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LUMINARY Memo #104

To: Distribution
From: D. Moore, D. Eyles
Date: 12 August 1969
Subject: LUMINARY 1B - Level 4 Lunar Landing Test Plan

Here is the LUMINARY 1B Level 4 Lunar Landing test plan and test summary.

LUMINARY 1B - Level 4 Lunar Landing Test Plan

Objective: Evaluate sequencing of guidance programs on the M. I. T. All-Digital Simulator in support of Apollo 12 (November, 1969).

Description: Level 4 consists of 4 tests for the Lunar Landing phase of the mission. They are as follows.

1) 1BLAND1 - Completely automatic landing from PDI, no state-vector or IMU errors incorporated. Programs used are in the following sequence:
   P00 - LGC Idling Program
   R03 - V48; DAP DATA LOAD Routine
   P63 - Braking Phase Program with R10, R11 running
   R12 - V57; State-vector update Routine with Landing Radar Read Routine
   P64 - Approach Phase Program
   P65 - Landing Phase Program (Automatic)
   P68 - Landing Confirmation Program

2) 1BLAND2 - Lunar Landing in the Rate-of-Descent Mode at touchdown, from PDI no State-Vector or LR or IMU errors. Programs used are in the following sequence:
   P00 - LGC Idling Program
   R03 - V48; DAP DATA LOAD Routine
   P63 - Braking Phase Program with R10, R11
   R12 - V57; State Vector Update Routine with Landing Radar Read Routine
   P64 - Approach Phase Program
   P65 - Landing Phase Program (Automatic)
   P66 - Landing Phase Program (R. O. D.)
   P67 - Landing Phase Program (Manual)
   P66 - Landing Phase Program (R. O. D.)
   P68 - Landing Confirmation Program

3) 1BLAND3 - Lunar Landing in the Manual Mode at touchdown; from PDI with no state-vector, LR, or IMU errors. Programs used are in the following sequence:

P00 - LGC Idling Program
R03 - V48; DAP DATA LOAD Routine
P63 - Braking Phase Program with R10, R11
R12 - V57; State-Vector Update Routine with Landing Radar Read Routine
P64 - Approach Phase Program
P65 - Landing Phase Program (Automatic)
P66 - Landing Phase Program (R. O. D.)
P67 - Landing Phase Program (Manual)
P68 - Landing Confirmation Program

4) 1BDOI - Descent Orbit Insertion Maneuver prior to PDI, no state-vector, LR, RR, or IMU errors. Program sequence is as follows:

P00 - LGC Idling Program
R03 - V48, DAP DATA LOAD Routine
P20 - Rendezvous Navigation Program
P30 - External Delta V Program
P40 - Descent Propulsion System Thrusting Program (to Burn Maneuver)
P52 - Inflight IMU Realignment Program
P40 - Descent Propulsion System Thrusting Program (to burn completion - DOI)
P63 - Braking Phase Program (through ignition algorithm)

Test Results: The Level 4 Test Plan Results are in two categories. The results for the Powered Descent tests include touchdown characteristics and some characteristics at selected points during the Powered Descent. The results for the Descent

Orbit Insertion Maneuver include ΔV required, burn time, velocity residuals after the DOI burn, and orbital parameters resulting from the DOI maneuver. The results are tabulated on the following pages.

NUMERICAL TEST RESULTS

1BDOI

Velocity to-be-gained:	(-72.5, 0, 13.9) f/s in local vertical coordinates
Magnitude:	73.8 f/s
Burn duration:	29.02 seconds
Velocity residual:	(.7, .2, .6) f/s in body coordinates
Perilune:	in P40 7.8 nm. after burn, in P30 7.2 nm.
Apolune:	in P40 59.7 nm. after burn, in P30 59.6 nm.
Time-from-perilune:	56 minutes 49 seconds after burn

From Verb 83

Range:	2.75 nm.
Range rate:	70.1 f/s
Theta:	122.01^{o}

	1BLAND1	1BLAND2	1BLAND3	
At high-gate*				
Altitude:	7567	7553	7568	feet
Vertical velocity:	-141.9	-142.4	-141.9	f/s
Horizontal velocity:	509.3	508.5	509.1	f/s
At 500 feet**	(484)	(491)	(492)	(feet)
Vertical velocity:	-15.0	-15.2	-15.3	f/s
Horizontal velocity:	67.2	67.1	67.3	f/s
At touchdown***				
Vertical velocity:	-3.0	-2.7	-6.3	f/s
Horizontal velocity:	0.5	7.5	-5.5	f/s
Latitude:	0.68745°	0.68749°	0.68736°	
Longitude:	23.72381°	23.72560°	23.72498°	
RCS fuel used:	10.12	13.89	9.97	kgs.

* AGC values, first pass in P64

** AGC values at actual altitude given in parentheses

*** environment values

Comments: Powered Descent

Test No. 1) This test involved a completely automatic landing (P65). The velocities at the various points in the simulation agree with the targeted values. The test shows that it is entirely feasible to use the Automatic Mode for a Lunar Landing.

Tests 2&3) These tests involved manual landings using for touchdown P66 and P67 respectively. Because the simulation of astronaut control in MIT's digital simulator is "open loop", horizontal velocity, in the first case, and in the second both horizontal and vertical velocity, are outside the allowable envelope. Before entering the manual programs velocities are completely nominal in these tests. These tests verify the manual programs although they demonstrate shortcomings of the (simulated) astronaut involved.

Conclusions: The sequences specified in the test plan have been shown to be compatible in simulated lunar landings and the Descent Orbit Insertion Maneuver. The Level 4 test objective has therefore been accomplished.