

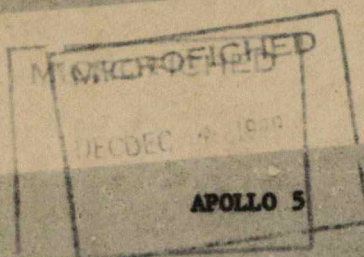
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MISSION REQUIREMENTS

204/LM-1

"B" TYPE MISSION

LM DEVELOPMENT

Revision 5

4 December 1967

NAS 9-4810

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MISSION REQUIREMENTS

Revision 5

NAS 9-4810

Prepared by TRW Systems
for
System Engineering Division
Apollo Spacecraft Program Office
Manned Spacecraft Center
Houston, Texas

William J. McKenzie
William J. McKenzie (TRW)
Associate Mission Staff Engineer

James L. Tomberlin
James L. Tomberlin
Mission Staff Engineer

Approved by Owen E. Maynard
Owen E. Maynard, Chief
Systems Engineering Division

Approved by George H. Low
George H. Low, Manager
Apollo Spacecraft Program

Concurrence Maxime A. Paget
Maxime A. Paget, Director
Engineering and Development

Concurrence Christopher C. Kraft, Jr.
Christopher C. Kraft, Jr.,
Director, Flight Operations

Concurrence Donald K. Slayton
Donald K. Slayton, Director
Flight Crew Operations

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1. PURPOSE

This document defines the spacecraft detailed test objectives for mission Apollo 5 (204/LM-1). The detailed test objectives comply with the Apollo Flight Mission Assignments Directive (Reference 1).

The Mission Requirements document provides mission planning support to insure the implementation and accomplishment of the primary mission intent (LM development).

This document will be the control document for all spacecraft mission requirements used in mission planning and has precedence over all MSC or contractor documents in this respect.

2. INTRODUCTION

The primary purpose of the Apollo 5 LM Mission is to flight verify the ascent and descent propulsion subsystems and the fire-in-the-hole (FITH) abort staging for manned flight.

2.1 MISSION PURPOSE

This is a B type mission (Ref. 4). The evaluation of the S-IVB/IU performance is an MSFC responsibility.

2.2 FLIGHT MISSION DESCRIPTION

The Apollo 5 Mission ascent-to-orbit will include the S-1B boost phase and the S-IVB orbit insertion burn. The nose cone will be jettisoned shortly after orbital insertion.

During the first orbit after SLA deployment, the LM will separate over Carnarvon from the S-IVB using the LM RCS. The launch vehicle command and control capability will be exercised after LM separation.

Approximately two and one half revolutions into the mission, the first DPS burn simulating the LLM DOI, will be made in-plane.

One half revolution later, the second DPS burn simulating the LLM braking and manual throttling, will be made out-of-plane. This burn ends in a FITH abort staging and the first APS burn.

Near the end of the fourth revolution, the second APS burn simulating the LLM duty cycle, will be performed out-of-plane and continued to propellant depletion.

2.3 DEFINITIONS

- 1) Categories of objectives as stated in sections 3 and 4 are based on the following definitions:
 - a) Mandatory - Failure to satisfactorily complete this objective on mission Apollo 5 will unduly compromise subsequent flight schedules and may require spacecraft configuration changes, such as addition of instrumentation.

- b) Primary - Must be accomplished before the lunar landing mission. Any primary objective not satisfactorily completed on mission Apollo 5 can be attempted on a subsequent mission without major impact. Such objectives are primary for the first opportunity to accomplish the objective. Demonstration on future missions will be classified as secondary or will be considered to be operational unless more than one demonstration is required to satisfy the intent of the objective. If the objective has not been satisfactorily accomplished when only one more opportunity remains, it will become mandatory.
- c) Secondary - Any operation or test which would provide data or experience to significantly improve knowledge of spacecraft, MSFN and MCCH performance or provide other engineering and scientific data. A secondary objective would not, by itself, prevent a lunar landing if the objective were not attempted.
- 2) Test Conditions stated in section 4 are those required conditions that must exist for the test objective to be satisfied.
- 3) Priorities as assigned to each item in the data list of section 4 for the objectives were based on the following definitions:
- a) Mandatory - A mandatory measurement is one which is necessary for the determination of the fulfillment of the test objective as stated.
- b) Highly Desirable - A highly desirable measurement is one which furnishes pertinent information about the accomplishment of an objective but is not necessary for its evaluation as stated.
- c) "Only mandatory measurements for mandatory objectives will be carried over as mandatory measurements in the Launch Mission Rules for 204/LM-1."
- 4) Previous editions of this document were written such that the verbs (i.e., "evaluate", "determine", "verify", and "demonstrate") in the statement of each objective had certain implications as to the amount of spacecraft instrumentation required to support that objective. Effective with this revision, none of the verbs in the statement of objectives (as used in sections 3 and 4) have any implications in regard to data requirements.

2.4 CONFIGURATION CONTROL OF THIS DOCUMENT

Configuration control of this document will be exercised by the Apollo 5 Mission Staff Engineer (MSE). Depending on the type of change, the authority to approve or reject a change is given to the CCB, the Apollo Spacecraft Program Manager or the MSE. The MSE will determine the type of change and submit the change to the approving authority as outlined below:

- 1) The CCB will approve changes which:
 - a) Result in a mission profile change
 - b) Add a new primary objective
 - c) Delete existing primary objective
 - d) Require spacecraft hardware or software change
 - e) Result in a mission rule or limitline change
 - f) Result in an objective priority change
 - g) Cause a schedule slip
- 2) The Apollo Spacecraft Program Manager (in lieu of the CCB) will approve changes of the above types that require immediate action.
- 3) The MSE will approve all other changes. PD7/Chief will receive request for changes and insure proper content of the proposed changes.
- 4) Mr. J. L. Tomberlin of the Apollo Spacecraft Program Office (ASPO) Systems Engineering Division is the Mission Staff Engineer for the Apollo 5 mission. Mr. W. J. McKenzie (TRW) is the Associate Mission Staff Engineer for the Apollo 5 mission and will discharge all functions of the MSE subject to review by the ASPO MSE. In the event of Mr. Tomberlin's absence, Mr. R. V. Battey, PD7/Chief, will assume the duties of the MSE.

The detailed procedures to be used for classifying and processing all changes are described in Appendix A, Configuration Control.

2.5 REASON FOR REISSUE

This document presents the fifth revision to the Mission Requirements for the unmanned LM mission Apollo 5 (formerly called AS-206).

This revision supersedes Reference 2 and has been prepared:

- 1) To change the format of the detailed test objectives in section 4 by clarifying and updating the Purpose, Test Conditions, and Success Criteria for each objective;
- 2) To include Background and Justification data for each objective and to renumber the objectives by subsystem and systems.

<u>NUMBER</u>	<u>SUBSYSTEM</u>
11.0	G&N
12.0	AGS
13.0	Propulsion
14.0	ECS
15.0	EPS
16.0	Communications & Instrumentation
17.0	Structures/Thermal
18.0	Sequencing
20.0	Operations/Systems

- 3) To add new objectives P15.1, P15.2, and P18.1 and to change S16.1 (S12).
- 4) To combine objective P1.3.1 and P1.3.2 into new objective M13.3 and to combine objectives P2.1 and P2.4 into new objective M20.2;
- 5) To delete objective S7 and P3 from this document;
- 6) To update the spacecraft configuration requirements in section 5;
- 7) To update the mission planning requirements in section 6;
- 8) To update the alternate mission and abort guidelines in section 7.

3. SUMMARY OF MISSION TEST OBJECTIVES

3.1 OBJECTIVE PRIORITIES

The following list of objectives for mission Apollo 5 establishes the priorities of the detailed spacecraft test objectives. In the event that real time planning of an abort or alternate mission becomes necessary, this priority list should be used.

<u>Priority Number</u>	<u>Objective Category/Number</u>	<u>Identification Title</u>
1	M20.1	FITH Abort Structural Effects
2	M20.2	FITH Abort Staging Dynamics
3	M20.3	FITH Abort Stability Control
4	M13.1	Characteristics of APS/DPS Start/Shutdown
5	M13.7	APS/DPS Burn Duration Effects
6	M13.4	Ascent Engine Burnout Characteristics
7	M17.1	LM Structural Integrity
8	M13.3	Primary Propulsion/Vehicle Interactions
9	M13.5	DPS Pressurization/Propellant Feed
10	M13.6	APS Pressurization/Propellant Feed
11	M13.8	RCS/APS Interconnect
12	M17.2	SLA/LM Launch Interaction Loads
13	M17.5	DPS/APS/RCS Thermal Effects
14	M17.4	Critical Equipment Area Vibration
15	M17.3	APS/DPS Oxidizer Tanks Vibration
16	P13.2	DPS Throttle Response
17	P13.9	LM/RCS Operation and Performance
18	P11.2	PGNCS Performance
19	P11.1	DPS Gimbal Actuators
20	P15.1	EPS Performance Evaluation
21	P18.1	Explosive Devices Performance
22	S14.1	LM ECS - Boost & Flight
23	S16.1	LM/MSFN Communications
24	S16.2	PCM/DFI Instrumentation Performance
25	S15.2	Nose Cap, LM/SLA Separation

3.2 CURRENT OMSF OBJECTIVES

The following primary mission objectives were assigned in Reference 1 by the Office of Manned Space Flight:

- 1) Verify operation of the following LM subsystems:
APS and DPS (including restart), and structure
- 2) Evaluate LM staging.
- 3) Evaluate the S-IVB/IU orbital performance. (MSFC responsibility)

The mandatory, primary and secondary mission test objectives (as detailed in section 4 of this document) support the OMSF objectives in the following manner.

MSC Objective Number	Identification Title	OMSF Objective Numbers	
		1	2
P11.1	DPS Gimbal Actuators	X	
P11.2	PGNCS Performance	-	-
M13.1	Characteristics of APS/DPS Start/Shutdown	X	X
P13.2	DPS Throttle Response	X	
M13.3	Primary Propulsion/Vehicle Interactions	X	
M13.4	Ascent Engine Burnout Characteristics	X	
M13.5	DPS Pressurization/Propellant Feed	X	
M13.6	APS Pressurization/Propellant Feed	X	
M13.7	APS/DPS Burn Duration Effects	X	
M13.8	RCS/APS Interconnect	X	-
P13.9	LM/RCS Operation and Performance	-	-
S14.1	LM ECS - Boost & Flight	-	-
P15.1	EPS Performance Evaluation	-	-
S15.2	Nose Cap, LM/SLA Separation	-	-
S16.1	LM/MSFN Communications	-	-
S16.2	PCM/DFI Instrumentation Performance	-	-
M17.1	LM Structural Integrity	X	
M17.2	SLA/LM Launch Interaction Loads	X	
M17.3	APS/DPS Oxidizer Tanks Vibration	X	
M17.4	Critical Equipment Area Vibration	X	
M17.5	DPS/APS/RCS Thermal Effects	X	
P18.1	Explosive Devices Performance	-	-
M20.1	FITH Abort Structural Effects		X
M20.2	FITH Abort Staging Dynamics		X
M20.3	FITH Abort Stability Control		X

3.3 POINT OF CONTACT FOR EACH OBJECTIVE

The following MSC representatives are designated as the point of contact for the indicated objectives. These representatives can provide additional information or initiate proposed changes in the manner as described in Section 2.4 of this document.

<u>Point of Contact</u>	<u>Office Symbol</u>	<u>Objective Number</u>	<u>Identification Title</u>
S. P. Weiss	ES12	M20.1	FITH Abort Structural Effects
S. P. Weiss	ES12	M20.2	FITH Abort Staging Dynamics
C. F. Wasson	EG43	M20.3	FITH Abort Stability Control
J. F. Hanaway	EG25	M20.3	FITH Abort Stability Control
C. E. Humphries	EP2	M13.1	Characteristics of APS/DPS
L. J. Haywood	EP2	M13.1	Start/Shutdown
L. J. Haywood	EP2	M13.7	APS/DPS Burn Duration Effects
C. E. Humphries	EP2	M13.7	APS/DPS Burn Duration Effects
C. E. Humphries	EP2	M13.4	Ascent Engine Burnout
			Characteristics
S. P. Weiss	ES12	M17.1	LM Structural Integrity
L. J. Haywood	EP2	M13.3	Primary Propulsion/Vehicle
C. E. Humphries	EP2	M13.3	Interactions
L. J. Haywood	EP2	M13.5	DPS Pressurization/Propellant
			Feed
C. E. Humphries	EP2	M13.6	APS Pressurization/Propellant
			Feed
C. E. Humphries	EP2	M13.8	RCS/APS Interconnect
N. R. Schulze	EP4	M13.8	RCS/APS Interconnect
S. P. Weiss	ES12	M17.2	SLA/LM Launch Interaction Loads
L. J. Haywood	EP2	P13.2	DPS Throttle Response
C. F. Wasson	EG43	P11.1	DPS Gimbal Actuators
J. F. Hanaway	EG43	P11.1	DPS Gimbal Actuators
C. F. Wasson	EG43	P11.2	PGNCS Performance
J. F. Hanaway	EG43	P11.2	PGNCS Performance
N. R. Schulze	EP4	P13.9	LM/RCS Operation and Performance
S. P. Weiss	ES12	M17.3	APS/DPS Oxidizer Tanks Vibration
S. P. Weiss	ES12	M17.4	Critical Equipment Area
			Vibration
J. A. Smith	ES12	M17.5	DPS/APS/RCS Thermal Effects
A. Campos	EE4	P15.1	EPS Performance Evaluation
R. E. Mayo	EC3	S14.1	LM ECS - Boost and Flight
J. C. Brady	EC3	S14.1	LM ECS - Boost and Flight
R. Irvin	EE13	S16.1	LM/MSFN Communications
A. D. Travis	EB3	S16.1	LM/MSFN Communications
R. Sinderson	EE16	S16.2	PCM/DFI Instrumentation
R. L. Giesecke	EE4	S16.2	Performance
R. A. Colonna	PD4	S15.2	Nose Cap, LM/SLA Separation
W. H. Simmons	EP4	P18.1	Explosive Devices Performance

3.4 OBJECTIVES CROSS REFERENCE

The following list of objectives provides a cross reference of the old and new numbers.

<u>Old Objective Number</u>	<u>New Objective Number</u>	<u>New Identification Title</u>
P1.3.1*	M13.3*	Primary Propulsion/Vehicle Interactions
P1.3.2*	M13.3*	Primary Propulsion/Vehicle Interactions
P1.3.4	P13.2	DPS Throttle Response
P1.3.5	P11.1	DPS Gimbal Actuators
P1.3.6	M13.1	Characteristics of APS/DPS Start/Shutdown
P1.3.7	M13.7	APS/DPS Burn Duration Effects
P1.3.9	M13.4	Ascent Engine Burnout Characteristics
P1.3.11	M13.5	DPS Pressurization/Propellant Feed
P1.3.12	M13.6	APS Pressurization/Propellant Feed
P1.5.1	M17.1	LM Structural Integrity
P1.5.2	M17.2	SLA/LM Launch Interaction Loads
P1.5.3	M17.3	APS/DPS Oxidizer Tanks Vibration
P1.12	M17.4	Critical Equipment Area Vibration
P1.13	M17.5	DPS/APS/RCS Thermal Effects
P1.14	M13.8	RCS/APS Interconnect
P2.1*	M20.2	FITH Abort Staging Dynamics
P2.2	M20.1	FITH Abort Structural Effects
P2.3	M20.3	FITH Abort Stability Control
P2.4*	M20.2*	FITH Abort Staging Dynamics
P3	DELETED	Launch Vehicle Upated H-1 Engine Performance (MSFC)
S7	DELETED	LM Thermal Response to Space Environment
S8	P11.2	PGNCS Performance
S9	P13.9	LM/RCS Operation and Performance
S10	P15.1	EPS Performance Evaluation
S11	S14.1	LM ECS - Boost & Flight
S12	S16.1	LM/MSFN Communications
S13	S16.2	PCM/DFI Instrumentation Performance
	S15.2	Nose Cap, LM/SLA Separation
	P18.1	Explosive Devices Performance

* Two old objectives combined into a single new objective.

NOTES: 1) Old objective P3 was deleted because launch vehicle 204 does not have uprated H-1 engines.

2) Old objective S7 was deleted because periods of exposure at fixed orientation were too short for determination of LM thermal response.

4. DETAILED TEST OBJECTIVES

This Detailed Test Objective section provides the details necessary for implementation of the mission objective into the flight plan, the criteria for data retrieval and data evaluation, and the criteria for determining that the mission objective was successfully accomplished.

Objectives listed in Section 3 which are related only to the launch vehicle are not repeated below since they are the responsibility of MSFC.

Unless otherwise stated, the engineering performance values as quoted in the objectives do not include instrumentation inaccuracies.

Where reference is made to LLM duty cycles, refer to MSC Report No. PM3/M-171/66, 30 October 1966, DRM IIA and DRM IIA appendices (Propulsion Appendix F).

P11.1 DPS GIMBAL ACTUATORS

Verify descent engine gimbaling response to control signals.

Purpose

Prior to manned LM flight, it is desirable to evaluate gimbal trim actuator operation in a free body/flight environment (engine thrust, engine heat and engine vibration).

Test Conditions

- 1) The approximate LLM DPS burns are required.
- 2) T.M. coverage shall be available approximately 1 minute preceding DPS engine ignition(s) through approximately 1 minute after DPS engine off commands.

Success Criteria

Descent engine gimbal drive actuators drive at $.2^{\circ}/\text{sec}$ in response to control signals as specified in LSP-470-30.

Evaluation

Operation of the actuator will be evaluated for correct response by comparing the gimbal rate with the control signals.

Data Requirements

Telemetry Measurements:

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GG 0001 X	PGNCS Downlink Data (To T/M)	PCMD	M
GH 1313 V	Volt, Pitch GDA Pos (Ret/Ext)	PCM	M
GH 1314 V	Volt, Roll GDA Pos (Ret/Ext)	PCM	M
GH 1323 X	Pitch Trim Fail	PCM	HD
GH 1330 X	Roll Trim Fail	PCM	HD

P11.1 DPS GIMBAL ACTUATORS

Background and Justification

Descent engine gimbaling will be verified to be performing its function of controlling cg thrust vector control by observing that the gimbal trim drives at approximately $.2^{\circ}/\text{Sec}$ in response to control signals.

Trim gimbal will allow the vehicle to limit cycle within the RCS jet deadband during the periods when angular error is less than approximately 1 or 2 degrees.

In the event the gimbal drive actuator does not properly position the descent engine nozzle for thrust vector control, spacecraft attitude control may be lost. Therefore, it is desirable that this objective be accomplished on an unmanned mission prior to the first manned LM mission. The effects of engine thrust, engine heat and engine vibration on gimbal trim actuator operation must be evaluated in a free body/flight environment. Ground testing cannot completely satisfy the constraints of this objective since a free body/flight environment would have to be simulated.

P11.2 PGNCs PERFORMANCE

Demonstrate PGNCs thrust vector control and attitude control capability and evaluate the performance of the DAP and IMU in a flight environment.

Purpose

PGNCs burn accuracy, attitude deadband control and TVC capability must be evaluated in flight. This is because structural dynamics, propellant slosh and IMU sensor performance in a flight environment are not well known from analysis and simulations. It is desirable that PGNCs performance be evaluated prior to manned LM flights.

Test Conditions

- 1) Continuous tracking and T/M coverage during LM descent and ascent burns.
- 2) Schedule heavy unstaged vehicle attitude hold in wide deadband over maximum T/M coverage area.
- 3) Vehicle attitude hold of the ascent stage in maximum deadband should be scheduled during the two orbits following the first APS burn.

Success Criteria

- 1) Actual apogee radius within * nm of desired apogee radius as a result of the first DPS burn.

* Allowable limit based on propagation of first DPS cutoff uncertainties to apogee. (Unofficial uncertainties for this burn exist in Vol. II of the existing GSOP. An official dispersion analysis is not available at this time.)
- 2) a) Vehicle \bar{R} and \bar{V} at start of random throttling for second DPS were within predicted uncertainties based on last state vector update and IMU alignment and sensor errors. (Unofficial uncertainties for this burn exist in Vol. II of the existing GSOP. An official dispersion analysis is not available at this time.)

- b) For the second DPS burn, the actual throttle commands agree (within instrumentation inaccuracy) to the pre-programmed values. (GSOP R-527 Vol. I, Rev. 2, page 4-20.)
- 3) APS 1 and 2 - Vehicle \bar{R} and \bar{V} for first and second APS burns at cutoff were within predicted uncertainties based on the IMU error model. (Unofficial uncertainties for this burn exist in Volume II of the existing GSOP. An official dispersion analysis is not available at this time.)
- 4) LM attitude control during descent engine operation and drifting flight.
 - a) At DPS ignition, disturbance torques were properly controlled by the RCS and DPS gimbaling (as specified in the LM-1 GSOP), and during the stable attitude phase of the DPS burn, the gimbal trim positions the thrust vector through the CG without RCS assistance.
 - b) Vehicle limit cycling during drifting flight (configurations of the LM staged near full and unstaged near full) were within predicted uncertainties based on the LM-1 DAP simulation data (Ref. TBD).
- 5) During ascent engine burn, disturbing accelerations were controlled by DAP in a fuel conserving mode, i.e., RCS propellant consumption were within predicted uncertainties based on LM-1 DAP simulation data (Ref. TBD).

Evaluation

The postflight evaluation will consist of the following:

- 1) Compare obtained orbit with targeted orbit conditions. First DPS burn (the simulated DOI) is an in-plane ΔV maneuver targeted for a specific apogee radius magnitude (r_a). (Tracking data and GG 0001 X.)
- 2) Burn #2
 - a) Compare actual and expected state vector during second DPS burn at start of random throttling. Second DPS burn is a simulated powered descent maneuver based on arrival on a specified orbit with pre-specified velocity conditions. (Tracking data and GG 0001 X.)
 - b) Compare actual thrust levels with pre-programmed command levels. When conditions in a) are obtained, the LGC simulates the hover phase by commanding a pre-programmed set of various throttle level settings for 10 sec. intervals. (GG 0001 X and GH 1331 V.)

- 3) Compare PGNCs indicated vehicle state vector at APS 1 and 2 cutoff with tracking estimates of vehicle state vector. (Tracking data and GG 0001 X.)
- 4) Observe convergence to limit cycle from RCS thruster firing data and rate and attitude data. (GH 1418 V through GH 1433 V, GG 0001 X, GH 1461 V, GH 1462 V, and GH 1463 V.)
- 5) Determine that RCS thruster firing duty cycle during the APS burns occurs in a fuel conserving mode. (GH 1418 V through GH 1433 V.)
- 6) Compare LGC downlink data with tracking data to determine IMU sensor performance.

Data Requirements

1) Telemetry Measurements:

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
CG 0001 X	PGNCs Downlink Data (To T/M)	PCMD	M
GG 6001 D	Vib, Nav Base (Roll)	PAM/FM	HD
GG 6002 D	Vib, Nav Base (Pitch)	PAM/FM	HD
GG 6003 D	Vib, Nav Base (Yaw)	PAM/FM	HD
GG 2112 V	Volt, IG 1X Res Out Sine	PCM	HD
GG 2113 V	Volt, IG 1X Res Out Cos	PCM	HD
GG 2142 V	Volt, MG 1X Res Out Sine	PCM	HD
GG 2143 V	Volt, MG 1X Res Out Cos	PCM	HD
GG 2172 V	Volt, OG 1X Res Out Sine	PCM	HD
GG 2173 V	Volt, OG 1X Res Out Cos	PCM	HD
GG 2121 V	Volt, IG 1X Res Sin (Expanded)	PCM	HD
GG 2151 V	Volt, MG 1X Res Sin (Expanded)	PCM	HD
GG 2181 V	Volt, OG 1X Res Sin (Expanded)	PCM	HD
GH 1461 V	Volt, Yaw RG Sig (0.8kc)	PCM	HD
GH 1462 V	Volt, Pitch RG Sig (0.8kc)	PCM	HD
GH 1463 V	Volt, Roll RG Sig (0.8kc)	PCM	HD
GH 1418 V	Volt, Jet No. 4U Driver Output, 28V	PCM	HD
GH 1419 V	Volt, Jet No. 4D Driver Output, 28V	PCM	HD
GH 1420 V	Volt, Jet No. 4F Driver Output, 28V	PCM	HD
GH 1421 V	Volt, Jet No. 4S Driver Output, 28V	PCM	HD
GH 1422 V	Volt, Jet No. 3U Driver Output, 28V	PCM	HD
GH 1423 V	Volt, Jet No. 3D Driver Output, 28V	PCM	HD
GH 1424 V	Volt, Jet No. 3F Driver Output, 28V	PCM	HD
GH 1425 V	Volt, Jet No. 3S Driver Output, 28V	PCM	HD
GH 1426 V	Volt, Jet No. 2U Driver Output, 28V	PCM	HD
GH 1427 V	Volt, Jet No. 2D Driver Output, 28V	PCM	HD
GH 1428 V	Volt, Jet No. 2F Driver Output, 28V	PCM	HD
GH 1429 V	Volt, Jet No. 2S Driver Output, 28V	PCM	HD

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GH 1430 V	Volt, Jet No. 1U Driver Output, 28V	PCM	HD
GH 1431 V	Volt, Jet No. 1D Driver Output, 28V	PCM	HD
GH 1432 V	Volt, Jet No. 1F Driver Output, 28V	PCM	HD
GH 1433 V	Volt, Jet No. 1S Driver Output, 28V	PCM	HD
GH 1331 V	Volt, Auto Thrust Commands	PCM	HD

- 2) MSFN Tracking Data - Tracking coverage required for all DPS and APS firings. Continuous coverage (HD). Coverage near end of each burn (M).

P11.2 PGNCS PERFORMANCE

Background and Justification

PGNCS burn accuracy and TVC capability must be evaluated in flight. This is because structural dynamics, fuel slosh and IMU sensor performance are not well known from analysis and simulations. Only through flight testing with actual hardware can satisfactory PGNCS TVC performance be assured. Also, the above mentioned uncertainties are dependent on the vehicle configuration, i.e., staged or unstaged and the quantity of fuel in the tanks. Therefore, to obtain a high degree of confidence, burns with both configurations over the full range of fuel loads are required.

During coasting flight, the LM is expected to stabilize in predicted limit cycle mode based on the attitude deadband selected. To substantiate RCS fuel budgeting, an evaluation of the actual limit cycle obtained is required. Demonstrations in the unstaged and staged configuration are required.

IMU performance is predictable based on histories of inertial component ground testing. Flight testing will substantiate these predictions and will help verify that no severe degradation results in the LM environment.

The above TVC data is definitely required for LM overall LLM qualification, and this development mission is ideal since the LM-1 DPS and APS burns are most representative of the LLM powered descent and ascent burns. DPS burns 1 and 2 use similar guidance laws to those planned for LM DOI and powered descent burns, respectively. APS burn 2 is representative of a lunar ascent type burn.

M13.1 CHARACTERISTICS OF APS/DPS START/SHUTDOWN

Determine DPS and APS start, restart and shutdown characteristics in a space environment.

Purpose

To assure that DPS and APS engines can be relied upon to satisfactorily meet the propulsion start and shutdown performance requirements including FITH abort necessary for manned LM operations. FITH dynamics, attitude control and structural effects are evaluated under objectives M20.1, M20.2 and M20.3.

Test Conditions

- 1) Two DPS burns of at least 5 seconds at 10% thrust.
- 2) Two APS firings must be made with each being in excess of two seconds duration.
- 3) Ullage maneuvers sufficient for settling propellants must proceed each burn of the DPS engine and the second APS engine burn.
- 4) The second DPS burn shutdown must be preceded by at least two seconds at the full throttle position.
- 5) The first APS burn should be effected by a FITH with DPS burning.
- 6) All DPS shutdowns must be initiated while operating at the full throttle position.

Success Criteria

- 1) General

Sufficient data were obtained to assure safe operation of the DPS and APS engines during start and stop for all burns including the FITH abort and no adverse reactions are detected.

2) APS

- a) APS start and shutdown transient performance should be within the limits defined in LSP-470-30.
 - (1) Transients: Paragraph 3.4.1.3.3.1.1.1.2
 - (2) Start and shutdown transients: Paragraph 3.4.1.3.3.1.2 (c)
 - (3) Impulse repeatability: Paragraph 3.4.1.3.3.1.2 (d)

3) DPS

- a) DPS start and shutdown transients performance should be within the limits specified in LSP-470-30.
 - (1) Transients: Paragraph 3.4.1.3.3.2.1.2
 - (2) Start and shutdown transients: Paragraph 3.4.1.3.3.2.5 (h)
 - (3) Impulse Repeatability: Paragraph 3.4.1.3.3.2.5 (i)

Evaluation

Following the flight, APS and DPS engine start and shutdown impulse will be determined by time integrating the respective chamber pressures over the transient periods. The resulting impulse and build-up characteristics will be correlated with propellant supply conditions to ascertain compliance. To verify that any noted anomalous performance is peculiar to start, a postflight analysis of the steady-state operating regimes will be conducted to appraise the normalcy of engine behavior immediately prior to shutdown. The start and shutdown impulse determined from chamber pressure will be verified by comparing start and shutdown impulse, derived from extrapolations of the steady state operating levels to the beginning of the start transients and to the end of the shutdown transients, using characteristic start and shutdown transient profile data obtained via ground tests.

During FITH, this estimate is subject to error as a result of the following:

- 1) The DPS data will not be retrievable subsequent to descent/ascent deadface which is scheduled to occur 0.447 seconds after the Abort Stage command. The expected DPS thrust decay period will be in excess of 0.9 seconds.
- 2) Certain APS data will not be retrievable prior to the aforementioned deadface (see Telemetry Measurements). The APS ignition is scheduled for T + 0.412 from deadface and is expected to reach 90% thrust within 0.310 seconds from ignition.
- 3) The APS effective thrust during the FITH start will be augmented by the "closed breach" firing phenomenon and must be adjusted accordingly.

To assist in defining these estimates, an analysis will be made of the DPS and APS steady-state regimes occurring prior to and subsequent to FITH, respectively. Thrust decay and build-up contours will be extrapolated from APS and DPS steady-state levels to the beginning of the APS start transient and to the end of the DPS shutdown transient, respectively.

Data Requirements

1) Telemetry Measurements

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GG 0001 X	PGNCS Downlink Data (To T/M)	PCM	HD
GH 1260 X	A.E. On/Off To Prop	PCM	HD
GP 0501 P	Press, Fuel Tank Ullage	FM/FM	HD
GP 1001 P	Press, Ox Tank Ullage	FM/FM	HD
GP 0718 T	Temp, Fuel Tank Fuel Bulk	PCM	HD
GP 1218 T	Temp, Ox Tank Ox Bulk	PCM	HD
GP 1501 P	Press, Fuel Isol Valve Inlet	PCM	HD
GP 1503 P	Press, Ox Isol Valve Inlet	PCM	HD
GP 2001 P	Press, Fuel Injector Inlet	FM/FM	HD*
GP 2006 P	Press, Ox Injector Inlet	FM/FM	HD*
GP 2010 P	Press, Thrust Chamber	PCM	HD
GP 2010 P	Press, Thrust Chamber	FM/FM	M*
GP 2706 T	Temp, Injector Surface	FM/FM	M*
GP 2801 D	Vib, Thrust Chamber XX Axis	FM/FM	M*
GP 2802 D	Vib, Thrust Chamber YY Axis	FM/FM	M*
GP 2803 D	Vib, Thrust Chamber ZZ Axis	FM/FM	M*
GQ 3603 Q	Quantity, Fuel Tank No. 1	PCM	HD
GQ 3604 Q	Quantity, Fuel Tank No. 2	PCM	HD
GQ 3611 P	Press, Engine Interface Fuel	PCM	HD
GQ 3611 P	Press, Engine Interface Fuel	FM/FM	HD

**

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GQ 3718 T	Temp, Fuel Tank No. 1 Fuel Bulk	PCM	HD
GQ 3719 T	Temp, Fuel Tank No. 2 Fuel Bulk	PCM	HD
GQ 3811 T	Temp, Engine Interface Fuel	FM/FM	HD
GQ 4103 Q	Quantity, Ox Tank No. 1	PCM	HD
GQ 4104 Q	Quantity, Ox Tank No. 2	PCM	HD
GQ 4111 P	Press, Engine Interface, Oxid	PCM	HD
GQ 4111 P	Press, Engine Interface, Oxid	FM/FM	HD
GQ 4218 T	Temp, Ox Tank No. 1 Ox Bulk	PCM	HD
GQ 4219 T	Temp, Ox Tank No. 2 Ox Bulk	PCM	HD
GQ 4311 T	Temp, Engine Interface, Oxid	FM/FM	HD
GQ 6510 P	Press, Thrust Chamber	PCM	HD
GQ 6510 P	Press, Thrust Chamber	FM/FM	M
GQ 6806 H	Pos, Variable Injector Actuator	PCM	M***
GQ 7301 D	Vib, Thrust Chamber XX Axis	FM/FM	M
GQ 7302 D	Vib, Thrust Chamber YY Axis	FM/FM	HD
GQ 7303 D	Vib, Thrust Chamber ZZ Axis	FM/FM	HD
GH 1331 V	Volt, Auto Thrust Command	PCM	M***

2) Trajectory Profile (HD).

*These channels are not transmitted prior to descent/ascent stage deadface.

**One of two mandatory.

***One of two mandatory.

M13.1 CHARACTERISTICS OF APS/DPS START/SHUTDOWN

Background and Justification

The purpose of this objective is to assure that the APS and DPS engines can be satisfactorily started and shutdown in the space environment. In the event engine start and shutdown operations are not satisfactory, crew and mission hazards are implied. Engine start, due to its dynamic nature, is of particular concern in terms of combustion stability. The DPS ground test program has given confidence that normal starts and shutdown transients will occur in the LM-1 flight. APS ground test history has, however, indicated start problems (viz., thrust chamber pressure rise rate and "over shoot"). The LM-1 APS (S/N E2B-36) did not demonstrate this tendency in ground test. The normal engine start transients are also grossly dependent upon the effectiveness of the preburn ullage maneuvers. Providing propellants are properly settled, the in-flight start transient should be no different and certainly no more hazardous than those conducted in the vacuum chamber test.

This objective encompasses the evaluation of the APS start and DPS shutdown during the FITH abort. As this is considered a hazardous operation, it must be successfully performed unmanned prior to performing it manned. The LM-1 mission presents the first opportunity to satisfy this constraint.

While DPS shutdown and APS start transients will be overlapping, sufficient DPS data obtainable prior to ascent/descent deadface and APS data obtainable subsequent to deadface should be sufficient to depict the DPS decay and APS buildup characteristics respectively.

With the exception of the FITH abort, all start transients, evaluated under this objective will be preceded by an LM/RCS ullage settling maneuver. Inherent in this objective is thus the verification of the ullage maneuvers, however, the RCS burn times planned for this mission are greater than required for subsequent missions. The FITH abort sequence and subsequent APS burn is preceded by a DPS burn and thus RCS ullage is not required to settle APS propellants prior to ignition. Satisfactory start of the

dependent upon burn time, but also upon throttle setting, an iterative relationship exists. While ground tests have indicated the LM-1 engine to be a "low" eroding engine, the correlations between thrust and actuator position will be applicable for subsequent missions. The resulting thrust profile will then be correlated to the actuator position profile. Cross correlations will then be made to determine the thrust command voltage to delivered thrust relationship. This relationship will then be studies in conjunction with similar relationships generated in acceptance test for the S/N 1026 DPS engine to determine ground to flight differences.

Data Requirements

1) Telemetry Measurements:

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GG 0001 X	PGNCS Downlink Data (To T/M)	PCM	M
GH 1331 V	Volt, Auto Thrust CMD	PCM	M
GQ 3603 Q	Quantity, Fuel Tank No. 1	PCM	HD
GQ 3604 Q	Quantity, Fuel Tank No. 2	PCM	HD
GQ 3611 P	Press, Engine Interface Fuel	PCM	HD
GQ 3611 P	Press, Engine Interface Fuel	FM/FM	M
GQ 3666 P	Del P, Fl Tk No. 1 Bot-Eng Interface	FM/FM	HD
GQ 3718 T	Temp, Fuel Tank No. 1 Fuel Bulk	PCM	HD
GQ 3719 T	Temp, Fuel Tank No. 2 Fuel Bulk	PCM	HD
GQ 4001 P	Press, Ox Tank No. 1 Ullage	FM/FM	HD
GQ 4103 Q	Quantity, Oxid Tank No. 1	PCM	HD
GQ 4104 Q	Quantity, Oxid Tank No. 2	PCM	HD
GQ 4111 P	Press, Engine Interface Oxid	PCM	HD
GQ 4111 P	Press, Engine Interface Oxid	FM/FM	M
GQ 4311 T	Del P, Ox Tk No. 1 Bot-Eng Interface	FM/FM	HD
GQ 6501 P	Press, Fuel Injector Inlet	FM/FM	HD
GQ 6506 P	Press, Ox Injector Inlet	FM/FM	HD
GQ 6510 P	Press, Thrust Chamber	PCM	HD
GQ 6510 P	Press, Thrust Chamber	FM/FM	HD
GQ 6806 H	Pos, Variable Injector Actuator	PCM	M
GQ 7301 D	Vib, Thrust Chamber XX Axis	FM/FM	HD
GQ 7302 D	Vib, Thrust Chamber YY Axis	FM/FM	HD
GQ 7303 D	Vib, Thrust Chamber ZZ Axis	FM/FM	HD

2) Trajectory Profile (HD).

P13.2 DPS THROTTLE RESPONSE

Background and Justification

The purpose of this objective is to assure that the DPS transient thrust response to throttling command signals from the LCC are satisfactory for LLM. In order to achieve this objective, two separate analyses are necessary; first, the injector throttling actuator response to the thrust commands must be determined and, second, the DPS engine thrust response to throttling actuator position must be determined.

As crew safety would not be directly compromised by poor responses if they were to occur in an earth orbital mission, the accomplishment of this objective is not a prerequisite to manned operations. An adverse DPS engine response to thrust commands on the LLM, however, could result in a mission abort or a loss of crew. For this reason, this objective requires accomplishment prior to the LLM.

The injector actuator response to thrust command signals can be determined by a time profile comparison between T/M measurements Variable Injector Actuator Position (GQ 6806 H) and the throttle command signals contained in the PGNS Downlink Data (GG 0001 V) and the Automatic Thrust Command Voltage (GH 1331 V). The DPS engine thrust response to injector actuator position necessitates indirect determination of DPS thrust from system measurements and velocity gains. A computer program, which is centered around a minimum variance treatment of flight data, will be used to determine the best estimate of DPS thrust during the mission. This analysis is of extreme importance as DPS thrust is significantly affected by thrust chamber throat erosion. Since throat erosion is not only dependent upon burn time, but also upon throttle setting, an iterative relationship exists. While ground tests have indicated the LM-1 engine to be a "low" eroding engine, the correlations between thrust and actuator position will be applicable for subsequent missions. The resulting thrust profile will then be correlated to the actuator position profile. Cross correlations will then be made to determine the thrust command voltage to delivered thrust relationship. This relationship will then be studied in conjunction

Evaluation

A postflight analysis will be performed to determine that the specified engine characteristics were maintained throughout the mission. A computer program, which embodies a minimum variance estimation technique, will be utilized to differentiate between vehicle, propulsion feed system, and engine data oscillatory correlations and noise in the state.

If degraded APS or DPS performance was indicated, vehicle rates and attitudes will be analyzed to determine if the degradation was caused by propulsion/vehicle interaction.

Data Requirements

1) Telemetry Measurements:

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GG 2112 V	Volt, IG IX Res Output, Sin	PCM	HD
GG 2113 V	Volt, IG IX Res Output, Cos	PCM	HD
GG 2121 V	Volt, IG IX Res Sin (Expanded)	PCM	HD
GG 2142 V	Volt, MG IX Res Output Sin	PCM	HD
GG 2143 V	Volt, MT IX Res Output Cos	PCM	HD
GG 2151 V	Volt, MG IX Res Sin (Expanded)	PCM	HD
GG 2172 V	Volt, OG IX Res Output, Sin	PCM	HD
GG 2173 V	Volt, OG IX Res Output, Cos	PCM	HD
GG 2181 V	Volt, OG IX Res Sin (Expanded)	PCM	HD
GH 1313 V	Volt, Pitch GDA Pos (Ret/Ext)	PCM	HD
GH 1314 V	Volt, Roll GDA Pos (Ext/Ret)	PCM	HD
GH 1331 V	Volt, Auto Thrust CMD	PCM	M*
GH 1462 V	Volt, Pitch RG Sig (.8 kc)	PCM	HD
GH 1463 V	Volt, Roll RG Sig (.8 kc)	PCM	HD
GG 0001 X	PGNCS Downlink Data (To T/M)	PCM	M**
GH 1418-33 V	Volt, Jet Driver Output, 28V	PCM	HD
GP 0001 P	Press, He Supply Tank No. 1	PCM	HD
GP 0002 P	Press, He Supply Tank No. 2	PCM	HD
GP 0025 P	Press, Reg. Out Manifold	PCM	HD
GP 2001 P	Press, Fuel Injector Inlet	FM/FM	HD
GP 2006 P	Press, Ox Injector Inlet	FM/FM	HD
GP 0201 T	Temp, He Supply Tank No. 1	PCM	HD
GP 0202 T	Temp, He Supply Tank No. 2	PCM	HD
GP 0501 P	Press, Fuel Tank Ullage	FM/FM	HD
GP 0616 P	Del P, Fuel Tk Bot To Interface	FM/FM	HD
GP 0718 T	Temp, Fuel Tank Fuel Bulk	PCM	HD
GP 0908 X	Fuel Tank Level Low	PCM	HD
GP 1001 P	Press, Ox Tank Ullage	FM/FM	HD
GP 1116 P	Del P, Ox Tk Bot To Interface	FM/FM	HD
GP 1218 T	Temp, Ox Tank Ox Bulk	PCM	HD
GP 1408 X	Ox, Tank Level Low	PCM	HD

<u>Measurement</u> <u>Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GP 1501 P	Press, Fuel Isol Valve Inlet	PCM	HD
GP 1503 P	Press, Ox Isol Valve Inlet	PCM	HD
GP 2010 P	Press, Thrust Chamber	PCM	HD
GP 2010 P	Press, Thrust Chamber	FM/FM	M
GP 2801 D	Vib, Thrust Chamber XX Axis	FM/FM	M
GP 2802 D	Vib, Thrust Chamber YY Axis	FM/FM	M
GP 2803 D	Vib, Thrust Chamber ZZ Axis	FM/FM	M
GQ 3603 Q	Quantity, Fuel Tank No. 1	PCM	M
GQ 3604 Q	Quantity, Fuel Tank No. 2	PCM	M
GQ 3611 P	Press, Eng Interface Fuel	PCM	HD
GQ 3611 P	Press, Eng Interface Fuel	FM/FM	HD
GQ 3718 T (1)	Temp, Fuel Tank No. 1 Fuel Bulk	PCM	HD
GQ 3719 T (1)	Temp, Fuel Tank No. 2 Fuel Bulk	PCM	HD
GQ 3811 T	Temp, Engine Interface Fuel	FM/FM	HD
GQ 4103 Q	Quantity, Ox Tank No. 1	PCM	M
GQ 4104 Q	Quantity, Ox Tank No. 2	PCM	M
GQ 4111 P	Press, Engine Interface Oxid	PCM	HD
GQ 4111 P	Press, Engine Interface Oxid	FM/FM	HD
GQ 4218 T (1)	Temp, Ox Tank No. 1 Ox Bulk	PCM	HD
GQ 4219 T (1)	Temp, Ox Tank No. 2 Ox Bulk	PCM	HD
GQ 4311 T	Temp, Engine Interface Oxid	FM/FM	HD
GQ 6501 P	Press, Fuel Injector Inlet	FM/FM	HD
GQ 6505 P	Press, Ox Injector Inlet	FM/FM	HD
GQ 6510 P	Press, Thrust Chamber	FM/FM	M**
GQ 6510 P	Press, Thrust Chamber	PCM	HD
GQ 6806 H	Pos, Variable Injector Actuator	PCM	M*
GQ 7301 D	Vib, Thrust Chamber XX Axis	FM/FM	M
GQ 7302 D	Vib, Thrust Chamber YY Axis	FM/FM	M
GQ 7303 D	Vib, Thrust Chamber ZZ Axis	FM/FM	M

2) Trajectory Profile (HD)

*One of two mandatory.

**One of two mandatory.

Background and Justification

The purpose of this objective is to determine that the APS and DPS dynamic characteristics and performance are not adversely effected by the vehicle and propulsion system induced operation. The elements concerned are vibration, propellant slosh and vehicle stability. The LM-1 mission is the first and only currently scheduled opportunity to satisfy this objective prior to manned LM operations. Adverse dynamic coupling between vehicle stability and propulsion system behavior can result in a crew and mission hazard. While current test and analytical results give no outstanding reasons to suspect such adverse interactions, the accomplishment of this objective prior to manned LM operations is required.

Ground testing cannot satisfy the constraints of this objective as such would require that a free body with flight accelerations be simulated. Ground testing together with analytical studies can, however, depict the dynamic environment under which engine combustion remains stable. The APS engine ground test history indicates cases of combustion instability. Steady-state instability, coined "footballs", appear linked with the current injector design. The LM-1 APS engine (S/N E2B-36), however, has not demonstrated this tendency toward instability. Nevertheless, particular attention will be given to this area in analyzing the LM-1 mission. As there is a high degree of uncertainty inherent in propellant slosh mode frequency, no direct means are available to isolate and define this mode during flight, save only during coast.

In-flight engine performance can be determined and correlated with the propellant supply conditions. It is doubtful, however, that propellant slosh or vehicle stability will be reflected in the supply conditions unless such oscillations are structurally catastrophic. None of the in-flight measurements associated with the pressurization, propellant feed and engine systems are adequate to differentiate between propellant slosh and vehicle instability incited by another mode outside the primary propulsion system. A computer program, which embodies a minimum variance

estimation technique, however, will be utilized to differentiate between vehicle and propulsion system induced oscillations.

This objective, when accomplished, will assure that no adverse propulsion subsystem/vehicle interactions will exist on manned LM missions as the pertinent configuration modifications planned subsequent to LM-1 are considered minor. Exception is taken, however, to the aforementioned "football" problem. The utility of the LM-1 test will necessitate study in the event a new APS injector design is effected in the flight test program.

M13.4 ASCENT ENGINE BURNOUT CHARACTERISTICS

Determine that no vehicle degradation which would affect crew safety occurs during APS burn to depletion.

Purpose

The accomplishment of this objective is pertinent to the LLM in that in the event of low level sensor uncovering during LM ascent, it may be necessary to burn the APS to propellant depletion to achieve orbit rather than to effect a manual shutdown prior to depletion.

Test Conditions

- 1) The second APS shutdown criteria will be propellant depletion.
- 2) APS/RCS interconnect is closed prior to APS propellant depletion.

Success Criteria

Sufficient data were obtained to determine that the burnout characteristics of the APS engine would not affect crew safety.

Evaluation

Following the flight, the shutdown impulse of the second APS burn will be ascertained using the time-integrated thrust chamber pressure decay, the propellant flow conditions implied by propellant tank low level sensor uncovering and empirical data derived from WSTF propellant depletion tests. In order to verify the propellant flowrate deduced from sensor uncovering, a postflight analysis will be performed to determine inflight steady-state engine performance, and propellant usage. The computer program to be used

in this analysis involve a minimum variance scheme which considers vehicle velocity gains and propellant and engine data obtained via MSFN. The shut-down impulse determined from chamber pressure will be verified by extrapolating from the steady-rate operating level to the end of the shut-down transient. A comparison will be made of the pressure decay profile determined from flight with that demonstrated in ground tests for like depletion cases.

Data Requirements

1) Telemetry Measurements:

<u>Measurement Number</u>	<u>Description</u>	<u>TV</u>	<u>Priority</u>
GG 0001 X	PGNCS Downlink Data (To T/M)	PCM	HD
GP 0001 P	Press, He Supply Tank No. 1	PCM	HD
GP 0002 P	Press, He Supply Tank No. 2	PCM	HD
GP 0019 P	Press, He Pri Upstream Reg Inlet	FM/FM	HD
GP 0020 P	Press, He Sec Upstream Reg Inlet	FM/FM	HD
GP 0025 P	Press, Reg Out Manifold	PCM	HD
GP 0201 T	Temp, He Supply Tank No. 1	PCM	HD
GP 0202 T	Temp, He Supply Tank No. 2	PCM	HD
GP 0501 P	Press, Fuel Tank Ullage	FM/FM	HD
GP 0616 P	Del P, Fuel Tk Bot to Interface	FM/FM	HD
GP 0718 T	Temp, Fuel Tank Fuel Bulk	PCM	HD
GP 0908 X	Fuel Tank Level Low	PCM	HD
GP 1001 P	Press, Ox Tank Ullage	FM/FM	HD
GP 1004 P	Press, Ox Tk Vent Rfl Vlv In	FM/FM	HD
GP 1116 P	Del P, Ox Tk Bot to Interface	FM/FM	HD
GP 1218 T	Temp, Ox Tank Ox Bulk	PCM	HD
GP 1408 X	Ox Tank Level Low	PCM	HD
GP 1501 P	Press, Fuel Isol Valve Inlet	PCM	M
GP 1503 P	Press, Ox Isol Valve Inlet	PCM	M
GP 2001 P	Press, Fuel Injector Inlet	FM/FM	M
GP 2006 P	Press, Ox Injector Inlet	FM/FM	M
GP 2010 P	Press, Thrust Chamber	PCM	HD
GP 2010 P	Press, Thrust Chamber	FM/FM	M
GP 2701 T	Temp, Thr Chm External Wall No. 1	FM/FM	HD
GP 2702 T	Temp, Thr Chm External Wall No. 2	FM/FM	HD
GP 2703 T	Temp, Thr Chm External Wall No. 3	FM/FM	HD
GP 2704 T	Temp, Thr Chm External Wall No. 4	FM/FM	HD
GP 2706 T	Temp, Injector Surface	FM/FM	HD
GP 2801 D	Vib, Thrust Chamber XX Axis	FM/FM	M
GP 2802 D	Vib, Thrust Chamber YY Axis	FM/FM	M
GP 2803 D	Vib, Thrust Chamber ZZ Axis	FM/FM	M

2) Trajectory Profile (HD).

*One of two mandatory.

Background and Justification

The purpose of this objective is to assure that hazardous behavior does not accompany an APS propellant depletion shutdown in a space environment. The accomplishment of this objective is pertinent to the LLM in that in the event of a propellant low level sensor indication during LM ascent, it may be necessary to burn the APS to propellant depletion to achieve a particular orbit, rather than to effect a manual shutdown prior to depletion. As an APS propellant depletion shutdown could induce abnormal shutdown transients, or at worst, prompt explosion, a crew hazard must be associated with this operation. For this reason, this objective must be first performed unmanned. A propellant depletion shutdown may occur as a result of fuel or oxidizer depletion each inciting different transient characteristics. Two separate flight tests are thus necessary: one for fuel depletion and another for oxidizer depletion. As APS burnout characteristics can be determined after de-manning the ascent stage in a manned mission, the propellant depletion mode which will not be demonstrated on the LM-1 mission can be conducted on any of the LM missions prior to the LLM missions.

Ground tests have been conducted at WSTF to assess propellant depletion shutdown transients. The currently available test results fail to indicate that this is a hazardous operation.

The successful accomplishment of this objective on the LM-1 mission (and the successful accomplishment of a similar objective to demonstrate the remaining depletion mode) would certify the APS safe for burnout operations on the LLM.

M13.5 DPS PRESSURIZATION/PROPELLANT FEED

Verify the operation of the DPS propellant feed and pressurization sections.

Purpose

Certify the DPS propellant feed and pressurization sections and the propellant gauging system for manned operations and the LLM.

Test Conditions

The approximate LLM DPS duty cycle will be required.

Success Criteria

- 1) The supercritical helium pressurization system should perform within the limits defined in specification LSP-470-30.
 - a) He/He internal heat exchanger: para. 3.4.1.3.3.2.3 (b)
 - b) Fuel/He Heat exchanger: para. 3.4.1.3.3.2.3. (e)
 - c) Pressure Budget: para. 3.4.1.3.3.2.3. (1)
 - d) Pressurization section nominal component characteristics: Table XIII
- 2) The propellant feed system should perform within the limits defined in specification LSP-470-30.
 - a) Mixture Ratio: para. 3.4.1.3.3.2.5 (k)
 - b) Interface Pressure: para. 3.4.1.3.3.2.3 (1)
 - c) Propellant Temperature: para. 3.4.1.3.3.2.5 (m)
 - d) Pressure Budget: para. 3.4.1.3.3.2.2. (1)
 - e) Quantity gauging: para. 3.4.1.3.3.2.2. (g)

3) Propellant Quantity Gauging System (PQGS)

The accuracy of the gauging system is within $\pm 1\%$ of full tank capacity except in the range of 8 to 25 percent where the error was less than $\pm .5\%$.

Evaluation

- 1) Following the flight an analysis will be conducted using pertinent T/M data to evaluate the following areas:
 - a) System pressure levels and oscillations.
 - b) He/He and He/fuel heat exchanger performance.
 - c) The helium solenoid valve, pressure reducer assembly, check valve, the relief valve and burst disc status and actuation.
 - d) The engine valve package and injector performance.
 - e) Pressurant and propellant utilization.
- 2) Particular attention will be given to the helium coils in the He/fuel heat exchanger to determine the degree to which fuel temperature is influenced.
- 3) A postflight analysis of the entire propulsion system will be conducted to ascertain pressurization/propellant feed/engine system compliance and to determine pressurant and propellant flow-rate profiles. This analysis will also assist in the authentication of analytical characterizations.
- 4) The computer program to be used in this analysis employs a minimum variance scheme which considers velocity gains and propellant and engine data obtained via MSFN as well as other pertinent design and performance data obtained from engine and system ground tests. In addition to determining engine performance (thrust, specific impulse and mixture ratio) this analysis will yield reconstructed consumable and stage weight histories. The reconstructed propellant weight history will be compared to the PQGS readings to determine PQGS errors and biases.

Data Requirements

1) Telemetry Measurements:

<u>Measurement</u> <u>Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GG 0001 X	PGNCS Downlink Data (To T/M)	PCMD	HD
GQ 3009 P	Press, He Pri Upstream Reg Inlet	FM/FM	M] **
GQ 3010 P	Press, He Sec Upstream Reg Inlet	FM/FM	M] **
GQ 3018 P	Press, He Reg Out Manifold	PCM	HD
GQ 3018 P	Press, He Reg Out Manifold	FM/FM	M*
GQ 3309 X	He Pri Sol Vlv Closed	PCM	HD
GQ 3310 X	He Sec Sol Vlv Open	PCM	HD
GQ 3435 P	Press, Super/Crit He Supply Tank	PCM	M***
GQ 3451 T	Temp, Super/Crit He Supply Outlet	FM/FM	HD
GQ 3455 T	Temp, Super/Crit He/He, Hx Inlet	FM/FM	HD
GQ 3459 T	Temp, Super/Crit He/He, Hx Outlet	FM/FM	HD
GQ 3463 T	Temp, Super/Crit Fuel/He Hx Outlet	FM/FM	HD
GQ 3501 P	Press, Ullage Fuel Tk No. 1	FM/FM	M*
GQ 3603 Q	Quantity, Fuel Tank No. 1	PCM	M] **
GQ 3604 Q	Quantity, Fuel Tank No. 2	PCM	M] **
GQ 3611 P	Press, Engine Interface Fuel	PCM	HD
GQ 3611 P	Press, Engine Interface Fuel	FM/FM	HD
GQ 3718 T	Temp, Fuel Tank No. 1 Fuel Bulk	PCM	M****
GQ 3719 T	Temp, Fuel Tank No. 2 Fuel Bulk	PCM	M****
GQ 3811 T	Temp, Engine Interface Fuel	FM/FM	M
GQ 4001 P	Press, Ox Tank No. 1 Ullage	FM/FM	M*
GQ 4103 Q	Quantity, Oxid Tank No. 1	PCM	M] **
GQ 4104 Q	Quantity, Oxid Tank No. 2	PCM	M] **
GQ 4111 P	Press, Engine Interface Oxid	PCM	HD
GQ 4111 P	Press, Engine Interface Oxid	FM/FM	HD
GQ 4218 T	Temp, Ox Tank No. 1 Ox Bulk	PCM	M****
GQ 4219 T	Temp, Ox Tank No. 2 Ox Bulk	PCM	M****
GQ 4311 T	Temp, Engine Interface Ox	FM/FM	HD
GQ 6510 P	Press, Thrust Chamber	PCM	HD
GQ 6510 P	Press, Thrust Chamber	FM/FM	HD
GQ 6806 H	Pos, Variable Injector Actuator	PCM	HD
GQ 7301 D	Vib, Thrust Chamber XX Axis	FM/FM	HD
GQ 7302 D	Vib, Thrust Chamber YY Axis	FM/FM	HD
GQ 7303 D	Vib, Thrust Chamber ZZ Axis	FM/FM	HD

*One of three mandatory.

**One of two mandatory.

***One of four mandatory - one hour prior to launch.

M13.5 DPS PRESSURIZATION/PROPELLANT FEED

Background and Justification

The purpose of this objective is to verify that the operational characteristics of the DPS super-critical pressurization and propellant feed systems in the space flight environment certifies this section for manned operation and the LLM. It is also the inherent purpose of this objective to quantitatively determine the DPS pressurization/feed system behavior under operational flight conditions for the purpose of ascertaining critical deficiencies and certification of overall design adequacy.

While the flight article hardware will be deemed flight qualified by the extensive ground test programs being conducted by the contractor (GAEC qual test) and WSTF, a requirement to verify flight operation prior to manned LM operations is necessary. This requirement is imposed out of necessity to verify helium consumption and the predictability thereof. The need for this requirement, however, has been re-emphasized by the recent explosion which occurred on LTA-5 at WSTF as a result of water trapped in the supercritical helium heat exchanger which froze during a test causing a structural weakness. The LM-1 fix was achieved by the installation of the LM-4 heat exchanger which was given extensive pressure tests. Subsequent heat exchangers will be manufactured with a more suitable brazing alloy. Since helium consumption is grossly regulated by the effectiveness of the He/He and fuel/He heat exchanger combination, flight data regarding heat exchanger performance is likewise necessary. In order to assure that sufficient helium quantity will be available for the LLM as well as other LM missions, the impact of the space environment and DPS duty cycle upon helium consumption must be realized. Perhaps the most useful information anticipated from flight is data which depicts the effect of near weightlessness on intra-tank heat transfer in the super-critical supply tank as natural convection is the mode of transfer. Since ground tests cannot simulate this phenomenon, flight data is necessary.

Knowledge of the heat transfer characteristics during flight accelerations is not only of critical concern in determining system effectiveness during engine burns, but is of extreme importance in defining the usable portion of the loaded quantity. A study of the problem of localized fuel freezing (in the fuel/He HX region) is also to be a part of this objective. Furthermore, LM missions subsequent to LM3 will be void of the DFI measurements. The only surviving measurement in the entire pressurization section will be the super-critical He supply tank pressure (GQ 3435 P). LM missions flown subsequent to LM 3, consequently afford little opportunity to augment knowledge in this area.

LM-1 differs from subsequent LM's in that it does not have an ambient helium bottle for initial propellant system pressurization. The absence of this bottle makes LM-1 a worst case demonstration of the pressurization and feed system.

Successful accomplishment of this objective on the LM-1 mission will certify the DPS propellant feed and pressurization systems for manned operations as well as the LLM.

M13.6 APS PRESSURIZATION/PROPELLANT FEED

Verify the operation of the APS propellant feed and pressurization sections.

Purpose

Validate the APS pressurization and propellant feed sections for manned LM operations and the LLM.

Test Conditions

The approximate LLM APS duty cycle is required.

Success Criteria

The Ambient Helium pressurization system and the propellant feed system should perform within the limits defined in specification LSP-470-30.

- 1) Pressure Budget: Paragraph 3.4.1.3.3.1.1.3
- 2) Mixture Ratio: Paragraph 3.4.1.3.3.1.2 (h)
- 3) Interface Pressure: Paragraph 3.4.1.3.3.1.2 (i)
- 4) Propellant Temperature: Paragraph 3.4.1.3.3.1.2 (j)
- 5) Low Level Sensors: Paragraph 3.4.1.3.3.1.1.2 (g)

Evaluation

- 1) Following the flight an analysis will be conducted using pertinent T/M data to evaluate the following areas:
 - a) System pressure levels and oscillations.
 - b) Pressurant and propellant utilization.
- 2) A postflight performance analysis of the entire propulsion system will be conducted to ascertain pressurization/propellant

feed/engine compliance and to determine pressurant and propellant flow-rate profiles. Results of this analysis will be used to authenticate the analytical characterizations which were formulated using ground test data.

Data Requirements

1) Telemetry Measurements

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
CG 0001 X	PGNCS Downlink Data (To T/M)	PCMD	HD
GP 0001 P	Press, HE Supply Tank No. 1	PCM	HD
GP 0002 P	Press, HE Supply Tank No. 2	PCM	HD
GP 0019 P	Press, HE Pri Upstream Ref Inlet	FM/FM	HD
GP 0020 P	Press, HE Sec Upstream Ref Inlet	FM/FM	HD
GP 0025 P	Press, Reg Out Manifold	FM/FM	M*
GP 0201 T	Temp, HE Supply Tank No. 1	PCM	HD
GP 0202 T	Temp, HE Supply Tank No. 2	PCM	HD
GP 0318 X	HE Pri Line Sol VLV Closed	PCM	HD
GP 0320 X	HE Sec Line Sol VLV Closed	PCM	HD
GP 0501 P	Press, Fuel Tank Ullage	FM/FM	M*
GP 0616 P	DEL P, Fuel Tk Bot to Interface	FM/FM	HD
GP 0718 T	Temp, Fuel Tank Fuel Bulk	PCM	HD
GP 0908 X	Fuel Tank Level Low	PCM	HD
GP 1001 P	Press, Ox Tank Ullage	FM/FM	M*
GP 1004 P	Press, Ox Tk Vent RLF VLV In	FM/FM	HD
GP 1116 P	DEL P, Ox Tk BOT to Interface	FM/FM	HD
GP 1218 T	Temp, Ox Tank Ox Bulk	PCM	HD
GP 1408 X	Ox Tank Level Low	PCM	HD
GP 1501 P	Press, Fuel ISOL Valve Inlet	PCM	HD
GP 1503 P	Press, Ox ISOL Valve Inlet	PCM	HD
GP 1801 X	ISOL Valve A Not Open (Part of GP 2997 U)		
GP 1802 X	ISOL Valve B Not Open (Part of GP 2998 U)		
GP 1805 X	BIPROP Vlv A Not Open (Part of GP 2997 U)		
GP 1806 X	BIPROP Vlv B Not Open (Part of GP 2998 U)		
GP 1811 X	ISOL Vlv A Not Closed (Part of GP 2997 U)		
GP 1812 X	ISOL Vlv B Not Closed (Part of GP 2998 U)		
GP 1813 X	BIPROP Vlv A Not Closed (Part of GP 2997 U)		
GP 1814 X	BIPROP Vlv B Not Closed (Part of GP 2998 U)		
GP 2001 P	Press, Fuel Injector Inlet	FM/FM	HD
GP 2006 P	Press, Ox Injector Inlet	FM/FM	HD
GP 2010 P	Press, Thrust Chamber	PCM	HD
GP 2997 U	Isol/Biprop Vlvs A Delta Pos	PCM	HD
GP 2998 U	Isol/Biprop Vlvs B Delta Pos	PCM	HD

*One of three are mandatory; the other two are highly desirable.

2) Trajectory Profile (HD).

M13.6 APS PRESSURIZATION/PROPELLANT FEED

Background and Justification

The purpose of this objective is to provide assurance that the operational characteristics of the APS pressurization and propellant feed sections for manned operations and the LLM are within specification. Inherent in this objective is the purpose to quantitatively determine the pressurant/propellant supply system behavior under flight conditions for the purpose of determining critical deficiencies and overall certification of design adequacy. Ground tests are inadequate to simulate flight accelerations. Since the pressurization/feed system is a vital function of the APS propulsion system operation, accomplishment of this objective is necessary prior to manned operations.

Successful accomplishment of this objective, together with successful ground testing, will validate the APS pressurization and propellant feed systems for manned LM operations.

M13.7 APS/DPS BURN DURATION EFFECTS

Determine the effects of burn duration on DPS and APS engine performance.

Purpose

To assure that long duration APS and DPS burns in the space environment do not precipitate unsatisfactory engine performance including thrust chamber burn through. Since a thrust chamber burn through could compromise crew safety, the accomplishment of this objective prior to manned operations is required.

Test Conditions

- 1) This objective will be implemented by the normal execution of the simulated Lunar Mission Duty Cycle. The DPS duty cycle will include a burn time in excess of 200 seconds at the Fixed Throttle Point (F.T.P.) and a burn time in excess of 200 seconds in the throttled mode (50 percent full thrust or less). Total burn time will be in excess of 640 seconds.
- 2) The second APS burn should be in excess of 392 seconds in duration.
- 3) Prior to ignition DPS and APS propellant tank pressures and propellant temperatures will be within the normal design operating range.

Success Criteria

- 1) APS performance should be within the limits specified in LSP-470-30 specification.
 - a) Engine Performance: para. 3.4.1.3.3.1.2 (a)
 - b) Mixture Ratio: para. 3.4.1.3.3.1.2 (h)
 - c) Steady State: para. 3.4.1.3.3.1.1.1.3
 - d) Combustion Stability: para. 3.4.1.3.3.1.1.1.3.1

2) DPS performance should be within the limits specified in LSP-470-30 Specification.

- a) Engine performance: para. 3.4.1.3.3.2.5 (a)
- b) Mixture Ratio: para. 3.4.1.3.3.2.5 (k)
- c) Steady State: para. 3.4.1.3.3.2.1.2
- d) Combustion Stability: para. 3.4.1.3.3.2.1.3.1
- e) Engine Temperature: para. 3.4.1.3.3.2.5 (p)

Evaluation

A postflight analysis will be performed to determine the APS and DPS steady-state performance which will be correlated to burn duration. The computer program to be used in this analysis employs a minimum variance scheme which considers velocity gains and propellant and engine data obtained via MSFN as well as other pertinent design and performance data obtained from engine and system ground tests. In addition to determining engine performance (thrust, specific impulse and mixture ratio) this analysis will yield reconstructed consumable and stage weight histories. These results will thus provide vital information concerning APS and DPS ΔV capabilities and performance and propellant margins.

The APS and DPS outer skin temperature profiles from flight will be compared to those obtained from ground tests. These flight profiles will be used in determining whether or not engine thermal specifications were violated.

Data Requirements

1) Telemetry Measurements:

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GG 0001 X	PGNCS Downlink Data (To T/M)	PCM	M
GP 0001 P	Press, He Supply Tank No. 1	PCM	HD
GP 0002 P	Press, He Supply Tank No. 2	PCM	HD
GP 0025 P	Press, Reg Out Manifold	FM/FM	HD
GP 0201 T	Temp, He Supply Tank No. 1	PCM	HD
GP 0202 T	Temp, He Supply Tank No. 2	PCM	HD
GP 0501 P	Press, Fuel Tank Ullage	FM/FM	M**

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GP 0616 P	Del P, Fuel Tk Bot To Interface	FM/FM	HD
GP 0718 T	Temp, Fuel Tank Fuel Bulk	PCM	M ¹
GP 0908 X	Fuel Tank Level Low	PCM	HD
GP 1001 P	Press, Ox Tank Ullage	FM/FM	M***
GP 1116 P	Del P, Ox Tank Bot To Interface	FM/FM	HD
GP 1218 T	Temp, Ox Tank Ox Bulk	PCM	HD
GP 1408 X	Ox Tank Level Low	PCM	HD
GP 1501 P	Press, Fuel Isol Vlv Inlet	PCM	M**
GP 1503 P	Press, Ox Isol Vlv Inlet	PCM	M***
GP 2001 P	Press, Fuel Injector Inlet	FM/FM	HD
GP 2006 P	Press, Ox Injector Inlet	FM/FM	HD
GP 2010 P	Press, Thrust Chamber	PCM	HD
GP 2010 P	Press, Thrust Chamber	FM/FM	M
GP 2701 T	Temp, Thr Chm External Wall No. 1	FM/FM	M*
GP 2702 T	Temp, Thr Chm External Wall No. 2	FM/FM	HD
GP 2703 T	Temp, Thr Chm External Wall No. 3	FM/FM	M*
GP 2704 T	Temp, Thr Chm External Wall No. 4	FM/FM	M*
GP 2706 T	Temp, Injector Surface	FM/FM	HD
GP 2801 D	Vib, Thrust Chamber XX Axis	FM/FM	HD
GP 2802 D	Vib, Thrust Chamber YY Axis	FM/FM	M
GP 2803 D	Vib, Thrust Chamber ZZ Axis	FM/FM	M
GQ 3009 P	Press, He Pri Upstream Reg Inlet	FM/FM	HD
GQ 3010 P	Press, He Sec Upstream Reg Inlet	FM/FM	HD
GQ 3018 P	Press, He Reg Out Manifold	PCM	HD
GQ 3501 P	Press, Ullage Fuel Tk No. 2	FM/FM	M ³
GQ 3603 Q	Quantity, Fuel Tank No. 1	PCM	M
GQ 3604 Q	Quantity, Fuel Tank No. 2	PCM	M
GQ 3611 P	Press Engine Interface Fuel	PCM	M
GQ 3611 P	Press Engine Interface Fuel	FM/FM	M ³
GQ 3666 P	Del P, Fl Tk No. 1 Bot-Eng Interface	FM/FM	HD ₂
GQ 3718 T	Temp, Fuel Tank No. 1 Fuel Bulk	PCM	M ₂
GQ 3719 T	Temp, Fuel Tank No. 2 Fuel Bulk	PCM	M ₂
GQ 3811 T	Temp, Engine Interface Fuel	FM/FM	HD
GQ 4001 P	Press, Ox Tank No. 1 Ullage	FM/FM	M ⁴
GQ 4103 Q	Quantity, Oxid Tank No. 1	PCM	M
GQ 4104 Q	Quantity, Oxid Tank No. 2	PCM	M
GQ 4111 P	Press, Engine Interface Oxid	PCM	M
GQ 4111 P	Press, Engine Interface Oxid	FM/FM	M ⁴
GQ 4116 P	Del P, Ox Tk No. 1 Bot-Eng Interface	FM/FM	HD ₂
GQ 4218 T	Temp, Ox Tank No. 1 Ox Bulk	PCM	M ₂
GQ 4219 T	Temp, Ox Tank No. 2 Ox Bulk	PCM	M ₂
GQ 4311 T	Temp, Engine Interface Oxid	FM/FM	HD
GQ 4455 X	Propellant Tanks Lqd Level Low	PCM	HD
GQ 6501 P	Press, Fuel Injector Inlet	FM/FM	HD
GQ 6506 P	Press, Ox Injector Inlet	FM/FM	HD
GQ 6510 P	Press, Thrust Chamber	PCM	HD
GQ 6510 P	Press, Thrust Chamber	FM/FM	M
GQ 6806 H	Pos, Variable Injector Actuator	PCM	M
GH 1331 V	Volt, Auto Thrust CMD	PCM	M

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GQ 7301 D	Vib, Thrust Chamber XX Axis	FM/FM	HD
GQ 7302 D	Vib, Thrust Chamber YY Axis	FM/FM	M } **
GQ 7303 D	Vib, Thrust Chamber ZZ Axis	FM/FM	M }
GQ 7206 T	Temp Injector Surface	FM/FM	HD
GQ 7211 T	Temp Eng Ht Sh Outer Surf No. 1	FM/FM	M } **
GQ 7212 T	Temp Eng Ht Sh Outer Surf No. 2	FM/FM	M }
GQ 7213 T	Temp Eng Ht Sh Outer Surf No. 3	FM/FM	M } **
GQ 7214 T	Temp Eng Ht Sh Outer Surf No. 4	FM/FM	M }

*One of three mandatory; remaining two highly desirable.

**One of two mandatory; the other highly desirable.

***One of two mandatory; the other highly desirable.

¹Mandatory to T-1 hour.

²One of four mandatory to T-1 hour.

³One of two mandatory.

⁴One of two mandatory.

M13.7 APS/DPS BURN DURATION EFFECTS

Background and Justification

The purpose of this objective is to assure that long duration APS and DPS burns in the space environment do not precipitate unsatisfactory engine performance. In addition, the purpose includes the qualitative determination of subsystem behavior under flight operational conditions for the purpose of determining critical deficiencies and certification of design adequacy. Accurate determination of subsystem performance for the purpose of ascertaining LM capability to satisfy design requirements and extent-margin for which it may be called upon is also considered inherent in this objective. Two major items related to crew safety are normally of concern in long duration burns: (1) thrust chamber burn through; (2) degraded performance which results from thrust chamber throat erosion. Since a thrust chamber burn through could compromise crew safety, the accomplishment of this objective prior to manned operations is necessary.

The LM-1 DPS engine (S/N 1026) is considered a "low" eroding engine relative to other engines to be flown on ensuing missions. The correlations to be drawn between engine performance and burn time are considered applicable to higher eroding chambers. While throat area (and consequently erosion) cannot be directly instrumented, it can be somewhat surmised through flight test data correlation. This correlation will be performed by a computer program which employs a minimum variance technique to yield the best estimate of engine performance based upon velocity gains and propellant/engine data obtained via MSFN.

The accomplishment of this objective on the LM-1 mission will contribute to the qualification of APS and DPS engines for manned LM operations. In the event, however, of an APS injector design change subsequent to LM-1, the utility of the data obtained from this objective must be appraised.

M13.8 RCS/APS INTERCONNECT

Verify APS/RCS operation using the APS/RCS propellant interconnect.

Purpose

Certify the RCS capability to utilize APS propellants prior to a LM manned mission. The RCS chamber pressure measurements are available only on LM-1.

Test Conditions

The APS/RCS interconnect should not be opened before 10 seconds of the second APS burn in order to provide a +X translation to the vehicle. This +X translation ensures that the propellants are settled (simulating start of lunar ascent) prior to the use of the interconnect propellant supply. The interconnect will be used for a minimum of 50 seconds.

Success Criteria

- 1) Propellant was supplied to the RCS engine for steady-state operation at a dynamic pressure between 172 and 192 psia.
- 2) RCS thruster vacuum thrust was between 95 and 108 pounds during continuous operation.
- 3) No adverse interactions between the APS and RCS were observed during APS/RCS interconnect use.
- 4) The propellant latch valves operated correctly and there were no detectable leaks when in the closed position.

Evaluation

- 1) Following the flight the TCA inlet and thruster chamber pressure data will be analyzed to ascertain the degree to which propellant supply conditions were satisfied.
- 2) The thruster chamber pressure data will be correlated with ground/static test data as well as inflight data obtained prior to and subsequent to use of the interconnect to determine thruster thrust.
- 3) APS fuel and oxidizer valve inlet pressures and APS thrust chamber pressure data will be analyzed to determine if these pressures were degraded during the interconnect test.
- 4) Propellant latch valve operation will be evaluated on the basis of valve position and system pressure.

Data Requirements

1) Telemetry Measurements:

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GP 0501 P	Press, Fuel Tank Ullage	FM/FM	HD
GP 0504 P	Press, Fuel Tk Vent Rlf Vlv In	FM/FM	HD
GP 0616 P	Del P, Fuel Tk Bot to Interface	FM/FM	HD
GP 0718 T	Temp, Fuel Tank Fuel Bulk	PCM	HD
GP 0908 X	Fuel Tank Level Low	PCME	HD
GP 1001 P	Press, Ox Tank Ullage	FM/FM	HD
GP 1116 P	Del P, Ox Tank Bot to Interface	FM/FM	HD
GP 1218 T	Temp, Ox Tank Ox Bulk	PCM	HD
GP 1501 P	Press, Fuel Isol Valve Inlet	PCM	HD
GP 1503 P	Press, Ox Isol Valve Inlet	PCM	HD
GR 1085 Q	Qty, Propellant Sys A	PCM	M*
GR 1101 P	Press, Helium Tank A	PCM	M*
GR 1095 Q	Qty, Propellant Sys B	PCM	M**
GR 1102 P	Press, Helium Tank B	PCM	M**

*, ** One of two mandatory, the other highly desirable.

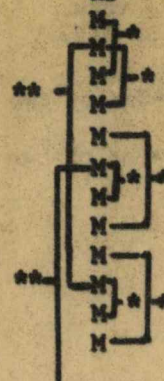
Measurement
Number

Description

TM

Priority

GR 2201 P	Press, A Fuel Mnfld	PCM	HD
GR 2202 P	Press, B Fuel Mnfld	PCM	HD
GR 2461 X	Fuel Main Feed S/O A Closed	(Part of GR 9609 U)	
GR 2462 X	Fuel Main Feed S/O B Closed	(Part of GR 9610 U)	
GR 3201 P	Press, A Oxid Mnfld	PCM	HD
GR 3202 P	Press, B Oxid Mnfld	PCM	HD
GR 3461 X	Oxid Main Feed S/O A Closed	PCM	HD
GR 3462 X	Oxid Main Feed S/O B Closed	PCM	HD
GR 4322 T	Temp, TCA Fuel Inlet, PR 4B Surf	FM/FM	HD
GR 4323 T	Temp, TCA Fuel Inlet, PR 3A Surf	FM/FM	HD
GR 4326 T	Temp, TCA Fuel Inlet, PR 2B Surf	FM/FM	HD
GR 4327 T	Temp, TCA Fuel Inlet, PR 1A Surf	FM/FM	HD
GR 4424 T	Temp, TCA Oxid Inlet, PR 3B Surf	FM/FM	HD
GR 4570 T	Temp, TCA Injector Head No. 4D	FM/FM	HD
GR 4571 T	Temp, TCA Injector Head No. 4F	FM/FM	HD
GR 4573 T	Temp, TCA Injector Head No. 3U	FM/FM	HD
GR 4574 T	Temp, TCA Injector Head No. 3D	FM/FM	HD
GR 4577 T	Temp, TCA Injector Head No. 2U	FM/FM	HD
GR 4578 T	Temp, TCA Injector Head No. 2D	FM/FM	HD
GR 4582 T	Temp, TCA Injector Head No. 1D	FM/FM	HD
GR 4583 T	Temp, TCA Injector Head No. 1F	FM/FM	HD
GR 5011 P	Press, TCA Fuel Inlet, PR 4A	FM/FM	HD
GR 5012 P	Press, TCA Fuel Inlet, PR 4B	FM/FM	HD
GR 5013 P	Press, TCA Fuel Inlet, PR 3A	FM/FM	HD
GR 5014 P	Press, TCA Fuel Inlet, PR 3B	FM/FM	HD
GR 5015 P	Press, TCA Fuel Inlet, PR 2A	FM/FM	HD
GR 5016 P	Press, TCA Fuel Inlet, PR 2B	FM/FM	HD
GR 5017 P	Press, TCA Fuel Inlet, PR 1A	FM/FM	HD
GR 5018 P	Press, TCA Fuel Inlet, PR 1B	FM/FM	HD
GR 5019 P	Press, TCA Oxid Inlet, PR 4A	FM/FM	HD
GR 5020 P	Press, TCA Oxid Inlet, PR 4B	FM/FM	HD
GR 5021 P	Press, TCA Oxid Inlet, PR 3A	FM/FM	HD
GR 5022 P	Press, TCA Oxid Inlet, PR 3B	FM/FM	HD
GR 5023 P	Press, TCA Oxid Inlet, PR 2A	FM/FM	HD
GR 5024 P	Press, TCA Oxid Inlet, PR 2B	FM/FM	HD
GR 5025 P	Press, TCA Oxid Inlet, PR 1A	FM/FM	HD
GR 5026 P	Press, TCA Oxid Inlet, PR 1B	FM/FM	HD
GR 5031 P	Press, Thrust Chamber No. 4U	FM/FM	HD
GR 5032 P	Press, Thrust Chamber No. 4D	FM/FM	HD
GR 5033 P	Press, Thrust Chamber No. 4F	FM/FM	HD
GR 5034 P	Press, Thrust Chamber No. 4S	FM/FM	HD
GR 5035 P	Press, Thrust Chamber No. 3U	FM/FM	HD
GR 5036 P	Press, Thrust Chamber No. 3D	FM/FM	HD
GR 5037 P	Press, Thrust Chamber No. 3F	FM/FM	HD
GR 5038 P	Press, Thrust Chamber No. 3S	FM/FM	HD
GR 5039 P	Press, Thrust Chamber No. 2U	FM/FM	HD
GR 5040 P	Press, Thrust Chamber No. 2D	FM/FM	HD
GR 5041 P	Press, Thrust Chamber No. 2F	FM/FM	HD
GR 5042 P	Press, Thrust Chamber No. 2S	FM/FM	HD



<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GR 5043 P	Press, Thrust Chamber No. 1U	FM/FM	
GR 5044 P	Press, Thrust Chamber No. 1D	FM/FM	
GR 5045 P	Press, Thrust Chamber No. 1F	FM/FM	
GR 5046 P	Press, Thrust Chamber No. 1S	FM/FM	
GR 6001 T	Temp, Quad Cluster No. 4	PCM	HD
GR 6002 T	Temp, Quad Cluster No. 3	PCM	HD
GR 6003 T	Temp, Quad Cluster No. 2	PCM	HD
GR 6004 T	Temp, Quad Cluster No. 1	PCM	HD
GR 9609 U	Main Prop Valves A Closed	PCM	HD
GR 9610 U	Main Prop Valves B Closed	PCM	HD
GR 9611 U	Mnfld Control Vlv A Not Closed	PCM	HD
GR 9612 U	Mnfld Control Vlv B Not Closed	PCM	HD
GR 9613 U	Mnfld X Feed Vlv Not Closed	PCM	HD
GR 9661 U	TCA Isol Valves 4A Closed	PCM	HD
GR 9662 U	TCA Isol Valves 4B Closed	PCM	HD
GR 9663 U	TCA Isol Valves 3A Closed	PCM	HD
GR 9664 U	TCA Isol Valves 3B Closed	PCM	HD
GR 9665 U	TCA Isol Valves 2A Closed	PCM	HD
GR 9666 U	TCA Isol Valves 2B Closed	PCM	HD
GR 9667 U	TCA Isol Valves 1A Closed	PCM	HD
GR 9668 U	TCA Isol Valves 1B Closed	PCM	HD
GG 0001 X	PGNCS Downlink Data (To T/M)	PCM	HD
GH 1461 V	Volt, Yaw RG Sig (0.8KC)	PCM	HD
GH 1462 V	Volt, Pitch RG Sig (0.8KC)	PCM	HD
GH 1463 V	Volt, Roll RG Sig (0.8KC)	PCM	HD
GG 2112 V	Volt, IG 1X Res Out, Sine	PCM	HD
GG 2113 V	Volt, IG 1X Res Out, Cos	PCM	HD
GG 2142 V	Volt, MG 1X Res Out, Sine	PCM	HD
GG 2143 V	Volt, MG 1X Res Out, Cos	PCM	HD
GG 2172 V	Volt, OG 1X Res Out, Sine	PCM	HD
GG 2173 V	Volt, OG 1X Res Out, Cos	PCM	HD
GG 2121 V	Volt, IG 1X Res Sin (Expanded)	PCM	HD
GG 2151 V	Volt, OG 1X Res Sin (Expanded)	PCM	HD
GG 2181 V	Volt, MG 1X Res Sin (Expanded)	PCM	HD
GH 1418 V	Volt, Jet Driver Output	PCM	HD
thru			
GH 1433 V	Volt, Jet Driver Output	PCM	HD

*One of two is mandatory; the other is highly desirable.

**One of two is mandatory; the other is highly desirable.

M13.8 RCS/APS INTERCONNECT

Background and Justification

The purpose of this objective is to assure that unacceptable RCS performance degradations do not accompany the APS propellants supplied via the APS/RCS interconnect. In addition, this objective is interpreted to include the accurate determination of RCS subsystem performance for the purpose of assessing its capability to satisfy design requirements.

In the event propellants are not properly supplied to the RCS engines during interconnect operations, a crew hazard could result. This objective must therefore be accomplished on an unmanned mission prior to interconnect propellant usage on a manned mission. The LM-1 mission presents the only opportunity to demonstrate this objective since the RCS chamber pressure measurements will be omitted on other missions.

Use of APS propellants by the RCS is currently a planned primary mode during the LLM main ascent in order to conserve the RCS propellant. This capability must, therefore, be qualified prior to the LLM.

Since the normal RCS propellant feed and pressurization systems will not be utilized during the interconnect operation, slight performance differences will result from interconnect propellant usage. It is imperative that these in-flight differences be correlated with ground test and analytical results.

The successful accomplishment of this objective on the LM-1 mission will certify RCS capability to utilize APS propellants on the LLM, providing the APS propellants remain settled.

P13.9 LM/RCS OPERATION AND PERFORMANCE

Verify performance and operational characteristics of the RCS.

Purpose

To qualify the RCS for manned operation and establish baseline system performance in a space environment.

Test Conditions

- 1) Continuous RCS firing in translation and rotation near the beginning of the mission and near the end.
- 2) RCS attitude control during DPS and APS and during one orbit coast period is required.

Success Criteria

- 1) The RCS pressurization and feed system satisfactorily supplied propellants to the engine at design temperatures and pressures and no leaks were detected.
- 2) Engine performance (at propellant supply temperatures between 40 and 100 degrees Fahrenheit) was as specified below:
 - a) The RCS engines developed a continuous operation vacuum thrust of 100 pounds plus or minus 5 percent
 - b) The RCS engine start and shutdown transients were not overly excessive.
- 3) The RCS performed in accordance with PGNCs Commands.

- 4) The following pre-programmed events were executed as designed:
 - a) DPS and APS ullage durations.
 - b) DPS and APS tailoff compensations.
- 5) TVC operation during DPS and APS burns was satisfactorily carried out within the allowable margin in accordance with paragraph 3.4.1.3.1.2.2.2 of Specification LSP-470-2B.
- 6) RCS quad temperatures were between 120° and 190°F.

Evaluation

- 1) Following the flight the Helium tank, regulators, propellant tank manifold, and TCA inlet pressures will be correlated to ascertain the degree to which pressurant and propellant supply conditions were satisfied.
- 2) TCA inlet and chamber pressure measurements will be used to estimate steady-state thrust and transient performance.
- 3) Data obtained from attitude stabilization and control during coast periods will contribute to evaluation of vehicle response to PGNCs supplied attitude commands. From attitude maneuvers prior to and following staging, attitude stabilization with different inertia configurations will be evaluated to determine effective thrust.
- 4) RCS propellant consumption will be estimated from two sources:
 - a) Using engine on times, flow rates implied by in-flight pressure measurements and ground test data.
 - b) Using P-V-T relationships of the RCS propellant and helium tanks.

Data Requirements

1) Telemetry Measurements:

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GR 1101 P	Press, Helium Tank A	PCM	M
GR 1102 P	Press, Helium Tank B	PCM	M
GR 1089 T	Temp, Helium Tank A	PCM	M
GR 1099 T	Temp, Helium Tank B	PCM	M
*GR 1201 P	Press, He Regulator A Output	PCM	HD
GR 1202 P	Press, He Regulator B Output	PCM	HD
GR 2121 T	Temp, Fuel Tank A	PCM	M
GR 2122 T	Temp, Fuel Tank B	PCM	M
GR 1085 Q	Qty., Propellant Sys A	PCM	M
GR 1095 Q	Qty., Propellant Sys B	PCM	M
GR 2201 P	Press, A Fuel Mnfld	PCM	M
GR 2202 P	Press, B Fuel Mnfld	PCM	M
GR 2461 X	Fuel Main Feed S/O A Closed	PCM	HD
GR 2462 X	Fuel Main Feed S/O B Closed	PCM	HD
GR 3201 P	Press, A Oxid Mnfld	PCM	M
GR 3202 P	Press, B Oxid Mnfld	PCM	M
GR 3461 X	Oxid Main Feed S/O A Closed	PCM	M
GR 3462 X	Oxid Main Feed S/O B Closed	PCM	M
GR 4322 T	Temp, TCA Fuel Inlet, PR 4B Surf	FM/FM	M*
GR 4323 T	Temp, TCA Fuel Inlet, PR 3A Surf	FM/FM	M*
GR 4326 T	Temp, TCA Fuel Inlet PR 2B Surf	FM/FM	M*
GR 4327 T	Temp, TCA Fuel Inlet, PR 1A Surf	FM/FM	M*
GR 4424 T	Temp, TCA Oxid Inlet, PR 3B Surf	FM/FM	M*
GR 4570 T	Temp, TCA Injector Head No. 4D	FM/FM	HD
GR 4571 T	Temp, TCA Injector Head No. 4F	FM/FM	HD
GR 4573 T	Temp, TCA Injector Head No. 3U	FM/FM	HD
GR 4574 T	Temp, TCA Injector Head No. 3D	FM/FM	HD
GR 4577 T	Temp, TCA Injector Head No. 2U	FM/FM	HD
GR 4578 T	Temp, TCA Injector Head No. 2D	FM/FM	HD
GR 4582 T	Temp, TCA Injector Head No. 1D	FM/FM	HD
GR 4583 T	Temp, TCA Injector Head No. 1F	FM/FM	HD
GR 5011 P	Press, TCA Fuel Inlet, PR 4A	FM/FM	HD
GR 5012 P	Press, TCA Fuel Inlet, PR 4B	FM/FM	HD
GR 5013 P	Press, TCA Fuel Inlet, PR 3A	FM/FM	HD
GR 5014 P	Press, TCA Fuel Inlet, PR 3B	FM/FM	HD
GR 5015 P	Press, TCA Fuel Inlet, PR 2A	FM/FM	HD
GR 5016 P	Press, TCA Fuel Inlet, PR 2B	FM/FM	HD
GR 5017 P	Press, TCA Fuel Inlet, PR 1A	FM/FM	HD
GR 5018 P	Press, TCA Fuel Inlet, PR 1B	FM/FM	HD
GR 5019 P	Press, TCA Oxid Inlet, PR 4A	FM/FM	HD
GR 5020 P	Press, TCA Oxid Inlet, PR 4B	FM/FM	HD
GR 5021 P	Press, TCA Oxid Inlet, PR 3A	FM/FM	HD
GR 5022 P	Press, TCA Oxid Inlet, PR 3B	FM/FM	HD
GR 5023 P	Press, TCA Oxid Inlet, PR 2A	FM/FM	HD

*This measurement inoperative.

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GR 5024 P	Press, TCA Oxid Inlet, PR 2B	FM/FM	HD
GR 5025 P	Press, TCA Oxid Inlet, PR 1A	FM/FM	HD
GR 5026 P	Press, TCA Oxid Inlet, PR 1B	FM/FM	HD
GR 5031 P	Press, Thrust Chamber No. 4U	FM/FM	HD
GR 5032 P	Press, Thrust Chamber No. 4D	FM/FM	M
GR 5033 P	Press, Thrust Chamber No. 4F	FM/FM	M
GR 5034 P	Press, Thrust Chamber No. 4S	FM/FM	M
GR 5035 P	Press, Thrust Chamber No. 3U	FM/FM	M
GR 5036 P	Press, Thrust Chamber No. 3D	FM/FM	M
GR 5037 P	Press, Thrust Chamber No. 3F	FM/FM	M
GR 5038 P	Press, Thrust Chamber No. 3S	FM/FM	M
GR 5039 P	Press, Thrust Chamber No. 2U	FM/FM	M
GR 5040 P	Press, Thrust Chamber No. 2D	FM/FM	M
GR 5041 P	Press, Thrust Chamber No. 2F	FM/FM	M
GR 5042 P	Press, Thrust Chamber No. 2S	FM/FM	M
GR 5043 P	Press, Thrust Chamber No. 1U	FM/FM	M
GR 5044 P	Press, Thrust Chamber No. 1D	FM/FM	M
GR 5045 P	Press, Thrust Chamber No. 1F	FM/FM	M
GR 5046 P	Press, Thrust Chamber No. 1S	FM/FM	M
GR 6001 T	Temp, Quad Cluster No. 4	PCM	M
GR 6002 T	Temp, Quad Cluster No. 3	PCM	M
GR 6003 T	Temp, Quad Cluster No. 2	PCM	M
GR 6004 T	Temp, Quad Cluster No. 1	PCM	M
GR 9609 U	Main Prop Valves A Closed	PCM	M
GR 9610 U	Main Prop Valves B Closed	PCM	M
GR 9611 U	Mnflld Control Vlv A Not Closed	PCM	M
GR 9612 U	Mnflld Control Vlv B Not Closed	PCM	M
GR 9613 U	Mnflld X Feed Vlvs Not Closed	PCM	HD
GR 9661 U	TCA Isol Valves 4A Closed	PCM	M
GR 9662 U	TCA Isol Valves 4B Closed	PCM	M
GR 9663 U	TCA Isol Valves 3A Closed	PCM	M
GR 9664 U	TCA Isol Valves 3B Closed	PCM	M
GR 9665 U	TCA Isol Valves 2A Closed	PCM	M
GR 9666 U	TCA Isol Valves 2B Closed	PCM	M
GR 9667 U	TCA Isol Valves 1A Closed	PCM	M
GR 9668 U	TCA Isol Valves 1B Closed	PCM	M
GG 0001 X	PGNCS Downlink Data (To T/M)	PCM	M
GH 1461 V	Volt, Yaw RG Sig (0.8KC)	PCM	HD
GH 1462 V	Volt, Pitch RG Sig (0.8KC)	PCM	HD
GH 1463 V	Volt, Roll RG Sig (0.8KC)	PCM	HD
GG 2112 V	Volt, IG 1X Res Out, Sin	PCM	HD
GG 2113 V	Volt, IG 1X Res Out, Cos	PCM	HD
GG 2142 V	Volt, MG 1X Res Out, Sin	PCM	HD
GG 2143 V	Volt, MG 1X Res Out, Cos	PCM	HD
GG 2172 V	Volt, OG 1X Res Out, Sin	PCM	HD
GG 2173 V	Volt, OG 1X Res Out, Cos	PCM	HD
GG 2121 V	Volt, IG 1X Res Sin (Expanded)	PCM	HD
GG 2151 V	Volt, MG 1X Res Sin (Expanded)	PCM	HD

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GG 2181 V	Volt, OG 1X Res Sin (Expanded)	PCM	HD
GG 2219 V	Volt, Pitch CDU DAC Out	PCM	HD
GG 2249 V	Volt, Yaw CDU DAC Out	PCM	HD
GG 2279 V	Volt, Roll CDU DAC Out	PCM	HD
GH 1418 V	Volt, Jet Driver Output	PCM	HD
through GH 1433 V			

*One of 5 mandatory, the remaining 4 highly desirable.

2) Trajectory Profile (HD)

713.9 LM/RCS OPERATION AND PERFORMANCE

Background and Justification

The purpose of this objective is to assure that the RCS performance is adequate to perform the required TVC, attitude control in the earth orbital environment. It is also the inherent purpose of this objective to quantitatively determine the RCS subsystem behavior under earth orbital conditions for the purpose of determining critical deficiencies and certification of overall design adequacy. Chamber pressure will not be instrumented on future missions so RCS performance will be determined from body rotation and translation data. For this reason it is important that a comparison of the two techniques for determining RCS performance be compared in this mission.

An additional capability of the RCS not encompassed by this objective is the cross-feed operation. This capability may be called upon in the LLM in the event one of the following contingencies occur:

- 1) LM/RCS System A or B failure upstream of Main Shutoff Valves.
- 2) Propellant exhaustion of either system A or B propellants.
- 3) Failure in either systems A or B which would require shutdown of the affected system (cross-feed permits the operative system to utilize the propellants from both systems).

The current flight test planning does not call for the verification of cross-feed operation. This test would not, in any manner, compromise crew safety and thus could be accomplished on a manned LM mission.

Ullage maneuvers are not verified in the LM-1 mission. The LM-1 DPS ullage times are for only two RCS engines operating while four RCS engines will actually be used. The LM-1 APS ullage time of 13 seconds is in excess of the ullage time calculated necessary for the expected propellant load.

The accomplishment of this objective on the LM-1 mission will qualify the LM/RCS for manned LM operations. However, the LM-1 mission does not flight certify the RCS rendezvous/docking phase of the LLM.

S14.1 LM ECS - BOOST AND FLIGHT

Verify satisfactory operation of portions of the LM ECS equipment.

Purpose

The purpose is to verify satisfactory performance of the glycol pumps, H₂O regulator and sublimator, cooling circuit flow arrangement, cabin dump valves and descent stage quick disconnects.

Test Conditions

During flight the cabin leak rate and cabin dump valves will determine the cabin pressure decay. The cabin pressure will remain above one psia until after the second APS burn.

Success Criteria

The ECS data

- 1) Flight rates the H₂O sublimator (conceptually), the glycol pump, and the H₂O regulators.
- 2) Provides confidence in the cooling circuit flow arrangement
- 3) Flight rates the self-sealing characteristics of the coolant circuit quick disconnects after descent staging
- 4) Confirms proper operation of the cabin dump valve

The ECS data verifies the anticipated flight range as listed below throughout the mission.

<u>Description</u>	<u>Anticipated Flight Range</u>	
	<u>Min.</u>	<u>Max.</u>
Del P, Prim Coolant Pump	32.8 psi	34.0
Coolant Accum Fluid Low Level	Non Activation	
Temp, Main S/B Coolant Inlet	TBD	TBD
Temp, Cabin HX Coolant Inlet	TBD	TBD
Temp, Regen HX Coolant Out (Hot)	TBD	TBD
Temp, Regen HX Coolant In (Hot)	TBD	TBD
Temp, Cabin HX Coolant Out	TBD	TBD
Press, Cabin	1.0 psia	6.1 psia
Press, Ascent O ₂ Tank No. 1	*4.25 psia	4.45 psia
Press, Ascent O ₂ Tank No. 2	*4.25	4.45
Del P, Main H ₂ O Reg/ARS	.5 psi	1.0 psi
Del P, Redund H ₂ O Reg/ARS	.5 psi	1.0 psi
Temp Main W/B Inlet Water	57°F	83°F
Temp, Ascent Tank No. 1 Outlet H ₂ O	TBD	TBD
Temp, Ascent Tank No. 2 Outlet H ₂ O	TBD	TBD
Quantity Ascent Tank No. 1 Water	TBD	-
Quantity Ascent Tank No. 2 Water	TBD	-
Press, Selected Pump Discharge(2 pumps operating)	38.8 psia	43.0 psia
Temp, Selected Coolant Loop	TBD	TBD

*@70°F or the equivalent press and temp

Evaluation

- 1) Water pressure control at the sublimator is the result of an initial gas pressure provided in the ascent water tanks, the water pressure regulator differential pressure (GF 4101 P and GF 4102 P) and the regulator reference pressure (LM-1 only) in the ascent oxygen tanks No. 1 and No. 2 (GF 3582 P and GF 3583 P). Performance will be confirmed by the above measurements.
- 2) Water glycol flow rate will be calculated from pump delta P (GF 2021 P), pump discharge pressure (GF 9997 U) and pump performance curves supported by coolant fluid low level (GF 2041 X). Normal configuration for this mission is with two glycol pumps operating.
- 3) Water Management will be assessed from the data gathered from water tank quantity measurements (GF 4582 Q and GF 4583 Q) and water temperature measurements (GF 4562 T, GF 4563 T and GF 4511 T).

- 4) Temperature control will be evaluated from the glycol flow rate above and the temperature measurement data (GF 2781 T, GF 2841 T, GF 2621 T, GF 2871 T, GF 2521 T and GF 9998 U). Performance, including the thermal load split into/from the glycol circuit, will be determined from the amount of water required to control the thermal load based on the status (i.e., on, off, standby) of coldplated components (Fig. 1) and the water depletion rate.
- 5) Cabin pressure data will be evaluated to determine if flight cabin leak rate is in excess of the prelaunch value. If flight leak rate is greater, cabin structure failure or cabin dump valve failure would be indicated.

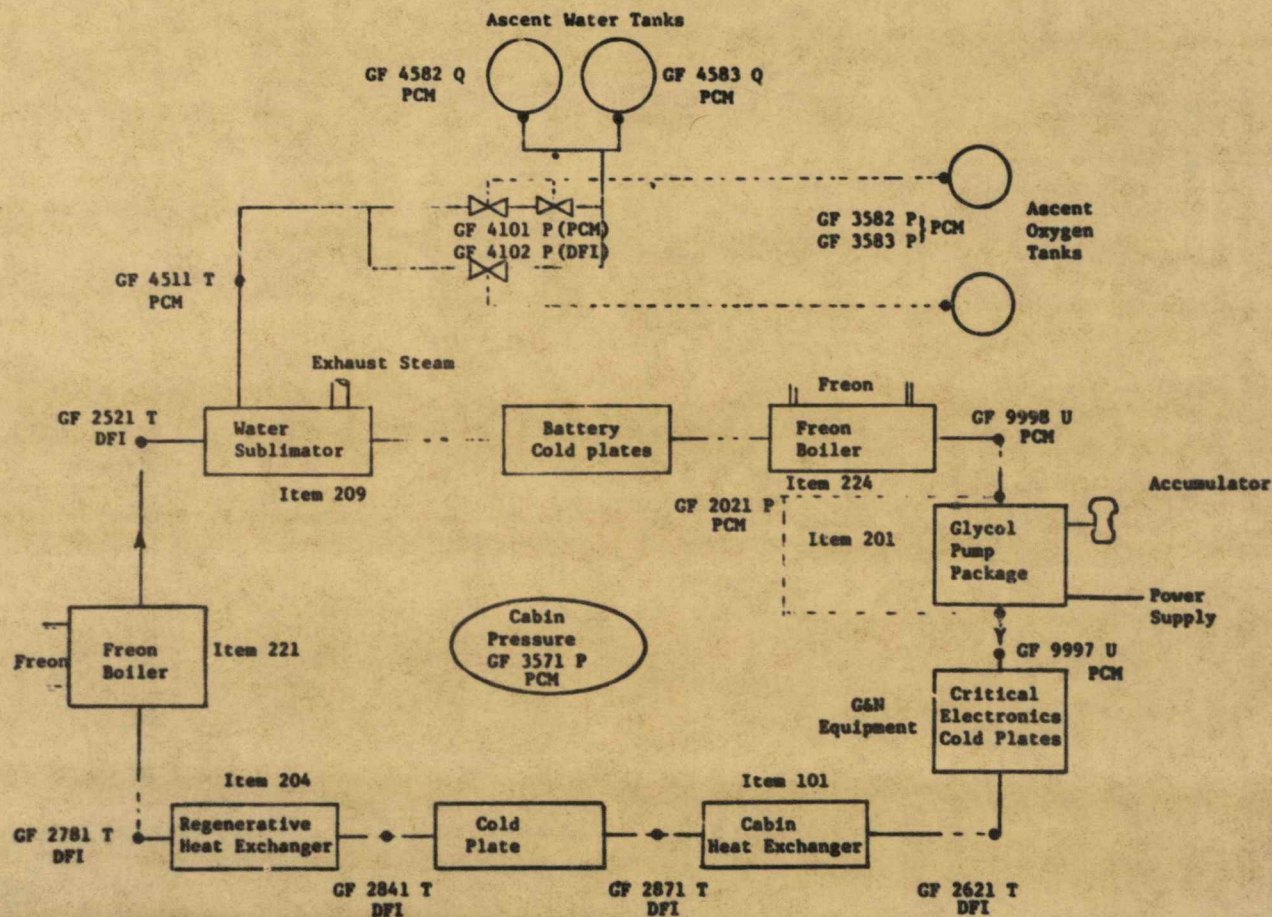
Data Requirements

Telemetry Measurements:

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GF 2021 P	Del P, Prim Coolant Pump	PCM	M
GF 2041 X	Coolant Accum Fluid Low Level	PCM	HD
GF 2521 T	Temp, Main W/B Coolant Inlet	DFI	HD
GF 2621 T	Temp, Cabin HX Coolant Inlet	DFI	HD
GF 2781 T	Temp, Regen HX Coolant Out (Hot)	DFI	HD
GF 2841 T	Temp, Regen HX Coolant In (Hot)	DFI	HD
GF 2871 T	Temp, Cabin HX Coolant Out	DFI	HD
GF 3571 P	Press, Cabin	PCM	M
GF 3582 P	Press, Ascent O ₂ Tank No. 1	PCM	M
GF 3583 P	Press, Ascent O ₂ Tank No. 2	PCM	M
GF 3591 P	Press, Safety Vlv No. 1 Servo	PCM	HD
GF 3592 P	Press, Safety Vlv No. 2 Servo	PCM	HD
GF 4101 P	Del P, Main H ₂ O Reg/ARS	PCM	M
GF 4102 P	Del P, Redund ² H ₂ O Reg/ARS	DFI	M
GF 4511 T	Temp Main W/B Inlet Water	PCM	HD
GF 4562 T	Temp, Ascent Tank No. 1 Outlet H ₂ O	DFI	HD
GF 4563 T	Temp, Ascent Tank No. 2 Outlet H ₂ O	DFI	HD
GF 4582 Q	Quantity, Ascent Tank No. 1 Water	PCM	M
GF 4583 Q	Quantity, Ascent Tank No. 2 Water	PCM	M
GF 9997 U	Press, Selected Pump Discharge	PCM	M
GF 9998 U	Temp, Selected Coolant Loop	PCM	M

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Item Nos. - for ready reference to GAEC documents

LM-1 Outline ECS Schematic

Figure 1

S14.1 LM ECS - BOOST AND FLIGHT

Background and Justification

The function of the LM-1 ECS is to provide active thermal control for the electrical/electronic components. To provide this, the LM-1 operating ECS consists of the following: the primary glycol circuit with heat rejection from one sublimator, water supplied from the ascent water tanks for cooling in the sublimator, and oxygen from the ascent tanks to provide a reference pressure for the water pressure regulator.

During prelaunch two freon boilers will maintain thermal control in the glycol circuit. In-flight cooling will be provided by a water sublimator. Three minutes after launch the LMP activates a solenoid valve which initiates water flow to the sublimator.

LM-1 has a peculiar plumbing arrangement with respect to the water pressure regulators and ascent oxygen tanks. Figure 1 schematically indicates how these components are plumbed. During sublimator operation water will flow from both ascent water tanks through the primary water pressure regulators. The redundant water pressure regulator can be selected through the LMP. However, this option is not scheduled and will only be used if a primary regulator fails closed. Visual observation will be used to ensure that the glycol accumulator is filled to its nominal value (65% and 68°F or press/temp equivalent) at the time of trim control unit disconnect.

During flight one glycol pump is sufficient to provide the required thermal control. However, it is mandatory that both glycol pumps be operating prior to launch. The reason for the prelaunch requirement is that the pump switching capability has been deleted from the LMP. To preclude loss of cooling in the event of a single glycol pump failure, both are required during prelaunch.

The pump performance curves required for DTO evaluation can be obtained from the LM-1 annotated OCP 33007 and the related Engineering Report. The LM cabin will be at atmospheric pressure or slightly above prior to launch. During the ascent phase the cabin pressure relief valve will allow cabin pressure to bleed to 5.6 psia (nominal). Once

the relief valves close the cabin pressure will continue to decay as a function of cabin leak rate. As a result of the LM-1 System Assessment Review (SAR) board meeting of 15 December 1966 there is a requirement to maintain pressure in the LM-1 cabin above one psia until after the 2nd APS burn. The intention is to monitor cabin pressure during burns and make an assessment of cabin structural integrity during these vibration periods. One psia as a lower limit can be explained as follows:

- below one psia pressure the instrumentation accuracy is relatively poor.
- If the pressure drops below 1.0 psia and remains at approximately 0.7 psia, the corona effect may exist. This is the phenomenon of gas ionization when the electric stress at the surface of a conductor exceeds a certain value. At higher values the stress results in a luminous discharge. This may be followed by component arcing and failure.

To ensure that the cabin pressure does remain above this one psia level, the maximum allowable cabin gas leak rate during prelaunch is 1.85 pounds per hour. (Conditions are (a) the cabin 5 psi above KSC atmospheric (b) the cabin pressurized with nitrogen.) GAEC memo LMO-561-158 dated 18 July 1967 with enclosure 1 (Test Project Engineering Report LPR 941-06068, 29 June 1967) defines the LM-1 cabin leak rate performance as 1.85 #/hr leakage at ground conditions and 0.69 #/hr at flight conditions. The LM-1 specification, LSP-470-30, defines the leak rate requirements.

Table 1 lists ECS measurements required for the flight test objective and for prelaunch readiness assessment. Operating limits during prelaunch and flight have been divided into two categories: normal and redline/critical. All values presented are based on test data, analyses, or specification values. The normal values are those expected for the LM-1 configuration. Critical limits are the extremes at which a component will operate; operation outside of these bounds has either not been experienced or will result in performance degradation or component failure.

The final two columns in Table 1 contain the measurement priority rating. The basis for these ratings is as follows:

- prelaunch - a mandatory rating is assigned to those measurements whose status must be known to ensure launch readiness and to imply satisfactory performance during flight. (USE prelaunch ratings)
- flight - a mandatory rating is assigned to those measurements whose information is required to satisfy the DTO.

Should the critical limits be exceeded, the launch should be held pending consultation with qualified ECS personnel.

With regards to flight, operation of the ECS is a mandatory function. Satisfactory accomplishment of the flight objective will:

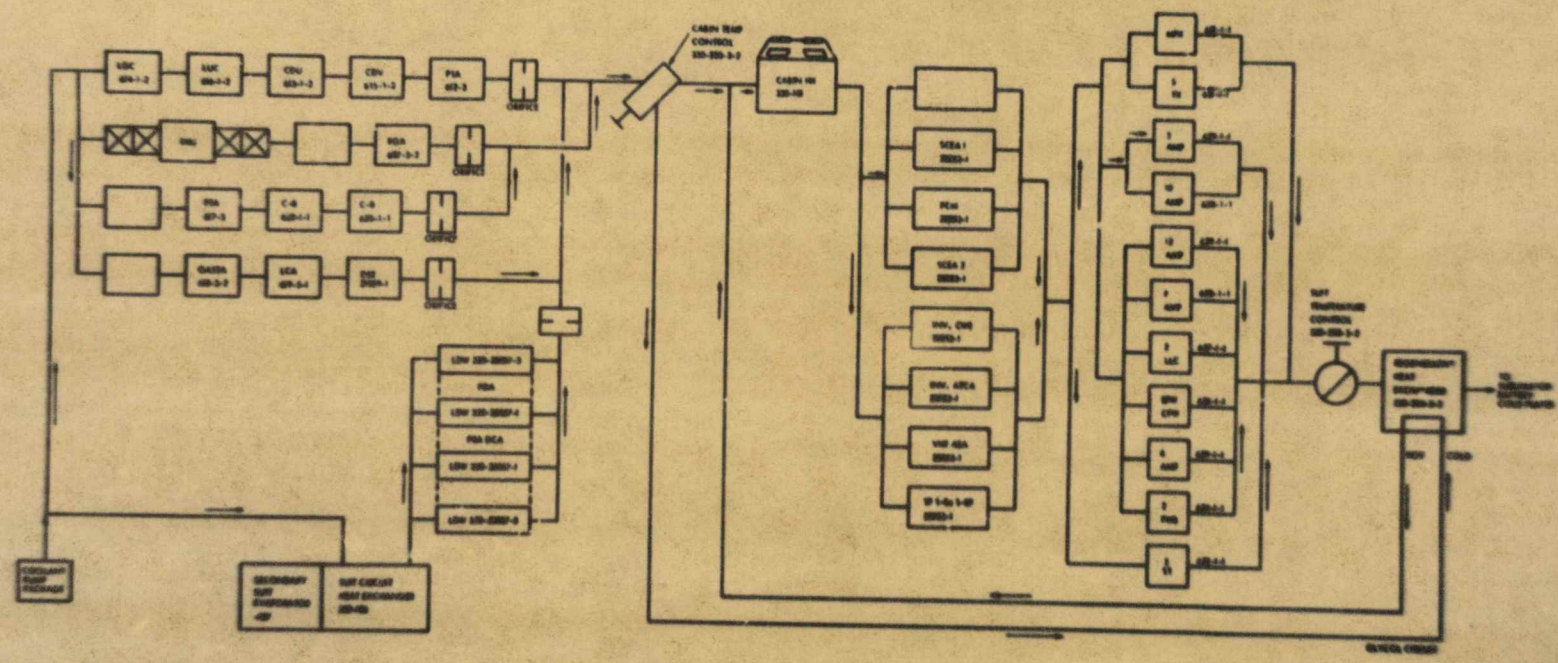
- flight rate the glycol pump, H_2O regulators and the H_2O sublimator
- provide confidence in the cooling circuit flow arrangement
- flight rate the self-sealing characteristics of the coolant circuit quick disconnects after descent staging

Parameter Description	Number	Prelaunch						Flight			Critical Limits		Status		
		Units	Normal			Redline		Normal			Min	Max	Prelaunch	Flight	
			Min	Nom	Max	Min	Max	Min	Nom	Max					
Del P, Prim Coolant Pump	GF 2021 P	psid	32.8	33.4	34	30	35.5	32.8	33.4	34	13	36.8	N	N	
Coolant Accum Fluid Low Level	GF 2041 X		N/A			N/A		non-activation			activation	N/A	N	ND	
Temp, Main W/B Coolant Inlet	GF 2521 T	°F	TBD	TBD	TBD	TBD		TBD	TBD	TBD	34	115	ND	ND	
Temp, Cabin HX Coolant Inlet	GF 2621 T	°F	TBD	TBD	TBD	35	TBD	TBD	TBD	TBD	35	102	ND	ND	
Temp, Regen HX Coolant Out (Hot)	GF 2781 T	°F	66	TBD	TBD	50	TBD	TBD	TBD	TBD	34	115	ND	ND	
Temp, Regen HX Coolant In (Hot)	GF 2841 T	°F	66	TBD	TBD	50	TBD	TBD	TBD	TBD	34	115	ND	ND	
Temp, Cabin HX Coolant Out	GF 2871 T		TBD	TBD	TBD			TBD	TBD	TBD	35	102	ND	ND	
Press, Cabin	GF 3571 P	psia	ambient			amb. amb.+6.1		1.0	6.1		zero	7.7	(1)	N	
Press, Ascent O ₂ Tank No. 1	GF 3582 P	psia	4.25	4.35	4.45	4.25	6.0	(2)	4.25	4.35	4.45	2.0	6.0	N	N
Press, Ascent O ₂ Tank No. 2	GF 3583 P	psia	4.25	4.35	4.45	4.25	6.0	(2)	4.25	4.35	4.45	2.0	6.0	N	N
Press, Safety Vlv. No. 1 Servo	GF 3591 P		N/A			N/A		1.0	6.1		TBD	TBD	ND	ND	
Press, Safety Vlv. No. 2 Servo	GF 3592 P		N/A			N/A		1.0	6.1		TBD	TBD	ND	ND	
Del P, Main H ₂ O Reg/ARS	GF 4101 P	psi	N/A			N/A		.5	.75	1.0	.5	1.0	(3)	N	
Del P, Redund H ₂ O Reg/ARS	GF 4102 P	psi	N/A			N/A		.5	.75	1.0	.5	1.0	(3)	N	
Temp Main W/B Inlet Water	GF 4511 T	°F	N/A			N/A		57	70	83	33	120	N/A	ND	
Temp, Ascent Tank No. 1 Outlet H ₂ O	GF 4562 T	°F	≤ amb.			33	amb.+10	TBD	TBD	TBD	33	120	ND	ND	
Temp, Ascent Tank No. 2 Outlet H ₂ O	GF 4563 T	°F	≤ amb.			33	amb.+10	TBD	TBD	TBD	33	120	ND	ND	
Quantity, Ascent Tank No. 1 Water	GF 4582 Q	ℓ	(5)94	47	100	70	(4)100	TBD	N/A	N/A	+	N/A	N	N	
Quantity Ascent Tank No. 2 Water	GF 4583 Q	ℓ	(5)94	97	100	70	(4)100	TBD	N/A	N/A	+	N/A	N	N	
Press, Selected Pump Discharge	GF 9997 U	psia	57.2			59	52.7	60	38.8	43.0		19	45.7	N	N
Temp, Selected Coolant Loop	GF 9998 U	°F	32	35	TBD	32	TBD	TBD	TBD	TBD	32	50	N	N	

- Note: (1) *information mandatory, S/C measurement pegged
 (2) @ 70°F or the equivalent pressure and temperature.
 (3) **measurement pegged
 (4) 70% from each tank is the minimum required for the normal mission plus two orbits; however, decay from initial loading is not acceptable.
 (5) 100% corresponds to 42.5 pounds of water.

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LH-1 COLD PLATE SCHEMATIC
FIGURE 1

P15.1 EPS PERFORMANCE EVALUATION

Verify LM EPS performance.

Purpose

Flight verification of the LM EPS a launch and space environment is desirable prior to manned LM operations.

Test Conditions

No special test conditions are required. It is desirable to maintain the LM-1 EPS configuration as close as feasible to the operational LM configuration.

Success Criteria

- 1) There were no performance inadequacies of the EPS that would preclude manned operation of the LM.
- 2) Sufficient data were obtained to determine that the EPS supplied all electrical requirements within preflight predicted limits. (Ref. LSP 470-30, Part II)

Evaluation

- 1) Values of the following measurements were compared with preflight predictions to determine that they were within the predicted ranges, (GC 0071 V, GC 0155 F, GC 0201 V - GC 0206 V, GC 0301 V, GC 0302 V, GC 3501 T - GC 3506 T).
- 2) The following measurements were examined to verify that no battery malfunctions had occurred, (GC 9961 U - GC 9966 U).
- 3) The following measurements were analyzed to determine that load division between paralleled batteries was within preflight predicted limits, (GC 1201 C - GC 1206 C).

- 4) Battery No. 6 voltage measurement (GC 0206 V) and current measurement (GC 1206 C) were used to verify that ascent stage battery No. 6 was turned on automatically during abort staging. Battery No. 5 voltage measurement (GC 0205 V) and current measurement (GC 1205 C) were used to verify that battery No. 5 was turned on by real time ground command prior to the second DPS burn. Measurements GC 4369 X - GC 4372 X were used to ascertain the configuration of the ascent batteries.
- 5) A load profile was constructed using battery voltages (GC 0201 V through GC 0206 V) and currents (GC 1201 C through GC 1206 C). Periods of high power were identified and the magnitudes of power demands were noted. Actual energy requirements were compared with preflight predictions specified in the "Apollo 5 Mission Consumable Analysis" which is based on the operational trajectory

Data Requirements

Telemetry Measurements:

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GC 0071 V	Volt, Inverter Bus	PCM	M
GC 0155 F	Freq, Inverter Bus	PCM	M
GC 0201 V	Volt, Battery No. 1	PCM	M
GC 0202 V	Volt, Battery No. 2	PCM	M*
GC 0203 V	Volt, Battery No. 3	PCM	M*
GC 0204 V	Volt, Battery No. 4	PCM	M*
GC 0205 V	Volt, Battery No. 5	PCM	M
GC 0206 V	Volt, Battery No. 6	PCM	M
GC 0301 V	Volt, Commander's Bus	PCM	M
GC 0302 V	Volt, System Engineer's Bus	PCM	M
GC 1201 C	Curr, Battery No. 1	PCM	M
GC 1202 C	Curr, Battery No. 2	PCM	M
GC 1203 C	Curr, Battery No. 3	PCM	M
GC 1204 C	Curr, Battery No. 4	PCM	M
GC 1205 C	Curr, Battery No. 5	PCM	M
GC 1206 C	Curr, Battery No. 6	PCM	M

*One of three is mandatory, the other two are highly desirable.

GC 3501 T	Temp, Battery No. 1	FM/FM	HD
GC 3502 T	Temp, Battery No. 2	FM/FM	HD
GC 3503 T	Temp, Battery No. 3	FM/FM	HD
GC 3504 T	Temp, Battery No. 4	FM/FM	HD
GC 3505 T	Temp, Battery No. 5	FM/FM	HD
GC 3506 T	Temp, Battery No. 6	FM/FM	HD

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GC 4369 X	Battery No. 5 on Cmdr's Bus	PCM	ND
GC 4370 X	Battery No. 6 on Cmdr's Bus	PCM	ND
GC 4371 X	Battery No. 5 on Sys Engr's Bus	PCM	ND
GC 4372 X	Battery No. 6 on Sys Engr's Bus	PCM	ND
GC 9961 U	Battery No. 1 Malfunction	PCM	N
GC 9962 U	Battery No. 2 Malfunction	PCM	N
GC 9963 U	Battery No. 3 Malfunction	PCM	N
GC 9964 U	Battery No. 4 Malfunction	PCM	N
GC 9965 U	Battery No. 5 Malfunction	PCM	N
GC 9966 U	Battery No. 6 Malfunction	PCM	N

One of three Mandatory, the other two are Highly Desirable.

P15.1 EPS PERFORMANCE EVALUATION

Background and Justification

This is the first time the LM will be subjected to a launch and space environment. This mission will demonstrate the performance of the LM EPS under these environments for the first time and will be performed prior to the first manning of the LM.

The configuration of the LM-1 EPS for this mission differs from that of subsequent vehicles and missions in the following respects:

- 1) Descent stage batteries will be predischarged and operated only in the high voltage configuration. There will be no switching between low and high voltage battery taps since the low voltage taps are not wired in LM-1.
- 2) Descent stage Battery No. 1 supplies the System Engineer's bus. Descent stage Batteries Nos. 2, 3, and 4 are in parallel to supply the Commander's bus.
- 3) The four battery feed tie circuit breakers are slugged. Therefore, they provide no circuit protection. However, circuit protection is provided in the ECA's.
- 4) All operating electronic equipment, except the S-band transmitter, will be turned on prior to launch and will remain on throughout the mission. The S-band transmitter will be turned on immediately prior to LM/S-IVB separation and remain on throughout the remainder of the mission.
- 5) The power load of LM-1 will differ considerably from subsequent manned LM missions due to operating equipment differences between unmanned and manned LM requirements. The end item data specifications control the equipment aboard and the operating and load contribution for each item.
- 6) Ascent stage battery No. 6 will be turned on automatically during abort staging. Ascent stage battery No. 5 will be turned on by real time ground command prior to the second DPS burn.

These configuration differences arise largely from the requirements of launching an unmanned LM in a powered-up mode. While the above noted configuration differences will have to be considered when the flight data are analyzed, they will not nullify the verification of the EPS performance nor prevent validation of the EPS for manned operation of the LM.

S15.2 NOSE CAP, LM/SLA SEPARATION

Evaluate the performance of the Spacecraft Jettison Controller (SJC) (SJC) and pyrotechnic devices in the execution of nose cap separation, SLA panel deployment and LM/SLA separation functions.

Purpose

The purpose is to verify SLA panel deployment and LM/SLA separation functional performance to establish confidence for subsequent missions. Evaluation of nose cap jettison functional performance to determine adequacy for this mission and any subsequent backup (dual launch) missions where nose caps may be utilized.

Test Conditions

There are no special test conditions for this objective.

Success Criteria

- 1) Verification of the SJC capability to receive the commands generated by the S-IVB digital computer LM mission programmer, and to initiate the sequence for nose cap separation, SLA panels deployment and LM/SLA separation.
- 2) Verification that the separation functions are not initiated by noise or other spurious signals.
- 3) Verification that the SJC pyro batteries supply appropriate voltages to fire the pyrotechnic devices which effect nose cap separation, SLA panels deployment and LM/SLA separation.
- 4) Verification that the pyrotechnic charges are adequate to perform the functions described in 1 and 3.

Evaluation

Telemetry will be analyzed for determination of the separation functions occurring in response to the S-IVB digital computer or LM

mission programmer inputs. The following signals will be analyzed for determination of normal SJC operation for each of the separation functions.

- 1) Nose cap separation
 - a) Cap separation relays
 - b) Cap/SLA physical monitors
- 2) SLA panels deploy
 - a) SLA deploy relays
 - b) SLA panel deploy
- 3) LM/SLA separation
 - a) LM/SLA separation relays

The pyro bus voltages will be analyzed for determination of proper input voltages to the pyrotechnic devices.

Each of the separation functions will be evaluated to determine the pyrotechnic charges ability to perform the intended function.

Data Requirements

Telemetry Measurements:

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GG 0001 X	PGNCS Downlink Data (To T/M)	PCMD	HD
AA 8198 X	Cap/SLA Phys Mon 1	IUTM	M
AA 8199 X	Cap/SLA Phys Mon 2	IUTM	M
AD 0600 X	Nose Cone Jet Relay Close A	IUTM	M
AD 0601 X	Nose Cone Jet Relay Close B	IUTM	M
AD 0610 X	SLA Panels Dply Relay A	IUTM	M
AD 0611 X	SLA Panels Dply Relay B	IUTM	M
AD 0602 X	LM/SLA Sep Rly Close A	IUTM	M
AD 0603 X	LM/SLA Sep Rly Close B	IUTM	M
GL 4222 X	DFI Measurement Switchover LM/SLA Sep	FM/FM	HD

S15.2 NOSE CAP, LM/SLA SEPARATION

Background and Justification

The necessity of implementing this objective on the AS-204/LM-1 mission can be assessed from the following.

The functional performance of the pyrotechnic devices associated with SLA panel deployment and LM/SLA separation must be verified to establish confidence for subsequent missions.

Mission AS-204/LM-1 affords the first opportunity to test the Spacecraft Jettison Controller (SJC) under flight conditions. Qualification of the operation of the SJC is a requirement for any subsequent mission involving the LM only, or any mission on which the LM and CSM are launched on separate launch vehicles. The nose cap, SLA panels deployment and LM/SLA separation sequences need to be demonstrated.

Ground testing of the separation functions involving the pyrotechnic devices have been successfully performed. Flight verification of these functions would be desirable.

S16.1 LM/MSFN COMMUNICATIONS

Verify performance of portions of the LM S-Band communication subsystem and its compatibility with MSFN.

Purpose

To verify that the S-Band communication subsystem being flown for the first time is compatible with the MSFN with respect to PRN, ranging PCM TM and RF uplink (simulated up-voice and up-data). This test is desirable prior to manned flight.

Test Conditions

- 1) It is highly desirable that this test objective be demonstrated during all mission phases from the time the S-Band transmitter is turned on at four seconds prior to LM/S-IVB separation, whenever line-of-sight exists between the active LM S-Band antenna (-Z axis antenna) and MSFN and/or A/RIA.
- 2) All uplink S-Band signal combinations from MSFN, consisting of combinations of PRN ranging, simulated up-voice (1000 Hz tone on 30 KHz subcarrier), and the unmodulated 70 KHz subcarrier, which will be utilized for up-data on later missions, will be used.
- 3) The downlink signal combination will consist of the S-Band carrier, PRN ranging, turned-around up-link subcarriers, and 51.2 kbps telemetry.
- 4) MSFN will track the LM via S-Band PRN ranging code and C-Band radar.
- 5) MSFN will simultaneously receive and record LM high bit-rate PCM telemetry data via the S-Band and the 237.8 MC VHF downlinks.
- 6) A/RIA will record high bit rate PCM telemetry via both VHF and S-Band and will dump these data to MSFN via VHF and/or S-Band when the A/RIA is within line-of-sight of the ground station.

- 7) Up-voice simulation will be verified by modulating the 30 KHz up-voice subcarrier with a 1000 Hz tone at selected MSFN stations. The subcarrier, modulated by the 1000 Hz tone, will be turned around in the ranging channel, placed on the S-Band downlink carrier, and recorded by MSFN for postflight analysis.

Success Criteria

- 1) Two-way RF lock via S-Band is established and maintained by MSFN with minimum loss of data.
- 2) Receipt by MSFN of valid S-Band tracking data for at least one MSFN station pass for each uplink/downlink signal combination.
- 3) Receipt by MSFN and A/RIA of the S-Band TM containing reliable information. (Favorable comparison with DFI PCM data)
- 4) Receipt by MSFN of the modulated 30 KHz uplink subcarrier and the unmodulated 70 KHz subcarrier.

Evaluation

Postflight analyses will be performed by a:

- 1) Comparison of plots of actual received carrier power (signal strength) as a function of time with plots of predicted received carrier power (signal strength) as a function of time for both the LM and MSFN. Data Requirements - 4, 5; Telemetry Measurements - GT 0992 B, GT 0993 E, GT 0994 V, GL 0501 W, GG 2112 V, GG 2113 V, GG 2142 V, GG 2143 V, GG 2172 V, GG 2173 V (LM attitude data).
- 2) Comparison of the established trajectories from S-Band tracking data alone, C-Band tracking data alone, and the most accurate data available (composite best estimated trajectory). Data Requirements - 2,3,4; Telemetry Measurement - GL 0501 W.
- 3) Bit error rate analysis of the S-Band PCM telemetry bit stream. Data Requirements - 2,7; Telemetry Measurement - GL 0300.
- 4) Comparison of corresponding PCM S-Band and VHF telemetry measurements. Data Requirements - 6,7; Telemetry Measurements - GL 0300, GL 0302, GL 0401 V, GL 0402 V, GL 0501 W.

- 5) Study of the effect of the turned-around uplink modulation on the downlink PCM telemetry. Data Requirements - 5,7; Telemetry Measurements - GL 0300, GL 0302, GL 0401 V, GL 0402 V.
- 6) Measurement and comparison of the signal-to-noise ratio of the 100 Hz uplink tone with signal-to-noise ratio predictions. Data Requirements - 8.
- 7) Study the effect on S-Band PCM telemetry when the LM is without uplink S-Band carrier lock. Data Requirements - 5, 7; Telemetry Measurements - GL 0300, GL 0302, GL 0401 V, GL 0402 V.

Data Requirements

1) Telemetry Measurements:

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GT 0992 B	Phase, St Ph Er, Slctd S-Band Xponder	PCM	HD
GT 0993 E	Power, Selected S-Band Smtr FR Pwr	PCM	HD
GT 0994 V	Volt, Selected S-Band Rcvr AGC	PCM	M
GL 0300	Frame Sync + ID	PCM	HD
GL 0302	Format ID	PCM	HD
GL 0401 V	Volt, Calib 85% HL	PCM	HD
GL 0402 V	Volt, Calib 15% HL	PCM	HD
GL 0501 W	Time, Mission Elapsed	PCM	HD
GG 2112 V	Volt, IG 1X Res Out, Sine	PCM	M
GG 2113 V	Volt, IG 1X Res Out, Cos	PCM	M
GG 2142 V	Volt, MG 1X Res Out, Sine	PCM	M
GG 2143 V	Volt, MG 1X Res Out, Cos	PCM	M
GG 2172 V	Volt, OG 1X Res Out, Sine	PCM	M
GG 2173 V	Volt, OG 1X Res Out, Cos	PCM	M

- 2) Unified S-Band Tracking data processor output data - high speed (HS) format M
- 3) C-Band radar data HD
- 4) MSFN ground station parameters HD
- 5) Written MSFN operator's log with comments such as acquisition times, discrepancies, and pertinent additional information HD
- 6) VHF PCM telemetry bit stream on the 237.8 MC carrier HD

7) Unified S-Band telemetry bit stream

N

8) PM composite signal containing the modulated
30 KHz subcarrier and 70 KHz unmodulated sub-
carrier

N

S16.1 LM/MSFN COMMUNICATIONS

Background and Justification

Although the primary objectives of this flight do not include communication validation, it will offer the first opportunity to flight qualify the operational LM S-Band communication system with the exception of the S-Band steerable antenna and one of the two S-Band omnidirectional antennas which will not be used.

On an unmanned mission, it is impossible to demonstrate all LM-MSFN communication possible on a manned mission. The following S-Band communication services will be exercised during this test:

- 1) PRN Ranging - Trajectories established by tracking of the LM by MSFN stations using pseudorandom noise ranging techniques will be compared with those established by tracking the C-Band trajectory to verify this important function prior to manned LM flights. C-Band tracking is primary for gathering data.
- 2) PCM Telemetry - Since S-Band PCM telemetry will be the prime source of subsystem data on the lunar missions, it is vital that this function be demonstrated. PCM high bit-rate telemetry will be compared with VHF PCM telemetry on this mission. VHF telemetry is primary for gathering data on this mission.
- 3) RF Uplink Capability:
 - a) Voice Communication - The S-Band communication link will be the prime voice contact between the LM and MSFN at lunar distances. On this mission, the up voice function will be simulated by modulating the 30 KHz subcarrier with a 1000 Hz tone which will be turned around in ranging channel, modulate the S-Band carrier and be recorded by MSFN for postflight analysis.
 - b) Command Capability - It is anticipated that updating information will be provided to such equipment as the LGC on operational missions. On this mission, an unmodulated 70 KHz subcarrier will be transmitted by MSFN to the LM, turned around in the ranging channel and modulate the S-Band carrier transmitted from the LM to the MSFN. The UHF command system will be used on this mission.

4) Acquisition and Handover:

- a) Initial Acquisition - will occur when CSM comes within the tracking sector of the MSFN station.
- b) Reacquisition - will occur if loss of lock occurs while CSM is within the tracking sector of the MSFN station.
- c) Handover - occurs when one station has two-way lock and the next station must acquire without a loss of down-data, and with a minimum loss of up-data.

S16.2 PCM/DFI INSTRUMENTATION PERFORMANCE

Evaluate the performance of the instrumentation subsystem during boost and LM propulsion subsystem operations.

Purpose

The purpose is to evaluate the response and assess any degradation of the LM instrumentation subsystem resulting from either the boost environment or the environments created by the ignition, operation and shutdown of the LM DPS and APS, and FITH. This is the only flight for which LM parameters are telemetered during the boost phase. This test is desirable prior to manned flight.

Test Conditions

- 1) During those portions of the flight when ground station coverage is available with emphasis during the following periods.
 - a) Earth Ascent phase.
 - b) Immediately following S-IVB shutdown.
 - c) Prior to, during and immediately following DPS and APS burns and FITH.
- 2) All MCCH or MCKK displays driven by operational instrumentation and all MCKK displays driven by development flight instrumentation (DFI) will be procedurally monitored during the boost and post-insertion phases for salient indications which will be reported for more comprehensive analysis after the flight.

Success Criteria

Unfiltered (ground station/decommutated) full sample rate data, both operational and DFI, processed for evaluation were adequate in all respects (noise, frequency response, bias, bit error rate, continuity and synchronization) during the subject environment.

Evaluation

- 1) The full sample subcarrier discriminated ground station data tapes acquired for evaluation will be ground station decommutated as required and presented on oscillographs, plots or tabulations in a full sample rate unfiltered format. These data will be compared against similar baseline outputs acquired during prelaunch OCP and during steady-state LM coast modes. This includes both VHF and S-Band data. Both transient and permanent effect will be analyzed and evaluated.
- 2) Essentially all telemetry outputs from the LM operational and DFI for the test periods noted will be evaluated for operation and response to environment.

Data Requirements

- 1) Prelaunch Baseline (Mandatory)

Prelaunch instrumentation status and configuration data will be forwarded to MSC for use in evaluation. This will include data from OCP K-8000, K-0005 and K-0007. Prelaunch instrumentation malfunction data will be included.

- 2) Tape Requirements for Postflight Evaluation (Mandatory)

Complete full sample ground station data tapes including the four PAM/FM/FM links (230.9 MC, 241.5 MC, 247.3 MC and 257.3 MC), the PCM link (237.8 MC) and operational S-Band PCM will be acquired for postflight evaluation from the stations covering boost, APS burns, DPS burns and the FITH.

- 3) Ground Station Parameter - Received RF Signal Strength*

* Mandatory during FITH, otherwise HD.

S16.2 PCM/DFI INSTRUMENTATION PERFORMANCE

Background and Justification

The LM Instrumentation Subsystem is the nucleus of data for the satisfaction of all mission objectives. It is therefore necessary to evaluate the flight performance of this subsystem at the earliest opportunity. SA 204/LM-1 also affords the only opportunity to evaluate the telemetry during the boost environment. It is imperative that systematic evaluation of the quality and validity of telemetry data be made so that proper impact on other subsystem analysis and evaluation can be made.

It is possible that the LM-1 to MSFN circuit margins will deteriorate due to plume impingement of the antennas during the FITH. In order to ascertain the validity of the data during this period of time, the type of evaluation specified in this objective is required.

The vibration environment induced by the APS-DPS propulsion burns has not been explicitly evaluated, with respect to its effect on the Instrumentation Subsystem. It is therefore desirable to evaluate the effects of this vibration environment upon the capability of the C&I subsystem to transmit reliable information to the MSFN stations.

The approach of evaluating the instrumentation subsystem independent of the other subsystems has the advantage of looking at the entire subsystem, under specific environmental conditions, early in the test program. If any abnormalities or unexpected malfunctions appear they can be analyzed and proper action taken at the earliest possible time.

M17.1 LM STRUCTURAL INTEGRITY

Demonstrate the structural integrity of the LM ascent and descent stages during Saturn IB launch, RCS, DPS and APS firings in an earth orbital environment.

Purpose

To demonstrate, prior to manned LM operations, the LM structural integrity for Saturn IB launch and earth orbital mission environments, and obtain data to verify the loads analysis methods.

Test Conditions

- 1) The LM structure will be subjected to the following environments:
 - a) Saturn IB launch environment.
 - b) As a minimum, the RCS must operate up to and including the second APS burn.
 - c) DPS duty cycle equivalent to the LLM DPS duty cycle.
 - d) APS duty cycle equivalent to the LLM APS duty cycle.
- 2) Cabin pressure will remain above one psia until after the second APS burn.

Success Criteria

- 1) The LM structure (ascent and descent) must survive all phases of the mission.
- 2) Sufficient valid data must be obtained to verify that the structural subsystem performed satisfactorily.

Evaluation

- 1) Acceleration, strain, and thermal data will be used in conjunction with other flight information (i.e., contained in data requirements section, paragraph 2) to determine the spacecraft loads.
- 2) Acceleration and vibration data will be used to determine the structural response of the LM stages and individual stage components during launch, SLA/LM separation, RCS operations, and DPS and APS firings.
- 3) Temperature data will be used in evaluating the design environment of the descent engine compartment and the effects of descent engine firing on the descent stage base heat shield. Additional thermal data will be used to evaluate the effects of the launch and earth orbital environments on the LM windows, cabin skin and antennas.
- 4) Cabin pressure data will be evaluated to determine that cabin structural integrity has been maintained through all mission phases.

Data Requirements

- 1) Telemetry Measurements:

- a) Strain:

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GA 0601 S	Load, +Z Beam Booster Strut No. 1	FM/FM	M
GA 0602 S	Load, +Z Beam Booster Strut No. 2	FM/FM	M
GA 0603 S	Load, +Z Beam Booster Strut No. 3	FM/FM	M
GA 0604 S	Load, +Z Beam Booster Strut No. 4	FM/FM	M
GA 0605 S	Load, -Z Beam Booster Strut No. 1	FM/FM	M
GA 0606 S	Load, -Z Beam Booster Strut No. 2	FM/FM	M
GA 0607 S	Load, -Z Beam Booster Strut No. 3	FM/FM	M
GA 0608 S	Load, -Z Beam Booster Strut No. 4	FM/FM	M > *
GA 0609 S	Load, +Y Beam Booster Strut No. 1	FM/FM	M
GA 0610 S	Load, +Y Beam Booster Strut No. 2	FM/FM	M
GA 0611 S	Load, +Y Beam Booster Strut No. 3	FM/FM	M
GA 0612 S	Load, +Y Beam Booster Strut No. 4	FM/FM	M
GA 0613 S	Load, -Y Beam Booster Strut No. 1	FM/FM	M
GA 0614 S	Load, -Y Beam Booster Strut No. 2	FM/FM	M
GA 0615 S	Load, -Y Beam Booster Strut No. 3	FM/FM	M
GA 0616 S	Load, -Y Beam Booster Strut No. 4	FM/FM	M
GA 2524 S	Load, +Y Desc Eng Supp Strut No. 4	FM/FM	HD

*Any 14 out of 16 are mandatory with the 2 lost measurements not in the same outrigger assembly.

b) Acceleration and Vibration:

Measurement Number	Description	TM	Priority
GA 2528 S	Load, -Y Desc Eng Supp Strut No. 4	FM/FM	HD
GA 1501 D	Vib, Asc Eng Supp, Struct Side No. 1	FM/FM	HD
GA 1502 D	Vib, Asc Eng Supp, Struct Side No. 2	FM/FM	HD
GA 1503 D	Vib, Asc Eng Supp, Struct Side No. 3	FM/FM	HD
GA 1571 D	Vib, Asc St Oxid Tank, X Axis	FM/FM	M
GA 1572 D	Vib, Asc St Oxid Tank, Y Axis	FM/FM	M
GA 1573 D	Vib, Asc St Oxid Tank, Z Axis	FM/FM	M
GA 2681 D	Vib, Desc St Oxid Tank No. 1, X Axis	FM/FM	M
GA 2682 D	Vib, Desc St Oxid Tank No. 1, Y Axis	FM/FM	M
GA 2683 D	Vib, Desc St Oxid Tank No. 1, Z Axis	FM/FM	M
GA 3001 A	Accel, X Axis No. 1	FM/FM	M
GA 3002 A	Accel, X Axis No. 2	FM/FM	M
GA 3003 A	Accel, Y Axis No. 1	FM/FM	M
GA 3004 A	Accel, Y Axis No. 2	FM/FM	M
GA 3005 A	Accel, Z Axis No. 1	FM/FM	M
GA 3006 A	Accel, Z Axis No. 2	FM/FM	M
GA 3601 D	Vib, Asc St Equip Rack, X Axis	FM/FM	M
GA 3602 D	Vib, Asc St Equip Rack, Y Axis	FM/FM	M
GA 3603 D	Vib, Asc St Equip Rack, Z Axis	FM/FM	M
GA 3661 D	Vib No. 1, Tunnel Equip Area	FM/FM	HD
GA 3662 D	Vib No. 2, Tunnel Equip Area	FM/FM	M
GA 3663 D	Vib No. 3, Tunnel Equip Area	FM/FM	HD
GG 6001 D	Vib, Nav Base (Roll)	FM/FM	M
GG 6002 D	Vib, Nav Base (Pitch)	FM/FM	M
GG 6003 D	Vib, Nav Base (Yaw)	FM/FM	M
GN 7691 D	Vib, RR Ant Dish	FM/FM	HD
GP 2801 D	Vib, Thrust Chamber XX Axis	FM/FM	M
GP 2802 D	Vib, Thrust Chamber YY Axis	FM/FM	HD
GP 2803 D	Vib, Thrust Chamber ZZ Axis	FM/FM	HD
GQ 7301 D	Vib, Thrust Chamber XX Axis	FM/FM	M
GQ 7302 D	Vib, Thrust Chamber YY Axis	FM/FM	HD
GQ 7303 D	Vib, Thrust Chamber ZZ Axis	FM/FM	HD

c) Temperature:

GA 0201 T	Temp No. 1, Descent Engine Cavity	FM/FM	M
GA 0202 T	Temp No. 2, Descent Engine Cavity	FM/FM	M
GA 0203 T	Temp No. 3, Descent Engine Cavity	FM/FM	M
GA 0204 T	Temp No. 4, Descent Engine Cavity	FM/FM	M

*One out of 4 is mandatory; the other 3 are highly desirable.

**One of two mandatory.

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GA 1113 T	Temp Top Surf Asc Stage Heat Sh	FM/FM	M
GA 2001 T	Temp No. 1, Heat Shield Desc Stage	FM/FM	M
GA 2002 T	Temp No. 2, Heat Shield Desc Stage	FM/FM	M
GA 2003 T	Temp No. 3, Heat Shield Desc Stage	FM/FM	M
GA 2004 T	Temp No. 4, Heat Shield Desc Stage	FM/FM	M
GA 2005 T	Temp No. 5, Heat Shield Desc Stage	FM/FM	M
GA 2006 T	Temp No. 6, Heat Shield Desc Stage	FM/FM	M
GA 2007 T	Temp No. 7, Heat Shield Desc Stage	FM/FM	M
GA 2008 T	Temp No. 8, Heat Shield Desc Stage	FM/FM	M
GA 2009 T	Temp No. 9, Heat Shield Desc Stage	FM/FM	M
GA 2010 T	Temp No.10, Heat Shield Desc Stage	FM/FM	M

*Any 7 out of 10 are mandatory; the other 3 are highly desirable.

GA 2201 T	Temp No. 1, Window	FM/FM	HD
GA 2202 T	Temp No. 2, Window	FM/FM	HD
GA 2203 T	Temp No. 3, Window	FM/FM	HD
GB 0204 T	Temp No. 1, Cabin Skin	FM/FM	HD
GB 0205 T	Temp No. 2, Cabin Skin	FM/FM	HD
GB 3727 T	Temp No. 1, Steerable SB Antenna	FM/FM	HD
GB 3728 T	Temp No. 2, Steerable SB Antenna	FM/FM	HD
GB 3729 T	Temp No. 3, Steerable SB Antenna	FM/FM	HD
GB 3730 T	Temp No. 1, SB Omni Antenna	FM/FM	HD
GB 3733 T	Temp, VHF In-Flight Antenna	FM/FM	HD
GA 0083 T	Temp, No. 1, +Z Land Leg Outrig No. 1	FM/FM	M
GA 0084 T	Temp, No. 1, +Z Land Leg Outrig No. 2	FM/FM	M

*One measurement is mandatory; the other is highly desirable.

GA 0085 T	Temp, No. 1, +Z Land Leg Apex Fit	FM/FM	M
GH 1313 V	Volt, Pitch GDA Pos (Ret/Ext)	PCM	M
GH 1314 V	Volt, Roll GDA Pos (Ret/Ext)	PCM	M
GR 5031 P	Press, Thrust Chamber No. 4U	FM/FM	HD
GR 5032 P	Press, Thrust Chamber No. 4D	FM/FM	HD
GR 5033 P	Press, Thrust Chamber No. 4F	FM/FM	HD
GR 5034 P	Press, Thrust Chamber No. 4S	FM/FM	HD
GR 5035 P	Press, Thrust Chamber No. 3U	FM/FM	HD
GR 5036 P	Press, Thrust Chamber No. 3D	FM/FM	HD
GR 5037 P	Press, Thrust Chamber No. 3F	FM/FM	HD
GR 5038 P	Press, Thrust Chamber No. 3S	FM/FM	HD
GR 5039 P	Press, Thrust Chamber No. 2U	FM/FM	HD
GR 5040 P	Press, Thrust Chamber No. 2D	FM/FM	HD
GR 5041 P	Press, Thrust Chamber No. 2F	FM/FM	HD
GR 5042 P	Press, Thrust Chamber No. 2S	FM/FM	HD
GR 5043 P	Press, Thrust Chamber No. 1U	FM/FM	HD
GR 5044 P	Press, Thrust Chamber No. 1D	FM/FM	HD
GR 5045 P	Press, Thrust Chamber No. 1F	FM/FM	HD
GR 5046 P	Press, Thrust Chamber No. 1S	FM/FM	HD

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GP 2010 P	Press, Thrust Chamber	FM/FM	M
GP 2010 P	Press, Thrust Chamber	PCM	HD
GQ 6510 P	Press, Thrust Chamber	FM/FM	M
GQ 6510 P	Press, Thrust Chamber	PCM	HD

d) Pressure:

GA 1133 P	Press, Top Surf Asc Stage Heat Sh	FM/FM	M
GF 3571 P	Cabin Pressure	FM/FM	M

2) Additional Data (time histories)

- a) Trajectory profile from liftoff through LM/SLA separation. (M)
- b) Dynamic pressure (q) and single angle of attack (α) (M) (Calculated)
- c) Wind data (t=0 wind sounding) from ground level to approximately 60,000 feet. (M)
- d) Booster thrust. (M)
- e) Booster engine gimbal angles. (M)
- f) Booster accelerations and rate gyros. (M)
- g) Ascent, descent and RCS thrust. (M)

M17.1 LM STRUCTURAL INTEGRITY

Background and Justification

This mission presents the first opportunity to subject a LM to a Saturn IB launch environment, LM/SLA separation, RCS operations, and DPS and APS firings in an earth orbital environment. To man the LM for these operations and environments, it is first necessary to demonstrate the LM's structural integrity under these conditions. These flight environments present critical structural design conditions for a considerable portion of the LM structure and equipment. The results from this flight will be compared to the analytical predictions for this flight condition, ground and flight test data, and design values. Demonstration of the LM structural integrity is mandatory prior to manned LM flight operations.

M17.2 SLA/LM LAUNCH INTERACTION LOADS

Determine the interaction loads between the LM and the SLA for a Saturn IB-LM launch environment.

Purpose

To obtain data for the determination of the SLA/LM interaction loads during launch so that the loads analysis methods can be verified and the adequacy of the LM structure for an updated Saturn I launch environment can be assessed.

Test Conditions

The spacecraft will be exposed to a Saturn IB launch environment.

Success Criteria

Sufficient valid data must be obtained to enable determination of the interaction loads between the LM and the SLA.

Evaluation

The interaction loads will be calculated from the recorded flight strain measurements. These interaction loads will then be compared to the design loads (NAA-GAEC ICD MH01-05118-424, paragraph 3.2) and to the analytical loads predictions (loads analysis) made for the flight conditions.

Data Requirements

Telemetry Measurements:

1) Strain:

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GA 0601 S	Load, +Z Beam Booster Strut No. 1	FM/FM	M
GA 0602 S	Load, +Z Beam Booster Strut No. 2	FM/FM	M
GA 0603 S	Load, +Z Beam Booster Strut No. 3	FM/FM	M
GA 0604 S	Load, +Z Beam Booster Strut No. 4	FM/FM	M
GA 0605 S	Load, -Z Beam Booster Strut No. 1	FM/FM	M
GA 0606 S	Load, -Z Beam Booster Strut No. 2	FM/FM	M
GA 0607 S	Load, -Z Beam Booster Strut No. 3	FM/FM	M
GA 0608 S	Load, -Z Beam Booster Strut No. 4	FM/FM	M
GA 0609 S	Load, +Y Beam Booster Strut No. 1	FM/FM	M
GA 0610 S	Load, +Y Beam Booster Strut No. 2	FM/FM	M
GA 0611 S	Load, +Y Beam Booster Strut No. 3	FM/FM	M
GA 0612 S	Load, +Y Beam Booster Strut No. 4	FM/FM	M
GA 0613 S	Load, -Y Beam Booster Strut No. 1	FM/FM	M
GA 0614 S	Load, -Y Beam Booster Strut No. 2	FM/FM	M
GA 0615 S	Load, -Y Beam Booster Strut No. 3	FM/FM	M
GA 0616 S	Load, -Y Beam Booster Strut No. 4	FM/FM	M

*Any 14 of 16 are mandatory with the 2 lost measurements not in the same outrigger assembly.

2) Acceleration:

GA 3001 A	Accel, X Axis No. 1	FM/FM	HD
GA 3002 A	Accel, X Axis No. 2	FM/FM	HD
GA 3003 A	Accel, Y Axis No. 1	FM/FM	HD
GA 3004 A	Accel, Y Axis No. 2	FM/FM	HD
GA 3005 A	Accel, Z Axis No. 1	FM/FM	HD
GA 3006 A	Accel, Z Axis No. 2	FM/FM	HD

3) Temperature:

GA 0083 T	Temp No. 1, +Z Land Leg Outrig No. 1	FM/FM	HD
GA 0084 T	Temp No. 1, +Z Land Leg Outrig No. 2	FM/FM	HD
GA 0085 T	Temp No. 1, +Z Land Leg Apex Fit	FM/FM	HD

4) Additional Data (Time Histories):

- a) Dynamic pressure (q) and angle of attack (α).
(M) (Calculated)
- b) Trajectory profile from liftoff to SLA/LM
separation. (M)
- c) Booster thrust. (M)
- d) Booster engine gimbal angles. (M)
- e) Booster accelerations and rate gyros. (M)
- f) Wind data (t=0 wind sounding) from ground level to
approximately 60,000 feet. (M)

N17.2 SLA/LM LAUNCH INTERACTION LOADS

Background and Justification

This mission presents the first opportunity to measure the response of a LM to a Saturn IB launch. At the present time, LM-1 will be the only LM spacecraft to have active telemetry during the launch and boost phase of flight. The loads that occur during the launch phase of the mission are critical for a considerable portion of the LM structure. These loads will be used to verify the loads analysis methods used to analytically predict the LM design loads. The measured loads will be compared with the design loads contained in NAA-GAEC ICD MH01-05118-424, paragraph 3.2 and to the analytical loads predictions based on measured flight conditions.

All sixteen LM strain measurements are necessary to accurately determine the force inputs to the LM from the SLA support structure. A complete understanding (i.e., contributions of LM and SLA to the total input) of these force inputs will not be possible, however, without the LM acceleration data. It is possible to calculate the LM-SLA interaction forces, with a small degree of error, if all the LM acceleration data are obtained along with fourteen of the sixteen strain measurements, with the two lost measurements not being in the same outrigger assembly.

N17.3 APS/DPS OXIDIZER TANKS VIBRATION

Determine the dynamic respons of the ascent and descent stage oxidizer tanks during flight induced environments.

Purpose

To obtain data on the vibratory response of the ascent and descent stage oxidizer tanks from liftoff through LM descent and ascent engine firings, for assessment of environmental vibration design criteria and ground certification tests prior to manned flight.

Test Conditions

The LM will be exposed to a launch environment and to descent and ascent stage engine firings.

Success Criteria

Sufficient data are obtained to determine the dynamic response of the ascent and descent stage oxidizer tanks for applicable mission phases.

Evaluation

The vibration data will be displayed against flight time and selected time slices will be subjected to power spectral density analysis. These data will be compared to design qualification levels in the technical specification (LSP-470-IC Table III for launch and boost, and LSP-520-001A Sec. 3.2 for lunar descent and ascent) and with data from vibration qualification and structural certification tests.

Data Requirements

Telemetry Measurements:

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GA 1571 D	Vib, Asc Stage, Oxid Tank, X Axis	FM/FM	M
GA 1572 D	Vib, Asc Stage, Oxid Tank, Y Axis	FM/FM	M
GA 1573 D	Vib, Asc Stage, Oxid Tank, Z Axis	FM/FM	M
GA 2681 D	Vib, Desc Stage, Oxid Tank No. 1, X Axis	FM/FM	M
GA 2682 D	Vib, Desc Stage, Oxid Tank No. 1, Y Axis	FM/FM	M
GA 2683 D	Vib, Desc Stage, Oxid Tank No. 1, Z Axis	FM/FM	M

Acceleration:

GA 3001 A	Accel, X Axis No. 1	FM/FM	HD
GA 3003 A	Accel, Y Axis No. 1	FM/FM	HD
GA 3005 A	Accel, Z Axis No. 1	FM/FM	HD
GA 3002 A	Accel, X Axis No. 2	FM/FM	HD
GA 3004 A	Accel, Y Axis No. 2	FM/FM	HD
GA 3006 A	Accel, Z Axis No. 2	FM/FM	HD

M17.3 APS/DPS OXIDIZER TANKS VIBRATION

Background and Justification

The APS/DPS oxidizer tanks are the largest single mass items in the LM vehicle and therefore are of special interest in the structural design, development, and testing phases of the mission. Ground static and dynamic testing has demonstrated that the tanks meet the specified environments without failure when tested for the individual environments, but this flight is the first opportunity to test these large mass items in the combined steady-state dynamic flight environments for launch and during APS and DPS burns.

Portions of the ascent and descent stage tank support structure are designed by vibration loads. The flight test data will provide a basis for assessment of structural design adequacy prior to manned flight by comparison to ground test results from both component qualification and vehicle level tests.

NI 7.4 CRITICAL EQUIPMENT AREA VIBRATION

Determine vibration levels in critical equipment areas, due to launch and to ascent and descent engine firings.

Purpose

The purpose is to determine, prior to manned LM flight, the vibration response of selected LM equipment when exposed to S-IB launch and LM engine environments.

Test Conditions

Data will be obtained from liftoff through completion of all LM engine firings. The LM will be exposed to flight environment from liftoff through all LM engine firings.

Success Criteria

Sufficient data are acquired during the launch phase and APS and DPS engine firing phases of the mission to determine the vibration response of the critical equipment areas.

Evaluation

The vibration response data are processed to obtain plots of g (RMS) versus time and selected time slices are subjected to power spectral density analysis. This information is then compared with design criteria levels in the technical specifications (LSP-470-1C Table III for launch and boost, and LSP-520-001B for lunar descent and ascent) and with data from the ground vibration test of LTA-3 and component qualification tests.

Data Requirements

Telemetry Measurements: Vibration:

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GA 1501 D	Vib, Asc Eng Supp Strct Side No. 1	FM/FM	HD
GA 1502 D	Vib, Asc Eng Supp Strct Side No. 2	FM/FM	HD
GA 1503 D	Vib, Asc Eng Supp Strct Side No. 3	FM/FM	HD
GA 3601 D	Vib, Asc Stage Equip Rack, X Axis	FM/FM	M
GA 3602 D	Vib, Asc Stage Equip Rack, Y Axis	FM/FM	M
GA 3603 D	Vib, Asc Stage Equip Rack, Z Axis	FM/FM	M
GA 3661 D	Vib, No. 1, Tunnel Equip Area	FM/FM	HD
GA 3662 D	Vib, No. 2, Tunnel Equip Area	FM/FM	M
GA 3663 D	Vib, No. 3, Tunnel Equip Area	FM/FM	HD
GG 6001 D	Vib, Nav Base (Roll)	FM/FM	M
GG 6002 D	Vib, Nav Base (Pitch)	FM/FM	M
GG 6003 D	Vib, Nav Base (Yaw)	FM/FM	M
GN 7691 D	Vib, RR Ant. Dish	FM/FM	HD
GP 2801 D	Vib, Thrust Chamber, XX Axis	FM/FM	M
GP 2802 D	Vib, Thrust Chamber, YY Axis	FM/FM	HD
GP 2803 D	Vib, Thrust Chamber, ZZ Axis	FM/FM	HD
GQ 7301 D	Vib, Thrust Chamber, XX Axis	FM/FM	M
GQ 7302 D	Vib, Thrust Chamber, YY Axis	FM/FM	HD
GQ 7303 D	Vib, Thrust Chamber, ZZ Axis	FM/FM	HD

N17.4 CRITICAL EQUIPMENT AREA VIBRATION

Background and Justification

The instrumentation locations chosen for this objective are selected on the basis of providing on overall coverage of LM vehicle vibration response levels, in addition to representing critical equipment items. In particular, the GG 6001 through 6003 on the Nav Base will be needed to verify the component qual test levels of the critical IMU and ASA units, and for use in LM DAP simulations requiring vibration error signals of the IMU during APS, DPS and RCS firings. The engine and engine support structure measurements will be correlated with engine qual test vibration levels and data from engine firing tests and ground test vibration environments. These data will also be available for malfunction detection if needed.

Vibration transducers GA 3601 through 3603 and GA 3661 through 3663 are located in multi equipment areas and are the only vibration measurements available in these areas. These measurements are necessary to verify equipment qualification environments and for evaluation purposes in the event of failure or off nominal performance of these items. Results of LTA-3 vibration tests and measurements made during the LTA-5 engine firing tests at WSTF have been factored into the component qualification test criteria. Measurements made during the LM-1 flight will verify the adequacy of these component vibration test levels.

M17.5 DPS/APS/RCS THERMAL EFFECTS

Evaluate the thermal and pressure response on heat shielding, structure, and outriggers when exposed to direct plume impingement and radiant heating from operation of the DPS, APS and RCS engines.

Purpose

The purpose of this objective is to obtain the thermal and pressure response of various structural and thermal elements and to obtain data necessary to upgrade the thermal analytical models used for providing preflight predictions to verify safe manned missions.

Test Conditions

- 1) DPS burn for approximately 200 seconds at full thrust
- 2) APS burn of short duration (FITH)
- 3) RCS = continuous burn (+X) for 8 seconds with descent stage attached.

Success Criteria

Sufficient data will be obtained to evaluate the thermal and pressure response of the LM to DPS, APS and RCS engine firings in order to assist in upgrading the lunar mission thermal analytical models.

Evaluation

The acquired data will be used to evaluate the accuracy and to upgrade the analytical models used to predict the in-flight structural temperatures. Specifically:

- 1) DPS - Base heat shield, engine compartment, landing radar antenna
- 2) APS - Base heat shield, blast deflector, engine compartment
- 3) RCS - Outrigger, thermal shield, S-Band and rendezvous radar antennas

The gimbale position of the DPS engine will be used for computing the view factor from the hot nozzle extension to the D/S base heat shield surface for use in radiative heat transfer calculations. The position is also needed in order to be able to predict the thermodynamic properties in the flow field where the flow field impinges on the spacecraft surfaces as the engine is gimbale.

Temperature data obtained on the steerable S-Band, VHF in-flight, LR, and RR antennas will be used to assess their capability to withstand the thermal environment.

Data Requirements

1) Telemetry Measurements:

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GA 0083 T	Temp No. 1, +Z Land Leg Outrig No. 1	FM/FM	M
GA 0084 T	Temp No. 1, +Z Land Leg Outrig No. 2	FM/FM	M
GA 0085 T	Temp No. 1, +Z Land Leg Apex Fit	FM/FM	M

* Any 2 out of these 3 are mandatory; the other is highly desirable.

**GA 0201 T	Temp No. 1, Descent Engine Cavity	FM/FM	M
**GA 0202 T	Temp No. 2, Descent Engine Cavity	FM/FM	M
**GA 0203 T	Temp No. 3, Descent Engine Cavity	FM/FM	M
**GA 0204 T	Temp No. 4, Descent Engine Cavity	FM/FM	M

* Any 3 out of these 4 are mandatory; the other is highly desirable.

GA 1113 T	Temp Top Surf Asc Stg Heat Sh	FM/FM	M
GA 1133 P	Press, Top Surf Asc Stg Heat Sh	FM/FM	M
**GA 2001 T	Temp No. 1, Heat Shield Desc Stg	FM/FM	M
**GA 2002 T	Temp No. 2, Heat Shield Desc Stg	FM/FM	M
**GA 2003 T	Temp No. 3, Heat Shield Desc Stg	FM/FM	M
**GA 2004 T	Temp No. 4, Heat Shield Desc Stg	FM/FM	M
**GA 2005 T	Temp No. 5, Heat Shield Desc Stg	FM/FM	M
**GA 2006 T	Temp No. 6, Heat Shield Desc Stg	FM/FM	M
**GA 2007 T	Temp No. 7, Heat Shield Desc Stg	FM/FM	M
**GA 2008 T	Temp No. 8, Heat Shield Desc Stg	FM/FM	M
**GA 2009 T	Temp No. 9, Heat Shield Desc Stg	FM/FM	M
**GA 2010 T	Temp No. 10, Heat Shield Desc Stg	FM/FM	M

* Any 6 out of these 10 are mandatory, the other 4 are highly desirable.

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GA 2201 T	Temp No. 1, Window	FM/FM	M *
GA 2202 T	Temp No. 2, Window	FM/FM	M
GA 2203 T	Temp No. 3, Window	FM/FM	HD

*Any 1 out of these two are mandatory, the other is highly desirable.

GB 0201 T	Temp No. 1, Asc Eng Cover-Cabin	FM/FM	HD
GB 0203 T	Temp, Cabin Tunnel	FM/FM	M
GB 0204 T	Temp No. 1, Cabin Skin	FM/FM	M *
GB 0205 T	Temp No. 2, Cabin Skin	FM/FM	M

* Any 1 out of these 2 is mandatory; the other is highly desirable.

GB 0301 T	Temp No. 1, Bot Surf Asc Stg	FM/FM	M
GB 0302 T	Temp No. 2, Bot Surf Asc Stg	FM/FM	M
GB 0303 T	Temp No. 3, Bot Surf Asc Stg	FM/FM	M
GB 0304 T	Temp No. 4, Bot Surf Asc Stg	FM/FM	M *
GB 0305 T	Temp No. 5, Bot Surf Asc Stg	FM/FM	M
GB 0306 T	Temp No. 6, Bot Surf Asc Stg	FM/FM	M
GB 0307 T	Temp No. 7, Bot Surf Asc Stg	FM/FM	M

* Any 5 out of these 7 are mandatory; the other 2 are highly desirable.

**GB 0401 T	Temp No. 1, Top Surf Desc Stg	FM/FM	M
**GB 0402 T	Temp No. 2, Top Surf Desc Stg	FM/FM	M *
**GB 0403 T	Temp No. 3, Top Surf Desc Stg	FM/FM	M

* Any 2 out of these 3 are mandatory; the other is highly desirable.

**GB 0521 T	Temp No. 1, Desc Eng Blast Deflect	FM/FM	M *
**GB 0522 T	Temp No. 2, Desc Eng Blast Deflect	FM/FM	M

* Any 1 out of these 2 is mandatory; the other is highly desirable.

GB 0601 T	Temp No. 1, Asc Eng Compartment	FM/FM	M
GB 0602 T	Temp No. 2, Asc Eng Compartment	FM/FM	M *
GB 0603 T	Temp No. 3, Asc Eng Compartment	FM/FM	M

* Any 2 out of these 3 are mandatory; the other is highly desirable.

GB 0621 P	Press No. 1, Asc Eng Compartment	FM/FM	M
GB 0622 P	Press No. 2, Asc Eng Compartment	FM/FM	HD
GB 0623 P	Press No. 3, Asc Eng Compartment	FM/FM	HD
GB 0801 P	Press No. 1, Bot Surf Asc Stg	FM/FM	M
GB 0802 P	Press No. 2, Bot Surf Asc Stg	FM/FM	M
GB 0803 P	Press No. 3, Bot Surf Asc Stg	FM/FM	M **
GB 0804 P	Press No. 4, Bot Surf Asc Stg	FM/FM	M
GB 0805 P	Press No. 5, Bot Surf Asc Stg	FM/FM	M

Measurement Number	Description	TM	Priority
GA 0806 P	Press No. 6, Bot Surf Asc Stg	FM/FM	M
GB 0807 P	Press No. 7, Bot Surf Asc Stg	FM/FM	M
GB 0808 P	Press No. 8, Bot Surf Asc Stg	FM/FM	M
GB 0809 P	Press No. 9, Bot Surf Asc Stg	FM/FM	M
GB 0810 P	Press No. 10, Bot Surf Asc Stg	FM/FM	M
GB 0811 P	Press No. 11, Bot Surf Asc Stg	FM/FM	M
GB 0812 P	Press No. 12, Bot Surf Asc Stg	FM/FM	M
GB 0813 P	Press No. 13, Bot Surf Asc Stg	FM/FM	M
GB 0814 P	Press No. 14, Bot Surf Asc Stg	FM/FM	M
GB 0815 P	Press No. 15, Bot Surf Asc Stg	FM/FM	M
GB 0816 P	Press No. 16, Bot Surf Asc Stg	FM/FM	M
GB 0817 P	Press No. 17, Bot Surf Asc Stg	FM/FM	M
GB 0818 P	Press No. 18, Bot Surf Asc Stg	FM/FM	M
**GB 0901 P	Press No. 1, Top Surf Desc Stg	FM/FM	M
**GB 0902 P	Press No. 2, Top Surf Desc Stg	FM/FM	M
**GB 0903 P	Press No. 3, Top Surf Desc Stg	FM/FM	M
**GB 0904 P	Press No. 4, Top Surf Desc Stg	FM/FM	M
**GB 0905 P	Press No. 5, Top Surf Desc Stg	FM/FM	M
**GB 0906 P	Press No. 6, Top Surf Desc Stg	FM/FM	M
**GB 0907 P	Press No. 7, Top Surf Desc Stg	FM/FM	M
**GB 3021 T	Temp No. 1, Int Desc Ins Blanket	FM/FM	M
**GB 3023 T	Temp No. 1, Surf Desc Ins Blanket	FM/FM	M
**GB 3025 T	Temp No. 2, Int Desc Ins Blanket	FM/FM	M
**GB 3027 T	Temp No. 2, Surf Desc Ins Blanket	FM/FM	M
**GB 3029 T	Temp No. 3, Int Desc Ins Blanket	FM/FM	M
**GB 3031 T	Temp No. 3, Surf Desc Ins Blanket	FM/FM	M
**GB 3033 T	Temp No. 4, Surf Desc Ins Blanket	FM/FM	M

*Any 5 out of these 7 are mandatory; the other 2 are highly desirable.

**Any 16 out of these 18 are mandatory; the other 2 are highly desirable.

GB 3035 T	Temp, LM Asc Outer Skin, Aft E.B.	FM/FM	M
**GB 3036 T	Temp, LM Desc Outer Skin, -Z Panel	FM/FM	M
GB 3727 T	Temp No. 1, Steerable S-Band Antenna Boom	FM/FM	M
GB 3728 T	Temp No. 2, Steerable S-Band Antenna	FM/FM	M
GB 3729 T	Temp No. 3, Steerable S-Band Antenna	FM/FM	M
GB 3730 T	Temp No. 1, S-Band Omni Antenna	FM/FM	M
GB 3733 T	Temp, VHF In-Flight Antenna	FM/FM	M

* Any 3 out of these 5 are mandatory; the other 2 are highly desirable.

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
**GN 7564 T	Temp LR Antenna Sensor No. 2	FM/FM	H *
**GN 7566 T	Temp LR Antenna Sensor No. 3	FM/FM	H *
GN 7721 T	Temp RR Antenna Sensor No. 3	PCM	H *
GN 7722 T	Temp No. 2, RR Antenna	PCM	H *
GH 1313 V	Pitch GDA Position	PCM	M
GH 1314 V	Roll GDA Position	PCM	M

*One of these two is mandatory, the other is highly desirable.

**NOT APPLICABLE AFTER FIRE-IN-THE HOLE ABORT

2) Additional Data:

Ascent, descent and RCS engine thrust (M).

Background and Justification

The proximity of the LM structure to the DPS, APS and RCS engine will result in plume impingement upon the structural elements and produce heating rates as large as 10 BTU/Sec-Ft^2 . The heating rate to the structure varies with locations and is governed by the amount of plume expansion in a space vacuum, the concentration of molecules (pressure) at the point of impingement, the structure thermal absorptance properties, and the temperature difference between the plume gas and the structure surface. The plume heating elevates the temperature of the impinged area and increases the mean temperature of the vehicle such that out-of-specification component temperatures may possibly be realized during subsequent mission phases. Combination of ablative and insulative materials have been used in the thermal design to minimize these effects.

A number of thermodynamic tests have been or are to be conducted which will be used to assess the plume heating effects primarily for design purposes, and are noted in the following list:

- 1) Tests conducted at GAEC research on 14 December 1966
 - a) Transient test of H-film properties
 - b) 4' x 8' panel test (Mylar and H-film superinsulation)
- 2) LTQ No. 811-086-18, "Fire-in-the-Hole 1/10 Scale Model Test (LM-1, 2 configuration)"
- 3) LTQ No. 811-086-20, "Plume Heating Response of D/S Skins"
- 4) LTQ No. 811-086-28, "CO₂ Fire-in-the-Hole - A/S and D/S Heat Shield and Blast Deflector Loads for Rotated A/S Engine (LM-3 and Subs.)"
- 5) LTQ No. 811-086-33, "Shock Tunnel Plume Heating Test A/S, D/S, and Fire-in-the-Hole."

This LM flight represents the only test where DPS burns, FITH abort, APS burns, and RCS firings are accomplished in the space environment prior to manning.

The impact of acquiring insufficient pressure and temperature data from this test will be:

- 1) It would be difficult to obtain a useful evaluation of the

effects of DPS, APS, and RCS engine burns on the adjoining structural elements under actual flight conditions.

- 2) Test data will not be available for evaluating the accuracy and upgrading the analytical models.

P18.1 EXPLOSIVE DEVICES PERFORMANCE

Demonstrate the operation of the Explosive Devices.

Purpose

Flight demonstration, prior to manned flight, that the LM ED can
1) pressurize the RCS, the DPS and APS, and 2) structurally separate the two stages during abort staging by deadfacing and cutting of electrical cables and release of the four nuts and bolts holding the stages together.

Test Conditions

No special test conditions are required.

Success Criteria

- 1) The RCS helium pressurization valves function (open) on command.
- 2) The DPS helium pressurization valves function (open) on command.
- 3) The ED system FITH abort functions occur on command.

Evaluation

- 1) At time of initial RCS pressurization a sharp increase in pressure from approximately 20 psi to a value greater than 100 psi will result.
- 2) At the time of initial Descent Engine pressurization, a sharp rise in pressure will be indicated. This will indicate that the pressure started in the helium tank can provide a blanket pressure in the descent propellant tanks.
- 3) A ten (10) second time slice will be taken commencing five seconds prior to FITH and will be examined. During this time slice it is expected that:
 - a) ED measurements will indicate that the ED bus has been armed.
 - b) ED measurements will indicate that the abort stage fire command was given.

- c) A sharp rise in helium pressure will indicate that the explosive devices in the Ascent helium lines have opened.
- d) Dynamic separation of the two stages will show that the cable cutters and nuts and bolts have functioned.

Data Requirements

1) Telemetry Measurements:

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GB 3102 H	Sep Dist Mon Interstage No. 1	FM/FM	HD
GB 3103 H	Sep Dist Mon Interstage No. 2	FM/FM	HD
GB 3104 H	Sep Dist Mon Interstage No. 3	FM/FM	HD
GB 3105 H	Sep Dist Mon Interstage No. 4	FM/FM	HD
GP 0019 P	Press He Pri Upstream Reg Inlet	FM/FM	M
GP 0020 P	Press He Sec Upstream Reg Inlet	FM/FM	M
GQ 3009 P	Press He Pri Upstream Reg Inlet	FM/FM	M
GQ 3010 P	Press He Sec Upstream Reg Inlet	FM/FM	M
GQ 3501 P	Press Ullage Fuel Tank No. 1	FM/FM	M
GQ 4001 P	Press Ox Tank No. 1 Ullage	FM/FM	M
GR 1202 T	Press He Regulator B Output	PCM	M
GR 2202 P	Press B Fuel Mnfld	PCM	HD
GR 3201 P	Press A Oxid Mnfld	PCM	HD
GR 3202 P	Press B Oxid Mnfld	PCM	HD
GY 0111 X	Sys A Battery Relay Open	PCM	M
GY 0112 X	Sys B Battery Relay Open	PCM	M
GY 0121 X	Sys A Staging Relay Open	PCM	M
GY 0122 X	Sys B Staging Relay Open	PCM	M

P18.1 EXPLOSIVE DEVICES PERFORMANCE

Background and Justification

This will be the first mission in which the LM will be exposed to the operational environment so it provides the first opportunity to demonstrate the performance of the LM explosive devices in that environment.

It is desirable that the ED system operation be verified prior to manned LM flights because of the critical functions it performs. These critical functions are:

- 1) None of the propulsion systems can function until pressurization is accomplished by means of explosive devices.
- 2) The ascent and descent stages cannot be separated without operation of explosive devices.

N20.1 FITH ABORT STRUCTURAL EFFECTS

Verify that the descent and ascent stage structure and thermal shield can satisfactorily withstand loads due to pressure and temperature buildup during fire-in-the-hole abort.

Purpose

To obtain pressure and temperature data during fire-in-the-hole abort for assessment of the LM structural integrity prior to first manned LM flight. The data will also be used to verify the analytical prediction methods.

Test Conditions

The LM structure will be exposed to a fire-in-the-hole abort environment (the abort stage function will be initiated while the descent stage engine is at max thrust).

The ascent stage data will be obtained from two seconds before to five seconds after completion of the FITH abort. The descent stage data will be obtained from two seconds before FITH until the DFT flyaway umbilical is demated.

The prelaunch cabin leak rate must be such that 1.0 psia remains through second APS shutdown.

Success Criteria

- 1) The LM structure must survive the FITH abort.
- 2) Sufficient valid data must be obtained to determine the loading induced by the pressure and temperature buildups.

Evaluation

The telemetered pressures, temperatures, separation distance and acceleration data will be used to determine the FITH abort induced loads. The calculated loads will be compared with the design loads and with ground

tests (scaled model tests with analytical predictions of full scale loads). From the comparisons an assessment of the LM structural integrity for FITH loads can be made.

Examination of the ascent stage base heat shield top surface temperature and pressure data (GA 1113 T and GA 1133 P, respectively) during this phase will indicate if structural damage occurred. A rise in temperature and pressure above expected levels may indicate cracks and/or holes in the heat shield. Assessment of the cabin structure can be made by using the cabin pressure data (GF 3571 P). A rapid change in the cabin pressure may indicate that structural damage occurred. These data will only give an indication if structural damage occurred during or after the FITH abort. It will not allow the determination of the cause (excessive temperatures and/or pressures).

The loads prediction method will be verified by comparing the actual time histories of pressure and temperature with those analytically predicted.

Data Requirements

Telemetry Measurements:

1) Temperature:

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GA 1113 T	Temp, Top Surf Asc Stage Heat Sh	FM/FM	M
GB 0201 T	Temp No. 1, Ascent Eng Cover - Cabin	FM/FM	M
GB 0301 T	Temp No. 1, Bot Surf Ascent Stage	FM/FM	M
GB 0302 T	Temp No. 2, Bot Surf Ascent Stage	FM/FM	M
GB 0303 T	Temp No. 3, Bot Surf Ascent Stage	FM/FM	M
GB 0304 T	Temp No. 4, Bot Surf Ascent Stage	FM/FM	M
GB 0305 T	Temp No. 5, Bot Surf Ascent Stage	FM/FM	M
GB 0306 T	Temp No. 6, Bot Surf Ascent Stage	FM/FM	M
GB 0307 T	Temp No. 7, Bot Surf Ascent Stage	FM/FM	M
*Any 5 out of 7 are mandatory; the other 2 are highly desirable.			
GB 0401 T	Temp No. 1, Top Surf Descent Stage	FM/FM	M
GB 0402 T	Temp No. 2, Top Surf Descent Stage	FM/FM	M
GB 0403 T	Temp No. 3, Top Surf Descent Stage	FM/FM	M

*Any 2 out of 3 are mandatory; the other one is highly desirable.

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GB 0521 T	Temp No. 1, Desc Eng Blast Deflect	FM/FM	ND
GB 0522 T	Temp No. 2, Desc Eng Blast Deflect	FM/FM	ND
GB 0601 T	Temp No. 1, Ascent Eng Compartment	FM/FM	M
GB 0602 T	Temp No. 2, Ascent Eng Compartment	FM/FM	M
GB 0603 T	Temp No. 3, Ascent Eng Compartment	FM/FM	M

*Any 2 out of 3 are mandatory; the other one is highly desirable.

GP 2701 T	Temp, Thr Chm External Wall No. 1	FM/FM	M
GP 2702 T	Temp, Thr Chm External Wall No. 2	FM/FM	M
GP 2703 T	Temp, Thr Chm External Wall No. 3	FM/FM	M
GP 2704 T	Temp, Thr Chm External Wall No. 4	FM/FM	M

*Any 2 out of 4 are mandatory; the other 2 are highly desirable.

2) Pressure:

GA 1133 P	Press, Top Surf Asc Stage Heat Sh	FM/FM	M
GB 0621 P	Press No. 1, Ascent Eng Compartment	FM/FM	M
GB 0622 P	Press No. 2, Ascent Eng Compartment	FM/FM	M
GB 0623 P	Press No. 3, Ascent Eng Compartment	FM/FM	M

*Any 2 out of 3 are mandatory; the other one is highly desirable.

GB 0801 P	Press No. 1, Bot Surf Ascent Stage	FM/FM	M
GB 0802 P	Press No. 2, Bot Surf Ascent Stage	FM/FM	M
GB 0803 P	Press No. 3, Bot Surf Ascent Stage	FM/FM	M
GB 0804 P	Press No. 4, Bot Surf Ascent Stage	FM/FM	M
GB 0805 P	Press No. 5, Bot Surf Ascent Stage	FM/FM	M
GB 0806 P	Press No. 6, Bot Surf Ascent Stage	FM/FM	M
GB 0807 P	Press No. 7, Bot Surf Ascent Stage	FM/FM	M
GB 0808 P	Press No. 8, Bot Surf Ascent Stage	FM/FM	M
GB 0809 P	Press No. 9, Bot Surf Ascent Stage	FM/FM	M
GB 0811 P	Press No.11, Bot Surf Ascent Stage	FM/FM	M
GB 0812 P	Press No.12, Bot Surf Ascent Stage	FM/FM	M
GB 0813 P	Press No.13, Bot Surf Ascent Stage	FM/FM	M
GB 0814 P	Press No.14, Bot Surf Ascent Stage	FM/FM	M
GB 0815 P	Press No.15, Bot Surf Ascent Stage	FM/FM	M
GB 0816 P	Press No.16, Bot Surf Ascent Stage	FM/FM	M
GB 0817 P	Press No.17, Bot Surf Ascent Stage	FM/FM	M
GB 0818 P	Press No.18, Bot Surf Ascent Stage	FM/FM	M

*Any 16 out of 17 are mandatory, the other 1 is highly desirable.

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GB 0901 P	Press No. 1, Top Surf Descent Stage	FM/FM	M
GB 0902 P	Press No. 2, Top Surf Descent Stage	FM/FM	M
GB 0903 P	Press No. 3, Top Surf Descent Stage	FM/FM	M
GB 0904 P	Press No. 4, Top Surf Descent Stage	FM/FM	M
GB 0905 P	Press No. 5, Top Surf Descent Stage	FM/FM	M
GB 0906 P	Press No. 6, Top Surf Descent Stage	FM/FM	M
GB 0907 P	Press No. 7, Top Surf Descent Stage	FM/FM	M

*Any 5 out of 7 are mandatory; the other one is highly desirable.

GF 3571 P	Cabin Press	PCM	M
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3) Distance:

GB 3102 H	Sep Dist Mon Interstage No. 1	FM/FM	M
GB 3103 H	Sep Dist Mon Interstage No. 2	FM/FM	M
GB 3104 H	Sep Dist Mon Interstage No. 3	FM/FM	M
GB 3105 H	Sep Dist Mon Interstage No. 4	FM/FM	M

4) Acceleration:

GA 3001 A	Accel, X Axis No. 1	FM/FM	M
GA 3002 A	Accel, X Axis No. 2	FM/FM	M
GA 3003 A	Accel, Y Axis No. 1	FM/FM	M
GA 3004 A	Accel, Y Axis No. 2	FM/FM	M
GA 3005 A	Accel, Z Axis No. 1	FM/FM	M
GA 3006 A	Accel, Z Axis No. 2	FM/FM	M
GH 1313 V	Volt, Pitch GDA Pos (Ret/Ext)	PCM	HD
GH 1314 V	Volt, Roll GDA Pos (Ret/Ext)	PCM	HD
GP 2010 P	Press, Thrust Chamber	PCM	HD
GP 2010 P	Press, Thrust Chamber	FM/FM	M
GQ 6510 P	Press, Thrust Chamber	PCM	HD
GQ 6510 P	Press, Thrust Chamber	FM/FM	HD

*Any 3 out of 4 are mandatory; the other one is highly desirable.

N20.1 FITH ABORT STRUCTURAL EFFECTS

Background and Justification

This mission is the first opportunity to subject a LM to a FITH abort in an orbital environment prior to manning the LM. The loads resulting from the pressure and temperature environment during FITH staging were major factors in the design of a considerable portion of the LM ascent and descent stage structures and thermal shields in the interstage area. Therefore, to insure crew safety during this maneuver, the verification of the ascent and descent stage structure and thermal shield to withstand the FITH pressure and thermal loading environment must be accomplished prior to the first manned LM flight. The design environment was obtained from scale model tests with analytical methods used to obtain the full scale loads. Recent ground test results and additional analysis have resulted in modifications to the LM-1 structure and thermal shield in the interstage area. The major items of concern were the ascent stage base heat shield, used to protect the ascent stage structure, and the descent stage structure, used to protect the descent stage propellant tanks. The data obtained from this flight will verify the structure and the loads and thermal analysis methods.

The verified analysis methods will be used to predict the FITH abort pressures and temperatures using data from the PA-1 ground tests.

M20.2 FITH ABORT STAGING DYNAMICS

Determine staging separation dynamics.

Purpose

The purpose is to verify that stage separation, by FITH abort, can be satisfactorily completed prior to manned flight.

Test Conditions

The staging is initiated by FITH abort [i.e. DPS engine is at maximum thrust (100% throttle)].

Success Criteria

Satisfactory staging will be accomplished if the relative dynamics of the two stages does not jeopardize crew safety nor mission success for subsequent manned missions.

Evaluation

- 1) Determine angular and linear accelerations of the ascent stage and that recontact did not occur (GA 3001 A through GA 3006 A, GG 0001 X, GH 1461 V through GH 1463 V).
- 2) Determine the relative displacement of the stages and the angular rates (GB 3102 H through GB 3105 H, GA 3002 A, GA 3004 A, GA 3006 A, GH 1461 V, 1462 V, 1463 V, GB 0801 P through GB 0812 P and GB 0901 P through GB 0907 P).
- 3) Data from related objectives will be used to assist in the evaluation of this objective.
- 4) Above evaluation must consider the effects of configuration difference in the LM-1 ascent engine nozzle (LM-1 ascent engine nozzle is not canted or rotated).

Data Requirements

Telemetry Measurements:

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GA 3001 A	Accel, X Axis No. 1	FM/FM	M
GA 3002 A	Accel, X Axis No. 2	FM/FM	HD
GA 3003 A	Accel, Y Axis No. 1	FM/FM	HD
GA 3004 A	Accel, Y Axis No. 2	FM/FM	HD
GA 3005 A	Accel, Z Axis No. 1	FM/FM	HD
GA 3006 A	Accel, Z Axis No. 2	FM/FM	HD
GB 3102 H	Sep Dist Mon Interstage No. 1	FM/FM	M
GB 3103 H	Sep Dist Mon Interstage No. 2	FM/FM	M
GB 3104 H	Sep Dist Mon Interstage No. 3	FM/FM	M
GB 3105 H	Sep Dist Mon Interstage No. 4	FM/FM	M
GG 0001 X	PGNCS Downlink Data (To T/M)	PCM	HD
GY 0121 X	Sys A Staging Relay Open	PCM	M
GY 0122 X	Sys B Staging Relay Open	PCM	M
GB 0801 P	Press No. 1, Bot Surf Asc Stage	FM/FM	M
GB 0802 P	Press No. 2, Bot Surf Asc Stage	FM/FM	M
GB 0803 P	Press No. 3, Bot Surf Asc Stage	FM/FM	M
GB 0804 P	Press No. 4, Bot Surf Asc Stage	FM/FM	M
GB 0805 P	Press No. 5, Bot Surf Asc Stage	FM/FM	M
GB 0806 P	Press No. 6, Bot Surf Asc Stage	FM/FM	M
GB 0807 P	Press No. 7, Bot Surf Asc Stage	FM/FM	M
GB 0808 P	Press No. 8, Bot Surf Asc Stage	FM/FM	M
GB 0809 P	Press No. 9, Bot Surf Asc Stage	FM/FM	M
GB 0810 P	Press No.10, Bot Surf Asc Stage	FM/FM	M
GB 0811 P	Press No.11, Bot Surf Asc Stage	FM/FM	M
GB 0812 P	Press No.12, Bot Surf Asc Stage	FM/FM	M
GB 0813 P	Press No.13, Bot Surf Asc Stage	FM/FM	M
GB 0814 P	Press No.14, Bot Surf Asc Stage	FM/FM	M
GB 0815 P	Press No.15, Bot Surf Asc Stage	FM/FM	M
GB 0816 P	Press No.16, Bot Surf Asc Stage	FM/FM	M
GB 0817 P	Press No.17, Bot Surf Asc Stage	FM/FM	M
GB 0818 P	Press No.18, Bot Surf Asc Stage	FM/FM	M

*Any 12 out of these 18 are mandatory; the other 6 are highly desirable.

GB 0901 P	Press No. 1, Top Surf Desc Stage	FM/FM	N
GB 0902 P	Press No. 2, Top Surf Desc Stage	FM/FM	N
GB 0903 P	Press No. 3, Top Surf Desc Stage	FM/FM	N
GB 0904 P	Press No. 4, Top Surf Desc Stage	FM/FM	N
GB 0905 P	Press No. 5, Top Surf Desc Stage	FM/FM	N
GB 0906 P	Press No. 6, Top Surf Desc Stage	FM/FM	N
GB 0907 P	Press No. 7, Top Surf Desc Stage	FM/FM	N

*Any 5 out of these 7 are mandatory; the other 2 are highly desirable.

Measurement
Number

Description

TM

Priority

GH 1461 V	Volt, Yaw RG Sig (.8 kc)
GH 1462 V	Volt, Pitch RG Sig (.8 kc)
GH 1463 V	Volt, Roll RG Sig (.8 kc)

PCM	H
PCM	H
PCM	H

Background and Justification

LM separation by FITH abort (DPS on) will not be planned on the Apollo manned development missions. Adequate data can be obtained from an unmanned demonstration of FITH abort. The LLM could require a FITH abort from the powered descent near the lunar surface, therefore, prior to the LLM a FITH abort separation must be successfully demonstrated.

It is currently planned to execute FITH separation (DPS - Off) on LM manned development missions. This test will be done to check the effects of changes in the APS configuration (e.g., engine cant or rotation) resulting in different interstage pressure pattern.

N20.3 FIFTH ABORT STABILITY CONTROL

Verify attitude control during fire-in-the-hole abort.

Purpose

The purpose of this objective is to verify that the LM ascent stage remains stable during and after a fire-in-the-hole abort prior to manned flight.

Test Conditions

- 1) Execute abort stage fire-in-the-hole sequence.
- 2) TM and tracking coverage required during fire-in-the-hole period.

Success Criteria

Data must indicate the ability of the DAP/RCS to maintain proper attitude control during fire-in-the-hole abort. This will be verified by determining that the following major DAP ascent control law functions were correctly applied to the computation of RCS control commands in response to vehicle attitude error, body rates, and angular accelerations:

- 1) Urgency logic (As specified in the latest Guidance System Operations Plan LM-1)
- 2) Axis selection logic using urgency functions
- 3) T_{Jet} (on time) computation logic
- 4) Pitch and roll jet-policy selection logic

Evaluation

Telemetry data will be utilized to verify satisfactory attitude control law computation and RCS on-off commands. (Measurement Numbers: GC 0001 X and GH 1481 V through GH 1433 V, GH 1461 V, GH 1462, and GH 1463 V)

Separation transients (body rates) will be evaluated with respect to preflight simulation data.

Tracking data will be evaluated to determine velocity vector errors during the APS burns.

Data Requirements

Telemetry Measurements:

<u>Measurement Number</u>	<u>Description</u>	<u>TM</u>	<u>Priority</u>
GC 0001 X	PGNCS Downlink Data (To T/M)	PCMD	M
GH 1418 V	Volt, Jet No. 4U Driver Output, 28V	PCME	M
GH 1419 V	Volt, Jet No. 4D Driver Output, 28V	PCME	M
GH 1420 V	Volt, Jet No. 4F Driver Output, 28V	PCME	M
GH 1421 V	Volt, Jet No. 4S Driver Output, 28V	PCME	M
GH 1422 V	Volt, Jet No. 3U Driver Output, 28V	PCME	M
GH 1423 V	Volt, Jet No. 3D Driver Output, 28V	PCME	M
GH 1424 V	Volt, Jet No. 3F Driver Output, 28V	PCME	M
GH 1425 V	Volt, Jet No. 3S Driver Output, 28V	PCME	M
GH 1426 V	Volt, Jet No. 2U Driver Output, 28V	PCME	M
GH 1427 V	Volt, Jet No. 2D Driver Output, 28V	PCME	M
GH 1428 V	Volt, Jet No. 2F Driver Output, 28V	PCME	M
GH 1429 V	Volt, Jet No. 2S Driver Output, 28V	PCME	M
GH 1430 V	Volt, Jet No. 1U Driver Output, 28V	PCME	M
GH 1431 V	Volt, Jet No. 1D Driver Output, 28V	PCME	M
GH 1432 V	Volt, Jet No. 1F Driver Output, 28V	PCME	M
GH 1433 V	Volt, Jet No. 1S Driver Output, 28V	PCME	M
GH 1461 V	Volt, Yaw RG Sig (.8kc)	PCM	M
GH 1462 V	Volt, Pitch RG Sig (.8kc)	PCM	M
GH 1463 V	Volt, Roll RG Sig (.8kc)	PCM	M

*1 of 2 mandatory with corresponding RCS chamber pressure.

N20.3 FITH ABORT STABILITY CONTROL

Background and Justification

Vehicle dynamics during the fire-in-the-hole abort staging event are not well known. The ability to maintain proper attitude control during a fire-in-the-hole abort should be satisfactorily demonstrated prior to manned LM operation.

Due to the short APS burn (≈ 5 sec.) and that the LM-1 engine is not canted, accomplishment of this objective must provide confidence that stability would exist for a canted LM engine and a longer duration APS burn.

5. SPACECRAFT CONFIGURATION

The spacecraft configuration for this mission consists of a spacecraft LM adapter (SLA), nose cap, and lunar module (LM). These spacecraft components are of standard configuration except as noted below.

5.1 SPACECRAFT LM ADAPTER (SLA)

- 1) Spacecraft jettison controller has been added.
- 2) UHF/VHF antennas (2) have been added.

5.2 NOSE CAP

- 1) A nose cap is used in lieu of a CSM for this mission.
- 2) The nose cap is detached from the SLA by pyrotechnic devices. Separation of the nose cap from the SLA is accomplished utilizing 24 springs which assures a minimum separation velocity of 7 ft./sec.
- 3) A launch escape system (LES) is not provided.

5.3 LUNAR MODULE (LM)

1) Equipment Added:

- a) LM Mission Programmer
- b) DFI Telemetry
- c) C-Band Transponders

2) Equipment Inoperative:

- a) O_2 Supply and Cabin Pressure Control Section
Note: Descent O_2 tank deleted, ascent O_2 tanks used to supply reference pressure to water management section.
- b) Atmosphere Revitalization Section
- c) Secondary Coolant Loop of Heat Transport Section
NOTE: Primary Coolant Loop will be operative.
- d) VHF Inflight Antennas (Operational)

e) S-Band Steerable Antenna

f) Rendezvous Radar Antenna

g) Landing Radar Antenna

h) S-Band Omni Antenna +Z Axis

Note: S-Band -Z axis omni antenna will be operative

i) All Displays with Minor Exceptions

3) Equipment Deleted:

a) Landing Point Designator

b) VHF Transceivers (Operational)

c) Landing Gear

d) Crew Provisions

e) Tracking Lights

f) Alignment Optical Telescope

g) Abort Guidance System

h) Rendezvous Radar Electronics

i) Landing Radar Electronics

j) Attitude Controller Assembly (2) (Removed prior to flight)

k) Thrust Translation Controller Assembly (2) (Removed prior to flight)

l) Descent O₂ Tank

4) Equipment Major Differences:

a) LM-1 cabin leak rate is greater than maximum specification value.

b) Descent battery #1 is connected to the systems engineer's buss and descent batteries #2, 3 and 4 are connected to the commander's buss. The normal LM configuration consist of two descent batteries on each buss.

c) Descent batteries will be predischarged and placed on high voltage tap prior to launch.

- d) Only a single AC buss is provided.
- e) Two primary water boilers (sublimators) in lieu of the one on other LM vehicles. One of these boilers will be used as a Freon boiler to supplement the prelaunch cooling equipment.
- f) The descent propulsion system is not equipped with the helium start bottle or lunar surface propellant tank vents.
- g) The ascent engine is not canted or rotated.
- h) Four jet ullage maneuvers are programmed using two jet ullage time durations. $DPS = 7.5 + .5 = 8.0 \text{ sec.}$
 $APS = 12.5 + .5 = 13.0 \text{ sec.}$
- i) RCS thrust chamber pressure transducers are analogue in lieu of pressure switches.
- j) Both ED batteries are mounted in the descent stage.
- k) LGC software programs are not used.
- l) PRA software is provided for contingent operations.
- m) LM thermal coating on top of descent stage has been increased.

6. MISSION PLANNING REQUIREMENTS

The Apollo 5 mission will be designed to demonstrate the LM crew safety items required on manned flights. Mission objectives will be confined to full duration burns of each stage, restart of each stage, fire-in-the-hole abort mode, and depletion burn of the ascent stage. Mission events which contribute to mission complexity and thus jeopardize the probability of objective achievement will not be a part of the formal mission (Reference 3).

The Apollo 5 mission will be formally concluded with the ascent engine burn to propellant depletion (APS-2 burn). If the LM systems have operated properly, all mission objectives will have been achieved at this time. The spacecraft (LM-1 ascent stage) will have sufficient consumables (electrical power, cooling water and RCS propellants) to remain active for approximately four additional revolutions. During this "post mission flight activity phase", some additional subsystems/systems tests will be conducted to obtain performance data for engineering evaluation.

These post mission flight activities will include "off nominal/critical limit" type performance tests such as forced helium ingestion by the RCS from a depleted APS, RCS operations with low feed pressure and RCS propellant depletion burns (includes quantity gauging evaluation). Additional critical limits data will be obtained as spacecraft systems fail from lack of cooling and/or low voltage if spacecraft telemetry systems life and ground station coverage permit.

System performance in contingent modes will also be evaluated during this post mission flight activity period. These contingent modes include:

- 1) DAP performance with various RCS thruster pairs isolated.
- 2) LGC acceptance of target, clock, and timer updates.
- 3) LGC and DAP response to commanded desired attitudes.
- 4) Inverter switchover circuitry performance and affects on buss voltage and loads.
- 5) Battery alternate feed path selection circuitry performance and its affects on buss voltages and loads.
- 6) Secondary S-Band selection circuitry performance and comparison of secondary S-Band performance with Primary S-Band performance.

- 7) Secondary water feed selection circuitry performance and its affects on ECS performance.
- 8) LMP performance while processing Real Time Commands and executing PRA sequences.
- 9) RCS thruster pair performance after being isolated and cold soaked for approximately 90 minutes.
- 10) Light ascent stage (no APS propellants) stability characteristics in maximum and minimum deadbands.

Mission objectives will not be provided for post-mission flight activities.

7. ALTERNATE MISSION AND ABORT GUIDELINES

Apollo 5 Mission Planning shall include development of an abort plan to assure achievement of the maximum number of mission objectives if an abort occurs during the orbit insertion phase (S-IVB operation). The Abort Plan should include a suborbital abort sequence designed to provide two burns of each of the LM engines (DPS & APS). The Abort Plan should also consider contingency orbit insertion with the LM descent engine for aborts late in the S-IVB phase.

Alternate mission plans shall include maximum usage of the DPS and APS including "FITH" abort. Burn durations shall be the maximum durations compatible with trajectory limit lines and ground station coverage.

8. EXPERIMENTS

No medical, scientific or Department of Defense experiments will be conducted.

APPENDIX A

CONFIGURATION CONTROL OF THIS DOCUMENT

Configuration control will be exercised by the MSE. Depending on the type of change, the authority to approve or reject a change is given to the CCB, the Apollo Spacecraft Program Manager or the MSE. The MSE will determine the type of change and submit the change to the approving authority as outlined below.

1. CCB will approve or reject changes which:
 - a. Result in a mission profile change
 - b. Add a new primary objective
 - c. Delete an existing primary objective
 - d. Require a spacecraft hardware or software change
 - e. Result in a mission rule or limitline change
 - f. Result in an objective priority change
 - g. Cause a schedule slip
2. The Apollo Spacecraft Program Manager, in lieu of the CCB, will approve or reject changes which are of the above type but which also require immediate action.
3. The MSE will approve or reject all other changes.

PD7/Chief will assume the MSE's change control responsibilities in the MSE's absence. In addition, PD7 will receive and insure proper content of the proposed changes.

The originator is responsible to prepare the proposed revision to include the below listed information and obtain his directorate's concurrence prior to submittal to PD7 along with an RECP if required. Similarly, the contractor will officially submit proposed revisions and, if applicable, an ECP. These should be sent to ASPO, attention: PD7. For those changes requiring CCB or Apollo Spacecraft Program Manager approval, PD7 will set up a MR revision meeting and act as secretary. The secretary will determine the attendance and notify the Division Point of Contacts. The Division Point of Contacts are as follows:

PT	A. D. Mardel
PE	O. G. Morris
E&D	P. M. Dean
FM	C. Huss/M. Jenkins
FC	E. F. Kranz
CF	N. R. Anderson
CA	Primary Crew
Contractors - NAR/A. K. Smith	
	GAEC/R. Pratt
	MIT/MSD - J. F. Hanaway will interface

The MSD will be the MR Revision Meeting Chairman. The chairman will have the responsibility to assign actions as necessary to determine the effect of the proposed revision on the following:

1. LV & S/C trajectories plans
2. Systems and consumable analyses
3. Mission rules and limit lines
4. Flight plans
5. Schedules

The MSE will present the MR revision and the results of the above meeting to the CCB or Apollo Spacecraft Program Manager with a recommendation. The originator of the revision will be present to answer any questions and to submit, if required, an RECP according to CCB procedures. The CCB procedures are defined in the ASPO Configuration Control Plan.

The MR and subsequent mission planning will implement the change after CCB, Apollo Spacecraft Program Manager or MSE approval depending upon the type of change. Approval will be documented by PD7 on a change identification page and, if required, a memo giving rationale and enclosing change pages. Rejections by the CCB will be documented in the CCB minutes and PD7 will prepare a memo for rejected changes by the Apollo Spacecraft Program Manager and the MSE and distribute as a minimum to the originator and his Division Chief.

The originator is responsible to submit the specified information as listed below:

1. To add a new objective, submit:
 - a. Statement of Objective

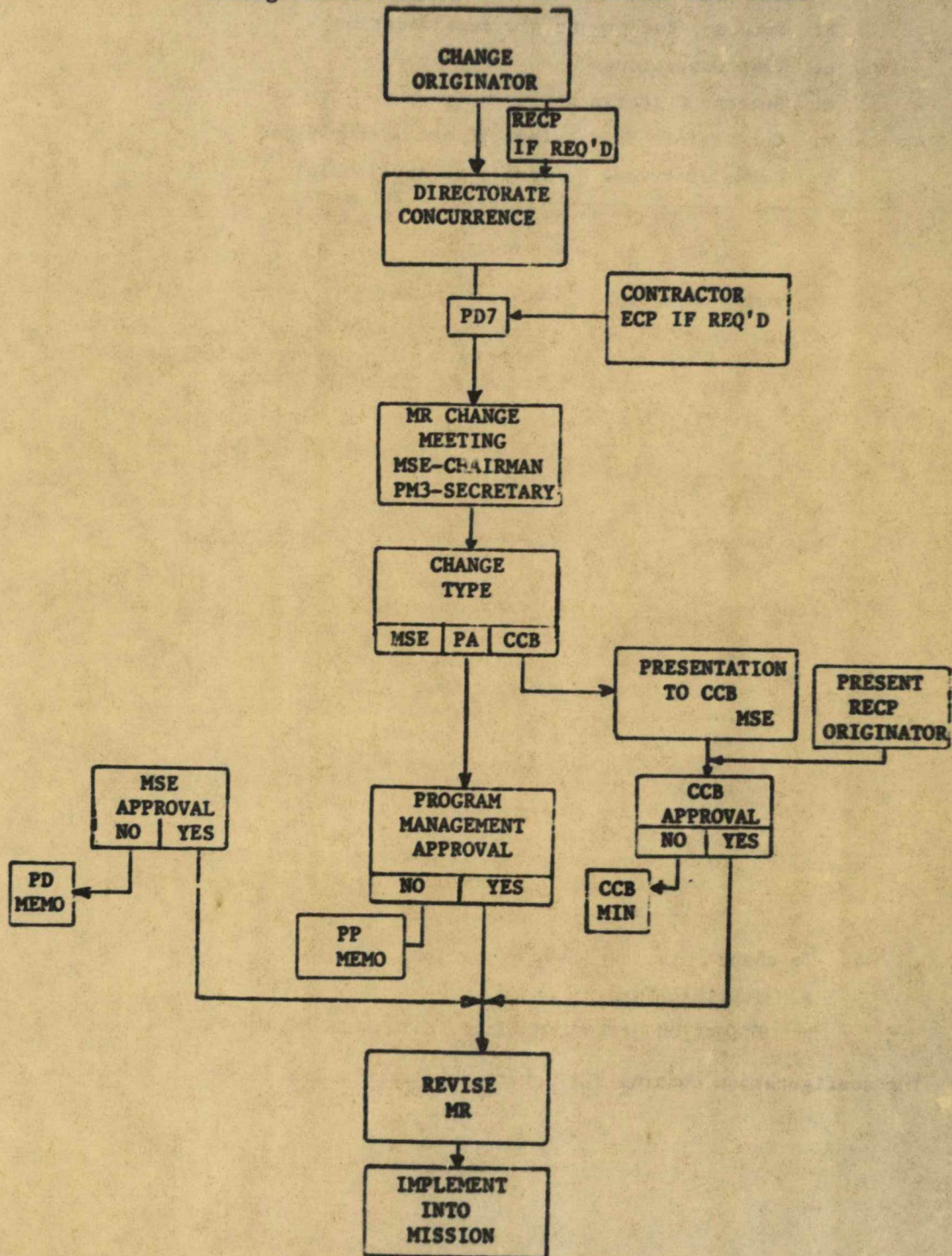
- b. Purpose, Background and Justification
 - c. Test Conditions
 - d. Success Criteria
 - e. Constraints to missions if not accomplished
 - f. Gross statement to cover, as applicable:
 - 1) Consumable requirements
 - 2) Trajectory requirements
2. To modify an existing objective, submit:
- a. Mandatory changes to each item above except Background and Justification. In addition to the above, include mandatory changes to evaluation and data requirements.
 - b. Justification for change.
3. To delete existing objective, submit:
- a. Justification
 - b. Purpose for existing objective and why the purpose is no longer valid

NOTE: The priority of objectives are based on the importance each one has compared to the others on that mission. Importance is usually based on the relative confidence of the ground and previous flight tests and analysis, constraint on subsequent mission planning and somewhat to the leadtime to incorporate in a subsequent mission. Therefore, the objective priority will not be changed because the non-accomplishment of this objective will prevent the non-accomplishment of a higher priority objective; e.g., CM-RCS secondary objective is not going to be made mandatory because non-accomplishment could prevent accomplishment of the number 1 heat shield objective on Apollo 4.

4. To change mission planning policy, submit:
- a. Justification
 - b. Effect on present nominal, alternate or abort mission

The configuration control flow chart is shown on the following page.

Configuration Control Of This Document Flow Chart



APPENDIX B

ACRONYM LIST

AC	Alternating Current
AE	Ascent Engine
AGC	Apollo Guidance Computer
AGS	Abort Guidance System
APS	Ascent Propulsion System
A/RIA	Apollo/Range Instrumentation Aircraft
AS	Ascent Stage
ASA	Abort Sensor Assembly
ASPO	Apollo Spacecraft Program Office
BTU	British Thermal Unit
CCB	Configuration Control Board
CG	Center of Gravity
C&I	Communications and Instrumentation
CM	Command Module
C/W	Caution and Warning
DAP	Digital Autopilot
DFI	Development Flight Instrumentation
DOI	Descent Orbit Injection
DPS	Descent Propulsion System
DRM	Design Reference Mission
DS	Descent Stage
DTO	Detailed Test Objective
ECA	Electronic Control Assembly
ECP	Engineering Change Proposal
ECS	Environmental Control Subsystem
ED	Explosive Device
EPS	Electrical Power Subsystem
FITH	Fire-In-The-Hole
FM	Frequency Modulation

FTP	Flight Test Plan
GAEC	Grumman Aircraft Engineering Corp.
GDA	Gimbal Drive Actuator
G&N	Guidance and Navigation
GSOP	Guidance System Operation Plan
HD	Highly Desirable
He	Helium
HS	High Speed
HX	Heat Exchanger
Hz	Hertz
ICD	Interface Control Drawing
IG	Inner Gimbal
IMU	Inertial Measurement Unit
IU	Instrument Unit
KBPS	Kilobits Per Second
KHz	Kilohertz
KSC	Kennedy Space Center
LES	Launch-Escape Subsystem
LGC	LM Guidance Computer
LLM	Lunar Landing Mission
LM	Lunar Module
LMP	LM Mission Programmer
LMR	Launch Mission Rules
LR	Landing Radar
LTA	LM Test Article
LV	Launch Vehicle
M	Mandatory
MC	Megacycles
MCCH	Mission Control Center, Houston
MCCK	Mission Control Center, Kennedy
MG	Middle Gimbal
MSE	Mechanical Support Equipment
MSFC	Marshall Space Flight Center
MSFN	Manned Space Flight Network

NAR	North American Rockwell
OCF	Operational Checkout Procedures
OG	Outer Gimbal
OMSF	Office of Manned Space Flight
PA-1	Prototype Ascent Propulsion Rig
PAM	Pulse Amplitude Modulation
PCM	Pulse Code Modulation
PCMD	Pulse Code Modulation Digital
PGNCS	Primary Guidance and Navigation Control Subsystem
PGNS	Primary Guidance & Navigation Subsystem
PPH	Pounds Per Hour
PQGS	Propellant Quantity Gaging System
PRA	Program Reader Assembly
PRN	Pseudo-Random Noise
PSI	Pounds Per Square Inch
PSIA	Pounds Per Square Inch Absolute
RCS	Reaction Control Subsystem
RECP	Request for Engineering Change Proposal
RF	Radio Frequency
RG	Rate Gyroscope
RMS	Root Mean Square
RR	Rendezvous Radar
S-1B	Saturn 1B
S-IVB	Saturn IVB
SAR	System Assessment Review
S/C	Spacecraft
SJC	Spacecraft Jettison Controller
SLA	Spacecraft Launch-Vehicle Adapter
S/N	Serial Number
TBD	To Be Determined
TCA	Thrust Chamber Assembly
TM	Telemetry
TVC	Thrust Vector Control

VHF
WSTF

Very High Frequency (30 - 300 MC)
White Sands Test Facility

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- (4) Apollo Spacecraft Flight Test Plan, 05952-H310-RO-00, 15 October 1967.

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