00635 | +37563 |      |
| 16/68 | -00752 | -05x45 | +30852 |      |
| 16/92 | +00103 | -00715 | +28741 |      |
| 06/63 | +00072 | -01819 | +10246 |      |
| 06/64 | +99x79 | -01830 | +07737 | 64   |
| 06/60 | +00047 | -00066 | +00195 | 66   |
| 06/60 | -00004 | -00002 | +00002 |      |
| 06/60 | +00015 | +00169 | +00034 |      |
| 06/94 | +27035 | +00568 | +00298 | 71   |
| 16/94 | +00001 | +00203 | +60376 |      |
| 16/85 | +00003 | -00000 | +00009 |      |
| 16/44 | +00692 | +00097 |        | 00   |
| 16/54 | +17248 | -04472 | +30654 |      |

Timeline of Test 6.2.3  
Abort Stage from Touchdown - A

| <u>Event</u>                  | <u>Time (G. E. T.)</u> |
|-------------------------------|------------------------|
| Start simulation              | 375834.8               |
| P00                           | 375850                 |
| V48 (R03) (CHANBKUP=00001)    | 375867                 |
| P63 initiation                | 375875                 |
| Start attitude maneuver (R60) | 375895                 |
| Finish attitude maneuver      | 375982                 |
| Abort button depress          | 376135                 |
| DPS engine ignition (PDI)     | 376137                 |
| Throttle up                   | 376163                 |
| LR data acceptance            | 376389                 |
| Throttle recovery             | 376583                 |
| P64 initiation                | 376698                 |
| P66 initiation                | 376822                 |
| Touchdown; DPS engine cutoff  | 376854                 |
| Abort Stage button depress    | 376857                 |
| P71 entry                     | 376870                 |
| APS engine cutoff             | 377294                 |
| V64 (R05)                     | 377345                 |
| V82 (R30)                     | 377358                 |
| V83 (R31)                     | 377378                 |
| P20                           | 377401                 |
| P32                           | 377472                 |
| End simulation                | 378395                 |

## TEST 6.3.1 LUNAR SURFACE OPERATIONS

### I. Test Objective

This test is made to demonstrate the LM IMU alignment capability for a nominal program sequence during the lunar surface stay.

### II. Test Description

#### Program Sequence

|        |                                                                                                 |
|--------|-------------------------------------------------------------------------------------------------|
| P68    | Lunar Surface Confirmation Program                                                              |
| P00    |                                                                                                 |
| P12    | Ascent Program                                                                                  |
| P57    | AT=1 Lunar Surface Alignment to REFSMMAT<br>(Recycle Gravity Determination)<br>(Reject Noun 93) |
| V41N72 | Radar Designate                                                                                 |
| P57    | AT-2 Lunar Surface Alignment to REFSMMAT<br>(Star and Planet)                                   |
| P57    | AT-2 Lunar Surface Alignment to REFSMMAT<br>(2 stars)                                           |
| V47    | AGS Initialization                                                                              |
| P06    | LGC Power Down Program                                                                          |
| P00    |                                                                                                 |
| P57    | AT-3 Lunar Surface Alignment to Landing Site<br>(1 star, Spiral-Cursor marks)                   |
| V64    | S-Band Antenna Routine                                                                          |
| V63    | Radar Selftest                                                                                  |
| P22    | Lunar Surface Navigation (No Update Mode)                                                       |
| V48    | DAP Data Load                                                                                   |
| P57    | AT-3 Lunar Surface Alignment to Landing Site<br>(1 star)                                        |
| V47    | AGS Initialization Routine                                                                      |
| V48    | DAP Data Load                                                                                   |

V82      Orbital Parameter Display  
P12      Ascent Program  
          (Terminate at TIG -5)  
P00

Initialization

Landing Site Lat. = 26.073, Long. = 3.653

## TEST DATA - ALIGNMENTS

### P68

NOUN 43

Lat. = 26.07, Long. = 3.66

(This agrees within .01 degs. of actual landing site)

### P57 AT-1 to REFSMMAT

NOUN 04 = .00

RECYCLE

NOUN 04 = .00

NOUN 05 = -.01

NOUN 93 = +.005, -.009, -.006

True misalignment after torquing

OG = .005, IG = .000, MG = .006

### P57 AT-2 to REFSMMAT

1st sighting: detent 2, starcode 01, sighting err = .00

2nd sighting: detent 4, starcode 00, sighting err = .00

NOUN 05 = .00

NOUN 93 = -.008, .001, -.008

True misalignment after torquing

OG = .004, IG = .005, MG = -.004

NOUN 89 AGC computed Landing Site

Lat. = 26.078, Long. = 3.642

(This agrees within .01 degs. of actual landing site)

### P57 AT-2 to REFSMMAT

1st sighting: detent 2, starcode 01, sighting err = .00

2nd sighting: detent 4, starcode 05, sighting err = .00

NOUN 05 = .00

NOUN 93 = -.003, -.006, .002

True misalignment after torquing

OG = .006, IG = .002, MG = -.005

NOUN 89 AGC Computed Landing Site

Lat. = 26.079, Long. = 3.652

(This agrees to within .01 degs. of actual landing site)

P57 AT-3 to Landing Site

NOUN 04 = .00

Sighting: detent 4, starcode 05, sighting err = .00

NOUN 05 = -.01

NOUN 93 = -.003, -.012, -.014

True misalignment after torquing

OG = -.000, IG = .001, MG = -.006

P57 AT-3 to Landing Site

NOUN 04 = .00

Sighting: detent 2, starcode 01, sighting err = .00

NOUN 05 = .00

NOUN 93 = +.005, +.000, +.017

True misalignment after torquing

OG = .011, IG = .000, MG = .004

TEST DATA - VERB 64 (S-Band Antenna Routine)

Pitch Angle = 71.578, err = .11 degrees

Yaw Angle = -63.09, err = -.19 degrees

VERB 82 (Orbital Parameter Display)

|             |       |            |
|-------------|-------|------------|
| AGC NOUN 44 | 62.7  | 52.5 (nm)  |
| ENV         | 62.64 | 52.48 (nm) |

### TEST 6.3.1.1 INFLIGHT ALIGNMENTS

#### I. Test Objective

This test is made to demonstrate the LM IMU alignment capability for a nominal program sequence using the P57 sighting mark procedure and normal inflight mark procedure.

#### II. Test Description Program Sequence

P00

V48 DAP Data Load

V41N72 RADAR Designate

P52 Alignment to REFSMMAT

Select P57 Sighting Procedure  
(star-planet, Cursor-Spiral marks)

V48 DAP Data Load

P52 Alignment to REFSMMAT  
(2 stars, normal X-Y marks)

P52 Alignment to REFSMMAT  
(Sun-Planet, normal X-Y marks)

P00

#### III. Test Initialization

1. IMU errors to reflect docked coarse aligned IMU.

## TEST DATA - Inflight Alignments

### P52 Alignment to REFSMMAT Using Cursor-Spiral Marking Technique

1st sighting: Detent 5, Starcode 00 (Planet), sighting err = .00

2nd sighting: Detent 1, Starcode 02, sighting err = .00

NOUN 05 = +.01

NOUN 93 = -.419, +.002, +.390

True misalignment after torquing

OG = .002, IG = -.007, MG = .011

### P52 Alignment to REFSMMAT

1st Sighting: Detent 2, Starcode 40, sighting err = .00

2nd Sighting: Detent 2, Starcode 45, sighting err = .00

NOUN 05 = .00

NOUN 93 = -.001, +.013, -.008

True misalignment after torquing

OG = -.001, IG = .004, MG = .006

### P52 Alignment to REFSMMAT

1st Sighting: Detent 2, Starcode 46 (Sun), sighting err = .01

2nd Sighting: Detent 2, Starcode 00 (Planet), sighting err = .00

NOUN 05 = .00

NOUN 93 = .001, .003, .001

True misalignment after torquing

OG = -.002, IG = .004, MG = .008

## TEST 6.3.2 ASCENT FROM LUNAR SURFACE

### I. Test Objective

This test is made to verify LM performance for a nominal program sequence for Ascent from the Lunar Surface.

### II. Test Description

#### Program Sequence

|                                 |                                         |
|---------------------------------|-----------------------------------------|
| P68                             | Lunar Surface Confirmation              |
| P00                             |                                         |
| V48                             | DAP Data Load                           |
| P12                             | Ascent                                  |
| Target for 1 n. m. out-of-plane |                                         |
|                                 | Yaw LM 40° after the nominal pitch over |
| V83                             | Request Rendezvous Parameter Display    |
| V64                             | S-Band Antenna Routine                  |
| P00                             |                                         |
| V48                             | DAP Data Load                           |
| V82                             | Request Orbital Parameter Display       |
| V83                             | Request Rendezvous Parameter Display    |
| P20                             | Rendezvous Navigation                   |
|                                 | No state vector update                  |
| V83                             | Request Rendezvous Parameter Display    |
| P34                             | TPI                                     |
| P00                             |                                         |

### III. Test Initialization

1. 10% TLOSS
2. 14.5 n. m. out of CSM plane

### Ascent Insertion Data

|                       | ENV    | LGC    | TARGETTED |
|-----------------------|--------|--------|-----------|
| H <sub>A</sub> (nm)   | 52.24  | 54.2   |           |
| H <sub>P</sub> (nm)   | 9.24   | 9.3    |           |
| Y (ft)                | 37.08  | 7191   | 7176      |
| H (ft)                | 57739  | 60531  | 60000     |
| HDOT (fps)            | 18.8   | 31.6   | 32.       |
| Forvel (fps)          | 5542.3 | 5541.0 | 5541.0    |
| Yaw (deg)             | 6.47   | 5.45   |           |
| Pitch (deg)           | -2.74  | -5.01  |           |
| V <sub>GX</sub> (fps) |        | -.2    |           |
| V <sub>GY</sub> (fps) |        | -1.0   |           |
| V <sub>GZ</sub> (fps) |        | 1.5    |           |

#### IV. Discussion of Results

In P12 the orbit achieved had an apolune of 54.2 n.m. and a perilune of 9.3 n.m. Three seconds after cutoff, V94 display were as follows:

VGX (LM) = -.2 ft/sec.  
altitude rate = 31.6 ft/sec.  
computed altitude = 60531 ft.

The N85 display of residuals were 0, -.3 and 1.8 ft/sec.

These are expected results.

In P34 the following values were computed:

|                             | AGC   | MAC   | ENV   |         |
|-----------------------------|-------|-------|-------|---------|
| Elevation angle             | 15.71 | 15.69 | 15.71 | degrees |
| Perigee altitude (Post TPI) | 47.8  | 48.2  | 48.2  | n.m.    |
| Delta V (TPI)               | 109.1 | 109.3 | 109.5 | ft/sec. |
| Delta V (TPF)               | 48.7  | 48.8  | 48.6  | ft/sec. |
| Delta VX (LV)               | 74.0  | 74.1  | 74.2  | ft/sec. |
| Delta VY (LV)               | -11.7 | -11.8 | -12.4 | ft/sec. |
| Delta VZ (LV)               | 79.3  | 79.4  | 79.5  | ft/sec. |

V. Conclusions and Special Comments

This test verifies the nominal Ascent from Lunar Surface sequence.

## TEST 6.4.1 LUNAR LANDING

### I. Test Objective

This test is made to verify LM performance during an automatic landing program sequence.

### II. Test Description

This test will exercise the landing site redesignation option prior to PDI to update targeted landing site. The abort discrete is failed throughout the landing. The LM is yawed left 50 degrees at PDI -3 min. The 50 degrees is removed at PDI +3 min.

#### Program Sequence

P00

N69 Landing Site Redesignation at PDI -10 min.

Down track -6865 ft.

Cross track +417 ft.

Altitude +380 ft.

V48 DAP Data Load

Set ABORT Backup Discrete

P63 Braking Phase at PDI -5 min.

V57 LR Enable

N69 Landing Site Redesignation at PDI +5 min.

Down track +653 ft.

Cross track +662 ft.

N68 Monitor range, TGO, Velocity

N92 Monitor throttle CMD, HDOT, H

P64 Approach Phase

P66 Vertical Phase

P68 Lunar Surface confirmation

P00

### III. Test Initialization

1. Terrain profile (+1<sup>0</sup>) error

#### 6.4.1 Automatic Landing with N69 Corrections

|                    |                      |                      |                           |
|--------------------|----------------------|----------------------|---------------------------|
| Ignition           | 376134.4             | Low gate             | 376821                    |
| Altitude: Yaw      | -51                  | Altitude             | AGC/ENV<br>189/208        |
| Pitch              | -178                 | Alt-rate             | -5.7/-5.5                 |
| Roll               | 0                    | V-horiz              | +4.7/ 5.5                 |
|                    |                      |                      |                           |
| V57: Time          | 376389               | Touchdown            | 376856                    |
| Altitude           | 40,010               | Altrate              | -5.8                      |
| Deltah             | -3531                | V-horiz              | +.2                       |
|                    |                      |                      |                           |
| Throttledown       | 376579               | Navigation errors    | R <sub>x</sub> 104 meters |
| TTF                | -176                 | (SM coords.)         | R <sub>y</sub> -1940      |
| Altitude           | 14201                |                      | R <sub>z</sub> -986       |
| Alt-rate           | -85.5                |                      | V <sub>x</sub> -0.4 m/sec |
| V-horiz            | 1149                 |                      | V <sub>y</sub> 0          |
| Range              | -168 n.m.            |                      | V <sub>z</sub> -.14       |
|                    |                      |                      |                           |
| Max thrust         |                      |                      |                           |
| after throttledown | 6527 lbs             | Fuel: RCS            | 21.2 lbs                  |
| Time               | 376702               | DPS                  | 18208 lbs                 |
| Altitude           | 7469                 |                      |                           |
|                    |                      |                      |                           |
| Highgate           | 376697               | RLS-Actual site      |                           |
| Altitude           | AGC/ENV<br>8473/8239 | (MF coords.) X       | 72.7 meters               |
| Alt-rate           | -198.5/-199.5        | Y                    | -350                      |
| v-horiz.           | 283/283.4            | Z                    | -118                      |
| Range              | -25                  |                      |                           |
|                    |                      |                      |                           |
| 500' : Time        | 376794               | Ground-Track coords. |                           |
| Altitude           | 496                  | Crossrange           | 399'                      |
| Alt-rate           | -17                  | Downrange            | -1168'                    |
| v-horiz.           | 42.6                 |                      |                           |

## TEST 6.4.2.1 LUNAR LANDING

### I. Test Objective

This test is made to verify LM performance during a nominal landing program sequence.

### II. Test Description

This test sequence exercises the landing site redesignation option in P63. The abort discrete is failed in P63, P64, P66.

LM is yawed left 50 degrees at TIG -3 min. The 50 degrees is removed at TIG +3 min.

#### Program Sequence

P00

V48 DAP Data Load

Set ABORT BACKUP

P63 Braking Phase

N69 Landing Site Redesignation at TIG +30 sec.

Down range 10 K ft.

Cross range 5 K ft.

P64 Approach Phase

P66 Vertical Phase

Entered at 700 ft. - Attitude Hold and  $\pm$  ROD switch

P00

### III. Test Initialization

1. Terrain profile ( $+1^0$ ) error.

#### 6.4.2.1 Landing with Redesignations (N69)

|                    |               |                     |                |            |
|--------------------|---------------|---------------------|----------------|------------|
| Ignition           | 376135.6      | Lowgate             | 376788         |            |
| Attitude: Yaw      | -50           | Altitude            | AGC/ENV        |            |
| Pitch              | -176          | Alt-rate            | 614/602        |            |
| Roll               | .1            | V-horiz.            | -23.2/-20.8    |            |
|                    |               |                     | +73.8/+73.7    |            |
| V57: Time          | 376391        | Touchdown           | 376874         |            |
| Altitude           | 40,565        | Alt-rate            | -3.9           |            |
| Deltah             | -4349         | V-horiz             | -.1            |            |
| Throttledown       | 376573        | Navigation errors   | R <sub>x</sub> | +39 m      |
| TTF                | -192          | (SM coords)         | R <sub>y</sub> | -1981      |
| Altitude           | 16,472        |                     | R <sub>z</sub> | -1019      |
| Alt-rate           | -72.4         |                     | V <sub>x</sub> | -.07 m/sec |
| V-horiz            | 1256.4        |                     | V <sub>y</sub> | 0          |
| Range              | -199          |                     | V <sub>z</sub> | -.16       |
| Max thrust         |               |                     |                |            |
| after throttledown | 6551          | Fuel: RCS           | 23.75 lbs      |            |
| Time               | 376678        | DPS                 | 18317 lbs      |            |
| Altitude           | 12,291        |                     |                |            |
| Highgate           | 376706        | RLS - Actual Site   |                |            |
| Altitude           | AGC/ENV       | (MF coords) X       | 477 m          |            |
| Alt-rate           | 7357/7224     | Y                   | 4624           |            |
| V-horiz            | -162.6/-163.1 | Z                   | -1464          |            |
| Range              | 284/286.3     | Ground-Track coords |                |            |
|                    | -25 NM        | Crossrange          | 5703'          |            |
|                    |               | Downrange           | 14,937'        |            |

## TEST 6.4.2.2 LUNAR LANDING

### I. Test Objective

This test is made to verify LM performance using nominal program procedures.

### II. Test Description

This test sequence exercises the landing site redesignation options in P63 and P64. The abort discrete is failed prior to P63.

LM is yawed left 50 degrees at TIG -3 min. The 50 degrees is removed at TIG +3.

#### Program Sequence

P00

V48      DAP Data Load  
          Set ABORT Backup

P63      Braking Phase

N69      Land Site Redesignation at TIG +30 sec.  
          Dwntrack 20 K ft  
          Crosstrack 20 K ft

P64      Approach Phase  
          ACA: 2(-EL), 2(+AZ)

P66      Vertical Phase  
          Enter at 700 ft. manually

P00

### III. Test Initialization

1. 10% TLOSS
2. Terrain profile (+1°) error.

#### 6.4.2.2 Landing with Redesignations (N69 & ACA)

|                    |               |                      |                |        |
|--------------------|---------------|----------------------|----------------|--------|
| Ignition           | 376135.6      | Lowgate              | 367802         |        |
| Attitude: Yaw      | -50           | Altitude             | AGC/ENV        |        |
|                    |               |                      | 560/570        |        |
| Pitch              | -178          | Alt-rate             | -20.6/-20.2    |        |
| Roll               | 0             | V-horiz              | +51.8/+50.9    |        |
|                    |               |                      |                |        |
| V57: Time          | 376420        | Touchdown            | 376885         |        |
| Altitude           | 39207         | Alt-rate             | -4.3           |        |
| Deltah             | -3150         | V-horiz              | -.1            |        |
|                    |               |                      |                |        |
| Throttledown       | 376565        | Navigation Errors    | R <sub>x</sub> | +23 m  |
| TTF                | -207          | (SM coords)          | R <sub>y</sub> | -2039  |
| Altitude           | 18,190        |                      | R <sub>z</sub> | -1059  |
| Alt-rate           | -58.5         |                      | V <sub>x</sub> | -.02   |
| V-horiz            | 1362.4        |                      | V <sub>y</sub> | -.02   |
| Range              | -233          |                      | V <sub>z</sub> | -.18   |
|                    |               |                      |                |        |
| Max. thrust        |               |                      |                |        |
| after throttledown | 9990 lbs      | Fuel: RCS            | 24.34 lbs.     |        |
| Time               | 376684        | DPS                  | 18392 lbs.     |        |
| Altitude           | 11,889        |                      |                |        |
|                    |               |                      |                |        |
| Highgate           | 376716        | RLS-Actual Site      |                |        |
| Altitude           | AGC/ENV       | (MF coords)          | X              | 2348 m |
|                    | 7065/6960     |                      | Y              | 7575   |
| Alt-rate           | -148.3/-149.7 |                      | Z              | -5110  |
| V-horiz            | 272/273.9     |                      |                |        |
| Range              | -25 NM        | Ground Track coords. |                |        |
|                    |               | Crossrange           | 21,370'        |        |
|                    |               | Downrange            | 23,900'        |        |

# 6.4.2.2B Landing with Redesignations (N69 and ACA) and reverse sign S.V. errors

|                               |                      |                               |                    |         |  |
|-------------------------------|----------------------|-------------------------------|--------------------|---------|--|
| Ignition                      | 376133.9             | Lowgate                       | 376799             |         |  |
| Altitude: Yaw                 | -52                  | Altitude                      | AGC/ENV<br>550/558 |         |  |
| Pitch                         | -178                 | Alt-rate                      | -21.0/-20.8        |         |  |
| Roll                          | -1                   | V-horiz                       | +49.5/48.8         |         |  |
| V57: Time                     | 376420               | Touchdown                     | 376870             |         |  |
| Altitude                      | 38,993               | Alt-rate                      | -4.9               |         |  |
| Deltah                        | -2725                | V-horiz                       | -.2                |         |  |
| Throttledown                  | 376563               | Navigation errors (SM coords) | R <sub>x</sub>     | +26 m   |  |
| TTF                           | -208                 |                               | R <sub>y</sub>     | -2992   |  |
| Altitude                      | 18,635               |                               | R <sub>z</sub>     | +1586   |  |
| Alt-rate                      | -55.5                |                               | V <sub>x</sub>     | -.01    |  |
| V-horiz                       | 1362.8               |                               | V <sub>y</sub>     | 0       |  |
| Range                         | -233                 |                               | V <sub>z</sub>     | -.34    |  |
| Max thrust after throttledown | 6452                 | Fuel: RCS                     | 24.41              |         |  |
| Time                          | 376684               | DPS                           | 18,248             |         |  |
| Altitude                      | 12,710               |                               |                    |         |  |
| Highgate                      | 376712               | RLS-Actual Site (MF coords)   |                    |         |  |
| Altitude                      | AGC/ENV<br>7618/7457 |                               | X                  | +2330 m |  |
| Alt-rate                      | -174.2/-174.4        |                               | Y                  | +6089 m |  |
| V-horiz                       | 281/284.7            |                               | Z                  | -5537 m |  |
| Range                         | -25 NM               | Ground Track coords           |                    |         |  |
|                               |                      | Crossrange                    | 24,478'            |         |  |
|                               |                      | Downrange                     | 15,240'            |         |  |

### TEST 6.4.2.3 LUNAR LANDING

#### I. Test Objective

This test is made to verify LM performance using nominal program procedures.

#### II. Test Description

This test sequence exercises the landing site redesignation option in P64. LM is yawed left 50 degrees at TIG -3 min. The 50 degrees is removed at TIG +3.

##### Program Sequence

P00

V48      DAP Data Load  
          Set ABORT BACKUP

P63      Braking Phase

V57      LR Enable

N68      Monitor Range, TGO, VI

N92      Thrust Monitor

P64      Approach Phase  
          Redesignate ACA: 2(+EL), 2(-AZ)

P66      Vertical Phase  
          Entered at 700 ft. Attitude Hold and  $\pm$  ROD increments

P00

#### III. Test Initialization

1. Terrain profile ( $+1^\circ$ ) error.

#### 6.4.2.3 Landing with Redesignations (ACA)

|                    |                      |                      |                      |
|--------------------|----------------------|----------------------|----------------------|
| Ignition           | 376135.6             | Lowgate              | 376786               |
| Attitude: Yaw      | -50                  | Altitude             | AGC/ENV<br>619/653   |
| Pitch              | -177                 | Alt-rate             | -19.4/-17.9          |
| Roll               | -1                   | V-horiz.             | +70.2/70.4           |
|                    |                      |                      |                      |
| V57: Time          | 376378               | Touchdown            | 376968               |
| Altitude           | 40,921               | Alt-rate             | -3.0                 |
| Deltah             | -4228                | V-horiz              | 0                    |
|                    |                      |                      |                      |
| Throttledown       | 376581               | Navigation errors    | R <sub>x</sub> +59 m |
| TTF                | -174                 | (SM coords)          | R <sub>y</sub> -1931 |
| Altitude           | 12,965               |                      | R <sub>z</sub> -969  |
| Alt-rate           | -87.3                |                      | V <sub>x</sub> -.07  |
| V-horiz            | 1148.7               |                      | V <sub>y</sub> -.14  |
| Range              | -167                 |                      | V <sub>z</sub> -.14  |
|                    |                      |                      |                      |
| Max. thrust        |                      |                      |                      |
| after throttledown | 6321                 | Fuel: RCS            | 22.22                |
| Time               | 376704               | DPS                  | 19318                |
| Altitude           | 6812'                |                      |                      |
|                    |                      |                      |                      |
| Highgate           | 376698               | RLS-Actual Site      |                      |
| Altitude           | AGC/ENV<br>7740/7543 | (MF coords) X        | -155 m               |
| Alt-rate           | -183.8/-184          | Y                    | +1894 m              |
| V-horiz            | 277/278.2            | Z                    | +29 m                |
| Range              | -25 NM               |                      |                      |
|                    |                      |                      |                      |
|                    |                      | Ground Track coords. |                      |
|                    |                      | Crossrange           | 122'                 |
|                    |                      | Downrange            | 6211'                |

|                           | 6.4.1             | 6.4.2.1          | 6.4.2.2  | 6.4.2.2B | 6.4.2.3  | 6.5.4    |
|---------------------------|-------------------|------------------|----------|----------|----------|----------|
| Ignition                  | 376134.4          | 376135.6         | 376135.6 | 376133.9 | 376135.6 | 376133.9 |
| Attitude Yaw              | -51 <sup>0</sup>  | -50 <sup>0</sup> | -50      | -52      | -50      | -52      |
| Pitch                     | -178 <sup>0</sup> | 176 <sup>0</sup> | -178     | -178     | -177     | -178     |
| Roll                      | 0 <sup>0</sup>    | 1 <sup>0</sup>   | 0        | -1       | -1       | -1       |
| V57: Time                 | 376389            | 376391           | 376420   | 376420   | 376378   | 376391   |
| Altitude                  | 40,010'           | 40,565'          | 39207    | 38,993   | 40,921   | 39963    |
| Deltah                    | -3531'            | -4349'           | -3150    | -2725    | -4228    | -3753    |
| Throttledown              | 376579            | 376573           | 376565   | 376563   | 376581   | 376571   |
| TTF                       | -176              | -192             | -207     | -208     | -174     | -192     |
| Alt.                      | 14201'            | 16472            | 18190    | 18,635   | 12965    | 17111    |
| Alt rate                  | -85.5'            | -72.4            | -58.5    | -55.5    | -87.3    | -66.1    |
| V-horiz                   | 1149'             | 1256.4           | 1362.4   | 1362.8   | 1148.7   | 1258.3   |
| Range                     | -168              | -199             | -233     | -233     | -167     | -199     |
| Max thrust<br>after TDOWN | 6527              | 6551             | 9990     | 6452     | 6321     | 6273     |
| Time                      | 376702            | 376678           | 376684   | 376684   | 376704   | 376710   |
| Altitude                  | 7469              | 12,291'          | 11,889'  | 12,710'  | 6812'    | 6938'    |
| Highgate                  | 376697            | 376706           | 376716   | 376712   | 376698   | 376705   |
| Alt                       | 8473              | 7357             | 7065     | 7618     | 7740     | 7878     |
| Altrate                   | -198.5            | -162.6           | -148.3   | -174.2   | -183.8   | -184.4   |
| V-horiz                   | 251               | 252              | 241      | 250      | 246      | 249      |
| range                     | -25               | -25              | -25      | -25      | -25      | -25      |
| Lowgate                   | 376821            | 376788           | 376802   | 3376799  | 376786   | 376801   |
| Alt                       | 189'              | 614'             | 560'     | 550'     | 619      | 429      |
| Alt-rate                  | -5.7              | -23.2            | -20.6    | -21.0    | -19.4    | -23.3    |
| V-horiz                   | +4.7              | +73.8            | +51.8    | +49.5    | +70.2    | 43.3     |
| Touchdown                 | 376856            | 376874           | 376885   | 376870   | 376968   | 376822   |
| Altrate                   | -5.8              | -3.9             | -4.3     | -4.9     | -3.0     | -2.2     |
| V-horiz                   | +2                | -1               | -1       | -2       | 0        | +5.9     |

|                                        | 6.4.1 | 6.4.2.1 | 6.4.2.2 | 6.4.2.2B | 6.4.2.3 | 6.5.4  |
|----------------------------------------|-------|---------|---------|----------|---------|--------|
| Navigation errors<br>(SM coords)       |       |         |         |          |         |        |
| $R_x$                                  | 104m  | +39 m   | +23 m   | +26 m    | +59 m   | +150 m |
| $R_y$                                  | -1940 | -1981   | -2039   | -2992    | -1931   | -2918  |
| $R_z$                                  | -986  | -1019   | -1059   | +1586    | -969    | +1657  |
| $V_x$                                  | -.04  | -.07    | -.02    | -.01     | -.07    | -.01   |
| $V_y$                                  | 0     | 0       | -.02    | 0        | -.14    | 0      |
| $V_z$                                  | -.14  | -.16    | -.18    | -.34     | -.14    | -.25   |
| Fuel: RCS                              | 21.2  | 23.75   | 24.34   | 24.41    | 22.22   | 23.98  |
| DPS                                    | 18208 | 18317   | 18392   | 18248    | 19318   | 17810  |
| RLS-Actual Site<br>(moon-fixed coords) |       |         |         |          |         |        |
| X                                      | 72.7m | 477     | 2348    | 2330     | -155    | 1164   |
| Y                                      | -350  | 4624    | 7575    | 6089     | 1894    | 2013   |
| Z                                      | -118  | -1464   | -5110   | -5537    | 29      | -2300  |
| Ground-Track coords                    |       |         |         |          |         |        |
| Crossrange                             |       | 5703'   | 21,370' | 24,478'  | 122'    | 8758'  |
| Downrange                              |       | 14937'  | 23,900' | 15,240'  | 6211'   | 6186'  |

|                           | All nominal<br>Auto landing<br>No N69' s | Nominal auto<br>landing w/-3K<br>downrange<br>error No N69' s | 6.4.1<br>w/16 errors<br>No N69' s | 6.4.1<br>w/16 errors &<br>N69' s | same, v<br>slosh &<br>IMU |
|---------------------------|------------------------------------------|---------------------------------------------------------------|-----------------------------------|----------------------------------|---------------------------|
| Ignition                  | 376134.8                                 | 376135.3                                                      | 376135.6                          | 376134.4                         | 376134                    |
| Altitude P                | -178 <sup>0</sup>                        | -177                                                          | -177                              | -178                             | -178                      |
| Y                         | -50 <sup>0</sup>                         | -50                                                           | -51                               | -51                              | -50                       |
| R                         | -1 <sup>0</sup>                          | 0                                                             | 0                                 | 0                                | -1                        |
| V57: Time                 | 376432                                   | 376420                                                        | 376385                            | 376389                           | 376377                    |
| Altitude                  | 37416'                                   | 38563                                                         | 40617                             | 40010                            | 40270                     |
| Deltah                    | +1833'                                   | -1952                                                         | -4101                             | -3531                            | -3846                     |
| Throttle down             | 376582                                   | 376582                                                        | 376581                            | 376579                           | 376579                    |
| TTF                       | -174                                     | -174                                                          | -175                              | -176                             | -176                      |
| Alt.                      | 12266                                    | 11600                                                         | 12974                             | 14201                            | 14254                     |
| Alt-rate                  | -87.6                                    | -86.8                                                         | -87.8                             | -85.5                            | -85.9                     |
| V-horiz                   | 1125                                     | 1125                                                          | 1148.2                            | 1148.9                           | 1148.6                    |
| range                     | -163                                     | -163                                                          | -167                              | -168                             | -168                      |
| Max thrust<br>after TDOWN | 6030                                     | 5952                                                          | 6312                              | 6527                             | 6494                      |
| Time                      | 376703                                   |                                                               | 376704                            | 376702                           | 376702                    |
| Altitude                  | 6753                                     |                                                               | 6812                              | 7469                             | 7460                      |
| Highgate                  | 376697                                   | 376698                                                        | 376698                            | 376697                           | 376697                    |
| Alt                       | 7606                                     | 7339                                                          | 7766                              | 8473                             | 8432                      |
| Alt-rate                  | -169.1                                   | -162.1                                                        | -184.6                            | -1985                            | -198.6                    |
| V-horiz                   | 252                                      | 250                                                           | 278                               | 251                              | 283                       |
| Range                     | -25                                      | -25                                                           | -25                               | -25                              | -25                       |
| 500' time                 | 376789                                   | 376789                                                        | 376792                            | 376794                           | 376794                    |
| Alt                       | 500'                                     | 485                                                           | 485                               | 496                              | 495                       |
| Alt-rate                  | -15.9'                                   | -14.8                                                         | -16.2                             | -17.0                            | -17.1                     |
| V-horiz                   | 52.6                                     | 52.8                                                          | 48.5                              | 42.6                             | 42.3                      |

|                                        | All nominal | Nominal auto | 6.4.1<br>No N69's | 6.4.1<br>N69's | same      |
|----------------------------------------|-------------|--------------|-------------------|----------------|-----------|
| Lowgate                                | 376821      | 376822       | 376820            | 376821         | 376821    |
| Alt                                    | 183         | 182          | 205               | 189            | 187       |
| Alt-rate                               | -3.6        | -3.5         | -6.6              | -5.7           | -5.3      |
| V-horiz                                | 5.4         | 5.5          | +7.0              | 4.7            | 4.6       |
| Touchdown                              | 376868      | 376869       | 376853            | 376856         | 376858    |
| Altrate                                | -3.8        | -3.7         | -6.7              | -5.8           | -5.6      |
| V-horiz                                | +1          | 0            | +1                | +2             | +1        |
| Navigation<br>errors                   |             |              |                   |                |           |
| R <sub>x</sub>                         | -9.29m      | -21.36 m     | -7.96 m           | +103.9m        | +102.32 m |
| R <sub>y</sub>                         | -73.87      | -67.14       | -1938.5           | -1935.4        | -1944.8   |
| R <sub>z</sub>                         | +13.65      | -803.54      | -980.46           | -982.9         | -976.5    |
| V <sub>x</sub>                         | +0.04       | +0.02        | -.07              | -.04           | -.05      |
| V <sub>y</sub>                         | -.09        | -.07         | 0                 | -.01           | 0         |
| V <sub>z</sub>                         | -.1         | -.04         | -.14              | -.15           | -.13      |
| Fuel: RCS                              | 46.35       | 31.25        | 53.23             | 55.83          | 64.6      |
| DPS                                    | 18307       | 18314        | 18162             | 18208          | 18229     |
| RLS-Actual Site<br>(moon-fixed coords) |             |              |                   |                |           |
| X                                      | 35.6 m      | -35 m        | -37 m             | 104 m          | 245 m     |
| Y                                      | 78.2 m      | 892 m        | 1538              | -1940          | -341      |
| Z                                      | -99.5 m     | -90 m        | -139              | -986           | -471      |
| Ground-Track coords                    |             |              |                   |                |           |
| Cross range                            | 356'        | 350'         | 590'              | 399'           | 1687'     |
| Downrange                              | 242'        | 2920'        | 5033'             | -1168'         | -1200'    |

## TEST 6.5.1 LM RCS DEORBIT BURN

### I. Test Objective

Verify proper operation and ascertain performance of the Erasable Memory RCS Guided Burn for LM Deorbit (P99) in Luminary revision 210.

### II. Test Description

The procedure followed is that enumerated in Luminary Memo #211. The following sequence is used in the test:

|       |                                                     |
|-------|-----------------------------------------------------|
| P00   | LGC Idling Program                                  |
| V82   | Orbital Parameters Display Routine (R30)            |
| V48   | DAP Data Load Routine (R03)                         |
| P30   | External $\Delta V$ Targetting Program              |
| V96   | Extended Verb to Interrupt Integration and GOTOPOOH |
| V71   | Universal Update - Block Address                    |
| V71   | Universal Update - Block Address                    |
| V71   | Universal Update - Block Address                    |
| V71   | Universal Update - Block Address                    |
| V72   | Universal Update - Single Address                   |
| V5N26 | Verification of P99 address                         |
| V30   | Request executive; call P99                         |
| V82   | Orbital Parameters Displays Routine (R30)           |
| P00   | LGC Idling Program                                  |

In the above sequence, the astronaut egresses from the LM after V96; so that the ground continues at the uplink sequence, V71.

### III. Test Initialization

1. Verified procedure and uplink for P99 as enumerated in Luminary Memo #211. Rev 1
2. Environment Initialization
  - A. LM-10 Vehicle.
  - B. CG and mass (fuel loadings, etc.) as agreed upon with MPAD; Guidance and Performance Division.

#### IV. Test Results

The test was performed according to the verified procedure in Luminary Memo #211 Revision 1. The data obtained from the on-line printout and DAP performance edit and plots gave evidence that the program and the procedure may be used with a reasonable assurance that the LM Deorbit will be successful in terms of the targetted impact parameters. A table of data comparison is included in this report.

The data is enumerated and the test is further explored and reported upon in Luminary Memo #218.

#### V. Test Conclusion

The objective has been achieved.

Timeline for Test 6.5.1  
LM RCS Deorbit Burn

| <u>Event</u>                  | <u>Time (G. E. T.)</u> |
|-------------------------------|------------------------|
| Start simulation              | 644180                 |
| P00                           | 644186                 |
| V82 (R30)                     | 644190                 |
| V48 (R03)                     | 644202                 |
| P30                           | 644219                 |
| V96                           | 644250                 |
| V71 (Uplink Erasable Program) | 644252                 |
| V30 (P99 entry)               | 644325                 |
| RCS ignition                  | 644783                 |
| RCS cutoff                    | 644865                 |
| V82 (R30)                     | 644870                 |
| P00                           | 644880                 |
| Lunar Impact                  | 646265                 |
| End of Simulation             | 646265                 |

Tabulated Displays

| DSKY(VN) | R1      | R2     | R3     | Mode |
|----------|---------|--------|--------|------|
| V37E00E  |         |        |        | 00   |
| V82E     |         |        |        |      |
| V04N12   | 00002   | 00001  |        |      |
| V16N44   | +60.5   | +58.2  |        |      |
| V48E     |         |        |        |      |
| V21N46   | 12021   |        |        |      |
| V21N47   | +5345   |        |        |      |
| V37E30E  |         |        |        | 30   |
| V6N33    | +179    | +6     | +22.70 |      |
| V6N81    | -161.1  | +57.3  | +94.6  |      |
| V6N42    | +60.9   | -53.1  | +195.4 |      |
| V16N45   | 0       | -8x50  | +16.93 |      |
| V96E     |         |        |        | 00   |
| V71      |         |        |        | 27   |
| V71      |         |        |        |      |
| V71      |         |        |        |      |
| V71      |         |        |        |      |
| V72      |         |        |        |      |
| V5N26E   | 13001   | 1420   | 12067  | 00   |
| V62E     |         |        |        |      |
| V30E     |         |        |        | 99   |
| V50N18   | +162.52 | +21.58 | +13.91 |      |
| V6N40    | -01x00  | +195.4 | 0      |      |
| V6N40    | -00x20  | +195.4 | +.1    |      |
| V6N40    | -00x01  | +195.4 | +.3    |      |
| V16N40   | -00x01  | +.1    | +195.9 |      |
| V16N85   | -.1     | -0     | +0     |      |
| V82E     |         |        |        |      |
| V16N44   | +60.9   | -53.2  | -21x30 |      |
| V16N85   | -.2     | -0     | +0     |      |
| V37E00E  |         |        |        | 00   |

# Test Facility Data Comparison

| Data             | MIT/CSDL Value      | NASA Value          |
|------------------|---------------------|---------------------|
| TIG              | 179:6:22.7 G. E. T. | 179:6:22.7 G. E. T. |
| $\Delta V$       | 195.4 fps           | 195.4 fps           |
| B. T.            | 81.79 sec           | 82.3 sec            |
| RCS fuel used    | 117.16 lb           | 115 lb              |
| Impact Velocity  | 5527.3 fps          | 5527.9 fps          |
| Impact Latitude  | 26.25° N            | 26.3° N             |
| Impact Longitude | 1.782° E            | 1.7° E              |
| Impact Time      | 1:79:31:7 G. E. T.  | 179:31:7.9 G. E. T. |

### TEST 6.5.3 ABORT STAGE AFTER TOUCHDOWN

#### I. Test Objective

Verify operation and ascertain performance of the APS Abort Program (after a nominal Lunar Landing) in Luminary revision 210.

#### II. Test Description

##### Program Sequence

P00 LGC Idling Program  
V48 DAP Data Load Routine (R03)  
P63 Braking Phase Program  
V57 State Vector Update Routine; LR Update (R12)  
P64 Approach Phase Program  
P66 Vertical Phase Program (R. O. D. - Auto)

##### Abort Stage

P71 APS Abort Program (after Touchdown)  
P00 LGC Idling Program  
V64 S-Band Antenna Routine (R05)  
V82 Orbital Parameters Display Routine (R30)  
V83 Rendezvous Parameter Display Routine (R31)  
P20 Rendezvous Navigation Program  
P32 Coelliptic Sequence Initiation Program

While in P71, the following sequences will be performed:

- I. Manual yaw maneuver to observe vehicle attitude control response to ACA when mode control is ATTHOLD.
- II. Monitor N76, N77, N85 via V16.

#### III. Test Initialization

1. Environment Initialization
  - A. LM-10 Vehicle

B. Terrain Profile with  $+1^{\circ}$  errors.

C. 10% TLOSS

2. CHANBKUP abort discrete not set (abort discrete not present)

#### IV. Test Results

Examination of the on-line printout, guidance edits, and DAP performance edit and plots revealed that the LGC Abort Program behaved in a nominal fashion. The correct targets were selected and the TGO and the desired downrange velocities were computed correctly. The insertion parameters were as targetted, with small  $\Delta V$  residuals in N85.

Throughout the simulation, Ascent nouns 76, 77, and 85 were monitored, and it was seen that the correct data was available through these nouns.

During this test, there were 25 lost downrupts. The analysis and report of these lost downrupts is included in LUMINARY Development Note #87 dated 14 June 1971.

#### V. Conclusion

The objective has been achieved.

### Figures of Merit - 6.5.3

| Data (insertion)          | Environment Value | LGC Value | Target Value |
|---------------------------|-------------------|-----------|--------------|
| Apolune (n.mi.)           | 72.4              | 70.0      | 70.5         |
| Perilune (n.mi.)          | 9.77              | 9.7       |              |
| Out of Plane distance     | -.03 n.mi.        | 9 ft.     | 0            |
| Altitude (ft)             | 55770             | 60327     | 60000        |
| Altitude rate (fps)       | 26.8              | 20.5      | 19.5         |
| Down range Velocity (fps) | 5571              | 5570      | 5571         |
| Yaw angle (deg)           | -3.24             | -1.76     |              |
| Pitch angle (deg)         | -5.29             | -7.15     |              |
| VGX Body (fps)            |                   | + .15     |              |
| VGY Body (fps)            |                   | -.6       |              |
| VGZ Body (fps)            |                   | +.81      |              |
| Theta [phase angle]       |                   | +10.06    |              |

Abort Stage from Touchdown - B  
Displays of Interest

| V/N   | R1     | R2     | R3     | Mode |
|-------|--------|--------|--------|------|
| 04/46 | 21112  | 00010  |        | 00   |
| 06/47 | +36702 | +38643 |        |      |
| 06/61 | -11x05 | -04x09 | -00002 | 63   |
| 50/18 | +35993 | +11006 | +00023 |      |
| 06/62 | +55639 | -01x00 | +00000 |      |
| 06/63 | +99999 | -00046 | +49855 |      |
| 06/63 | -03838 | -00604 | +40533 |      |
| 06/64 | +99x37 | -01770 | +06659 | 64   |
| 06/60 | +00033 | -00065 | +00187 | 66   |
| 06/94 | +07461 | +00230 | +00044 | 71   |
| 16/94 | -00001 | +00206 | +60289 |      |
| 16/85 | +00002 | -00013 | +00021 | 00   |
| 16/44 | +00697 | +00097 |        |      |
| 16/54 | +17163 | -04480 | +30624 |      |

Timeline of Test 6.5.3  
Abort Stage from Touchdown - B

| <u>Event</u>                  | <u>Time (G. E. T.)</u> |
|-------------------------------|------------------------|
| Start simulation              | 375834.8               |
| P00                           | 375848                 |
| V48 (R03) (CHANBKUP = 00010)  | 375867                 |
| P63 initiation                | 375874                 |
| Start attitude maneuver (R60) | 375895                 |
| End attitude maneuver         | 375982                 |
| DPS engine ignition (PDI)     | 376137                 |
| Throttle up                   | 376163                 |
| LR Data acceptance            | 376377                 |
| Throttle down                 | 376583                 |
| P64 initiation                | 376698                 |
| P66 initiation                | 376822                 |
| Touchdown (DPS engine off)    | 376854                 |
| Abort stage button depress    | 376857                 |
| P71 entry                     | 376863                 |
| APS engine cutoff             | 377294                 |
| P00                           |                        |
| V64 (R05)                     |                        |
| V82 (R30)                     |                        |
| V83 (R31)                     |                        |
| P20                           |                        |
| End simulation                |                        |

## TEST 6.5.4 LUNAR LANDING

### I. Test Objective

Verify operation and ascertain performance of a lunar landing sequence in which P66 is entered at 700 ft. altitude and the landing proceeds from there.

### II. Test Description

The Auto Throttle backup discrete is set.

#### Program Sequence

|     |                                                   |
|-----|---------------------------------------------------|
| P00 | LGC Idling Program                                |
| V48 | DAP Data Load Routine (R03)                       |
|     | Set Auto Throttle Backup discrete                 |
| P63 | Braking Phase Program                             |
| V57 | State Vector Update Routine (LR Update; R12)      |
| N69 | Downtrack 10k ft, crosstrack 5k ft at TIG +5 min. |
| P64 | Approach Phase Program                            |
| P66 | Vertical Descent Program (R. O. D. -ATTHOLD)      |
| P68 | Landing Confirmation Program                      |
| P00 | LGC Idling Program                                |

### III. Test Initialization

#### 1. Environment Initialization

- A. Terrain profile with  $+1^{\circ}$  error
- B. 10% TLOSS

#### 2. CHANBKUP abort discrete not set (abort discrete not present)

## TEST 6.5.5 DOCKED DPS PLANE CHANGE BURN

### I. Test Objective

Verify operation and ascertain performance of the plane-change burn while in the Docked Configuration.

### II. Test Description

#### Program Sequence

|     |                                                                   |
|-----|-------------------------------------------------------------------|
| P00 | LGC Idling Programs                                               |
| V48 | R03, DAP Data Load Routine;<br>Load DAP for docked configuration. |
| V62 | Display Total Attitude Error                                      |
| V77 | Rate Command and Attitude Hold                                    |
| P30 | External Delta-V. Targetting Program                              |
| P40 | DPS Burn Program                                                  |
| V82 | Orbital Parameter Display Routine (R30)                           |
| P00 | LGC Idling Program                                                |

### III. Test Initialization

1. State Vectors, TIG,  $\Delta V$  required was supplied by MPAD at NASA/MSC.
2. Environment Initialization:  
CG and Mass (fuel loadings, etc.) as given by MPAD at NASA/MSC.

#### IV. Test Results

The Docked-DPS Plane Change burn was performed as indicated in the description. The on-line printout and DAP performance edit and plots indicated that the control of the CSM-LM docked configuration was excellent. The fact that the LM-10 vehicle is heavier, by about a ton, than the LM-8 vehicle is possibly responsible for the better control performance in this test than in the Apollo 14 Level 6 Plane Change test.

#### V. Conclusion

The objective has been achieved.

Timeline for Test 6.5.5  
Docked-DPS Plane Change

| <u>Event</u>                  | <u>Time (G. E. T.)</u> |
|-------------------------------|------------------------|
| Start simulation              | 594350.6               |
| P00                           | 549364                 |
| V48 (R03)                     | 594378                 |
| V62                           | 594389                 |
| V77                           | 594391                 |
| P30 entry                     | 594393                 |
| P40 entry                     | 594423                 |
| Start attitude maneuver (R60) | 594426                 |
| End attitude maneuver         | 594611                 |
| DPS ignition                  | 594772                 |
| DPS cutoff                    | 594858                 |
| P00                           | 594865                 |
| End simulation                | 594868                 |

Docked-DPS Plane Change  
Displays of Interest

| V/N   | R1     | R2     | R3     | Mode |
|-------|--------|--------|--------|------|
| 04/46 | 31021  | 00011  |        | 00   |
| 06/47 | +36860 | +37277 |        |      |
| 06/33 | +00165 | +00012 | +5059  | 30   |
| 06/81 | -00088 | +03085 | +00000 |      |
| 06/42 | +00596 | +00596 | +03086 |      |
| 50/18 | +00214 | +35929 | +33817 | 40   |
| 06/40 | -01x00 | +3086  | +00000 |      |
| 06/40 | -00x01 | +3084  | +00007 |      |
| 16/40 | -00x00 | +00008 | +03086 |      |
| 16/85 | +00007 | +00000 | -00001 |      |

## TEST 6.5.6 DOCKED DPS TEI BURN

### I. Test Objective

Verify operation and ascertain performance of the TEI burn while in the Docked Configuration.

### II. Test Description

#### Program Sequence

|     |                                                                  |
|-----|------------------------------------------------------------------|
| P00 | LGC Idling Program                                               |
| V48 | R03, DAP Data Load Routine;<br>Load DAP for docked configuration |
| V62 | Display Total Attitude Errors                                    |
| V77 | Rate Command and Attitude Hold                                   |
| P30 | External Delta-V Targetting Program                              |
| P40 | DPS Burn Program                                                 |
| V82 | Orbital Parameter Display Routine (R30)                          |
| P00 | LGC Idling Program                                               |

### III. Test Initialization

1. State vectors, TIG,  $\Delta V$  as supplied by MPAD at NASA/MSC.
2. Environment Initialization:  
CG and Mass (fuel loadings, etc.) as given by MPAD at NASA/MSC.

#### IV. Test Results

The Docked-DPS TEI burn was performed as indicated in the description. The on-line printout and DAP performance edit and plots indicated that the control of the CSM-LM docked configuration was satisfactory. The LM-10 vehicle is heavier by about a ton, than the LM-8 vehicle. For this reason the control performance in this test is better than that experienced in the test performed for Apollo 14 Level 6.

In this test, it was noted that DPS fuel depletion occurred 2.9 seconds before nominal DPS cutoff. The Guidance and Performance division of MPAD at NASA/MSC was consulted on the matter of whether the data seen was to be expected from the initialization parameters. MIT/CSDL was informed that the DPS  $\Delta V$  capability at the TEI time used in this test was not sufficient to complete the TEI burn by approximately 3 seconds. Since this statement is compatible with the observed data, and the test was made primarily to test the performance of DAP control, the test was not rerun with new initialization parameters. This was the only off-nominal occurrence.

#### V. Conclusion

The objective has been achieved.

Timeline for Test 6.5.6  
Docked-DPS TEI

| <u>Event</u>           | <u>Time (G. E. T.)</u> |
|------------------------|------------------------|
| Start simulation       | 805008                 |
| P00                    | 805021                 |
| V48                    | 805027                 |
| V62                    | 805045                 |
| V77                    | 805048                 |
| P30                    | 805051                 |
| P40                    | 805082                 |
| DPS ignition           | 805429                 |
| DPS cutoff (depletion) | 806040                 |
| V82                    | 806047                 |
| P00                    | 806051                 |
| End simulation         | 806055                 |

Docked-DPS TEI  
Displays of Interest

| V/N   | R1     | R2     | R3     | Mode |
|-------|--------|--------|--------|------|
| 04/46 | 31021  | 00011  |        | 00   |
| 06/47 | +36860 | +36281 |        |      |
| 06/33 | +00223 | +00043 | +04762 | 30   |
| 06/81 | +29335 | -08163 | -01035 |      |
| 06/42 | +99999 | +00585 | +30467 |      |
| 50/18 | +17751 | +19166 | +35845 | 40   |
| 06/40 | -01x00 | +30467 | +00000 |      |
| 06/40 | -00x01 | +30464 | +00007 |      |
| 16/40 | -00001 | +00173 | +30302 |      |
| 16/85 | +00173 | +00004 | +00001 |      |
| 16/44 | +99999 | +00572 |        |      |