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LUMINARY Memo. #180 Revision 1

To: Distribution
From: David Moore
Date: 15 December 1970
Subject: Apollo 14 LM De-Orbit Test

Summary

This memo concerns itself with the tests and results of the Apollo 14 LM Deorbit Erasable Memory RCS-Guided Burn Program, P99. An approved procedure for this program was performed using the MIT/CSDL All Digital Simulator for Luminary 178; Luminary 1D. The parameters obtained from this test are tabulated in this memo along with a description of the procedure for P99 usage. The NASA/MSC Guidance and Performance branch of MPAD agreed to duplicate the vehicle properties and the procedure involved for data comparison. The values of pertinent data is tabulated and comparison is made between the burn times of the RCS jets in each test. Note also the accuracy of the test in attaining the desired orbit. The memo includes a tabulation of the LM lunar impact point as was seen in the MIT/CSDL simulation. It is noted that the data between the NASA/MSC and MIT/CSDL simulations compare favorably.

Purpose

The purpose of the test was to carry out an approved sequence designed to impact the LM onto the lunar surface at such a point as to be advantageous to the seismometer studies to be carried out during the Apollo 14 mission.

Sequence

The sequence used for this impact burn was a verified astronaut-ground combined effort sequence of events. The procedure was performed with the assumption that the LM timeline had been faithfully followed and that the target parameters for the P30 LGC targetting program had been uplinked to the LM. The astronaut configures the spacecraft and performs P30 using the previously uplinked data. After astronaut egress and LM separation, the ground calls P99 via extended verb V30. The ground then monitors the DSKY during the burn, at cutoff and during coast to impact as the orbital parameters are displayed via V82. This display of orbital parameters is used to ascertain burn performance.

Discussion

The Erasable Memory RCS-guided burn program, P99, was thoroughly discussed and the progress of development enumerated in Luminary Memo #168 by R. Covelli. The NASA/MSC simulation data is tabulated as is the results of the MIT/CSDL simulation. The data pertinent to study in order to ascertain performance is burn time and individual RCS jet on time.

As can be noted, the burn time of each test compares favorably at approximately 77 seconds. The individual jet-on times also compare very closely between the tests. The NASA/MSC simulation involved only the 4 jets (2, 6, 10, 14) for the burn whereas the MIT/CSDL test involved all 16 jets as in an actual guided burn. Of course, the 4 jets (2, 6, 10, 14) in the MIT/CSDL test were on for the X-axis burn and the other jets were on for slight rotations occurring as a result of the on-off fluctuations of the main 4 jets. The 4 jets in question then, have compatible jet-on times for each test facility. This leads to the conclusion that the data obtained by the MIT/CSDL test is accurate. Therefore, the test results show that the burn performance was of a nature that the LM Deorbit may be carried out with reasonable assurance and that the impact point will be that for which the program was targetted.

NASA/MSC - MIT/CSDL Target Parameters for P99

TIG = 147:52:58.95 G.E.T.

$\underline{\Delta V}$ = (-180, +36.5, 0) fps

Desired Apolune = +58.7 n.m.
Desired Perilune = -63.6 n.m.

MIT/CSDL Impact Point

Latitude = 3.5° S
Longitude = 19.3° W

MIT/CSDL ERCS Data Summary

BASIC VALUES:

In the test the following data was basic:

$\underline{R}$ = (1789942, 414484.9, -175215)
$\underline{V}$ = (240.58, -1308.82, -819.48)

$$\text{REFSMMAT} = \begin{matrix} -.267 & -.867 & -.418 \\ +.193 & -.424 & +.859 \\ -.944 & +.148 & +.294 \end{matrix}$$

IMU Compensation = nil

RCS fuel = 352 lb.

APS fuel = 244 lb.

Total LM Wt. = 5268 lb.

$\underline{CG}$ = (257.619, 1.056, 2.242) inches

Procedure for LM Deorbit Burn - P99

ACTION	SIGNIFICANCE
V82E	Call Orbital Parameter Display Routine
V16N44	R1 =
	R2 =
	R3 =
V48E	DAP Data Load Routine
V21N46E12021E	Set DB = 5^{o}
Proceed (V33E)	Accept Dap Configuration
V21N47E +5268E	LM Weight
Proceed (V33E)	Accept LM Weight
V37E30E	Call P30 - External Delta-V Targetting
V6N33	Ignition Time (Astronaut Load via V25)
V33E (Proceed)	Accept Ignition Time
V06N81	Delta-V Components (Astronaut Load Via V25)
Proceed	Accept Delta-V Components
V6N42	R1 = Apolune after burn
	R2 = Perilune after burn
	R3 = Delta-V for burn
Proceed	Accept parameters
V16N45	R2 = Time from ignition
Proceed	Exit Targeting Program
V96E	Reset POOH flag to terminate
	P00 integration routine during P99
	P00 appears
Guidemode-Primary (PGNCS)	Configure Spacecraft prior to egress
PGNCS Select - AUTO	
ASC ENG ARM - OFF	
Update Uplink - Enable	Prepare uplink for ground action.
Uplink erasable data load	Ground takes over from this point.

ACTION	SIGNIFICANCE
V5N26E	Verify address for erasable memory burn
R1 = 13001	program, P99
R2 = 01420	
R3 = 12067	
V30E	Call P99
V50N18	Burn attitude
V33E	Do burn attitude maneuver
V06N18	Monitor maneuver
V50N18	Maneuver completed
E	Accept burn attitude
V6N40	Monitor countdown to TIG
	R2 = -00X30 Avg. G on (R3 $\neq$ 0)
	R2 = -00X00 Ignition
V06N40	Monitor burn
V16N40	RCS cutoff
V33E	Continue to find burn residuals
V16N85	Burn residuals
V82E	Orbital Parameters Displays Routine
	R1 = Apolune
V16N44	R2 = Perilune
	R3 = Time free-fall to 35K ft.
V33E	Accept Orbital Parameters
V16N85	Burn residuals
V33E	Exit Burn Program
V37	Select Another Program
00E	Select P00

Tabulated Displays - P99 LM Deorbit Burn

DSKY (VN)	R1	R2	R3	Mode
V82E				0
V16N44	+60.4	+58.7		
V48E				
V21N46	12021			
V21N47	+5268			
V37E30E				30
V6N33	+147	+52	+5895	
V6N81	-180.0	+36.5	+0	
V6N42	+58.7	-63.6		
V16N45	0	-06X00	+11.41	
V48E				
V21N46	12011			
V96E				0
V71				27
V72				
V71				
V30E				99
V50N18	+163.10	+6.41	+43.71	
V6N40	-01X00	+183.7	+0	
V6N40	-00X25	+183.6	+.1	
V6N40	+00X00	+183.6	+.4	
V16N40	=00X01	+.0	+183.4	
V16N85	+.1	+0	+0	
V82E				
V16N44	+58.7	-63.5	-24X53	
V16N85	+.3	0	0	
V37E00E				00

RCS DATA SUMMARY

Jet #	Time on (sec)	# Firings	Fuel used (lb.)
1	.18	16	.09
2	77.14	13	27.94
3	.27	23	.13
4	.09	8	.04
5	.36	32	.18
6	74.36	170	27.27
7	.26	22	.12
8	.09	8	.04
9	.19	16	.09
10	69.38	224	25.45
11	.27	23	.13
12	.09	8	.04
13	.37	33	.18
14	77.41	37	28.08
15	.26	22	.12
16	.09	8	104

Total RCS fuel used = 110.01 lb.

NASA/MSC ERCS Data Summary

Mass = 5268 lbs.

CG = (257.76, 1.04, 2.4) inches

R, V, and REFSMMAT equal to MIT/CSDL values.

RCS Data Summary

Jet #	Time on	# Firings
2	77.76	1
6	74.63	116
10	69.2	238
14	77.76	1

Burn time = 77.88

Total RCS fuel = 110 lbs.

Burn residuals small.