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LUMINARY Memo #218

To: Distribution
From: David Moore
Date: 19 May 1971
Subject: Apollo 15 LM De-Orbit Performance Test

Summary

This memo is concerned with the test and results of the Apollo 15 LM Deorbit Erasable Memory RCS-guided Burn Program, P99. A verified procedure for this program was performed using the MIT/CSDL All-Digital Simulator for Luminary 210; Luminary 1E. Along with a detailed description of the procedure used in this test, the following parameters are tabulated: initialization parameters, burn parameters and desired results, DSKY displays from the MIT/CSDL simulation, data comparison between the NASA and MIT test facilities, and an RCS data summary from the MIT simulation. In addition, plots obtained in this test indicate the duty cycle and the DAP performance during the burn.

From the data presented in this memo, it is seen that the performance of P99 is favorable. It can then be concluded that the LM can be expected to impact the lunar surface at the desired position.

Purpose

The purpose of this test was to carry out a verified sequence designed to impact the LM onto the lunar surface at the desired point, in order that seismometer studies can be carried out during the Apollo 15 mission.

Sequence

The sequence used for this LM impact burn was a previously verified astronaut-ground combined effort sequence of events. It was performed with the assumption that the LM Timeline was followed. The procedure was as follows:

The astronaut configures the spacecraft and performs P30 (LGC targetting program) using data previously uplinked or voice-transmitted from the ground. After astronaut egress and LM separation, the ground calls P99 via extended verb V30. The ground then monitors the displays on the flight-controller's DSKY until RCS ignition. During the burn the flight-controller's DSKY as well as the Orbital Maneuvers Downlist is monitored. After RCS-cutoff, and during LM coast until lunar surface impact, the ground monitors displays via the flight-controller's DSKY and vehicle parameters via the Coast/Align Downlist.

The performance of the program is ascertained from the burn time, the burn residuals at RCS cutoff, the orbital parameters from V82, time of lunar impact, and position of lunar impact.

Remarks

The Erasable Memory Program for a guided RCS burn, for Luminary 1E is thoroughly discussed in Luminary Memo #211 Revision 1. The performance of this program is noted from the tabulation of results from an MIT/CSDL All Digital Simulation of P99.

Also tabulated is the initialization data (obtained from the NASA/MPAD Data Book), NASA/MSC simulation data, and the displays from the DSKY in the MIT/CSDL simulation. In addition, the procedure used to perform this test simulation is detailed.

Finally, the DAP performance results appear in the form of plots of vehicle parameters.

Discussion

As can be seen from the tabulated data results, this Level 6 performance test indicates that the Erasable Memory Burn Program, for a guided RCS burn; P99 has met the design criteria in that:

- A) The program was written so that the LM Deorbit could be performed in a predictable and accurate fashion.
- B) The simulation of the nominal LM Deorbit for Apollo 15 produces data which compares favorably with the desired burn results from NASA/MPAD.

Furthermore, inspection of the Autopilot performance plots reveal that the vehicle attitude errors and attitude rates are small and reasonably within the vehicle parameter limits.

A comparison of data between the NASA and MIT/CSDL test facilities appears in Table IV.

Conclusion

It has been seen that the data from each test facility compares favorably and that the autopilot-guidance vehicle plots reveal that the performance of this simulation was well within reasonable limits and that any variations (vehicle attitude errors, etc.) can be predicted and are accounted for in the Digital Autopilot operation.

It may therefore be concluded that the LM Deorbit Burn using P99-Erasable Memory Program for a guided RCS burn may be carried out with the assurance, given by the test simulation reported upon, that the targetted impact point will be attained.

APPENDIX

- A. Procedure for LM Deorbit Burn for Apollo 15
- B. Tables
 - I. Initialization Parameters
 - II. Burn Parameters and Desired Results
 - III. Tabulated Displays
 - IV. Test Facility Data Comparison
 - V. RCS Data Summary
- C. Duty Cycle Plot for P99
- D. Figures (1-11) - DAP Performance Plots

Procedure for P99 LM Deorbit in Apollo 15

<u>Action</u>	<u>Meaning</u>
V37E00E	Call POO
V82E	Call Orbital Parameter Routine (R30)
V4N12 R1 = 00002 R2 = 00001	Option code display for "This" (LM) vehicle
Proceed	Accept this vehicle for parameter computation
V16N44 R1 R2	Orbital Parameter Display Apolune Altitude Perilune Altitude
Proceed	Complete orbital parameter routine (R30)
V48E	Call DAP Data Load Routine (R03)
V04N46	DAP Configuration
Load N46 via V21	Load Desired DAP Configuration
Proceed	Accept DAP Configuration
V06N47	LM Weight
Load N47 via V21	Load Desired LM Weight
Proceed	Complete DAP Data Load Routine (R03)
V37E30E	Call P30 - External ΔV Targetting Program
V06N33	TIG for ERCS Burn
Load N33 via V25	Load Desired TIG
Proceed	Accept TIG
V06N81	ΔV to be accomplished by ERCS Burn
Load N81 via V25	Load Desired ΔV
Proceed	Accept ΔV

<u>Action</u>	<u>Meaning</u>
V06N42 R1 R2 R3	Expected Orbital parameters Apolune Altitude of new orbit Perilune Altitude (negative → impact) ΔV for ERCS burn.
Proceed	Accept new orbital data
V16N45 R2	Time to go until ERCS TIG
Proceed	Complete External ΔV Targetting Program (P30)
V37 Flashing	Please select another program
V96E POO appears in mode lights	exit, go to P00 (Reset POOHFLAG to terminate POO integration routine for P99)
Guidemode - Primary (PGNCS) PGNCS Select - AUTO ASC Eng. arm - off	Configure Spacecraft prior to egress
Update Uplink - Erasable	Prepare uplink for ground action
Uplink erasable program	Ground takes over from this point
V5N26E R1 = 13001 R2 = 01420 R3 = 12067	Verify Address for erasable memory burn program - P99
V30E	Call P99 via Extended Verb
V50N18	Burn Attitude
V33E	Do burn attitude maneuver
V50N18	Maneuver completed

<u>Action</u>	<u>Meaning</u>
E	Accept burn attitude
V06N40 R2	Monitor countdown to TIG (Time to go in R2)
V06N40 R2 = 00X29	Average G-Routine on at TIG-30
V06N40 R2 = 00X00	TIG: Powered Flight Downlist selected; P42 guidance equations enabled; DAP offset acceleration estimator enabled.
V06N40 R2	Monitor Countdown to Cutoff (Time to go in R2)
V16N40	RCS cutoff; DAP offset acceleration estimator disabled.
V33E	Accept Cutoff conditions
V16N85	Burn residuals.
V82E	Call orbital parameter Routine (R30)
V16N44 R1 R2 R3	Orbital Parameters Display Apolune Altitude Perilune Altitude Time-free-fall to 35K ft
V33E	Accept Orbital Parameters
V16N85	Burn residuals
V33E	Accept
V37 Flashing	Select another program
00E	Select POO
POO appears in Mode lights	Average G Routine off; Coast/Align Downlist selected.

End of P99 - Apollo 15 - Procedure