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LUMINARY Memo #214 Revision 1

To: Distribution
From: Luminary Test Group
Date: 6 April 1971
Subject: Level 6 Test Description for Luminary 1E

This memo includes a detailed description of 16 level 6 digital simulation tests which 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) 1σ 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.

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

TPI -38 TPI +45

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.

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 before entering P63.

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.

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
Manual Throttle to 99% and ABORT at 7K ft.
ATTITUDE HOLD
P70 DPS Abort Program
Switch to AUTO
ABORT STAGE at DPS depletion
ATTITUDE HOLD
P71 APS Abort Program
Switch to AUTO
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. Terrain profile with $+1^{o}$ errors.

   B. 10% TLOSS

2. CHANBKUP abort discrete set in P00.

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 at touchdown
ATTITUDE HOLD
P71 APS Abort Program
Switch to AUTO

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. Terrain profile with $+1^{o}$ errors

   B. 10% TLOSS

2. CHANBKUP abort discrete set in P00

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 (Recycle Gravity Determination) (Reject Noun 93)
V41N72	Radar Designate
P57	AT-2 Lunar Surface Alignment to REFSMMAT (Star and Planet)
P57	AT-2 Lunar Surface Alignment to REFSMMAT (2 stars)
V47	AGS Initialization
P06	LGC Power Down Program
P00	
P57	AT-3 Lunar Surface Alignment to Landing Site (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 (1 star)
V47	AGS Initialization Routine
V48	DAP Data Load

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

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 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
V64	S-Band Antenna Routine
V83	Request Rendezvous Parameter Display
P00	
V82	Request Orbital Parameter Display
P20	Rendezvous Navigation
	No state vector update
V83	Request Rendezvous Parameter Display
P34	TPI
P00	

III. Test Initialization

1. 10% TLOSS

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 ($+1^{o}$) error

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 ± ROD switch
P00	

III. Test Initialization

1. Terrain profile ($+1^{o}$) error.

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.
	Downtrack 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 ($+1^{o}$) error.

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 ± ROD increments
P00	

III. Test Initialization

1. Terrain profile ($+1^{o}$) error.

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 Rev. 1 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 ΔV Targetting Program
V48	DAP Data Load Routine (R03)
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. Approved procedure and uplink for P99 as enumerated in Luminary Memo #211 Rev. 1.
2. Environment Initialization

   A. CG and mass (fuel loadings, etc.) as agreed upon with MPAD; Guidance and Performance Division.

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

The Auto Throttle Backup discrete is set during test sequence. The Abort Backup discrete is clear.

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)
P64	Approach Phase Program
P66	Vertical Phase Program (R. O. D. - Auto)

Abort Stage after Touchdown

P71	APS Abort Program
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. Terrain Profile with $+1^{o}$ errors.

   B. 10% TLOSS

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

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 $+1^{o}$ 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; 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, ΔV required to be supplied by MPAD at NASA/MS
2. Environment Initialization:
   CG and Mass (fuel loadings, etc.) as given by MPAD at NASA/MSC.

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; 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, ΔV as required to be supplied by MPAD at NASA/MSC.
2. Environment Initialization:
   CG and Mass (fuel loadings, etc.) as given by MPAD at NASA/MSC.