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INTRODUCTION

Volume V presents detailed test plans for the multiple systems tests described in Section 5.0 of Volume I. These detailed test plans specify the test location and define the manner in which S&ID will accomplish the testing required to qualify the Apollo spacecraft for manned earth-orbital flight.

Information included in the detailed test plans defines the test vehicle configuration, test concepts and objectives, data requirements, on-site and off-site receiving requirements, acceptance and checkout tests, significant test procedures, and required test equipment and facilities.

Detailed test plans for multiple systems tests will be incorporated in this volume at least six months before the tests are scheduled to begin. As soon as the airborne spacecraft (S/C) detailed test plans (Sections 1.0, 2.0, and 3.0) are approved by NASA, they will be issued separately by NASA as Project Apollo Flight Mission Directives, and will not appear in this volume.

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1.0 PAD ABORT DETAILED TEST PLANS

1.1 BOILERPLATE 6 DETAILED TEST PLAN

The over-all requirements for the Apollo Pad Abort Test I at White Sands Missile Range are contained in the NASA Project Apollo Working Paper No. 1049A, Project Apollo Flight Mission Directive for Pad Abort I, dated 24 January 1963 (Confidential). This document supplements and takes precedence over all previous issues of the S&ID Boilerplate 6 Detailed Test Plan.

Apollo Pad Abort Test I was conducted successfully at White Sands Missile Range on 7 November 1963. Details are contained in SID 63-1416, Project Apollo Flight Test Report, Boilerplate 6, dated 7 December 1963.

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2.0 LITTLE JOE II DETAILED TEST PLANS

2.1 BOILERPLATE 12 DETAILED TEST PLAN

The over-all requirements for the Apollo High-q Abort Test Mission A-001 at White Sands Missile Range are contained in the NASA Project Apollo Working Paper No. 1065, Project Apollo Flight Mission Directive for Mission A-001, dated 31 January 1963 (Confidential). This document supplements and takes precedence over all previous issues of the S&ID Boilerplate 12 Detailed Test Plan.

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3.0 APOLLO-SATURN DETAILED TEST PLANS*

3.1 BOILERPLATE 13 DETAILED TEST PLAN

The over-all requirements for the Apollo Boilerplate 13 vehicle for launch environment test at the Atlantic Missile Range are contained in NASA Project Apollo Working Paper 1085, Project Apollo Flight Mission Directive for Mission A-101, dated 31 July 1963 (Confidential). This document supplements and takes precedence over all previous issues of the S&ID Boilerplate 13 Detailed Test Plan.

3.2 BOILERPLATE 15 DETAILED TEST PLAN

The Boilerplate 15 Detailed Test Plan is presented on the following pages as an independent document, capable of being removed as a unit from this volume. The paragraphs, tables, pages, and illustrations are all numbered and listed separately from the over-all numeration of this volume. There are 112 pages in this document including pages i through vii and 1 through 105.

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DETAILED TEST PLAN
BOILERPLATE 15
(U)

11 November 1963

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1.0 INTRODUCTION

1.1 PURPOSE

This document presents the detailed test plan for Boilerplate 15 to be utilized for testing at Downey and AMR until superseded by the NASA Project Apollo Flight Mission Directive for Boilerplate 15.

1.2 SCOPE

The scope of this detailed test plan is to specify test objectives, describe vehicle configuration, establish system priorities, present flight trajectories, and describe the instrumentation requirements for Boilerplate 15 testing, as well as the S&ID method of qualifying the test vehicle for the mission.

1.3 PRECEDENCE OF REPORTS

The detailed test plan for Boilerplate 15 will take precedence over all other reports and documents concerned with Boilerplate 15 testing except the NASA Project Apollo Flight Mission Directive for Boilerplate 15, when published.

1.4 AMENDMENTS

This document shall be revised quarterly or as often as necessary to reflect changes in the test plan and to provide additional information not available at time of publication.

1.5 DEFINITION OF OBJECTIVE TERMINOLOGY

The definitions of terms used in connection with the objectives are as follows:

1. Demonstrate. This term denotes the occurrence of an action or an event during a test. The accomplishment of an objective of this type requires a qualitative answer. The answer will be derived through the relation of this action or event to some other known information or occurrence. This category of objective implies a minimum of airborne instrumentation, and/or that the information be obtained external to the spacecraft.

2. Determine. This term denotes the measurement of performance of any system or subsystem. This category implies a quantitative investigation of over-all operation, which generally includes instrumentation for measuring basic inputs and outputs of the system or subsystem. The information obtained should indicate to what extent the system is operating as designed. The instrumentation should allow performance deficiencies to be isolated to either the system or to the system inputs.

3. Evaluate. This term denotes the measurement of performance of any system or subsystem, as well as the performance and/or interaction of its components that are under investigation. The accomplishment of objectives of this type requires quantitative data on the performance of both the system or subsystems and their components. The performance levels will then be analyzed for their contribution toward performance of the system. This category will provide the most detailed information of any of these categories.

4. Obtain Data. This term denotes the gathering of engineering information which is to be measured to augment the general knowledge required in the development of the over-all spacecraft. This category may also be used for supplemental investigation such as environmental studies and ground equipment studies. The degree of instrumentation is not implied by this definition.

5. Establish. This term denotes the gathering of engineering information for the development of ground procedures and operating techniques. Objectives in this category are not necessarily dependent on analytic studies.

1.6 DEFINITION OF OBJECTIVES

Test objectives are described as Apollo first-order or Apollo second-order. These categories are defined as follows:

1. Apollo First-Order Test Objectives. These test objectives must be achieved for the mission to be successful. They define the main purpose for conducting the test. Malfunction of spacecraft systems, ground support equipment (GSE), or instrumentation, which jeopardizes the attainment of first-order test objectives, will require a countdown hold or launch scrub until such time as a fix can be made.

2. Apollo Second-Order Test Objectives. Second-order test objectives are those desired to support future Apollo flights or to supply supplementary data for over-all spacecraft evaluation. Malfunction of spacecraft systems, GSE, or instrumentation, which jeopardizes the attainment of second-order test objectives, will not require a hold after start of countdown. Corrections thereafter may be made at the discretion of the NASA test director or the project engineer.

1.7 DEFINITION OF SYSTEM PRIORITIES

The spacecraft systems are assigned primary (P) or secondary (S) priorities. During the initial test program, when incomplete systems are tested, this definition will apply to the subsystem and component level.

1.7.1 Primary Systems (P)

Primary systems are those systems functionally required for the spacecraft to successfully complete its planned mission or to accomplish first-order test objectives. A hold or scrub will be mandatory if any of the primary systems indicate improper operation. A positive indication of satisfactory operation must be available for launch.

1.7.2 Secondary Systems (S)

Secondary systems are those systems not functionally required for the spacecraft to complete its planned mission. Malfunction of secondary systems will not require a mandatory countdown hold or scrub. Corrections thereafter may be made at the discretion of the NASA test director or the project engineer.

2.0 TEST OBJECTIVES AND SYSTEM PRIORITIES

2.1 GENERAL

The primary purpose of this mission is to demonstrate launch vehicle and spacecraft compatibility and alternate mode of launch escape system (LES) jettison, and to determine environmental parameters for verification of design criteria. The boilerplate spacecraft will be placed in an earth orbit by the Saturn I launch vehicle (SA-7). No recovery of the spacecraft is planned.

2.2 TEST OBJECTIVES

2.2.1 First-Order Test Objectives

1. Demonstrate the physical compatibility of the launch vehicle and boilerplate spacecraft under preflight and flight conditions.

2. Determine the launch and exit environmental parameters to verify design criteria.

3. Demonstrate the alternate mode of launch escape tower jettison, using the launch escape and pitch control motors.

2.2.2 Second-Order Test Objectives

1. Demonstrate the structural integrity of the launch escape system during the launch and boost phase.

2. Demonstrate the compatibility of the R & D communications and instrumentation system with the launch vehicle systems.

3. Determine the spacecraft boost and orbital trajectory parameters.

2.3 SYSTEM PRIORITIES

1. Launch Escape System

   a. Pitch control motor P

   b. Launch escape motor P

c.	Tower jettison motor	S
d.	Escape tower separation system	P
2.	Electrical Power System (EPS)	
a.	Battery power system	P
b.	LES sequencer	P
3.	Communications and Instrumentation System	
a.	Telemeter and antenna system	P
b.	Radar beacon	S
c.	Instrumentation	P and S
	(Parameter priorities are listed in B-15 Measurement Requirements, SID 63-565.)	
4.	Environmental Control System (ECS)	
a.	Equipment cooling system	S

3.0 MISSION DESCRIPTION

3.1 GENERAL FLIGHT PLAN

Boilerplate 15 will be launched into an earth orbit by the Saturn I (SA-7) from AMR launch complex 37. The SA-7 launch vehicle consists of a first stage S-I, a second stage S-IV, and an instrument unit (IU). The launch azimuth will be 90 degrees true with a programmed roll accomplished by the S-I to a flight azimuth of 105 degrees true. The trajectory will be controlled during powered phases of the flight by flight control signals to the S-I and S-IV from the instrument unit's inertial guidance system. The LES will be jettisoned by the alternate mode using the launch escape and pitch control motors, and the S-IV, instrument unit, and Apollo Boilerplate 15 combination will be inserted into orbit. The combination will tumble in earth orbit for an estimated life of two to three days. Telemetry and radar beacon signals will be monitored on at least the first pass over the AMR after orbit insertion. No recovery is planned. Boilerplate 15 configuration is shown in Figure 1.

3.2 SEQUENCE OF EVENTS AND FLIGHT PARAMETERS

The sequence of events and flight parameters from S-I ignition through orbit injection and S-IV cutoff are presented in Table 1.

3.3 TRAJECTORIES

The flight profile and trajectories for Boilerplate 15 are presented in Figures 2 through 9.

3.4 FLIGHT CONSTRAINTS

Flight constraints define the minimum mandatory tests which must be completed on each major vehicle system prior to launch. Failure to satisfactorily complete these tests will cause a flight hold. The flight constraints for Boilerplate 15 are presented in Table 2. The status of these constraints will be determined on a monthly basis. Final constraint review will normally occur during the test vehicle acceptance data package review at the AMR after boilerplate launch vehicle mating.

[redacted]

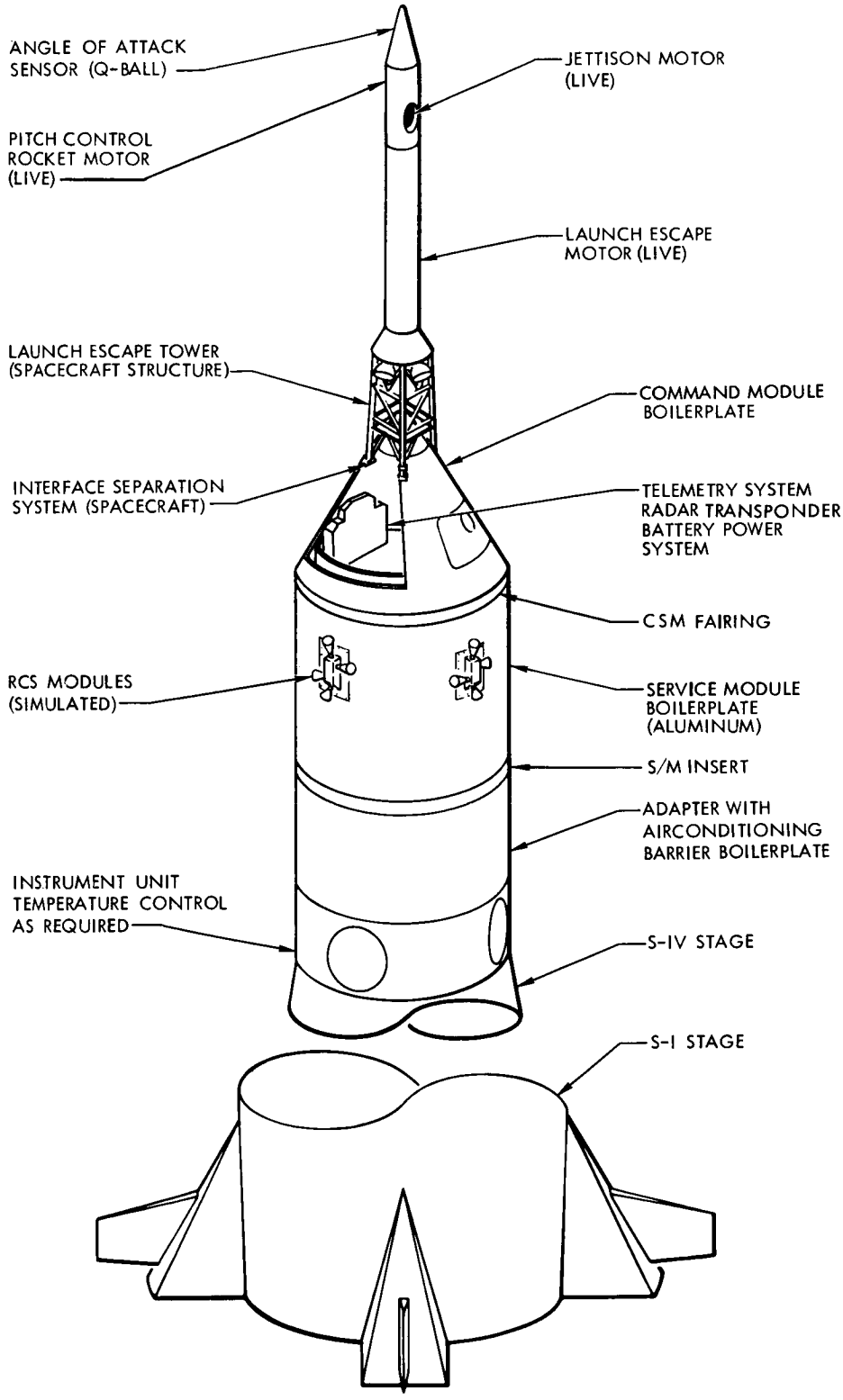

Figure 1. Boilerplate 15 Configuration

[redacted]

Table 1. Boilerplate 15 Sequence of Events and Flight Parameters

Time (sec)	Event	Earth-Fixed Velocity (ft/sec)	Altitude (ft)	Earth-Fixed Flight Path Angle (deg)	Dynamic Pressure (lb/ft^2)	Mach No.
T - 3.42	S-I ignition	0	0	90	0	0
T + 0	Lift-off	0	0	90	0	0
T + 69.5	Max Q	1,481	38,770	58.7	720	1.5
T + 141.7	S-I inboard engine cutoff	8,212	198,187	25.8	28.3	7.9
T + 147.7	S-I burnout, ullage rocket ignition, S-I/S-IV separation	8,718.3	219,886	24.8	11	8.9
T + 150.7	S-IV ignition	8,678.4	230,750	24.4	7	9.1
T + 160.7	Escape tower jettison	8,752.5	265,581	22.8	1.3	10.3
T + 165.7	Initiation of optimum attitude control	8,799	282,272	22	0.5	10.4
T + 429.7	Peak altitude	14,563.5	667,567	0	0	–
T + 624.5	Orbit injection, S-IV cutoff	24,242.3	607,609	0	0	–

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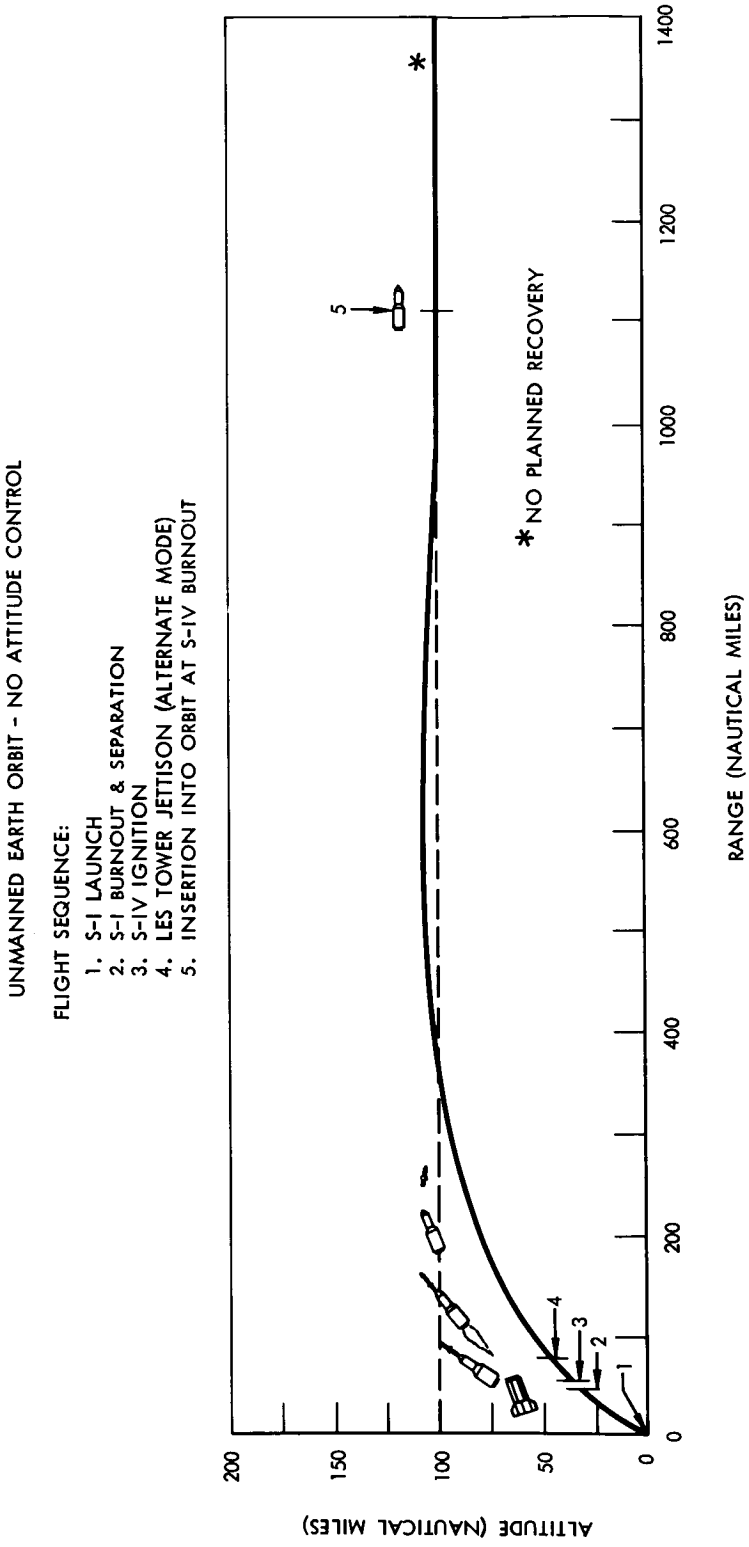

Figure 2. Boilerplate 15 Mission Launch Profile

[redacted]

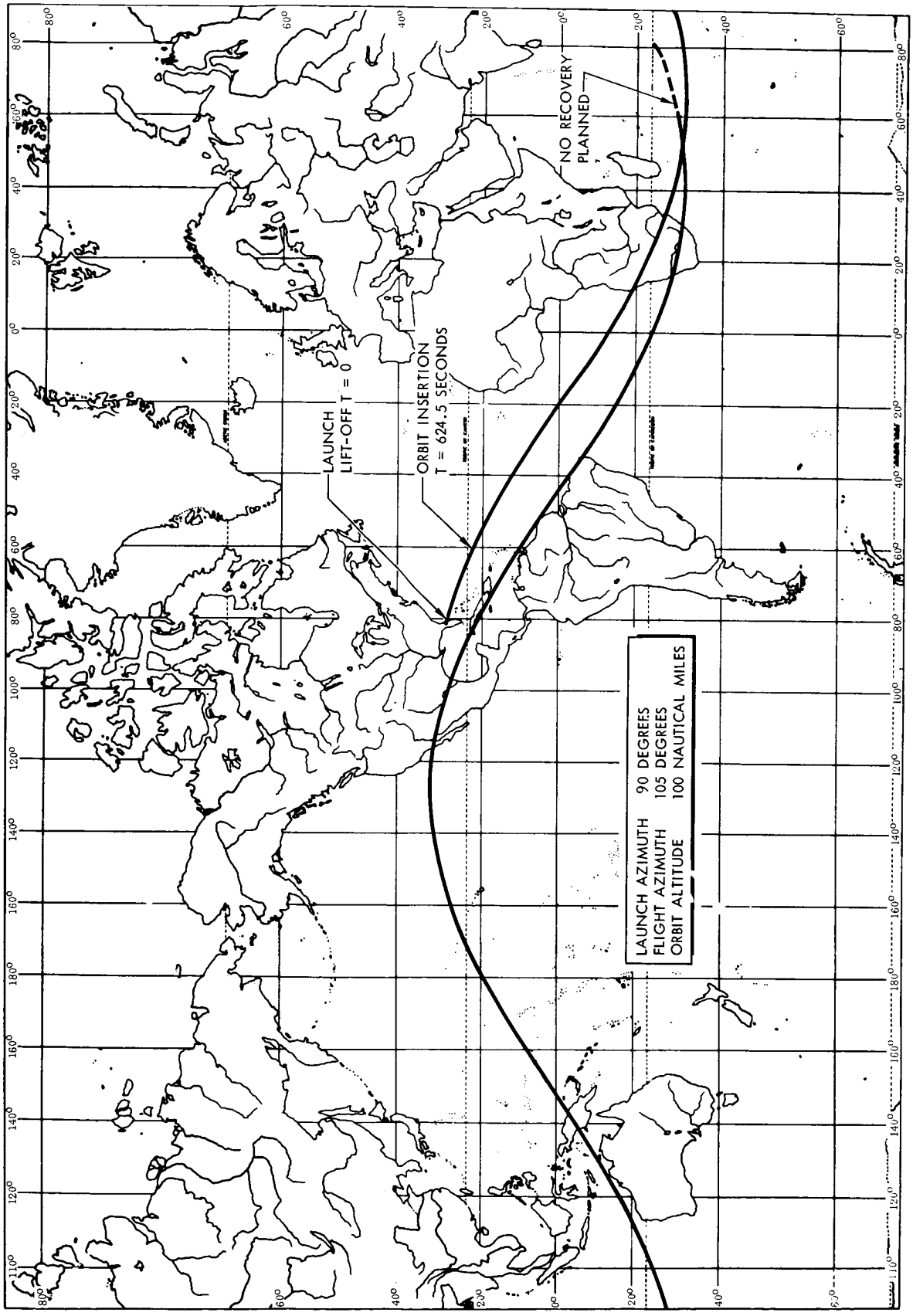

Figure 3. Boilerplate 15 Earth Orbital Trace

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[redacted]

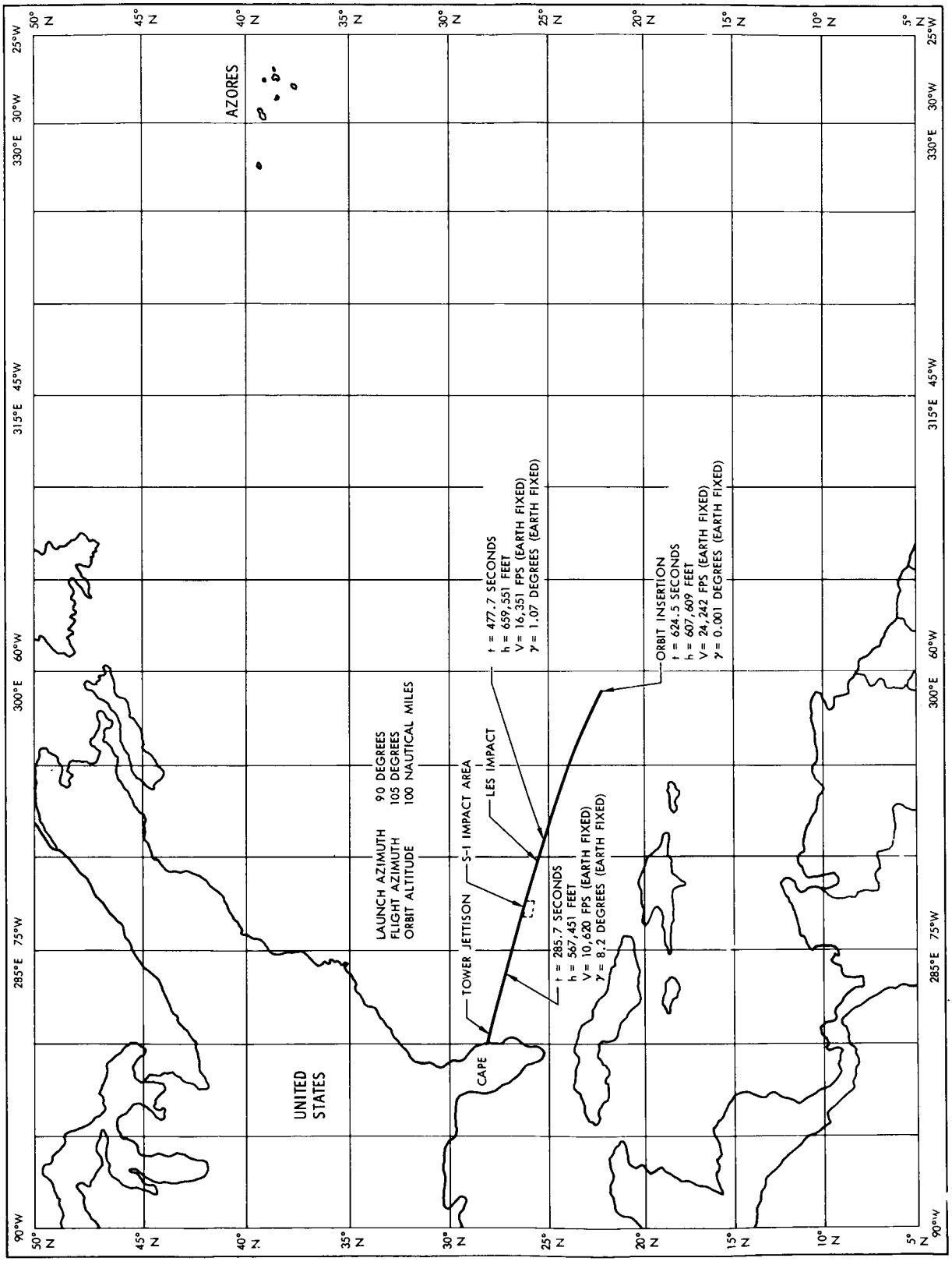

Figure 4. Boilerplate 15 Boost Trajectory Earth Trace (Latitude Versus Longitude)

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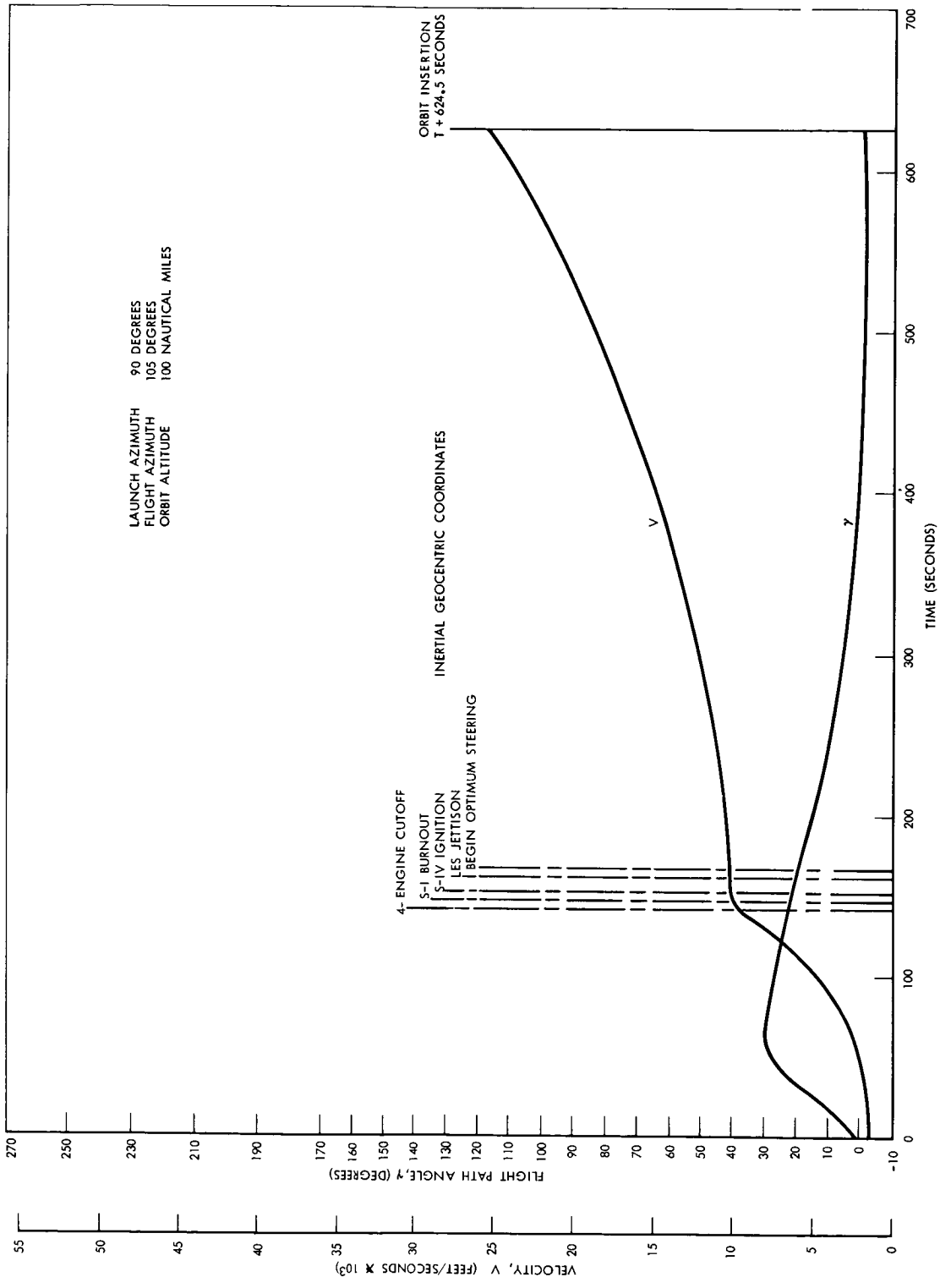

Figure 5. Boilerplate 15 Boost Phase Velocity/Flight Path Angle Versus Time

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[redacted]

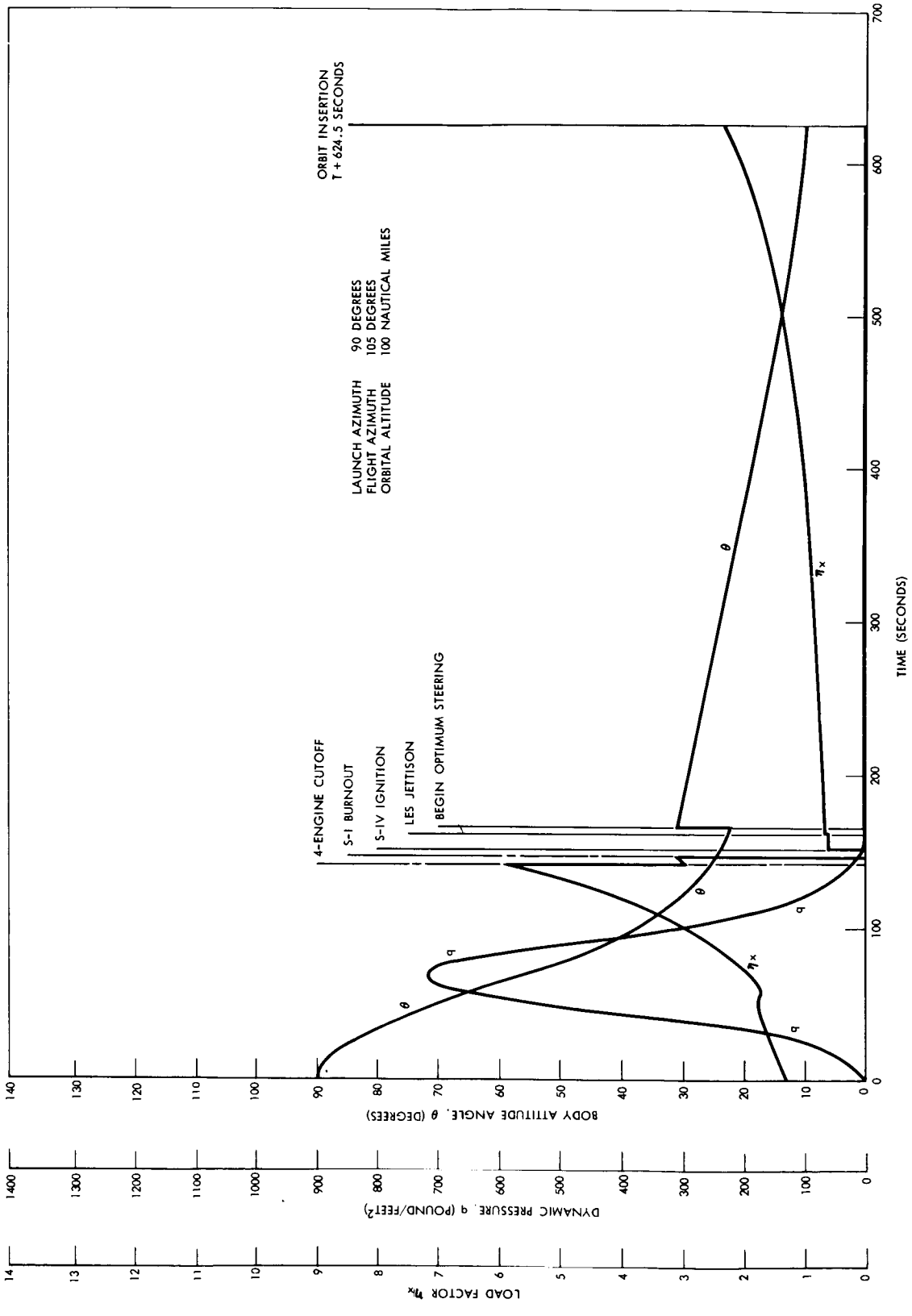

Figure 6. Boilerplate 15 Boost Phase Load Factor, Dynamic Pressure, and Attitude Angle Versus Time

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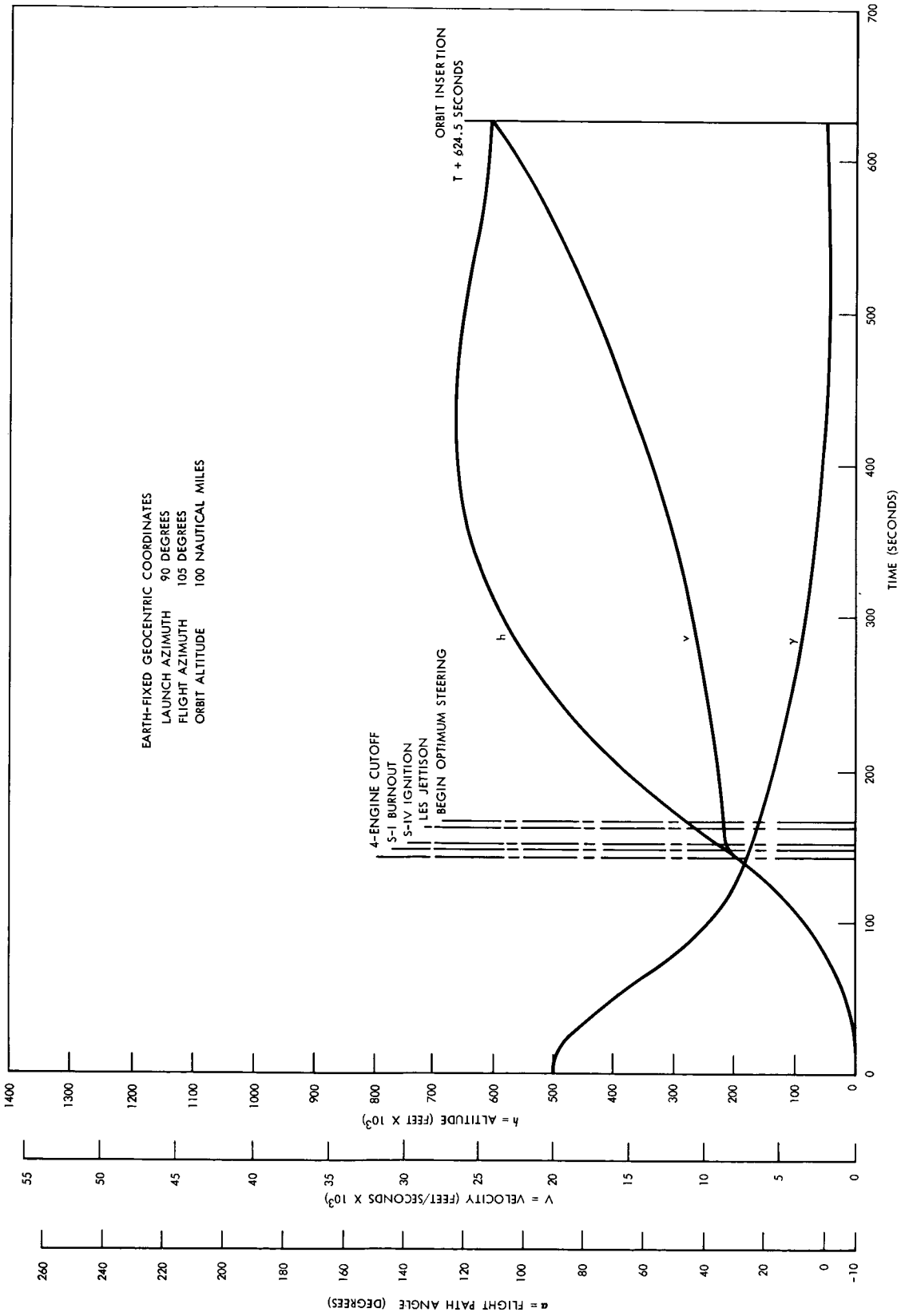

Figure 7. Boilerplate 15 Boost Phase Altitude, Velocity, and Flight Path Angle Versus Time

[redacted]

[redacted]

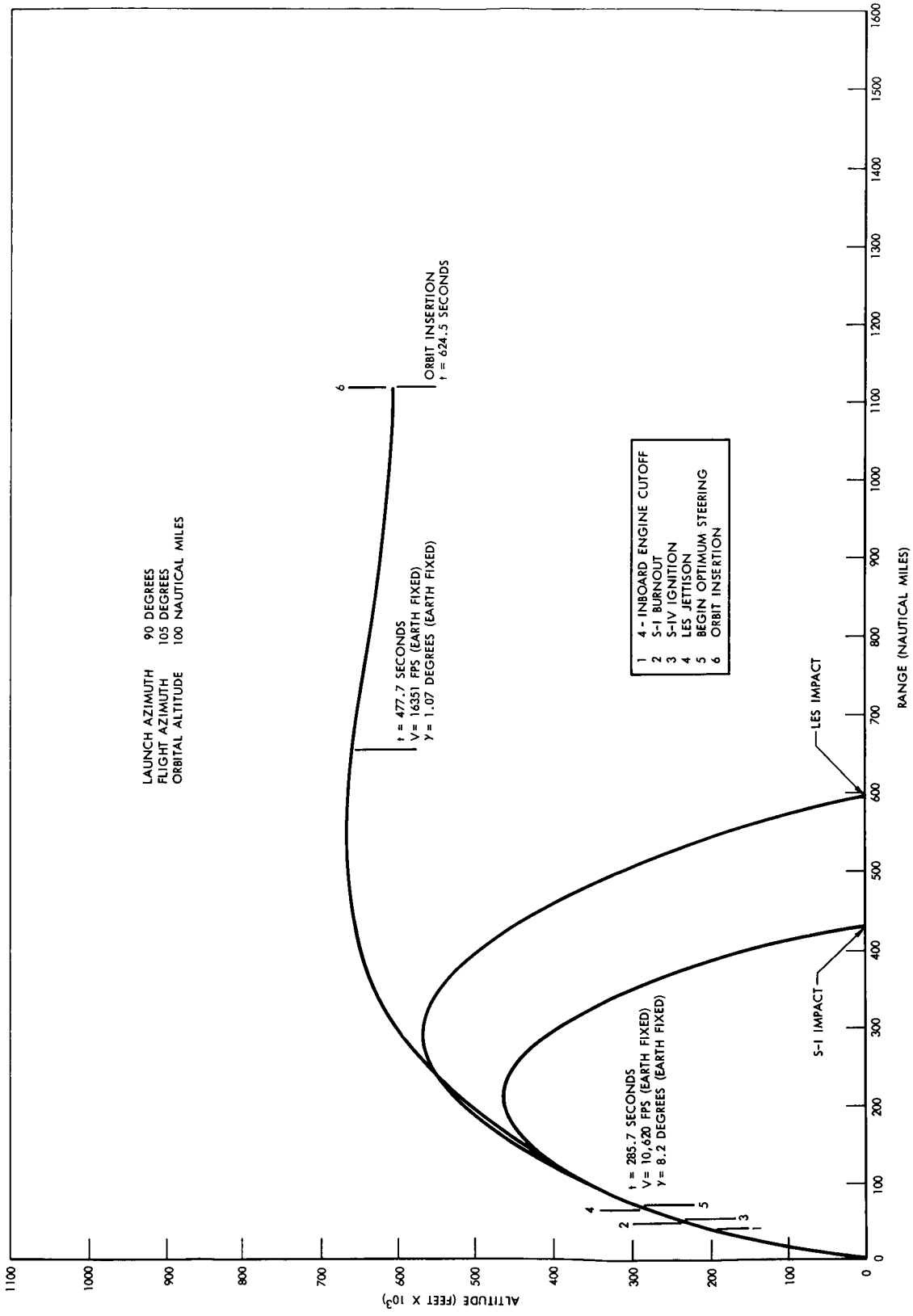

Figure 8. Boilerplate 15 Boost Phase Altitude Versus Range

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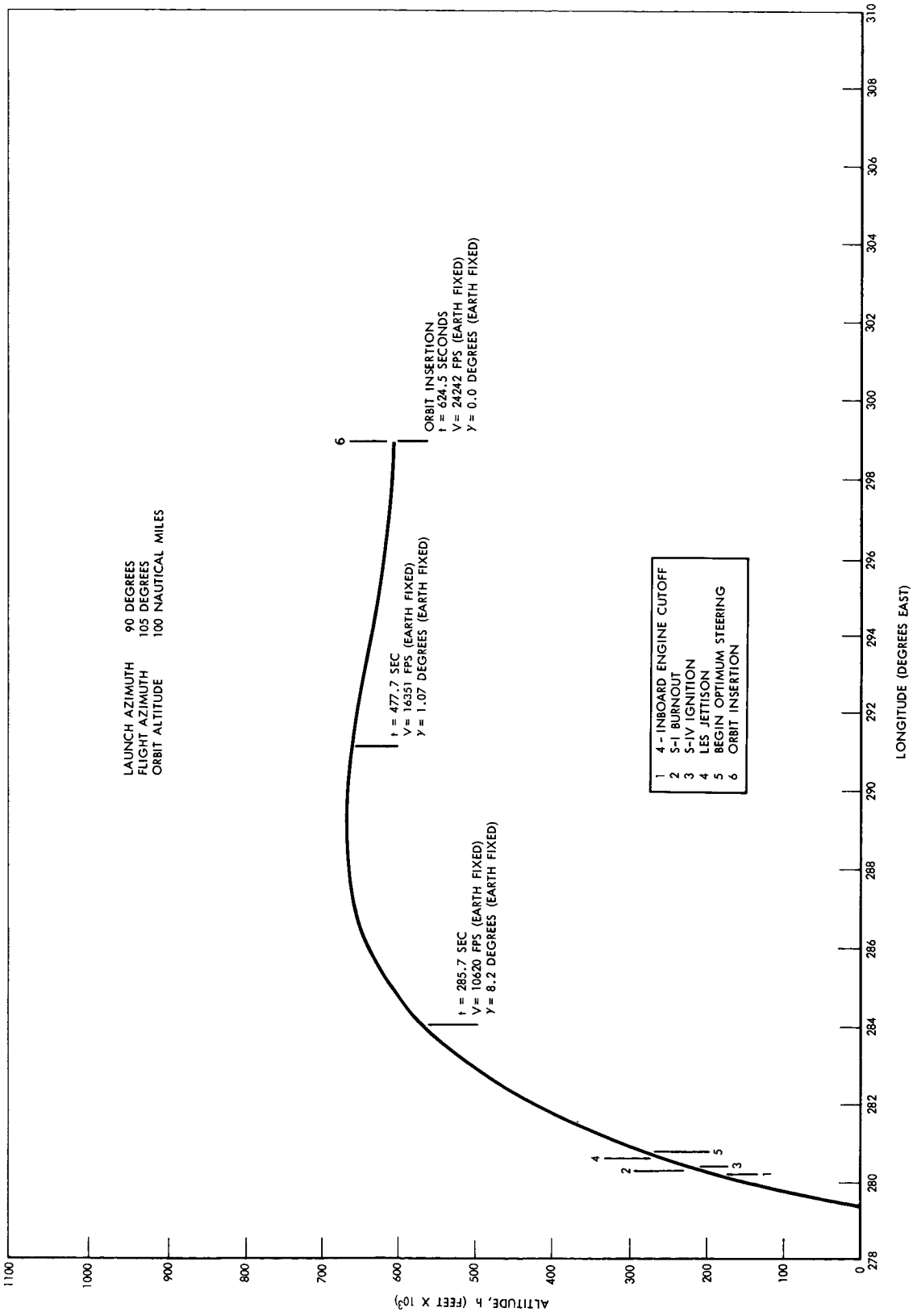

Figure 9. Boilerplate 15 Altitude Versus Longitude

[redacted]

Table 2. Boilerplate 15 Flight Constraints

Hardware	Constraint	Required Completion Date*
Tower jettison motor	Minimum of three firings of flight configuration motors and igniter cartridges—no unexplained deviation from Specification MC467-0001	10 April 1964
Pitch control motor	Minimum of three firings of flight configuration motors and igniter cartridges—no unexplained deviation from Specification MC901-0002	10 April 1964
Launch escape motor	Minimum of three firings of flight configuration motors and igniter cartridges—no unexplained deviation from Specification MC467-0005	10 April 1964
Sequencer system	Satisfactory completion of sequencer system mockup tests per ATR2547	10 April 1964
CM tower release system	Completion of separation system tests per ATR102B	10 April 1964
LES sequencer	Completion of flight worthiness tests per MA0205-0014	10 April 1964
Sequencing box	Completion of flight worthiness tests per MA0405-0002	10 April 1964

*Completion date required to proceed with AMR integrated systems test on schedule

[redacted]

4.0 DESCRIPTION OF TEST VEHICLE

4.1 SPACECRAFT WEIGHT AND BALANCE

Boilerplate 15 weights, center of gravity, and moments of inertia are presented in Table 3.

4.2 LAUNCH ESCAPE SYSTEM

The launch escape system consists of live pitch control, tower jettison, and launch escape motors. The LES also includes a structural skirt and spacecraft escape tower equipped with separation mechanism, instrumentation sensors, and wiring. Mounted within the nose cone is a Q-ball pressure sensing system.

4.2.1 Q-Ball

The Q-ball is a dynamic pressure sensor that provides pitch, yaw, and dynamic pressure signals to the instrument unit for trajectory control during the boost phase. The Q-ball is 19 inches long, weighs approximately 23 pounds, and is attached to the ballast enclosure.

4.2.2 Ballast Enclosure

The ballast enclosure forms the structure between the Q-ball and the pitch control motor support structure. It has a truncated-cone shape and provides the enclosure for the lead ballast which is attached to the pitch control motor support structure.

4.2.3 Pitch Control Motor

The pitch control motor is a live solid-propellant motor providing a thrust of 3400 pounds with a burn time of 0.5 seconds. the motor is 9 inches in diameter, 22 inches long, and weighs 35 pounds. The housing for the motor forms the structure between the ballast enclosure and the tower jettison motor.

4.2.4 Tower Jettison Motor

The tower jettison motor is a solid-propellant motor 26 inches in diameter, 47 inches long, and weighs 550 pounds. Two unequal exhaust

Table 3. Boilerplate 15 Weight, Center of Gravity, and Inertia Summary

Item	Weight (lb)		Center of Gravity (in.)*			Moments of Inertia (Slug-ft^2)		
	Ballast	Total	x	y	z	Roll (x)	Pitch (y)	Yaw (z)
Launch escape system	180	6,870	1,299.5	0	0.9	259	9,560	9,560
Command module	2,614	9,115	1,041	2.2	5.3	5,711	4,129	4,115
Service module	1,668	5,773	935.2	-2.6	-2.9	6,917	5,692	5,725
Service module insert		1,145	840.1	0	0	1,438	792	792
Adapter	402	2,567	765.5	-0.9	0.7	3,208	2,132	2,132
Total lift-off payload		25,470	1,050	0.1	1.3	17,410	180,800	180,780
Minus launch escape system		6,606						
Total in-orbit payload		18,600	957.9	0.1	1.8	17,145	50,747	50,740

*Centers of gravity are in the NASA reference system except that the longitudinal origin is 998.7 inches below the tangency of the command module structure mold line.

area thrust nozzles are positioned 30 degrees from the motor mean center line to provide a resultant thrust axis of 2.5±.5 degrees from the motor mean centerline in the pitch plane. Nominal thrust is 33,000 pounds for a burning time of 1.2 seconds.

4.2.5 Launch Escape Motor

The launch escape motor is a solid-fuel motor 26 inches in diameter, 183 inches in length, and weighs approximately 4826 pounds. Four fixed exhaust nozzles are canted to minimize impingement of jet blast on the CM. Resultant nominal thrust is 155,000 pounds at 36,000-foot altitude and 70 F.

4.2.6 Tower Structure

The launch escape tower is a truncated rectangular cross-section pyramid made of welded tubular titanium alloy. The tower is approximately 120 inches high with a base 46 by 50 inches. The tower forms the intermediate structure between the CM and the structural skirt. The tower structure is covered with an ablative material and is attached to the CM by explosive bolts with redundant shaped cutter charges.

4.2.7 Tower Sequencer

Dual sequencer units (channel A and B) are provided for the LES and are located on the tower structure. Each unit consists of one motor switch. An output voltage from the mission sequencer (located in the command module) drives each motor switch to the ARM position. The switches then allow electrical power from the pyro bus to fire simultaneously the tower separation explosive bolts and shaped charge squibs and the launch escape and pitch control motor ignition squibs.

4.2.8 Tower Separation System

The LES on Boilerplate 15 provides for automatic tower separation and jettison, using the launch escape and pitch control motors. Tower jettison will be initiated 10 seconds after S-IV ignition by a signal from the instrument unit to the mission sequencer. The mission sequencer in turn energizes the dual tower sequencer motor switches, which allow electrical power from the pyro batteries to energize simultaneously the tower separation explosive bolt, the shaped charge squibs, and the launch escape and pitch control motor ignition squibs. The tower assembly is separated and propelled clear of the CM trajectory by the launch escape and pitch control motors.

4.3 COMMAND MODULE

The command module is a boilerplate structure simulating the size, shape, weight, and center of gravity of the spacecraft airframe. The conical shaped module is 154 inches in diameter and 135 inches long. The aluminum stiffener frame and skin structure has cork exterior covering and interior fiberglass insulation. The module with its equipment and ballast weighs approximately 9115 pounds.

4.3.1 Crew Compartment

The crew compartment uses the frame stiffeners of the exterior shell for mounting the instrumentation, the electrical power system, and the ballast required to maintain the required CM weight and center of gravity. Also included in the compartment are the equipment cooling system, the telemetry system, and the measurement sensors. An aluminum alloy hatch is provided for prelaunch entrance to the crew compartment. The hatch cover is fastened to the CM by bolts.

4.3.2 Aft Heat Shield

The boilerplate heat shield is composed of an inner and outer layer of resin-impregnated glass laminations over an aluminum honeycomb core and is attached to the CM by four adjustable struts. The shield is similar to the spacecraft configuration except that it does not utilize ablative material.

4.3.3 Forward Compartment Cover

The command module forward compartment apex structure forms the forward section of the CM and consists of an aluminum alloy skin and stiffeners. Assembled at the apex is a fiberglass honeycomb radome housing the telemetry antenna.

4.3.4 Communications and Instrumentation System

The boilerplate communications and instrumentation systems are discussed in Section 7. These systems will remain in operation until battery power is expended.

4.3.5 Environmental Control System

The cooling system provides a continous flow of cool air to maintain the cabin air temperatures below 100 F during the preflight and initial boost phase and provides cold plates for the communications equipment. The system is designed to accommodate an umbilical disconnect at T minus 150 seconds. The system consists of a reservoir, coolant pump, five

coldplates, heat exchanger, fan, thermal control valves, pressure accumulator, water-glycol coolant solution, and associated plumbing. Power is supplied by the EPS.

4.3.6 Electrical Power System

The R & D electrical power system consists of three dual sets of 28-volt batteries, a power control box, a junction box, and associated wiring. The first set, consisting of two pyrotechnic batteries, is used by the tower release system and the launch escape and pitch control motor squibs. Each battery is a silver-oxide zinc 140 watt-hour Eagle Picher battery connected to a separate pyro bus. The second set of two logic batteries is of the same type and capacity as the pyro batteries and is used by the mission sequencer and escape tower motor switches. Each battery is connected to a separate bus. The third set of dual batteries is used to power the instrumentation and telemetry system, the equipment cooling system, and the radar transponders. Each battery is a silver-oxide zinc 3300 watt-hour Eagle Picher battery.

4.3.7 Mission Sequencer

The mission sequencer is a solid-state switching device located in the command module. The unit contains redundant transistor switches (channel A and B) which provide control of the two tower motor switches located in the tower sequencer. Ten seconds after S-IV ignition a signal from the instrument unit is received by the mission sequencer. Transistor switches are then energized by the logic battery voltage, and a signal is provided to the tower sequencer. In addition to the firing circuitry, the unit contains provisions for SAFE/ARM control from the GSE hard-line monitoring and telemetering monitoring.

4.4 SERVICE MODULE PLUS INSERT AND CM/SM FAIRING

The boilerplate service module is a cylindrical aluminum structure 154 inches in diameter and 124 inches long. An exterior nonstructural fairing 28 inches long, between the command module and the service module, houses a nonfunctioning separation mechanism, support structure for distribution of basic loads imposed by the command module on the service module, and fixed umbilical connections between the two modules. The length of the SM, including the CM/SM fairing, is 152 inches. The boilerplate SM length is extended to simulate airframe configuration by an aluminum insert 52 inches long, which is attached to the adapter. The length of the SM plus CM/SM fairing plus insert is 204 inches. The SM contains, in addition to the fixed umbilical, instrumentation sensors, ballast to simulate weight and c. g., fiberglass dummy reaction control system (RCS)

nozzles to simulate external configuration, four flush-mounted C-band antennas, and an umbilical fitting for external electrical and fluid lines. Total weight of the SM including the insert and ballast is approximately 6918 pounds.

4.5 SPACECRAFT ADAPTER

The adapter is a cylindrical aluminum structure attached to the instrument unit with bolts. It is 154 inches in diameter and 92 inches long. Within the adapter are measurement sensors and Apollo-Saturn interface wiring. No separation from the SM or the IU is required. Total weight is approximately 2567 pounds, including ballast. A panel which acts as an air barrier is mated between the adapter and the Saturn I instrument unit.

4.6 INSTRUMENT UNIT

The instrument unit of the Saturn I is a cylindrical section attached to the forward end of the S-IV stage containing the guidance and control system, flight sequencers, telemetry system, tracking system, electrical power system, and emergency detection system logic circuitry.

4.7 LAUNCH VEHICLE

The launch vehicle for Boilerplate 15 is a Saturn I, designated SA-7, consisting of a first stage S-I, second stage S-IV, and an instrument unit. The S-I generates a nominal sea-level thrust of 1,500,000 pounds using eight Rocketdyne H-1 engines burning liquid oxygen (LOX) and kerosene (RP-1). The S-IV generates a nominal vacuum thrust of 90,000 pounds using six Pratt & Whitney RL-10-43 engines burning LOX and liquid hydrogen (LH_2).

[redacted]

5.0 STRUCTURAL DESIGN CRITERIA

In general, the boilerplates are designed to the spacecraft's expected environmental conditions in the prelaunch, liftoff, boost, and earth orbit phases of the mission. More details of the structural design criteria are available in SID 62-700-2.

6.0 AERODYNAMIC STABILITY

Aerodynamic data for the launch configuration (Saturn I launch vehicle plus the Apollo spacecraft) are presented in Figures 10, 11, and 12.

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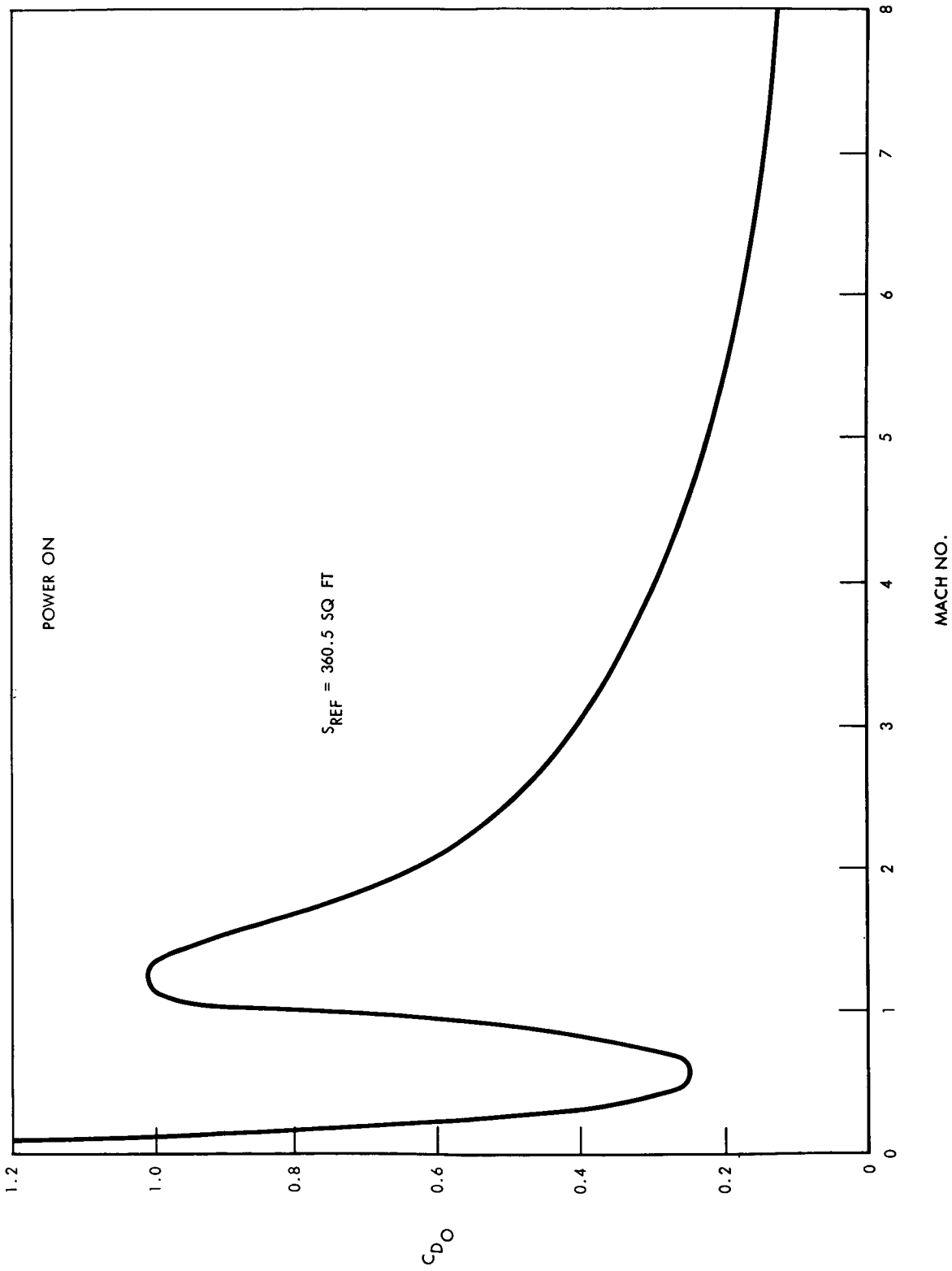

Figure 10. Saturn I Launch Vehicle Plus Apollo Drag Coefficient at Zero Lift

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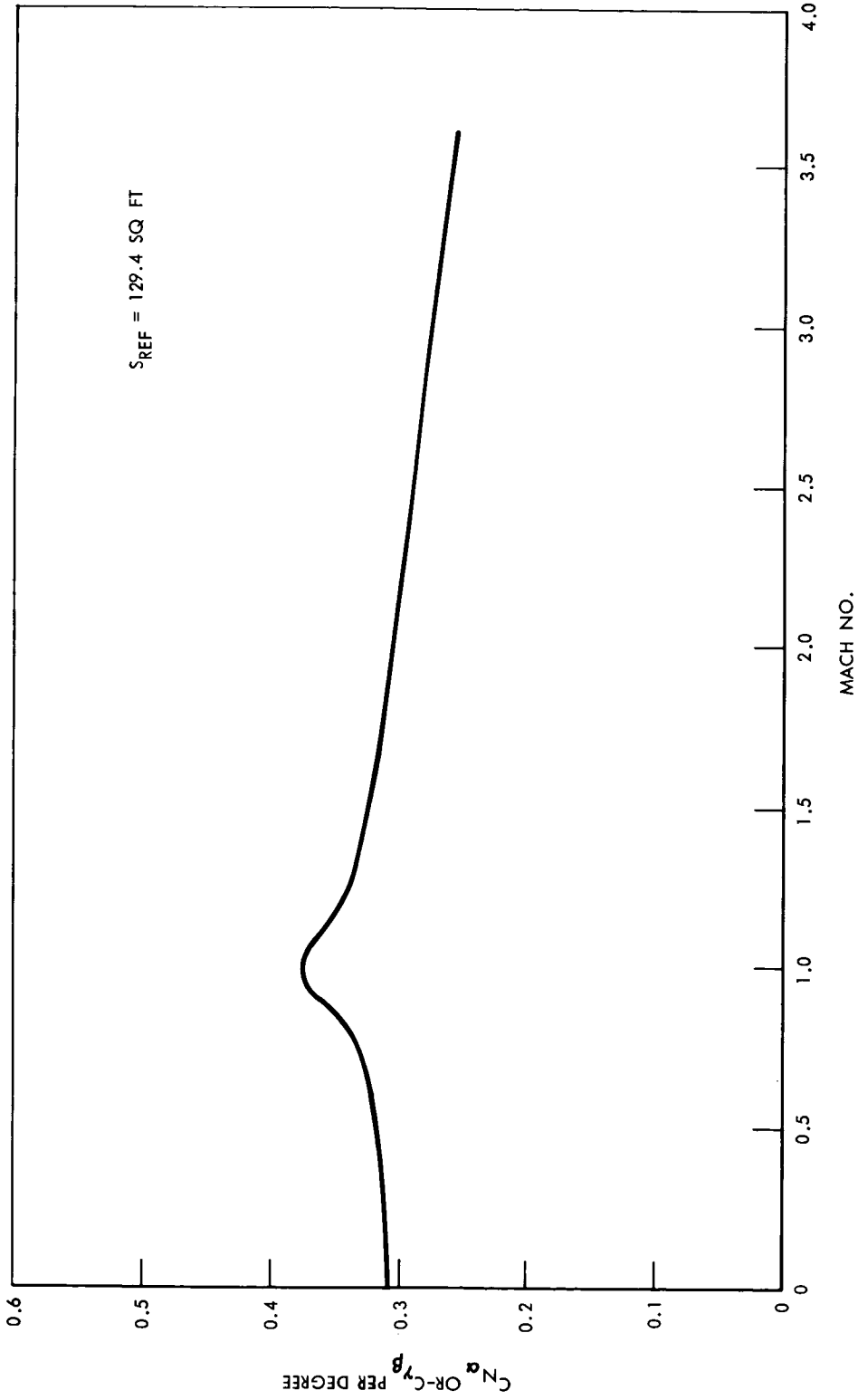

Figure 11. Saturn I Launch Vehicle Plus Apollo Normal Force and Side Force Derivatives

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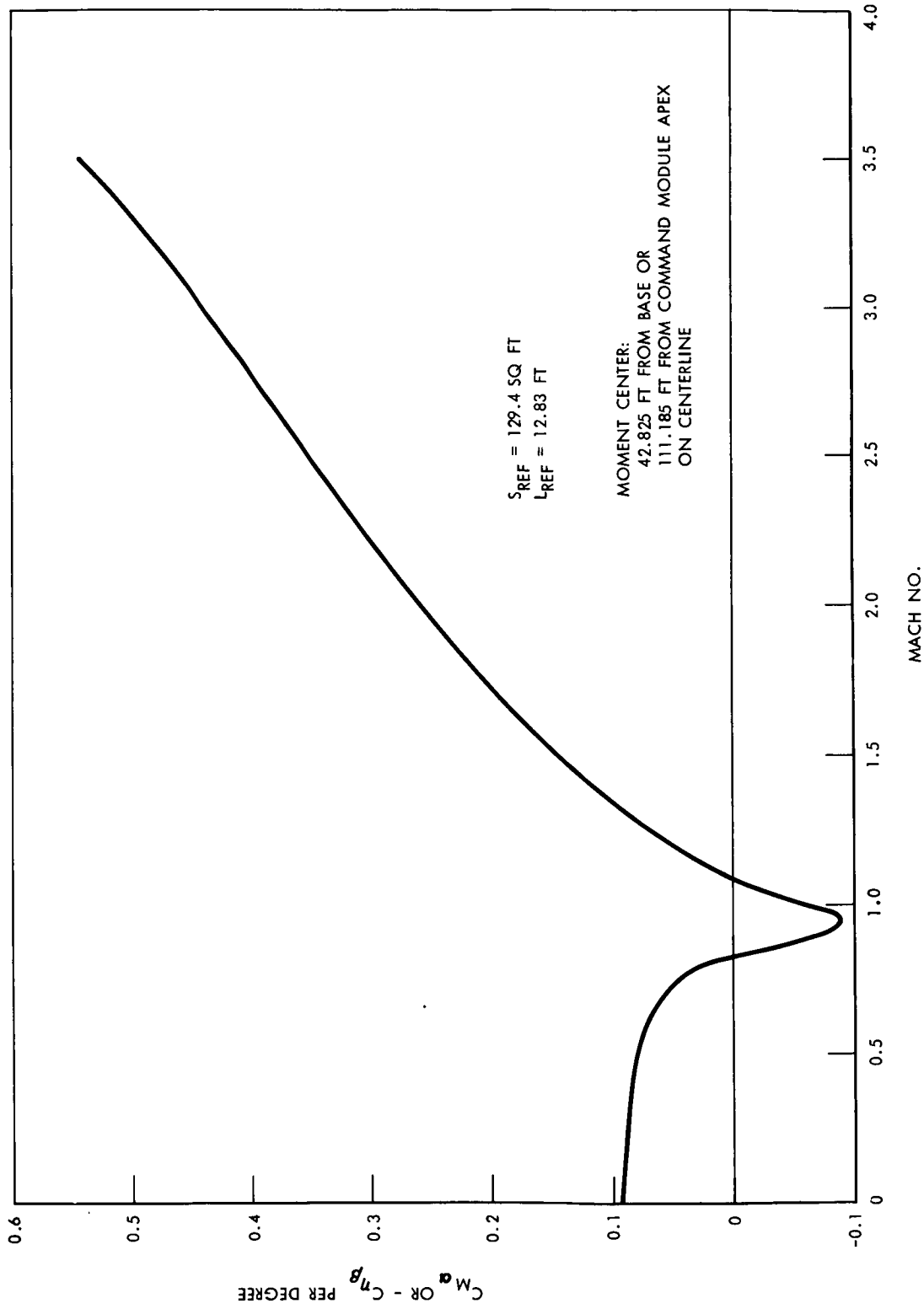

Figure 12. Saturn I Launch Vehicle Plus Apollo Pitching Moment and Yawing Moment Derivatives

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7.0 INSTRUMENTATION REQUIREMENTS

7.1 ON-BOARD INSTRUMENTATION

A block diagram of the on-board instrumentation system is presented in Figure 13. Figures 14 through 16 show the various measurement locations. The measurement list for Boilerplate 15 is presented in Table 4. The umbilical requirements are tabulated in Table 5.

7.2 DATA ACQUISITION SYSTEM

Three FM/FM telemetering systems operating in the VHF band between 216 and 260 megacycles are used to transmit data acquired on board the flight vehicle. Each telemetry (TM) system consists of a subcarrier oscillator package and transmitter unit. One of the three TM's will include a 90-sample by 10 revolutions per second commutator plus 11 continuous channels. The second TM will have 11 continuous channels and a 90-sample by 1.25 revolutions per second commutator. The last TM will have 12 continuous channels. The transmitter frequencies are TM A-237.8MC, TM B-247.3MC, and TM C-257.3MC.

7.2.1 Signal Conditioner Package

A signal conditioner unit is used to adapt all signals received from transducers to the required TM input signal and to direct this conditioned signal to the respective TM. All-range (R) and zero (Z) calibration circuitry is included in the unit. Z and R equal 15 and 85 percent, respectively, of a full scale (0 to 5 volts) signal.

7.2.2 C-Band Transponder

Dual radar transponders used to provide for tracking and metric data generation by ground tracking stations are installed in the CM. Each transponder is an AN/DPN-66 (SST-102A) and operates in the C-band (5395 to 5905 megacycle) range. The system can accommodate up to three identical serial interrogation pulses.

7.2.3 Telemetry Antenna

The telemetry antenna system consists of a multiplexer, filter, and VHF omni-antenna. The antenna on Boilerplate 15 is located under a radome on the nose or forward compartment apex of the CM.

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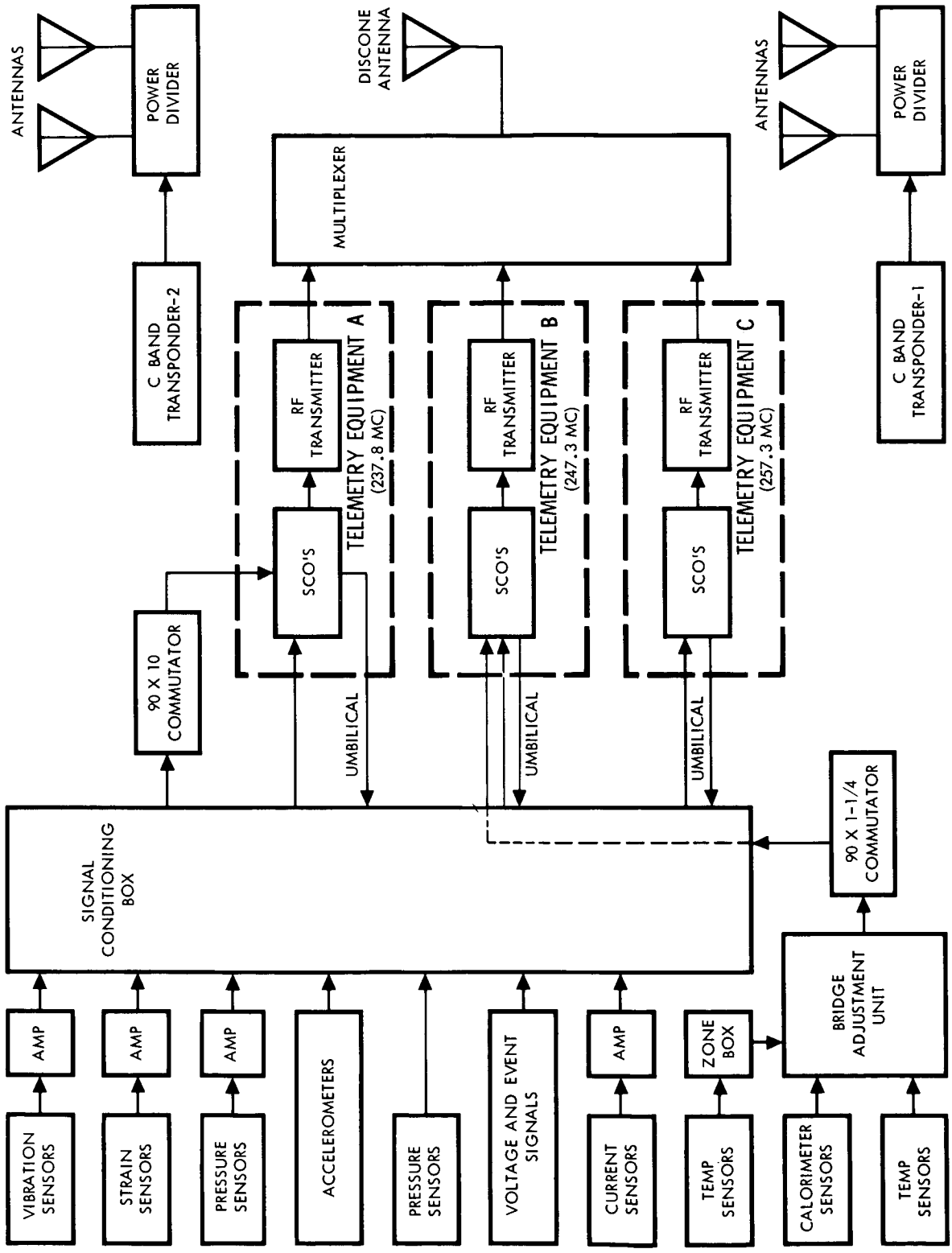

Figure 13. Boilerplate 15 R&D Communications and Instrumentation System

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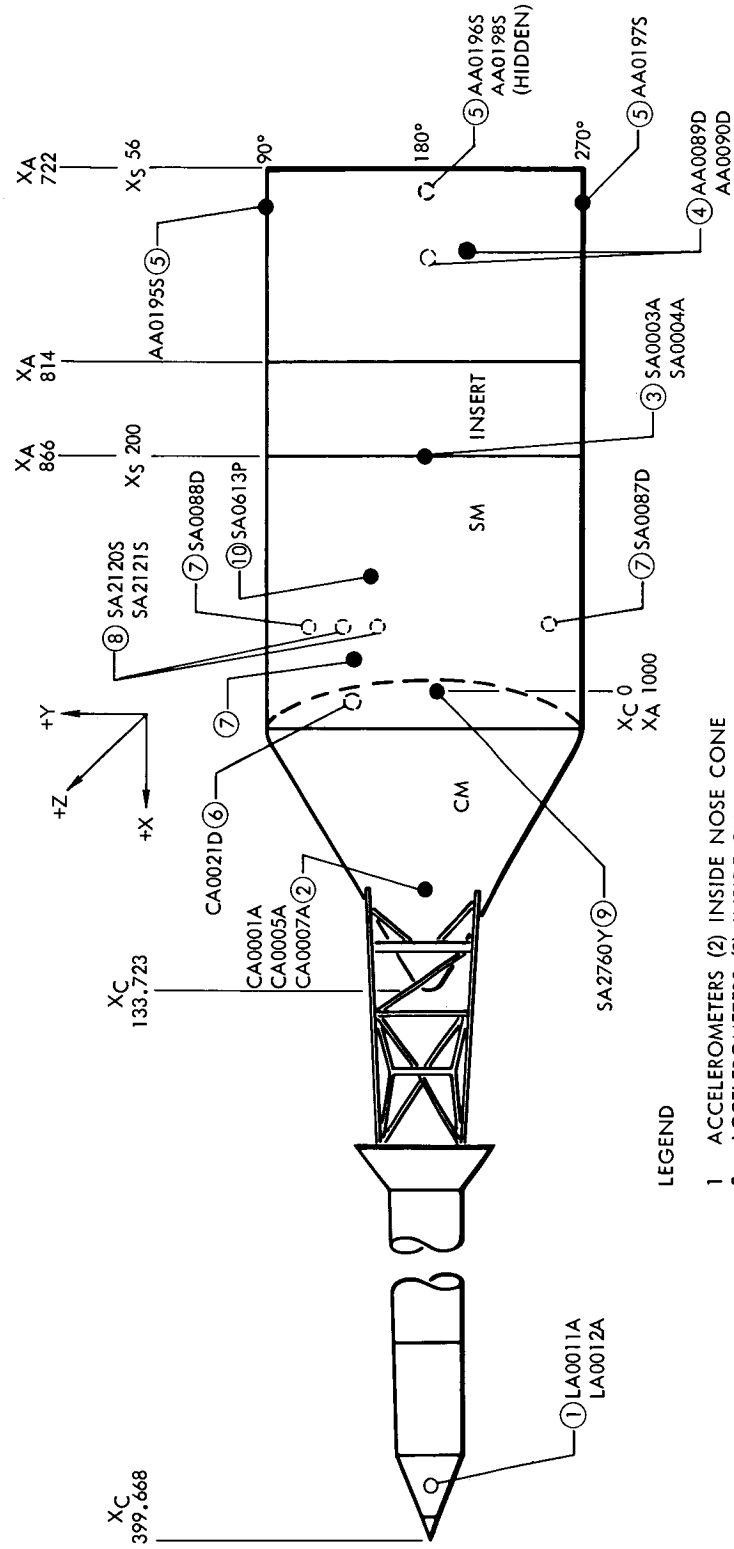

LEGEND

1 ACCELEROMETERS (2) INSIDE NOSE CONE
2 ACCELEROMETERS (3) INSIDE CM
3 ACCELEROMETERS (2) INSIDE SM
4 VIBRATION TRANSDUCERS (2) INSIDE ADAPTER
5 STRAIN GAGES (4) ON ADAPTER
6 VIBRATION TRANSDUCER (1) INSIDE CM
7 VIBRATION TRANSDUCER (3) INSIDE SM
8 STRAIN GAGES (2) ON SM
9 SM ACOUSTIC
10 SM INTERIOR PRESS.

● EXPOSED
○ HIDDEN

NOTES:

1. THE MEASUREMENT LOCATIONS ARE REFERENCED FROM THE +Z AXIS (+Z = 0°), AND THE MEASUREMENT ANGLE INCREASES AS THE MEASUREMENT LOCATION CHANGES PROGRESSIVELY FROM THE +Z AXIS TO THE +Y AXIS.
2. SEE THE MEASUREMENT LISTS FOR SPECIFIC MEASUREMENT LOCATIONS.
3. THE DIAGRAM IS NOT DRAWN TO SCALE

Figure 14. Boilerplate 15 Measurement Locations (Sheet 1 of 3)

[redacted]

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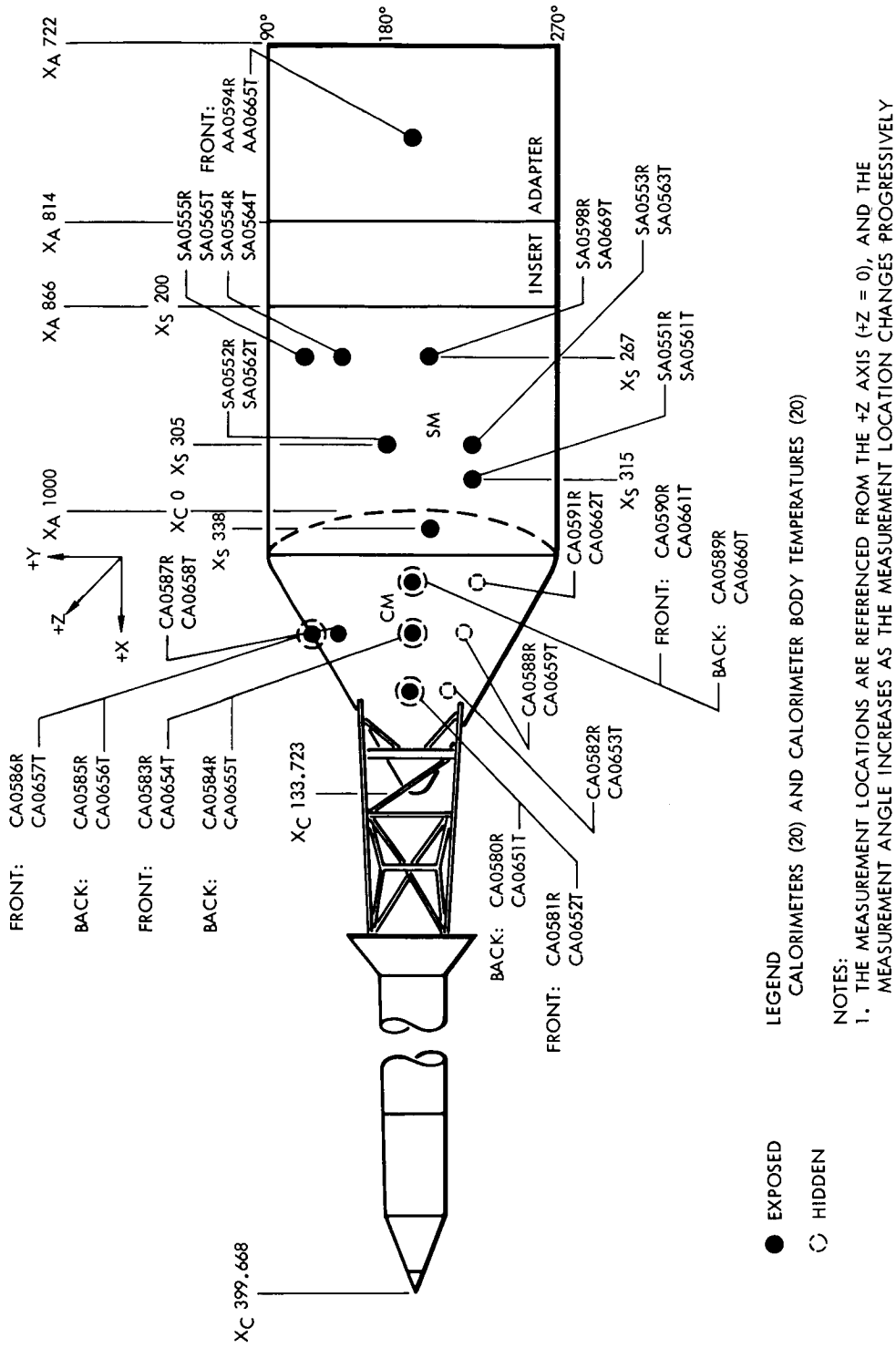


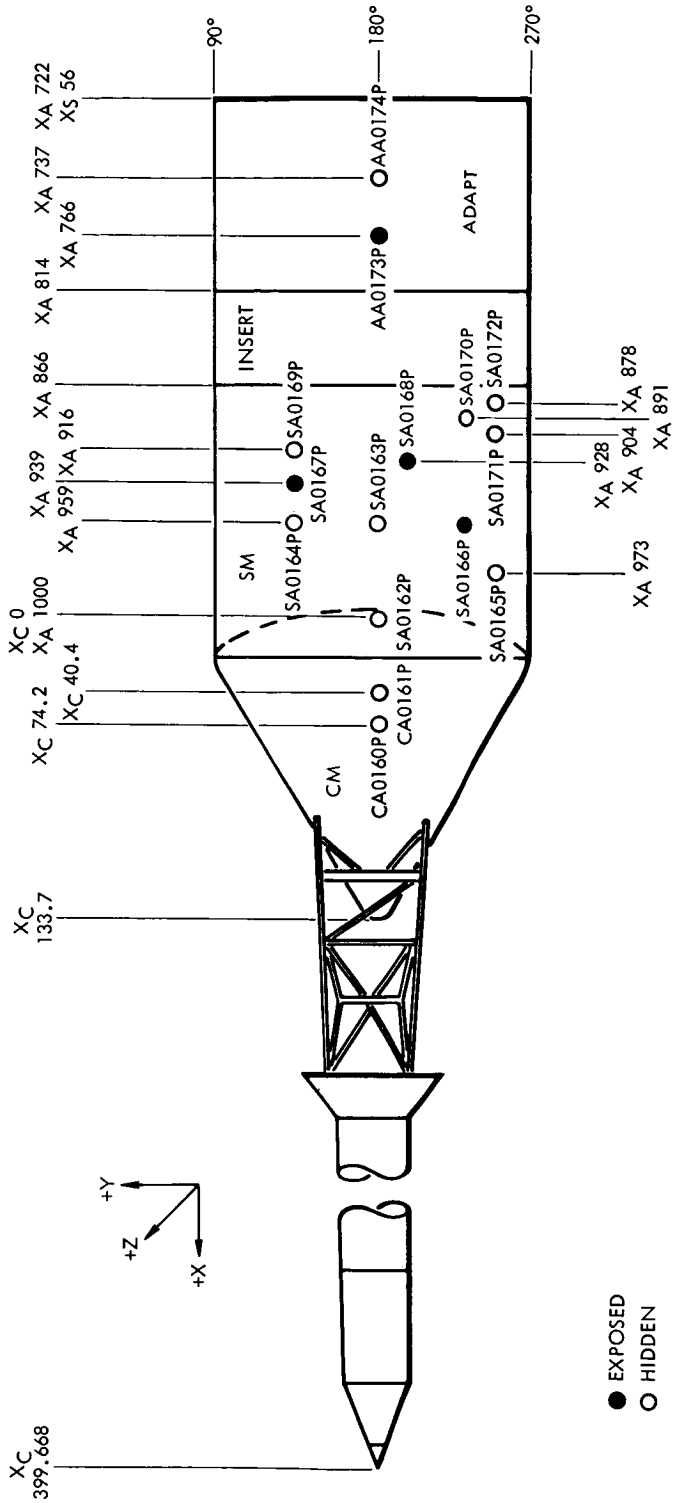
NOTES:

1. THE MEASUREMENT LOCATIONS ARE REFERENCED FROM THE +Z AXIS (+Z = 0), AND THE MEASUREMENT ANGLE INCREASES AS THE MEASUREMENT LOCATION CHANGES PROGRESSIVELY FROM THE +Z AXIS TO THE +Y AXIS.
2. SEE THE MEASUREMENT LISTS FOR SPECIFIC MEASUREMENT LOCATIONS.
3. THE DIAGRAM IS NOT DRAWN TO SCALE.

Figure 14. Boilerplate 15 Measurement Locations (Sheet 2 of 3)

[redacted]

[redacted]



LEGEND:
15 FLUCTUATING PRESSURES

NOTES:

1. THE MEASUREMENT LOCATIONS ARE REFERENCED FROM THE +Z AXIS (+Z = 0°), AND THE MEASUREMENT ANGLE INCREASES AS THE MEASUREMENT LOCATION CHANGES PROGRESSIVELY FROM THE +Z AXIS TO THE +Y AXIS.
2. SEE THE MEASUREMENT LISTS FOR SPECIFIC MEASUREMENT LOCATIONS.
3. THE DIAGRAM IS NOT DRAWN TO SCALE.

Figure 14. Boilerplate 15 Measurement Locations (Sheet 3 of 3)

[redacted]

[redacted]

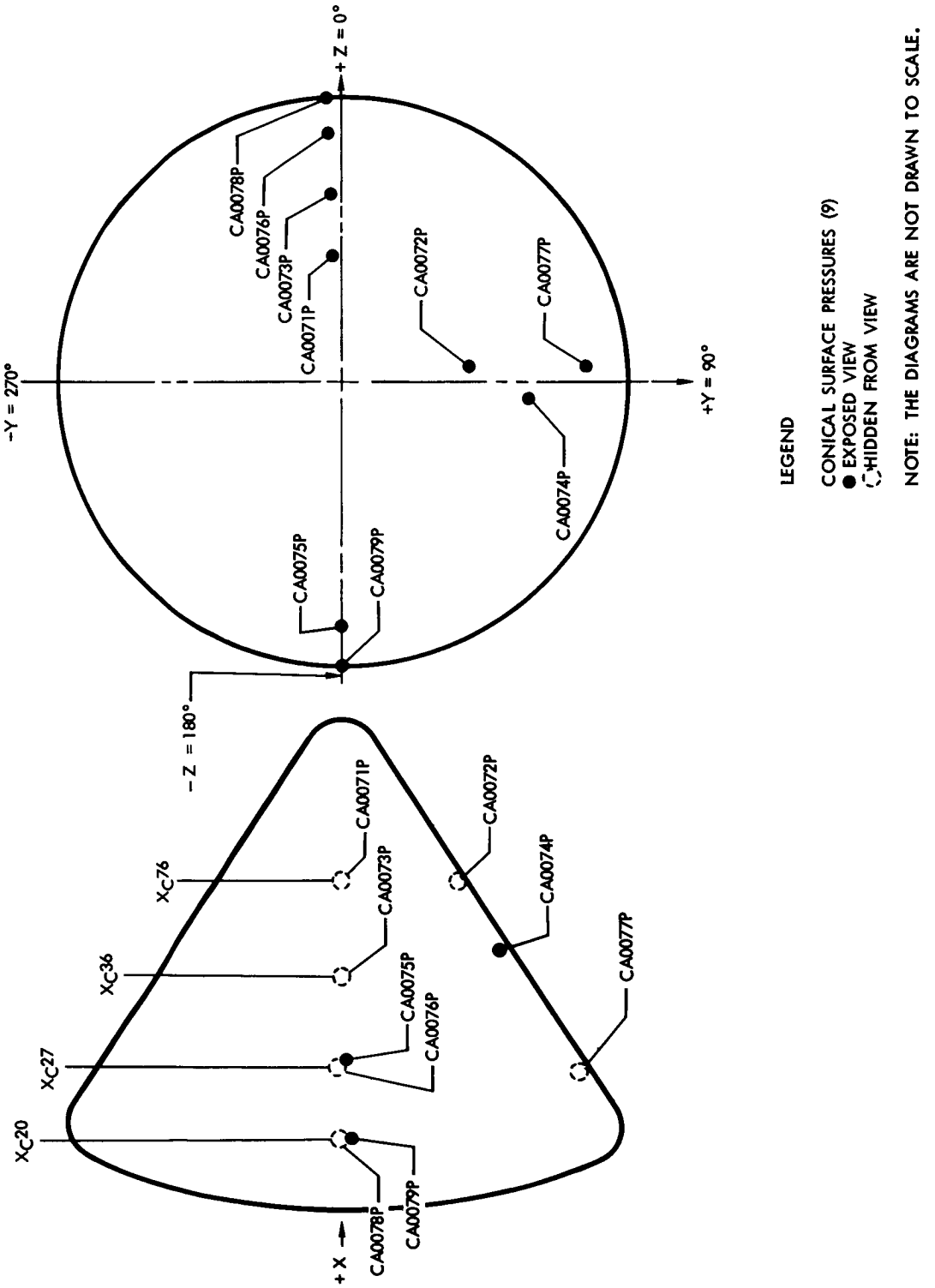


Figure 15. Boilerplate 15 Command Module Static Pressure Measurement Locations

[redacted]

[redacted]

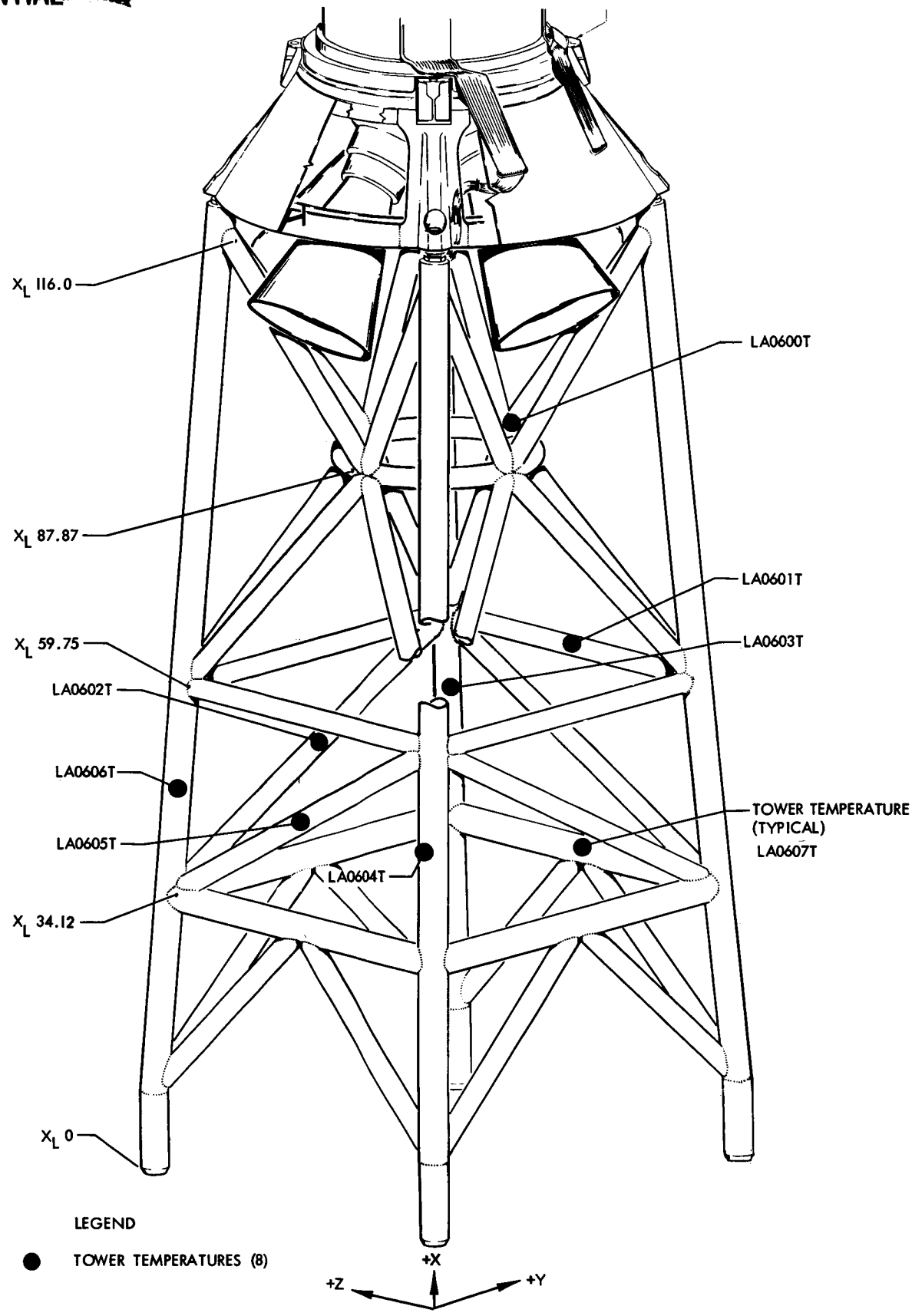


Figure 16. Boilerplate 15 LES Tower Temperature Measurement Locations

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Table 4. Boilerplate 15 Measurement List

SYSTEM
STRUCTURES

NOVEMBER 13, 1963
PAGE NO. 1

MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION
C A0001	A X AXIS SPACECRAFT ACCEL HIGH	C- 8	-2	+10	G	P	0-30	CPS	XC78,YC0,ZC21
S A0003	A Z AXIS SPACECRAFT ACCEL SM	A- 6	-0.5	+0.5	G	P	0-20	CPS	XA866,YA0,ZA73
S A0004	A Y AXIS SPACECRAFT ACCEL SM	C- 7	-0.5	+0.5	G	P	0-20	CPS	XA866,YA0,ZA73
C A0005	A Y AXIS SPACECRAFT ACCEL	C- 6	-0.5	+0.5	G	P	0-20	CPS	XC78,YC0,ZC21
C A0007	A Z AXIS SPACECRAFT ACCEL	B- 6	-0.5	+0.5	G	P	0-20	CPS	XC78,YC0,ZC21
L A0011	A Y AXIS TOWER ACCEL	B- 8	-2	+2	G	P	0-30	CPS	XL380,YL0,ZL6
L A0012	A Z AXIS TOWER ACCEL	B- 7	-2	+2	G	P	0-30	CPS	XL380,YL6,ZL0
C A0021	D CM RADIAL VIBRATION 1	A-16	-50	+50	G	P	20-1000	C	XC14,YC40.4,ZC37.3
C A0071	P CONICAL SURFACE PRESSURE 1	A-E -66	+0	+15	PSIA	M	10	S/S	XC76,357DEG
C A0072	P CONICAL SURFACE PRESSURE 2	A-E -67	+0	+15	PSIA	M	10	S/S	XC76,87DEG
C A0073	P CONICAL SURFACE PRESSURE 3	A-E -68	+0	+15	PSIA	M	10	S/S	XC36,357DEG
C A0074	P CONICAL SURFACE PRESSURE 4	A-E -69	+0	+15	PSIA	M	10	S/S	XC36,93DEG
C A0075	P CONICAL SURFACE PRESSURE 5	A-E -70	+0	+15	PSIA	M	10	S/S	XC29,180DEG
C A0076	P CONICAL SURFACE PRESSURE 6	A-E -71	+0	+15	PSIA	M	10	S/S	XC27,357DEG
C A0077	P CONICAL SURFACE PRESSURE 7	A-E -72	+0	+15	PSIA	M	10	S/S	XC27,87DEG
C A0078	P CONICAL SURFACE PRESSURE 8	A-E -73	+0	+15	PSIA	M	10	S/S	XC20,357DEG
C A0079	P CONICAL SURFACE PRESSURE 9	A-E -74	+0	+15	PSIA	M	10	S/S	XC20,180DEG

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Table 4. Boilerplate 15 Measurement List (Cont)

SYSTEM
STRUCTURES

NOVEMBER 13, 1963
PAGE NO. 2

MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION
S A0086 D SM	RADIAL VIBRATION 2	C-18	-50	+50	G	P	20-1000	C	XA965.2,YA42.8,ZA-57.
S A0087 D SM	RADIAL VIBRATION 3	C-17	-50	+50	G	P	20-1000	C	XA953,YA-53.9,ZA47.7
S A0088 D SM	RADIAL VIBRATION 4	B-17	-50	+50	G	P	20-1000	C	XA940.4,YA68.3,ZA22.8
A A0089 D	ADAPTER RADIAL VIBRATION 5	LV TM-	-50	+50	G	P	25-2000	C	XA777.7,YA0,ZA72
A A0090 D	ADAPTER RADIAL VIBRATION 6	LV TM	-50	+50	G	P	25-2000	C	XA777.7,YA-15.5,ZA-71
C A0160 P	FLUCTUATING PRESSURE 1	B-18	+0	+15	PSIA	M	1000	CPS	XC74.2,0 DEG
C A0161 P	FLUCTUATING PRESSURE 2	C-15	+0	+15	PSIA	M	300	CPS	XC40.4,180 DEG
S A0162 P	FLUCTUATING PRESSURE 3	B-15	+0	+15	PSIA	M	300	CPS	XA1000,329.25DEG
S A0163 P	FLUCTUATING PRESSURE 4	A-15	+0	+15	PSIA	M	300	CPS	XA959,24.1DEG
S A0164 P	FLUCTUATING PRESSURE 5	C-14	+0	+15	PSIA	M	300	CPS	XA959,58.9DEG
S A0165 P	FLUCTUATING PRESSURE 6	B-14	+0	+15	PSIA	M	300	CPS	XA973,277.5DEG
S A0166 P	FLUCTUATING PRESSURE 7	A-14	+0	+15	PSIA	M	300	CPS	XA959,215.3DEG
S A0167 P	FLUCTUATING PRESSURE 8	C-13	+0	+15	PSIA	M	300	CPS	XA939,147.9DEG
S A0168 P	FLUCTUATING PRESSURE 9	A-13	+0	+15	PSIA	M	300	CPS	XA928,187.25DEG
S A0169 P	FLUCTUATING PRESSURE 10	A-12	+0	+15	PSIA	M	300	CPS	XA916,58.9DEG
S A0170 P	FLUCTUATING PRESSURE 11	C-12	+0	+15	PSIA	M	300	CPS	XA891,316.6DEG
S A0171 P	FLUCTUATING PRESSURE 12	B-12	+0	+15	PSIA	M	300	CPS	XA904,277.25DEG

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Table 4. Boilerplate 15 Measurement List (Cont)

SYSTEM
STRUCTURES

NOVEMBER 13, 1963
PAGE NO. 3

MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION
S A0172 P	FLUCTUATING PRESSURE 13	A-11	+0	+15	PSIA	M	300	CPS	XA878,277.25DEG
A A0173 P	FLUCTLATING PRESSURE 14	C-11	+0	+15	PSIA	M	300	CPS	XA766,180 DEG
A A0174 P	FLUCTUATING PRESSURE 15	B-11	+0	+15	PSIA	M	300	CPS	XA737,0 DEG

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Table 4. Boilerplate 15 Measurement List (Cont)

SYSTEM
STRUCTURES

NOVEMBER 13, 1963
PAGE NO. 4

MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION
A A0195 S	STRAIN 1 ADAPTER	A- 9	-1000	+1000	UI/IN	M	100	CPS	XA736,YA76,ZA0
A A0196 S	STRAIN 2 ADAPTER	A-10	-1000	+1000	UI/IN	M	100	CPS	XA736,YA0,ZA-76
A A0197 S	STRAIN 3 ADAPTER	B-10	-1000	+1000	UI/IN	M	100	CPS	XA736,YA-76,ZA0
A A0198 S	STRAIN 4 ADAPTER	C-10	-1000	+1000	UI/IN	M	100	CPS	XA736,YA0,ZA76
S A0550 R	HEAT FLUX (CALORIMETER) 17	B-13-28	+0	+5	B/F/S	M	1.25	S/S	XS338,183DEG
S A0551 R	HEAT FLUX (CALORIMETER) 18	B-13-29	+0	+5	B/F/S	M	1.25	S/S	XS315,187.2DEG
S A0552 R	HEAT FLUX (CALORIMETER) 20	B-13-31	+0	+5	B/F/S	M	1.25	S/S	XS305,177DEG
S A0553 R	HEAT FLUX (CALORIMETER) 13	B-13-24	+0	+5	B/F/S	M	1.25	S/S	XS305,187.2DEG
S A0554 R	HEAT FLUX (CALORIMETER) 14	B-13-25	+0	+5	B/F/S	M	1.25	S/S	XS267,160DEG
S A0555 R	HEAT FLUX (CALORIMETER) 16	B-13-27	+0	+5	B/F/S	M	1.25	S/S	XS267,145DEG
S A0560 T	CALORIMETER BODY TEMP 17	B-13-48	+0	+300	DEG C	S	1.25	S/S	XS338,183DEG
S A0561 T	CALORIMETER BODY TEMP 18	B-13-49	+0	+300	DEG C	S	1.25	S/S	XS315,187.2DEG
S A0562 T	CALORIMETER BODY TEMP 20	B-13-51	+0	+300	DEG C	S	1.25	S/S	XS305,177DEG
S A0563 T	CALORIMETER BODY TEMP 13	B-13-44	+0	+300	DEG C	S	1.25	S/S	XS305,187.2DEG
S A0564 T	CALORIMETER BODY TEMP 14	B-13-45	+0	+300	DEG C	S	1.25	S/S	XS267,160DEG
S A0565 T	CALORIMETER BODY TEMP 16	B-13-47	+0	+300	DEG C	S	1.25	S/S	XS267,145DEG

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Table 4. Boilerplate 15 Measurement List (Cont)

SYSTEM
STRUCTURES

NOVEMBER 13, 1963
PAGE NO. 5

MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION
C A0580 R	HEAT FLUX (CALORIMETER) 1	B-13-12	+0	+25	B/F/S	M	1.25	S/S	XC74,3DEG
C A0581 R	HEAT FLUX (CALORIMETER) 2	B-13-13	+0	+25	B/F/S	M	1.25	S/S	XC74,180DEG
C A0582 R	HEAT FLUX (CALORIMETER) 3	B-13-14	+0	+25	B/F/S	M	1.25	S/S	XC74,319DEG
C A0583 R	HEAT FLUX (CALORIMETER) 4	B-13-15	+0	+25	B/F/S	M	1.25	S/S	XC53,180DEG
C A0584 R	HEAT FLUX (CALORIMETER) 5	B-13-16	+0	+25	B/F/S	M	1.25	S/S	XC52,3DEG
C A0585 R	HEAT FLUX (CALORIMETER) 6	B-13-17	+0	+25	B/F/S	M	1.25	S/S	XC52,80DEG
C A0586 R	HEAT FLUX (CALORIMETER) 7	B-13-18	+0	+25	B/F/S	M	1.25	S/S	XC52,85DEG
C A0587 R	HEAT FLUX (CALORIMETER) 8	B-13-19	+0	+25	B/F/S	M	1.25	S/S	XC52,95DEG
C A0588 R	HEAT FLUX (CALORIMETER) 9	B-13-20	+0	+25	B/F/S	M	1.25	S/S	XC52,319DEG
C A0589 R	HEAT FLUX (CALORIMETER) 10	B-13-21	+0	+25	B/F/S	M	1.25	S/S	XC27,3DEG
C A0590 R	HEAT FLUX (CALORIMETER) 11	B-13-22	+0	+25	B/F/S	M	1.25	S/S	XC27,180DEG
C A0591 R	HEAT FLUX (CALORIMETER) 12	B-13-23	+0	+25	B/F/S	M	1.25	S/S	XC27,319DEG
A A0594 R	HEAT FLUX (CALORIMETER) 19	B-13-30	+0	+5	B/F/S	M	1.25	S/S	XA770,183DEG
S A0598 R	HEAT FLUX (CALORIMETER) 15	B-13-26	+0	+5	B/F/S	M	1.25	S/S	XA933,183DEG
L A0600 T	TOWER TEMPERATURE 1	B-13-52	+0	+150	DEG C	M	1.25	S/S	XL90,YL12,ZL0
L A0601 T	TOWER TEMPERATURE 2	B-13-53	+0	+150	DEG C	M	1.25	S/S	XL61,YL22,ZL0
L A0602 T	TOWER TEMPERATURE 3	B-13-54	+0	+150	DEG C	M	1.25	S/S	XL47,YL0,ZL23

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Table 4. Boilerplate 15 Measurement List (Cont)

SYSTEM
STRUCTURES

NOVEMBER 13, 1963
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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION
L A0603 T	TOWER TEMPERATURE 4	B-13-55	+0	+150	DEG C	M	1.25	S/S	XL47,YL24,ZL23
L A0604 T	TOWER TEMPERATURE 5	B-13-56	+0	+150	DEG C	M	1.25	S/S	XL47,YL-24,ZL-23
L A0605 T	TOWER TEMPERATURE 6	B-13-57	+0	+150	DEG C	M	1.25	S/S	XL47,YL-24,ZLO
L A0606 T	TOWER TEMPERATURE 7	B-13-58	+0	+150	DEG C	M	1.25	S/S	XL47,YL-24,ZL23
L A0607 T	TOWER TEMPERATURE 8	B-13-59	+0	+150	DEG C	M	1.25	S/S	XL36,YL24,ZLO
C A0610 T	CM INTERIOR TEMP	B-13- 4	+0	+150	DEG C	S	1.25	S/S	CM INTERIOR
C A0611 P	CM INTERIOR PRESS	A-E -88	+0	+15	PSIA	S	10	S/S	CM INTERIOR
S A0612 T	SM INTERIOR TEMP	B-13- 5	+0	+150	DEG C	S	1.25	S/S	SM INTERIOR
S A0613 P	SM INTERIOR PRESS	A-E- 87	+0	+15	PSIA	S	10	S/S	SM INTERIOR
C A0651 T	CALORIMETER BODY TEMP 1	B-13-32	+0	+300	DEG C	S	1.25	S/S	XC74,3DEG
C A0652 T	CALORIMETER BODY TEMP 2	B-13-33	+0	+300	DEG C	S	1.25	S/S	XC74,180DEG
C A0653 T	CALORIMETER BODY TEMP 3	B-13-34	+0	+300	DEG C	S	1.25	S/S	XC74,319DEG
C A0654 T	CALORIMETER BODY TEMP 4	B-13-35	+0	+300	DEG C	S	1.25	S/S	XC53,180DEG
C A0655 T	CALORIMETER BODY TEMP 5	B-13-36	+0	+300	DEG C	S	1.25	S/S	XC52,3DEG
C A0656 T	CALORIMETER BODY TEMP 6	B-13-37	+0	+300	DEG C	S	1.25	S/S	XC52,80DEG
C A0657 T	CALORIMETER BODY TEMP 7	B-13-38	+0	+300	DEG C	S	1.25	S/S	XC52,85DEG
C A0658 T	CALORIMETER BODY TEMP 8	B-13-39	+0	+300	DEG C	S	1.25	S/S	XC52,95DEG

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Table 4. Boilerplate 15 Measurement List (Cont)

SYSTEM
STRUCTURES

NOVEMBER 13, 1963
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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION
C A0659 T	CALORIMETER BODY TEMP 9	B-13-40	+0	+300	DEG C	S	1.25	S/S	XC52,319DEG
C A0660 T	CALORIMETER BODY TEMP 10	B-13-41	+0	+300	DEG C	S	1.25	S/S	XC27,3DEG
C A0661 T	CALORIMETER BODY TEMP 11	B-13-42	+0	+300	DEG C	S	1.25	S/S	XC27,180DEG
C A0662 T	CALORIMETER BODY TEMP 12	B-13-43	+0	+300	DEG C	S	1.25	S/S	XC27,319DEG
A A0665 T	CALORIMETER BODY TEMP 19	B-13-50	+0	+300	DEG C	S	1.25	S/S	XA770,183DEG
S A0669 T	CALORIMETER BODY TEMP 15	B-13-46	+0	+300	DEG C	S	1.25	S/S	XA933,183DEG
S A2120 S	STRAIN 1 SERVICE MODULE	B-16	-4000	+4000	UI/IN	M	250	CPS	XA940.4,62.25DEG
S A2121 S	STRAIN 2 SERVICE MODULE	C-16	-4000	+4000	UI/IN	M	250	CPS	XA940.4,77.25DEG
S A2760 Y	SERVICE MODULE ACOUSTIC	LV TM	+150	+170	DB	S	25-3000	C	XS339,0 DEG

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Table 4. Boilerplate 15 Measurement List (Cont)

SYSTEM
ELECTRICAL

NOVEMBER 13, 1963
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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION
C C0001	V DC VOLTAGE MAIN BUS A	A-E -24	+22	+32	VDC	P	10	S/S	PWR CONTROL BOX
C C0002	V DC VOLTAGE MAIN BUS B	A-E -25	+22	+32	VDC	P	10	S/S	PWR CONTROL BOX
C C0003	V DC VOLTAGE LOGIC BUS A	A-E -22	+0	+36	VDC	P	10	S/S	LES SEQUENCER
C C0004	V DC VOLTAGE LOGIC BUS B	A-E -23	+0	+36	VDC	P	10	S/S	LES SEQUENCER
C C0005	C TOTAL DC CURRENT	A-E -26	+0	+50	AMPS	P	10	S/S	PWR CONTROL BOX

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Table 4. Boilerplate 15 Measurement List (Cont)

SYSTEM
LAUNCH ESCAPE

NOVEMBER 13, 1963
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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION
B D0001 X	S-I LIFT OFF SIGNAL	A-9,A-10			STEP	M	100	CPS	SIG COND BOX
L D0033 X	TWR JETT AND SEP RELAY CLOSE A	A-E -29			STEP	P	10	S/S	TWR LES SEQUENCER
L D0034 X	TWR JETT AND SEP RELAY CLOSE B	A-E -29			STEP	P	10	S/S	TWR LES SEQUENCER
C D0039 V	S-I SEP SIGNAL A	A-E -37	+0	+36	VDC	P	10	S/S	LES SEQUENCER
C D0040 V	S-I SEP SIGNAL B	A-E -38	+0	+36	VDC	P	10	S/S	LES SEQUENCER
C D0185 V	DC VOLTAGE TWR PYRO BUS A	A-E -28	+0	+36	VDC	P	10	S/S	LES SEQUENCER
C D0186 V	DC VOLTAGE TWR PYRO BUS B	A-E -35	+0	+36	VDC	P	10	S/S	LES SEQUENCER

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Table 4. Boilerplate 15 Measurement List (Cont)

SYSTEM
COMMUNICATIONS AND INSTRUMENTATION

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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION
C T0201	T TM RF XMTR A TEMP	B-13- 6	+0	+150	DEG C	S	1.25	S/S	TM RF XMTR A
C T0202	T TM RF AMP A TEMP	B-13- 7	+0	+150	DEG C	S	1.25	S/S	TM RF AMP A
C T0203	T TM RF XMTR B TEMP	B-13- 8	+0	+150	DEG C	S	1.25	S/S	TM RF XMTR B
C T0204	T TM RF AMP B TEMP	B-13- 9	+0	+150	DEG C	S	1.25	S/S	TM RF AMP B
C T0205	T TM RF XMTR C TEMP	B-13-10	+0	+150	DEG C	S	1.25	S/S	TM RF XMTR C
C T0207	T TM RF AMP C TEMP	B-13-11	+0	+150	DEG C	S	1.25	S/S	TM RF AMP C

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Table 5. Boilerplate 15 Electrical Umbilical Functions

Item	Function	Voltage Range (vdc)	Wire Gage	Origin	Connect Pin
SM TO GSE					
1. Regulated power supply (5 vdc)	Monitor	0 to 5	16	SCB	S15J1-56
2. Main battery current total	Monitor	0 to 5	16	Signal conditioner	S15J1-55
3. Umbilical separation	Monitor	28	20	Umbilical	S15J1-30
4. Umbilical separation	Monitor	28	20	Umbilical	S15J1-31
5. ECS coldplate inlet temperature (+)	Monitor	0 to 5	20	ECS	S15J1-52
6. ECS coldplate inlet temperature (-)	Return	0 to 5	20	ECS	S15J1-53
7. ECS coldplate outlet temperature (+)	Monitor	0 to 5	20	ECS	S15J1-50
8. ECS coldplate outlet temperature (-)	Return	0 to 5	20	ECS	S15J1-51
9. ECS coolant outlet pressure (+)	Monitor	0 to 5	20	ECS	S15J1-48

Table 5. Boilerplate 15 Electrical Umbilical Functions (Cont)

Item	Function	Voltage Range (vdc)	Wire Gage	Origin	Connect Pin
10. ECS coolant output pressure common (-)	Return	0 to 5	20	ECS	S15J1-49
11. ECS CM air temperature (+)	Monitor	0 to 5	20	ECS	S15J1-46
12. ECS CM air temperature (-)	Return	0 to 5	20	ECS	S15J1-45
13. ECS tank outlet temperature (+)	Monitor	0 to 5	20	ECS	S15J1-32
14. ECS tank outlet temperature (-)	Return	0 to 5	20	ECS	S15J1-41
15. ECS inlet pressure (+)	Monitor	0 to 5	20	ECS	S15J1-35
16. ECS inlet pressure (-)	Return	0 to 5	20	ECS	S15J1-36
17. Shield					S15J1-54
18. Shield					S15J1-47
19. Signal common to GSE	Return	0 to 5	16	Signal conditioner	S15J1-60
20. Signal common to GSE	Return	0 to 5	16	Signal conditioner	S15J1-59

Table 5. Boilerplate 15 Electrical Umbilical Functions (Cont)

Item	Function	Voltage Range (vdc)	Wire Gage	Origin	Connect Pin
21. Instrumentation bus control	Holding	28	16	PCB	S15J2-28
22. External power bus A	Power	28	16	PCB	S15J2-41
23. External power bus B	Power	28	16	PCB	S15J2-42
24. External power bus A	Power	28	16	PCB	S15J2-45
25. External power bus A	Power	28	16	PCB	S15J2-46
26. External power bus B	Power	28	16	PCB	S15J2-58
27. External power bus B	Power	28	16	PCB	S15J2-57
28. External power bus B	Power	28	16	PCB	S15J2-37
29. External power bus B	Power	28	16	PCB	S15J2-38
30. External power ground	Return	28	16	PCB	S15J2-59
31. External power ground	Return	28	16	PCB	S15J2-60
32. External power ground	Return	28	16	PCB	S15J2-47
33. External power ground	Return	28	16	PCB	S15J2-48
34. External power ground	Return	28	16	PCB	S15J2-43

Table 5. Boilerplate 15 Electrical Umbilical Functions (Cont)

Item	Function	Voltage Range (vdc)	Wire Gage	Origin	Connect Pin
35. External power ground	Return	28	16	PCB	S15J2-44
36. External power ground	Return	28	16	PCB	S15J2-40
37. External power ground	Return	28	16	PCB	S15J2-39
38. Main bus A monitor and regulation (+)	Meter	28	16	PCB	S15J2-35
39. Main bus A monitor and regulation (-)	Meter	28	16	PCB	S15J2-36
40. Main bus B monitor and regulation (+)	Meter	28	16	PCB	S15J2-34
41. Main bus B monitor and regulation (-)	Meter	28	16	PCB	S15J2-33
42. Logic battery A voltage	Meter	28	16	Sequencer	S15J2-23
43. Logic battery B voltage	Meter	28	16	Sequencer	S15J2-19
44. Pyro battery A voltage	Meter	28	20	Sequencer	S15J2-17
45. Pyro battery B voltage	Meter	28	20	Sequencer	S15J2-18
46. Battery A monitor and bleed	Monitor	28	16	PCB	S15J2-56

Table 5. Boilerplate 15 Electrical Umbilical Functions (Cont)

Item	Function	Voltage Range (vdc)	Wire Gage	Origin	Connect Pin
47. Battery B monitor and bleed	Monitor	28	16	PCB	S15J2-55
48. Bus A power transfer	Monitor	28	16	PCB	S15J2-16
49. Bus B power transfer	Monitor	28	16	PCB	S15J2-15
50. TM A RF transmitter control	Holding	28	16	PCB	S15J2-29
51. TM RF power amplifier ON (latching relay)	Momentary	28	16	PCB	S15J2-30
52. C-band transponder 1 control	Holding	28	16	PCB	S15J2-31
53. C-band transponder 2 control	Holding	28	16	PCB	S15J2-32
54. ECS instrumentation power	Power	28	16	ECS	S15J2-27
55. ECS instrumentation common	Return	28	16	ECS	
56. GSE relay power (+)	Power	28	16	Relay box	S15J2-53
57. GSE relay power (-)	Return	28	16	Relay box	S15J2-54
58. Shield	Shield to be used				S15J2-25
59. R calibrate	Momentary	28	20	Junction box	S15J3-51

Table 5. Boilerplate 15 Electrical Umbilical Functions (Cont)

Item	Function	Voltage Range (vdc)	Wire Gage	Origin	Connect Pin
60. Z calibrate	Momentary	28	20	Junction box	S15J3-52
61. TM B RF transmitter control	Holding	28	16	JB 2	S15J3-39
62. TM C RF power amplifier - OFF control (latching relay)	Momentary	28	16	JB 2	S15J3-40
63. TM calibration enable control	Holding	28	16	JB 2	S15J3-43
64. TM calibration auto-manual control	Holding	28	16	PCB	S15J3-44
65. TM calibration control manual step	Momentary	28	16	JB 2	S15J3-45
66. Tower sequencer A and B safe command	Momentary	28	20	Sequencer	S15J3-38
Tower sequencer A and B safe command	Momentary	28	16	Sequencer	S15J3-35
67. Tower sequencer safe command common (-)	Return	28	16	Sequencer	S15J3-59
Tower sequencer safe command common (-)	Return	28	16	Sequencer	S15J3-34

Table 5. Boilerplate 15 Electrical Umbilical Functions (Cont)

Item	Function	Voltage Range	Wire Gage	Origin	Connect Pin
68. ECS external control	Holding	28 vdc	20	PCB	S15J3-56
69. Voltmeter common (-)	Return	28 vdc	16	Sequencer	S15J3-55
70. TM composite video A	Monitor	Video	Coaxial	Modulation package	S13P201
71. TM composite video B	Monitor	Video	Coaxial	Modulation package	S13P202
72. TM composite video C	Monitor	Video	Coaxial	Modulation package	S13P203
73. TM composite video spare	Spare	Video	Coaxial	Modulation package	S13P204
ADAPTER CONNECTOR					
1. Q-ball heater power (+)	Power	115 vac	20	S-I GSE	A15J1-MM
2. Q-ball heater power (-)	Return	115 vac	20	S-I GSE	A15J1-PP
3. Q-ball heater power shield terminate	Shield	0 vdc	20	Q-ball	A15J1-NN
4. Q-ball electronic power (+)	Power	28 vdc	20	Instrument unit	A15J1-c

Table 5. Boilerplate 15 Electrical Umbilical Functions (Cont)

Item	Function	Voltage Range	Wire Gage	Origin	Connect Pin
5. Q-ball electronic power common (-)	Return	0 vdc	20	Instrument unit	A15J1-b
6. Q-ball electronic power shield terminate	Shield	0 vdc	20	Q-ball	A15J1-a
7. Q-ball simulate command	Power	28 vdc	20	S-I GSE	A15J1-e
8. Q-ball surface temp TLM ref (+)	Signal	0 vdc 0 to 5 vdc	20	Q-ball	A15J1-s
9. Q-ball surface temp TLM ref (-)	Return	0 vdc	20	Instrument unit	A15J1-r
10. Q-ball dynamic pressure TLM (+)	Signal	0 to 5 vdc	20	Q-ball	A15J1-g
11. Q-ball dynamic pressure TLM ref (-)	Return	0 vdc	20	Instrument unit	A15J1-f
12. Q-ball alpha-q yaw TLM (+)	Signal	0 to 5 vdc	20	Q-ball	A15J1-i
13. Q-ball alpha-q yaw TLM ref (-)	Return	0 vdc	20	Instrument unit	A15J1-h
14. Q-ball alpha-q pitch TLM (+)	Signal	0 to 5 vdc	20	Q-ball	A15J1-k

Table 5. Boilerplate 15 Electrical Umbilical Functions (Cont)

Item	Function	Voltage Range	Wire Gage	Origin	Connect Pin
15. Q-ball alpha-q pitch TLM ref (-)	Return	0 vdc	20	Instrument unit	A15J1-j
16. Q-ball alpha-q yaw output (+)	Signal	0 to 30 vdc	20	Q-ball	A15J1-n
17. Q-ball alpha-q yaw output (-)	Signal	0 to 30 vdc	20	Q-ball	A15J1-m
18. Q-ball alpha-q pitch output (+)	Signal	0 to 30 vdc	20	Q-ball	A15J1-q
19. Q-ball alpha-q pitch output (-)	Signal	0 to 30 vdc	20	Q-ball	A15J1-p
20. Q-ball signal shield terminate	Shield	0 vdc	20	Q-ball	A15J1-d
21. Pyro switches indicate ARM	Monitor	28 vdc	20	Sequencer	A15J2-S
22. Pyro switches indicate SAFE	Monitor	28 vdc	20	Sequencer	A15J2-R
23. Pyro buses arm command	Power	28 vdc	20	S-I GSE	A15J2-L
24. Pyro bus A safe command	Power	28 vdc	20	S-I GSE	A15J2-M
25. Pyro bus B safe command	Power	28 vdc	20	S-I GSE	A15J2-N
26. Pyro bus A indicate ON	Monitor	28 vdc	20	Sequencer	A15J2-T
27. Pyro bus B indicate ON	Monitor	28 vdc	20	Sequencer	A15J2-U

Table 5. Boilerplate 15 Electrical Umbilical Functions (Cont)

Item	Function	Voltage Range	Wire Gage	Origin	Connect Pin
40. LES sequencer common (-)	Return	0 vdc	20	Sequencer	A15J2-a
41. Shield terminate	Shield	0 vdc	20	Instrument unit	A15J2-i
42. Instrument bus A battery power off command	Holding	28 vdc	20	S-I GSE	A15J3-b
43. Instrument B battery power off command	Holding	28 vdc	20	S-I GSE	A15J3-c
44. Instrument bus control common	Return	0 vdc	20	PCB	A15J3-a
45. Launch escape tower jettison command power	Power	28 vdc	20	Sequencer	A15J3-e
46. Launch escape tower jettison command	Signal	28 vdc	20	Instrument unit	A15J3-f
47. Lift-off indication power	Power	28 vdc	20	Sequencer	A15J3-h
48. Lift-off indication	Signal	28 vdc	20	Instrument unit	A15J3-j
49. Shield terminate	Shield	0 vdc	20	Instrument unit	A15J3-g

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Table 5. Boilerplate 15 Electrical Umbilical Functions (Cont)

Item	Function	Voltage Range	Wire Gage	Origin	Connect Pin
28. Logic switches indicate ARM	Monitor	28 vdc	20	Sequencer	A15J2-k
29. Logic switches indicate SAFE	Monitor	28 vdc	20	Sequencer	A15J2-e
30. Logic buses arm command	Power	28 vdc	20	S-I GSE	A15J2-b
31. Logic bus A safe command	Power	28 vdc	20	S-I GSE	A15J2-c
32. Logic bus B safe command	Power	28 vdc	20	S-I GSE	A15J2-P
33. Logic bus A indicate ON	Monitor	28 vdc	20	Sequencer	A15J2-m
34. Logic bus B indicate ON	Monitor	28 vdc	20	Sequencer	A15J2-n
35. LES indicate POWER	Power	28 vdc	20	S-I GSE	A15J2-f
36. Launch escape tower jettison command power	Power	28 vdc	20	Sequencer	A15J2-g
37. Launch escape tower jettison command	Signal	28 vdc	20	Instrument unit	A15J2-h
38. Launch escape tower jettison indicate FIRE	Monitor	28 vdc	20	Sequencer	A15J2-V
39. Launch escape tower jettison indicate SAFE	Monitor	28 vdc	20	Sequencer	A15J2-Z

7.2.4 C-Band Antennas

The C-band antenna system will consist of four flush-mounted, circular-polarized antennas and two power dividers. Each C-band transponder will utilize one power divider and two antennas. The antennas will be located 90 degrees apart around the upper portion of the SM (X_a = 954.08). The C-band antennas will be used to receive interrogation pulses and to transmit the transponder reply.

8.0 TRACKING AND SUPPORT DATA REQUIREMENTS

8.1 GENERAL

Detailed tracking and support data requirements are included in the AMR Program Requirements Document. These requirements include parameters, coverage intervals, accuracies and data disposition. This section will briefly outline the type of coverages to be provided by AMR.

8.2 METRIC TRAJECTORY DATA

Metric trajectory data on the spacecraft are required from launch through orbital insertion. The three types of data acquisition systems utilized are fixed optical, tracking cinetheodolite optical, and electronic tracking. During the initial phase of boost the primary data source will be the optical tracking systems with the radar beacon tracking system as the primary source thereafter. The tracking systems are required to provide CM position velocity, acceleration and attitude, and other data as specified in the AMR Program Requirements Document. AMR support will consist of continuous tracking during the boost phase and through orbit insertion (approximately fifteen minutes total). If the radar transponders remain operative after orbit insertion the AMR will also be requested to track the spacecraft during the next pass over the AMR. It is required that all three telemetry data links be received continuously by the AMR from just prior to lift-off through orbit insertion.

8.3 PHOTOGRAPHIC DATA

8.3.1 Documentary Photograph Coverage

Complete photographic documentary records of all key events associated with the test are required. The following activities will be covered:

Transportation
Preflight preparations and checkout
Flight operations
Postflight activity and events

8.3.2 Engineering Sequential Photographic Coverage

Visible events data coverage from prelaunch through the mid-course boost phase of the flight is required. This events coverage

[redacted]

will be provided by engineering sequential optical systems and will include the following:

1. Fixed motion picture coverage:

   Prelaunch phase. A continuous emergency surveillance, from T-2 hours to T+5 seconds, operating at two frames per second, will be provided.

   Launch phase. Lift-off coverage at 200 frames per second will be provided for structural surveillance of Apollo spacecraft interface areas.

2. Tracking motion picture coverage:

   Launch phase. S-I staging, S-IV ignition, and escape tower separation will be covered by 500-inch lenses at 20 frames per second.

8.4 TIMING

Time codes indicating time of day referenced to Greenwich mean time are required when recording data. The timing codes used will be specified in the B-15 Operations Requirements document. The following are preferred time codes:

1. AMR-B-1 time code. 1 pps 17-digit binary width amplitude modulated (10 cps)

2. AMR-D-5 time code. 100 pps 17-digit binary width code amplitude modulated (1000 cps)

All magnetic tape recordings should contain the time codes specified in items 1 and 2. All other data recordings, such as those on strip charts and oscillograms, should contain the time code specified in item 1.

A common time reference will be used for correlation of data from all data acquisition systems. Time distribution equipment will be furnished by the AMR at all test sites.

8.5 METEOROLOGICAL DATA

Surface and upper air observations at 500-foot intervals from sea level to 250,000 feet at launch are required for post-flight data analysis.

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These observations shall include altitude, temperature, wind direction and velocity and relative humidity data.

8.6 DATA DISPOSITION

The disposition of data will be as follows:

1. Final trajectory data in tab form and in the binary coded decimal (BCD) format on magnetic tape are required within 3 working days.

2. Engineering sequential film copies and event times are required within 24 hours.

3. Final meteorological data of launch conditions are required within 24 hours.

4. Preliminary trajectory data in tabulated form and BCD format on magnetic tape are required for quick-look evaluation within 2 calendar days.

9.0 PRELAUNCH OPERATION

9.1 TEST PREPARATION, S&ID, DOWNEY

The initial spacecraft test sequence will be accomplished in the spacecraft test preparation area at the S&ID Downey facility, prior to shipping the boilerplate to AMR. The sequence of test operations, consisting of five phases, is presented in block diagram form in Figure 17.

9.1.1 Phase 1, Spacecraft and GSE Preparation

The boilerplate, which is composed of the launch escape system, CM/SM, SM insert, and spacecraft adapter, will be received by test preparation from Manufacturing. A receiving inspection will be conducted on the boilerplate and associated GSE during the Manufacturing close-out. The vehicle system and subsystems will be examined to ensure compliance with the latest configuration requirements, and any necessary updating of the boilerplate and GSE will be accomplished. Instrumentation packages not previously installed by Manufacturing will be installed. During this phase the GSE will be installed and facility interface checked, and GSE validation of all individual checkout consoles will be accomplished. After individual validation, the GSE will be integrated and verified for proper operation as a system. The GSE will then be connected to the vehicle systems through umbilicals, and interconnecting electrical cables will be continuity-checked and connected to their respective modules. Modules will be physically unmated in the test preparation area. During this period the LES sequencer will be bench-checked with the LES bench maintenance equipment (BME), verified for proper operation, and installed in the boilerplate spacecraft.

9.1.2 Phase 2, Individual Systems Test

The various interconnecting cables and lines will be installed, and the individual system tests will be performed using operational test procedures. Prior to the start of individual system checkout, a complete electrical power distribution check will be conducted from the ground power unit to the primary electrical busses and to other spacecraft systems power connections. The spacecraft batteries will be activated, charged, and then installed in the CM in preparation for the EPS individual system checkout. The EPS checkout will verify the operations of the electrical power systems, using GSE to verify specified ranges, limits, and tolerances. Both ground

[redacted]

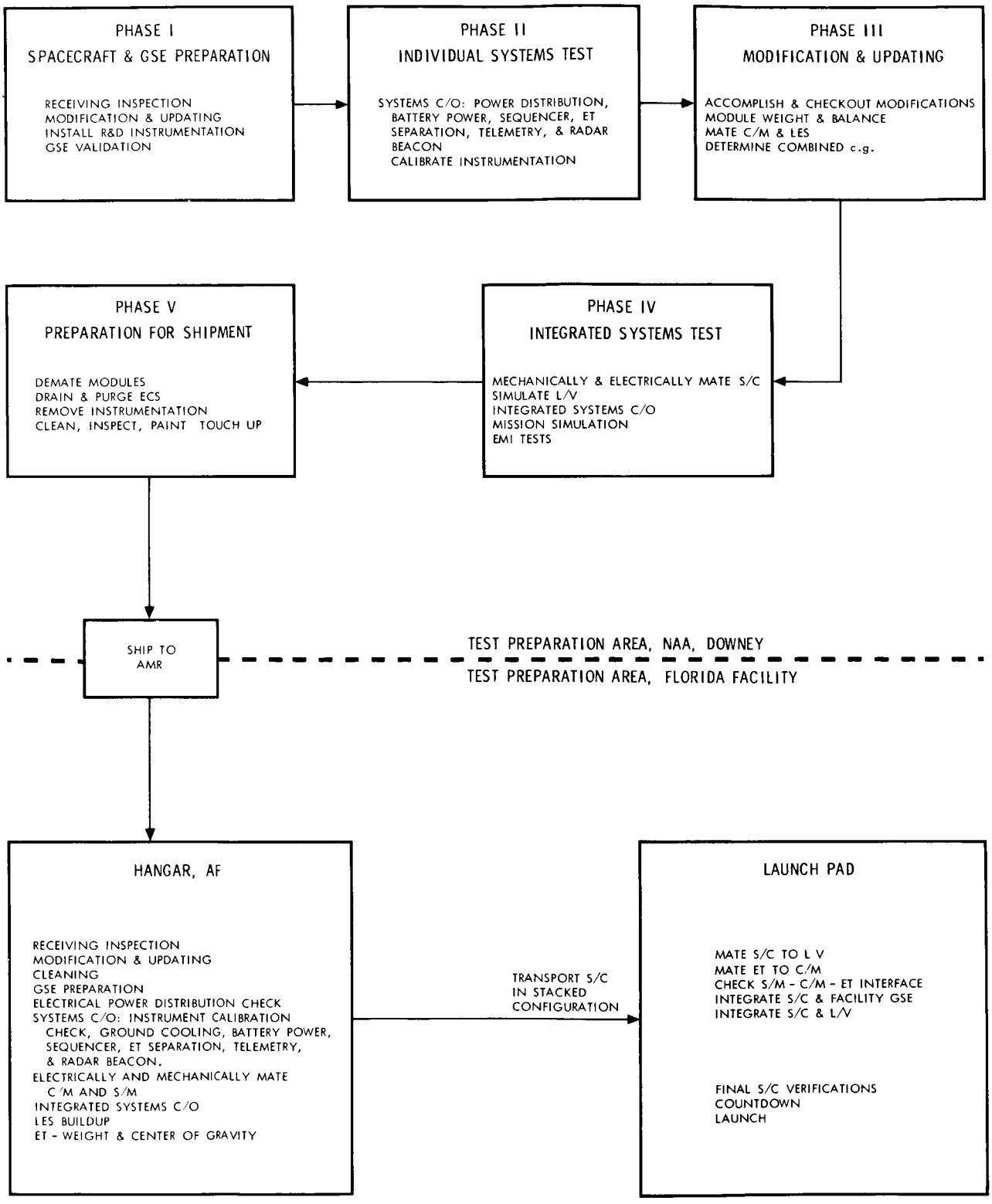

Figure 17. Boilerplate 15 Test Preparation Flow Diagram

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power and internal battery power will be verified for satisfactory operation. The LES substitute unit, pyro substitute unit, and the launch vehicle substitute unit will be connected and verified as operational during this test. The environmental control system will be serviced with water-glycol from the water-glycol GSE cart. This system will be leak-checked and the valve functions will be verified. The on-board ECS pump and fan will be checked when the environmental control system is operated. The environmental control system will be turned on to provide instrumentation cooling required in support of the tests. Instrumentation tests will include the checkout and operation of the complete on-board telemetry system. End-to-end calibration will be made on all instruments, consisting of a 5-point calibration for linear transducers and an 11-point calibration for nonlinear measurements. The antenna systems will be checked for proper output signals. The ground station will support tests as required to provide specific data to the data group and system engineers.

9.1.3 Phase 3, Modification and Updating

Modifications and updating of the flight hardware and GSE will be accomplished and checked out. Weight and balance checks will be conducted on the individual modules of the SC. The CM and LES will be mated and weighed and the center of gravity determined.

9.1.4 Phase 4, Integrated Systems Test

The boilerplate spacecraft modules will be vertically mated, mechanically and electrically, to flight configuration, and their alignment requirements will be verified. GSE handling equipment will be used and evaluated during this operation. An integrated systems test will be conducted in this configuration, all systems being activated individually to verify their compatibility with each other while operating. The conclusion of this test will consist of a flight simulation which will include a sequence of operations duplicating the entire flight mission. In addition, electromagnetic interference tests will be conducted to determine effects during systems operations. The monitoring and control of the vehicle will be via the TM link and transitional control (TC) consoles respectively.

9.1.5 Phase 5, Preparation for Shipment

This preparation is the final one prior to shipment to AMR. The boilerplate spacecraft modules will be demated, and individual modules and associated GSE will be prepared for shipment to the field. This phase will include cleaning, painting as required, purging of the ECS, and final close-out in compliance with transportation requirements. It is to be noted that the techniques and procedures used in the test preparation area

will approximate field site techniques and procedures, consistent with the limitations of the Downey facility.

9.2 TEST PREPARATION, FLORIDA FACILITY, HANGAR AF

Upon arrival at AMR, the test vehicle components and GSE will be positioned in checkout stations, and all access covers and doors will be removed. A receiving inspection will be performed to determine the extent, if any, of shipping damage. All components will be visually inspected, and part numbers and serial numbers will be compared with the workbook configuration. A review of all existing design paperwork, by NAA-AMR personnel in conjunction with Downey personnel, will determine any updating required. Any work necessary to clear workbook discrepancies will be accomplished. Any changes in the instrumentation will be followed by a complete calibration of affected instruments. A 1-point calibration check will be made on all other instruments. The GSE will be revalidated as required. The GSE will then be connected to the systems, and detailed functional checks will be performed on each individual system. The environmental control system will be gas-leak checked at operational pressure. A pump rotational check will be made. Thermoswitches, valves, and fan will be functionally checked. The system will be filled and bled with a 40-percent water, 60-percent glycol solution. The complete system and fan will then be operationally checked out. The LES sequencer will be checked with power off and then functionally checked with power on. The LES will be completely built up, with the exception of pyro-initiators. Telemetry and radar transponder checks will include frequencies, power output levels, calibration, and tuning. Power system checks will include monitoring the load current under simulated operating conditions for a specified length of time to verify the capabilities of the batteries. Ground cooling will be required for all of the above checks to maintain an acceptable equipment temperature. All checks will utilize detailed checkout procedures designed to penetrate to the component level. The boilerplate spacecraft components will be mated, with the exception of the LES, using a hydra-set for the mating operations. Integrated system checks will then be conducted to include simulated countdown and flight. The modules in the stacked configuration will then be transported to the launch pad.

9.3 COMBINED SYSTEMS CHECK, LAUNCH PAD

9.3.1 Preparations

The spacecraft will be mated with the launch vehicle and the alignment verified. The escape tower will be installed on the spacecraft. All GSE will be connected, and the launch facilities will be validated. The launch

complex checkout will follow, including control center, launch vehicle, and spacecraft. An automatic ground control station (NASA) air conditioning system will be used to maintain acceptable equipment temperature.

9.3.2 Prelaunch

Ground tests of the telemeter and the radar transponder will include frequencies, power output levels, calibration, and tuning. Prelaunch checkout of the electrical power system will consist of final circuit verification of the electrical distribution system and monitoring of the instrumentation battery system voltage and current. LES prelaunch checkout requires the installation of hot bridgewire (HBW) simulators that are connected to an event recorder. Checkout will consist of exercising the logic and pyro-bus-arm-safe relays, initiating the sequencer (either locally or from the blockhouse), recording the sequenced events, and monitoring the logic and pyro-batteries during sequencer operation. The HBW simulators will verify adequate firing energy and monitor for inadvertent transients. A telemetry recording of the above sequences will be made to verify proper LES instrumentation operation.

9.4 OPERATIONAL TEST PROCEDURES

Operational test procedures (OTP) are prepared for the detailed checkout of each individual system, integrated systems verification, and countdown procedures. The operational test procedures for Boilerplate 15 applicable to test preparation, S&ID Downey and Florida facility, are presented in Tables 6 and 7 respectively.

9.5 LAUNCH DAY ACTIVITIES

By the start of countdown, Boilerplate 15 will have been mated and installed upon the launch vehicle. The on-board systems will have been checked and tested to assure that the systems are in operative condition. The LES system will have been installed with pyrotechnics shorted. Batteries will have been installed, checked, and unloaded.

9.5.1 Countdown Activities

The countdown activities as presently envisioned are presented in Table 8. The official countdown is the responsibility of MSC/MSFC and LOC and will be coordinated and written at AMR.

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Table 6. Boilerplate 15 Operational Test Procedures, Test Preparation, S&ID Downey

OTP Number	Title
0003	Integrated Systems Checkout with Simulator
1008	Electrical Power System Checkout
1012	Battery Servicing
1040	Launch Escape System Checkout
1047	Electrical Power System Checkout Using System Measuring Devices (SMD)
1048	Launch Escape System Checkout using SMD
2014	LES Escape Tower (ET) Disassembly
3004	Preparation for Receiving Inspection
3013	Mate and Demate Escape Tower CM
3014	Mate and Demate CM/SM
3015	Mate and Demate SM/SM Insert
3016	Mate and Demate SM Extension Spacecraft Adapter (SC_A)
3018	Mate and Demate CM Forward Heat Shield
3020	SM Weight and C. G. Determination
3021	SC_A/SM Extension Weight and C. G. Determination
3022	Launch Escape System Weight and C. G. Determination
3028	CM Weight and C. G. Horizontal and Vertical
3029	CM/LES Alignment, Gross Weight, and C. G. Determination

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Table 6. Boilerplate 15 Operational Test Procedures, Test Preparation, S&ID Downey (Cont)

OTP Number	Title
3034	CM Weight Fixture Assembly Installation and Alignment
3037	Assembly and Leveling of LES Weight and Balance Fixture
5000	ECS Checkout
5022	Environmental Control System Checkout Using SMD
8011	Functional Verification of R & D Pressure Transducer Systems
8018	TM System Checkout (Spacecraft)
8019	Radar Beacon (RB) System Checkout (Spacecraft)
8020	R & D Temperature System Checkout
8022	Vibration Systems Checkout
8023	TM Antenna System Checkout
8060	Checkout of the R & D Strain Sensing System
8061	Accelerometer Checkout
8071	Beacon Antenna System Checkout
8101	Pressure Transducer Checkout Using SMD
8102	TM System Checkout Using SMD
8103	RB System Checkout Using SMD
8104	Temperature Transducer Checkout Using SMD
8105	Vibration Transducer Checkout Using SMD
8106	TM Antenna Checkout Using SMD

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Table 6. Boilerplate 15 Operational Test Procedures, Test Preparation, S&ID Downey (Cont)

OTP Number	Title
8107	Strain Gage Checkout Using SMD
8108	Accelerometer Checkout Using SMD
8110	Beacon Antenna Checkout Using SMD
9002	Functional Verification of A14-001 Launch Escape Tower Substitute Unit.
9003	Functional Verification of Pyrotechnic Initiators Substitute Set
9004	EPS Console Validation
9005	A14-021 Launch Vehicle (LV) Simulator Unit Validation
9006	Auxiliary Crane Control Checkout
9007	Test Conductor Console Checkout
9008	Cable Continuity Checkout
9009	Launch Escape Sequencer BME Validation
9011	LES Console Validation
9012	Instrumentation and Communication Console Validation
9013	RB Checkout Unit Validation
9014	Signal Conditioner Console Validation
9015	ECS Console Validation
9016	Battery Charger Checkout
9017	Water-Glycol Cooling Unit Checkout

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Table 6. Boilerplate 15 Operational Test Procedures, Test Preparation, S&ID Downey (Cont)

OTP Number	Title
9019	GSE Integrated Checkout, Hangar
9022	Procedure for Data Recording Group Functional Verification
9032	Umbilical Checkout and Hookup, Hangar
9034	Electrical Terminal Distributor Validation
9035	Umbilical Junction Box Validation
9039	DC Power Supply Validation
9102	GSE Integrated Checkout using SMD
9103	Water-Glycol Cooling Unit Checkout Using SMD
9104	MSFC Patch Panel and Logic Distributor Sub Unit 1 (A14-075)
9105	SC/GSE Crossover Distributor (A14-076)
9192	Functional Checkout of the Apollo Test Box 1, Signal Verification Unit (9FC-5472)
10002	Test Configuration Checklist
10003	Test Configuration Checklist Using SMD

Table 7. Boilerplate 15 Operational Test Procedures, AMR

OTP Number	Title
0003	Integrated Systems Checkout with Simulator, Hangar
0004	Integrated Systems Checkout 1
0005	Final Systems Verification, Pad
0006	Precount
0007	Countdown
0009	Integrated Systems Checkout 2
0021	Post Countdown Securing
0028	Integrated Systems Checkout 3
1008	EPS Checkout (Electrical Power System)
1050	Sequential Systems Checkout
1051	Power and Sequential Pre-Installation Acceptance (PIA) Procedure
1052	Battery Installation Spacecraft
1053	Battery Removal Spacecraft
3044	LES Total Weight and C. G. Determination
3045	LES Buildup
3063	Spacecraft Off-Loading and Preparation for Receiving Inspection
3065	Spacecraft Handling and Transportation to Launch Complex
3067	Mate SM Insert to Adapter
3068	Demate SM Insert From Adapter

Table 7. Boilerplate 15 Operational Test Procedures, AMR (Cont)

OTP Number	Title
3069	Mate SM to SM Insert
3070	Demate SM from SM Insert
3071	Mate CM to SM
3072	Demate CM From SM
3073	Mate Forward Heat Shield to CM
3074	Demate Forward Heat Shield From CM
3075	Mate LES to CM
3076	Demate LES From CM
3077	Escape Tower Fit Check
3078	CM Crew Access Cover Removal
3079	CM Crew Access Cover Installation
3080	Spacecraft Adapter Instrument Unit Fit Check
3081	Air Barrier Installation
3082	Air Barrier Removal
4057	Rocket Motor Receiving, Inspection, Storage, and Handling
4058	Pyro Receiving, Inspection, Storage, and Handling
5000	ECS Checkout
5020	ECS PIA Procedure
5023	CM Leakage Rate Check
5024	ECS Service

Table 7. Boilerplate 15 Operational Test Procedures, AMR (Cont)

OTP Number	Title
5025	ECS Drain and Purge
8111	Instrumentation Functional Checkout
8112	Instrumentation System PIA Procedure
8113	Radio Frequency (RF) System Functional Checkout
8114	Antenna Voltage Standing Wave Ratio (VSWR) Test
8115	RF System PIA Procedure
8130	RF Compatibility Test
9002	LES Substitute Unit Validation
9003	Pyro Substitute Unit Validation
9005	Launch Vehicle Simulator Unit Validation
9006	Auxiliary Crane Control Checkout
9010	Pyro Checkout Equipment Validation
9019	GSE Integrated Checkout, Hangar
9032	Umbilical Checkout and Hookup, Hangar
9033	Umbilical Checkout and Hookup, Pad
9036	Water-Glycol Unit Checkout, Pad
9037	GSE Integrated Checkout, Pad
9038	Ground Cooling Cart Checkout
9100	Cable Continuity Checkout, Pad 34
9101	Cable Continuity Checkout, Pad 37B

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Table 7. Boilerplate 15 Operational Test Procedures, AMR (Cont)

OTP Number	Title
9106	GSE Receiving and Inspection
9107	Water-Glycol, Complex Checkout
9108	Complex Wiring Checkout
9109	GSE Handling and Transportation to Launch Complex
9111	A14-011 Activation, GSE, Hangar
9113	A14-011 Deactivation, GSE, Hangar
9114	Procedure for Facility Checkout, GSE
10000	Hangar Checklist
10001	Pad Checklist

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Table 8. Boilerplate 15 Countdown Activities

Time	Activity	Location
T-6:00:00	Ordnance crew only on pad	Pad-37b
	Check continuity; install launch escape and pitch motor initiators (completed by T-5:40:00).	Spacecraft
T-5:40:00	Install conditioned solid propellant turbine spinners (completed by T-4:40:00).	S-I
T-4:30:00	Install hypergol cartridges (completed by T-4:10:00).	S-I
T-4:10:00	Check continuity; install separation initiators and connect electrical plugs (completed by T-3:35:00).	S-IV
	Check continuity, install spinner and destruct initiators, and connect electrical plugs (completed by T-3:30:00).	S-I
T-3:30:00	Verify systems (completed by T-2:40:00).	Spacecraft
	1. ECS pump check	
	2. TM checks	
	3. Power transfer checks	
	4. Beacon checks	
	5. Sequencer check	
	Connect LES and Sequencer electrical plugs.	
T-3:05:00	Fill LO_2 tank to 98 percent (completed by T-2:40:00).	S-IV
T-2:46:00	Fill LO_2 tank to 10 percent (completed by T-2:25:00).	S-I

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Table 8. Boilerplate 15 Countdown Activities (Cont)

Time	Activity	Location
T-2:40:00	Remove carry-on GSE (completed by T-2:30:00).	Spacecraft
	Replenish LO_2 tank to 99.75 percent (stop at T-0:02:20).	S-IV
T-2:30:00	Close hatch (completed by T-2:20:00).	Spacecraft
T-2:20:00	Remove gantry (complete by T-1:30:00).	Pad 37b
T-1:30:00	Clear pad of personnel.	
	Fill LO_2 to 100 percent.	S-I
T-1:00:00	Start LO_2 replenish.	S-I
T-0:50:00	Start final fuel level correction (complete by T-0:40:00).	S-I
T-0:45:00	Start fuel pressurization.	S-I
T-0:40:00	Final fuel level correct	S-I
	Start spacecraft GN_2 purge.	Spacecraft
	Start LH_2 tanking to 95 percent.	S-IV
T-0:35:00	Turn on hydraulic power and gimbal engines.	S-IV
T-0:30:00	Turn on Q-ball heater.	Spacecraft
T-0:25:00	Turn on ECS fan and pump	Spacecraft
T-0:20:00	Turn on instrumentation bus, TM, and transponder.	Spacecraft
T-0:05:20	Pressurize fuel tank.	S-I
	Check engines gimballed and return to null.	S-IV
	Replenish LH_2 to 99 percent.	S-IV

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Table 8. Boilerplate 15 Countdown Activities (Cont)

Time	Activity	Location
T-0:04:00	Change power over to internal, ECS to internal.	Spacecraft
	Arm pyro busses.	Spacecraft
T-0:03:30	Turn on ECS ready light.	Spacecraft
	Turn on LES ready light.	Spacecraft
T-0:03:00	Turn TM power to high.	Spacecraft
T-0:02:50	Calibrate TM.	Spacecraft
T-0:02:31	Firing command	S-I
T-0:02:30	Begin power transfer.	S-IV
	Start LO_2 pressurization.	S-IV
	Start LO_2 bubbling.	S-I
T-0:02:20	Turn RF ready light on.	Spacecraft
T-0:02:10	Start LH_2 replenishing to 100 percent.	S-IV
T-0:02:00	Turn spacecraft ready light on.	Spacecraft
T-0:01:28	Turn LO_2 bubbling off.	S-I
	Start LO_2 pressurization.	S-I
T-0:00:35	Start S-IV calibration.	S-IV
	Complete LO_2 pressurization.	S-IV
	Complete LO_2 replenishing.	S-IV
	Complete LH_2 replenishing.	S-IV
T-0:00:45	Complete S-IV calibration.	S-IV

Table 8. Boilerplate 15 Countdown Activities (Cont)

Time	Activity	Location
T-0:00:25	Start S-I power transfer.	S-I
T-0:00:05	Complete LO_2 pressurization.	S-I
	Complete power transfer.	S-I
T-0:00:00	Ignition command	S-I
T+0:00:01	Engine start	S-I
	Umbilical disconnect	Spacecraft and S-1
	Module GN_2 purge-off	Spacecraft
T+0:00:03:42	Hold down release	S-I
	Lift-off	

10.0 TEST MANAGEMENT ORGANIZATION

10.1 DOWNEY TEST PREPARATION ORGANIZATION

The Downey Test Preparation Organization is depicted in Figure 18. Major responsibilities of the B-15 test preparation team are as follows:

1. B-15 test project engineer

   a. Plan, schedule, and conduct all tests performed on B-15 after manufacturing completion and prior to shipment to AMR.

   b. Review and approve operational test procedures.

   c. Review and approve test preparation work schedules.

2. Systems group

   a. Initiate and implement individual systems detailed checkout procedures, and evaluate test results.

   b. Conduct individual and integrated systems checkout and operating procedures.

3. GSE group

   a. Prepare and conduct GSE operational test procedures.

   b. Direct GSE maintenance, and review GSE support manuals.

   c. Coordinate GSE requirements and GSE instrumentation calibration.

4. Instrumentation group

   a. Establish special instrumentation installation, calibration, and checkout procedures.

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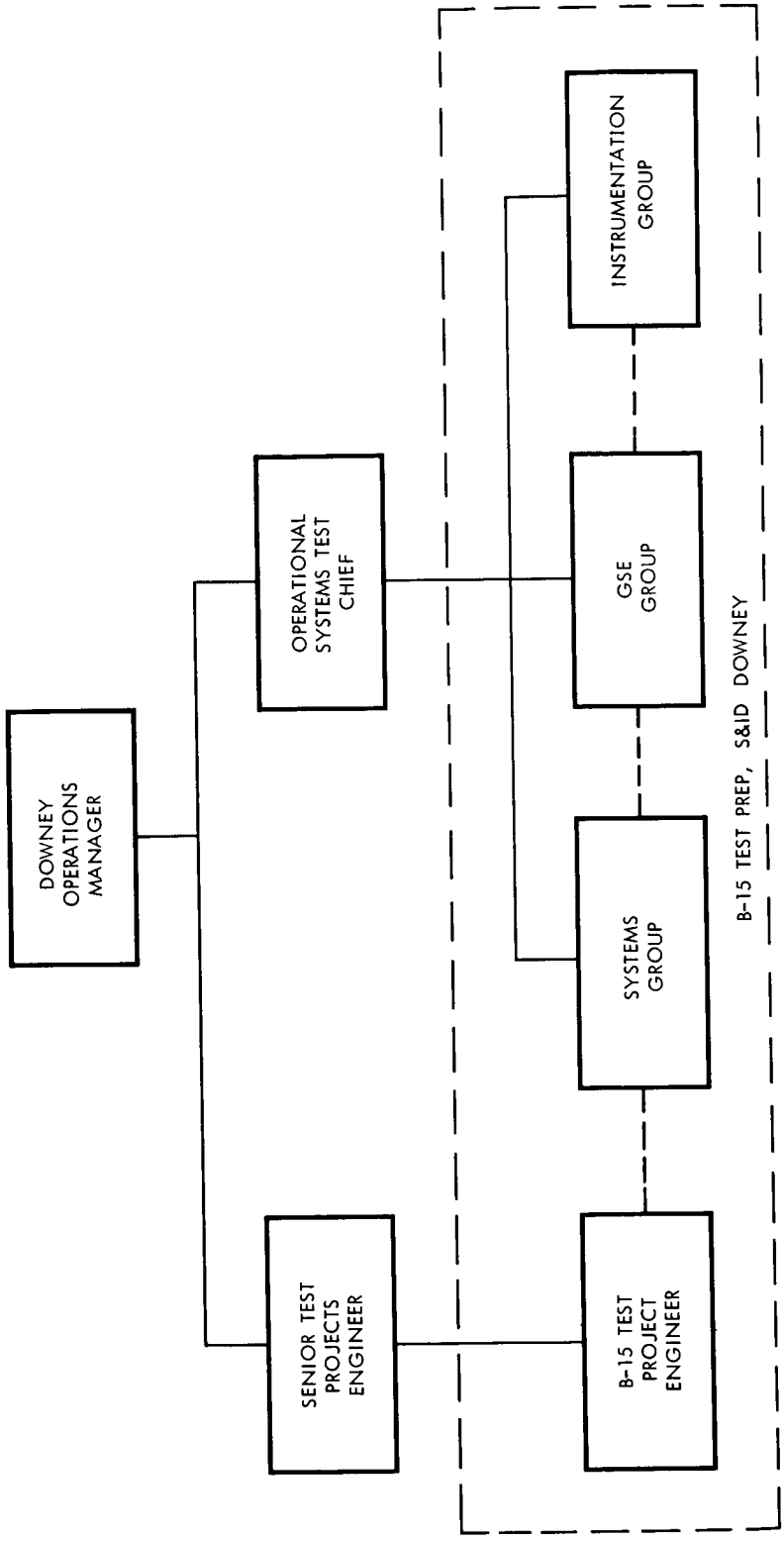

Figure 18. Test Preparation, Downey

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b. Coordinate the measurement list and OTP Engineering data requirements.

c. Direct instrumentation test activities.

10.2 FLORIDA FACILITY CHECKOUT AND LAUNCH OPERATIONS

The Florida facility test organization is shown in Figure 19. The Florida facility checkout and launch group responsibilities are as follows:

1. Florida facility Apollo operations manager

   a. Provide over-all direction of Apollo operation at AMR.

   b. Be responsible to Downey Test and Operations Director, Florida facility General Manager, and NASA for interpreting and implementing the policies and directions of the Apollo test program at AMR.

   c. Be responsible for establishing effective working relations with NASA-POD and associate contractors.

2. Test operations group

   a. Coordinate and schedule all S&ID activities at AMR.

   b. Provide over-all planning to ensure completion of tests in accordance with test schedules.

   c. Coordinate with NASA, Downey, and associate contractors at AMR.

   d. Prepare all schedules and review test plans and procedures.

   e. Direct and control all systems checkout and launch operations.

3. Systems group

   a. Ensure readiness of spacecraft system for all checkout and flight operations.

   b. Operate system monitor and control equipment during checkout operations under the direction of Test Operation group.

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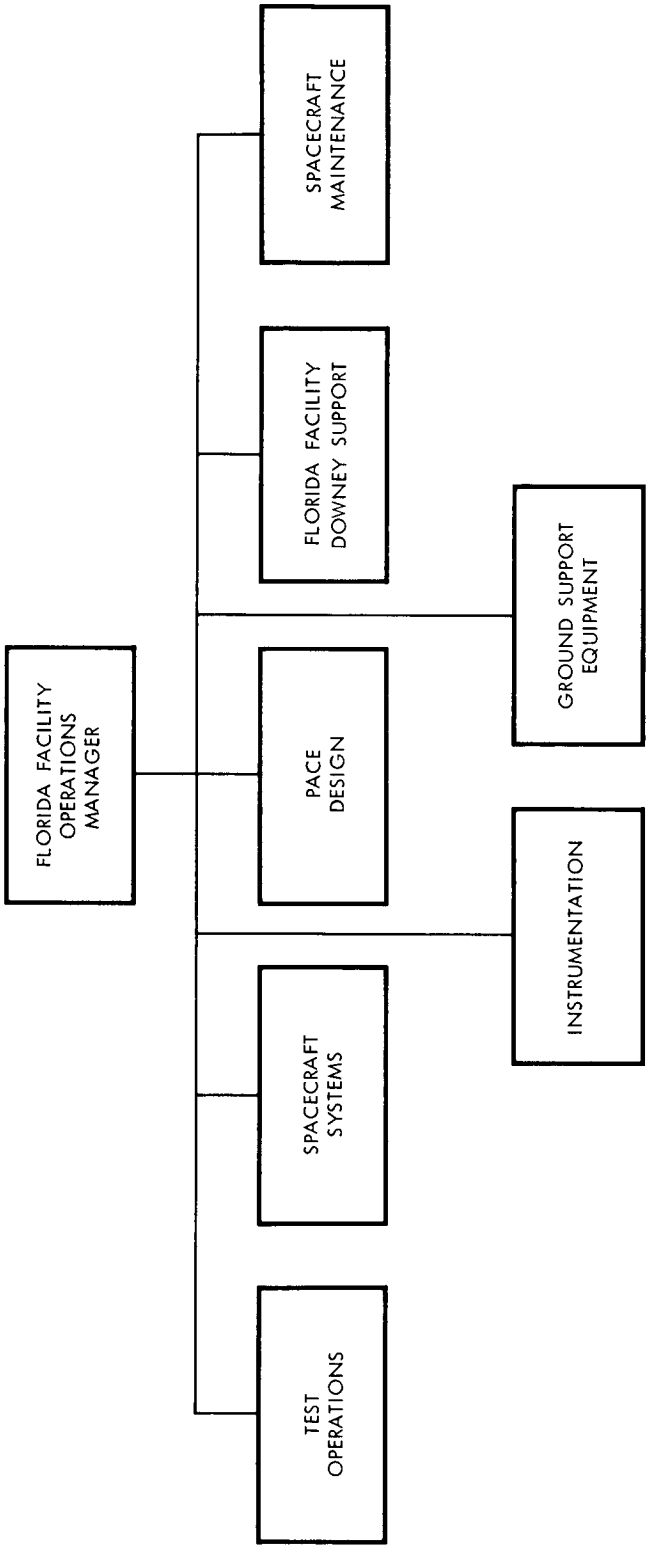

Figure 19. Test Preparation, Florida Facility

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c. Be responsible for the acceptance and preparation of the test vehicle and for checkout of all systems prior to launch operations.

d. Prepare individual system checkout procedures for test operation approval.

e. Acquire and process the data in accordance with the test plan, and perform preliminary data analysis as required to support test operations.

4. Instrumentation group

a. Direct all instrumentation calibrations, checkouts, and test activities.

b. Coordinate the instrumentation measurements and OTP Engineering data requirements.

c. Coordinate quick-look and calibration data with data groups.

5. Ground Support Equipment group

a. Develop checkout and maintenance procedures for all GSE.

b. Ensure readiness of GSE to support spacecraft system checkout and launch operations, and evaluate GSE adequacy and performance during ground operations.

c. Ensure facility-GSE compatibility and readiness to support all spacecraft operations.

d. Provide design and drafting support for test operations.

6. Florida Facility Downey Support group

a. Provide technical support of all tasks associated with the Florida facility field operations.

b. Prepare and publish detail test plans for each test vehicle.

c. Assist in the preparation of Florida facility support requirements and publish program requirement documents.

7. Spacecraft Maintenance

a. Provide technicians for test operations.

b. Provide administration and supervision of all technicians.

8. PACE Design

a. Provides engineering liaison with NASA-PPO and Downey.

b. Conducts PACE breadboard evaluation.

c. Coordinates PACE site activation.

11.0 RECOVERY REQUIREMENTS

There are no recovery requirements for Boilerplate 15.

12.0 LAUNCH DAY REQUIREMENTS

12.1 WEATHER REQUIREMENTS FOR LAUNCH

The following minimum weather requirements for launch will be monitored from L-3 days until launch.

1. Ambient temperature must be between 20 and 140 F.
2. No ground-level icing is allowable.
3. Launch must take place from sunrise to one hour before sunset.
4. The cloud cover must permit optical tracking to 300,000 feet.
5. Winds at a 100-foot elevation may not exceed 22.5 knots steady state.
6. Winds at a 200-foot elevation may not exceed 25.9 knots steady state.

A gust factor of 1.4 is allowable for wind readings.

13.0 PAD AND RANGE SAFETY REQUIREMENTS

13.1 PAD SAFETY

Pad safety is under the direction of the pad safety supervisor. All provisions of the General Range Safety Plan, Volume I, AFMTC Pamphlet 80-2, are applicable unless specifically expected, modified or supplemented.

13.2 RANGE SAFETY

Range safety is the responsibility of the range safety officer. All critical or potentially hazardous operations must be cleared with him prior to accomplishment. Range safety requirements will be in accordance with the General Range Safety Plan, Volume II, AFMTC Pamphlet 80-2. This document supplements the general safety policies and procedures prescribed in AFMTC regulation 80-9.

14.0 DATA HANDLING, ANALYSIS, AND REPORTING

14.1 DATA HANDLING AND PROCESSING

Data Engineering will support Downey preparation testing, field prelaunch testing, and launch flight operations of Boilerplate 15 by rapid data processing and presentation for analysis and evaluation of system performance. They will maintain instrumentation calibration curves, monitor real-time data displays, assist in determining areas of data playback, and submit the test data in report form for analysis. During the launch operation, spacecraft-generated data will be transmitted via RF link to AMR acquisition sites and recorded on magnetic tapes. Selected data will be displayed at the sites in real time on oscillograms or strip charts for monitoring purposes. Subsequent to the flight, other data will be processed at the field data processing station for additional preliminary analysis. A copy of each magnetic tape, containing the data acquired during the flight operation, will be transmitted to the Apollo Data Engineering within 24 hours after the flight. These tapes will then be processed and the data presented in the appropriate forms for detailed analysis and reporting. The data to be provided by the AMR and the time periods required will be specified in the B-15 Operations Requirements document. The AMR-acquired tracking data (radar and optical) will be reduced at the range processing center and submitted to Apollo Data Engineering as follows:

14.1.1 Preliminary Data

Preliminary data in the launch-pad-centered rectangular coordinate system are required within 48 hours after the flight. If the above data requirements cannot be fulfilled, radar data containing time, azimuth, elevation, and slant range from each tracking station will be required within the same time period. Also required will be the coordinates of each radar and the calibration correction. All data are required on magnetic tapes and in tabular form.

14.1.2 Final Data

The tracking data will be processed into the required outputs as specified in the program requirements document (PRD). These data will be required on magnetic tape in BCD format compatible with IBM 700-series computers and in tabular form. The data are required within three working days following the mission. Copies of all engineering sequential film and their tabulated event times are required within 24 to 48 hours after launch.

The meteorological data will be required in tabular form and on IBM cards within 24 hours after launch.

14.2 CALIBRATION DATA

System calibration checks on each parameter will be conducted in the Downey test preparation area. The results obtained from the calibrations will be run through an IBM 7090 computer to determine the best curve fit of the values. These data will be plotted and transported with the vehicle to the field test site. The field test site personnel will perform calibration checks on each measurement and compare the results with the Downey calibrations. Transducer measurements found outside acceptable limits will be rechecked and replaced as required to bring these measurements within acceptable tolerances. When a transducer or the signal conditioning is changed, a new calibration will be made. After plotting to verify the calibration, the information will be forwarded to Downey.

14.3 DATA ANALYSIS AND TEST EVALUATION

The detailed analysis of all test data for systems and over-all test evaluation will be accomplished jointly by Test Integration, the various engineering design groups, Test and Operations, and Data Engineering. In the field, personnel will view the quick-look evaluation flight data to determine preliminary operating performance of the spacecraft and to verify that the test objectives were fulfilled. Questionable areas will be verified with additional playbacks made at the field data processing station. This preliminary information will be distributed in the field reports. At Downey the telemetry tapes will be processed and the data presented in preliminary format on oscillograph records. The records will be annotated and validated, and a chronology of major events will be determined and checked for proper sequence. A preliminary evaluation of the flight performance will be conducted during a data review with Apollo Test and Operations, Test Integration and the design groups. Specific areas of interest arising from this review will be further investigated. After the preliminary data review has been completed, the telemetry data will be processed into a final format (digitized) and presented in report form. Specific areas of interest arising from the preliminary review will be noted in greater detail. The final data will be qualified for consistency with the preliminary data and inspected for accuracy. Preliminary tracking data may be further processed through computers at Downey into the required outputs. This data will be reviewed for consistency and completeness and released to the appropriate groups. All final tracking data will be forwarded to Downey, edited, further processed if necessary, and presented in report form. The processed telemetry and tracking data will then be compiled into data reports and released to Test Integration, the various engineering design groups, and Test and Operations for a detailed system analysis and over-all flight performance evaluation, and for inclusion in the S&ID final test report.

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14.4 S&ID TEST REPORTING

14.4.1 T+5 Day Data Submittal Report

This report will contain all processed telemeter data presented in analog form of function value versus time, and will be required for submittal five calendar days after receipt of the tapes in Downey. No analysis will be required in this report.

14.4.2 T+30 Day Spacecraft Flight Report

This report will contain the detailed systems analysis and will be due thirty calendar days after receipt of the tapes at Downey.

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15.0 GROUND SUPPORT EQUIPMENT

15.1 GENERAL

Items of GSE are either shop-released for B-15 (in which case they are normally assigned to the spacecraft at Downey and remain with the vehicle through launch operations), or they are time-shared, as designated, with another vehicle. After the launch, the GSE utilized at the AMR will be recycled to Downey for updating and reassignment if major modification is required. Otherwise the equipment will remain at AMR for time-sharing with subsequent vehicles. GSE planning and requirements are presented in SID 62-564.

Four general groups of GSE will be utilized in the various areas of checkout and testing.

C Checkout equipment (systems control and monitoring devices, interconnecting cables, and power distribution systems)

H Handling equipment (sling, dollies, supports, etc.)

A Auxiliary equipment (protective covers, dummy motors, simulators, etc.)

S Servicing equipment (battery chargers, fluid transfer and booster units, etc.)

15.2 GROUND SUPPORT EQUIPMENT LIST

The ground support equipment assigned to Boilerplate 15 is shown in Table 9.

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Table 9. Boilerplate 15 Ground Support Equipment

GSE Model Number	Nomenclature	Remarks
A14-001	Launch Escape System Substitute Unit	Shop-released*
A14-003	Pyrotechnics Initiators Substitute Set	Time-share B-14 Downey B-13 AMR**
A14-007	LES Optical Alignment Set	Shop-released
A14-009	Spacecraft Adapter Cover	Shop-released Downey Time-share B-13 AMR
A14-010	CM Cover	Time-share B-12 Downey B-13 AMR
A14-011	Ground Cooling Cart	Time-share B-13 AMR B-23 Downey
A14-020	SM Cover	Shop-released
A14-021	Launch Vehicle Substitute Unit C1	Shop-released
A14-022	LES Cover	Time-share B-13 AMR
A14-024	Disconnect Set Umbilical, Fluid Elect.	Shop-released
A14-026	Cap and Plug Set	Shop-released
A14-027	Adapter, Cap and Plug Set	Shop-released (modification kit shop-released to rework)

*Shop-release signifies an item purchased for B-15 first usage. This item normally will accompany B-15 to Downey test prep and AMR. However, in specified cases the item is for B-15 usage at facility indicated with possible time-share at other facility.

**Time-share signifies an item which is actually shared in usage with indicated boilerplate or reallocated to B-15 from indicated boilerplate.

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Table 9. Boilerplate 15 Ground Support Equipment (Cont)

GSE Model Number	Nomenclature	Remarks
A14-028(2)	Optical Alignment Set	GFP Downey Time-share B-13 AMR
A14-035(2)	Vacuum Cleaner	Time-share B-13 AMR, B-12 Downey
A14-036	Ground Air Circulating Unit	Shop-released
A14-037	Adapter and Duct Set	Time-share B-13 AMR B-12 Downey
A14-038	Launch Escape Motor, Dummy (Lockheed)	Time-share B-13 Downey
A14-039	Launch Escape Jettison Motor Dummy (Thiokol)	Time-share B-13 Downey
A14-040	Launch Escape Pitch Control Motor, Dummy (Lockheed)	Time-share B-13 Downey
A14-046	Crane Control, Auxiliary	Time-share B-12 Downey B-13 AMR
A14-047	Box Level	Time-share B-12 Downey B-13 AMR
A14-075(2)	MSFC Patch and Logic Distributor Substitute Unit	Time-share B-13
A14-076	SC GSE Crossover Distributor	Time-share B-13
A14-130	Set Wrench, LES Tower Explosive Bolts	Time-share B-13
A14-134	Crane Control, Auxiliary (10-ton)	To be determined
C14-021	Telemetry Ground Station	Time-share with all units Downey
C14-029	LE Sequencer BME	Time-share B-13

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Table 9. Boilerplate 15 Ground Support Equipment (Cont)

GSE Model Number	Nomenclature	Remarks
C14-032	Antenna Checkout Group	Time-share B-13 Downey NASA Provided to AMR
C14-051	Pyrotechnics BME	Time-share B-13 AMR
C14-112	C-Band Radar Transponder, Checkout Unit	Shop-released. Stays at Downey. Time-share B-13 AMR
C14-135(2)	Signal Conditioner	Shop-released (101) Time-share B-13 (201)
C14-166	R&D C-Band Antenna Coupler	Time-share B-12 All Downey units
C14-177	Electrical Cable Set (AMR)	Time-share B-13 AMR pad 37
C14-180	Electrical Cable Set (AMR)	Time-share B-13 AMR pad 34
C14-186	Electrical Cable Set	Shop released Downey. Time-share B-13 AMR.
C14-191	Terminal Distributor	Shop-released Downey. Time-share B-13 AMR.
C14-192(2)	Umbilical Junction Box	Time-share B-13 Downey and one at AMR (basic) Time-share B-13 pad 34 and 37 (101)
C14-414(2)	Launch Control Group	Shop-released (basic) Downey. Time-share B-13 AMR (101)

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Table 9. Boilerplate 15 Ground Support Equipment (Cont)

GSE Model Number	Nomenclature	Remarks
C14-418	Spacecraft Ground Power Supply	Shop-released
C14-420(2)	Data Distributor and Recording Console	Shop-released (Basic) Downey. Time-share B-13 AMR (101)
C14-427	Cal. Unit Flow Rate	Time-share B-14 Downey. Time-share AMR unit at AMR.
C14-434	Test Harness LEM	Time-share B-12 Downey
C14-458	Static EMI Checkout Device	Time-share B-13 AMR.
C14-465	Electrical Cable Set	Shop-released
H14-002	Sling, LET	Time-share B-12 Downey B-13 AMR
H14-011(2)	Launch Escape Alignment Stand	Time-share B-12 Downey B-13 AMR
H14-016	LES Weight and Balance Fixture	Shop-release Downey. Time-share B-13 AMR
H14-017	Weight and Balance Fixture Spacraft	Time-share B-12 Downey B-13 AMR
H14-018	Escape Tower Support	Shop-released Downey. Time-share B-13 AMR
H14-021	GSE Handling Cart	Shop-released Downey. Time-share B-13 AMR
H14-027	Adapter, Rail Transfer, Skirt	Time-share B-12 Downey B-13 AMR

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Table 9. Boilerplate 15 Ground Support Equipment (Cont)

GSE Model Number	Nomenclature	Remarks
H14-029	Sling, Skirt	Time-share B-12 Downey B-13 AMR
H14-030	Spacecraft Support Base	Time-share B-13 AMR B-14 Downey
H14-040	Elect. Weight Kit (3000 lb.)	Time-share B-12 Downey. To be assigned AMR
H14-041	Elect. Weight Kit (30,000 lb.)	Time-share B-12 Downey. To be assigned AMR
H14-042(2)	Hoist Beam SM and SC Adapter	Shop-released Downey. Time-share B-13 AMR
H14-043	Sling, Jettison Motor	Time-share B-1 Downey B-13 AMR
H14-052	Positioning Trailer, Narrow Base	Time-share B-1 Downey B-13 AMR
H14-054	Jettison Motor Support	Time-share B-12 Downey B-13 AMR
H14-055	Launch Escape Motor Support	Time-share B-12 Downey B-13 AMR
H14-057	Forward Compartment Shield Sling	Time-share B-12 Downey B-13 AMR
H14-074	SC Sling (with LES)	Time-share B-23 Downey B-13 AMR
H14-083	Cradle, Transport LES	Time-share B-12 Downey B-13 AMR
H14-084	Adapter, Roll-over	Time-share B-12 Downey B-13 AMR

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Table 9. Boilerplate 15 Ground Support Equipment (Cont)

GSE Model Number	Nomenclature	Remarks
H14-085(2)	Sling, Horizontal Handling LES and LE Motor	Shop-released (1 unit Downey 1 unit AMR). Time-share B-13 AMR
H14-086(2)	Support Base Assembly Tubular, Boilerplate	Shop-released (1 unit). Time-share other unit B-13 Downey and AMR
H14-090	Stand, Access, Recovery area	Time-share BP-12 Downey B-13 AMR
H14-091	Stand, Access, CM Hatch	Time-share B-12 Downey B-13 AMR
H14-092	Sling, Pitch Control Motor, Inter-Struc.	Time-share B-12 Downey B-13 AMR
H14-093	Boatswain's Chair	Time-share B-12 Downey B-13 AMR
H14-094	Sling, Set Motor Pitch Control Motor, Nose Cone	Time-share B-12 Downey B-13 AMR
H14-096	Hook, Ballast Pickup, LES	Time-share B-12 Downey B-13 AMR
H14-097(2)	Stand, Access, LES Buildup	Time-share B-12 Downey B-13 AMR
H14-099(2)	Wrench, Pitch Control Motor, LES	Time-share B-12 Downey B-13 AMR
H14-101	Platform, Access (3 feet by 10 feet)	Need further data; no shop-release quantity for AMR

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Table 9. Boilerplate 15 Ground Support Equipment (Cont)

GSE Model Number	Nomenclature	Remarks
H14-109	Access Stand, SM (External)	Shop-release Remains at Downey Time-share B-13 AMR
H14-111	Access Stairs, CM Hatch	Time-share B-13 AMR B-13 Downey (one remains at Downey)
H14-126	Beam, Weight and Balance SM and Adapter	Time-share B-13 AMR B-13 Downey (one remains at Downey)
H14-127	Cable Fitting Weight and Balance, SM and Adapter	Time-share B-13 Downey B-13 AMR (one remains at Downey)
H14-131	Spacecraft Vertical Transport Vehicle	Time-share B-13 AMR
H14-139(4)	Forward Compartment Heat Shield Retention Bolt Guide	Shop-released
H14-140	Cartridge Test Chamber	Time-share B-13 AMR
H14-145	Sling, Shipping Container	Shop release
H14-146	Carriage Assembly Boatswain's Chair Trolley	Shop release pending
H14-147	SM Internal Working Platform	Shop-release Downey. Time-share B-13 AMR.
H14-9001	Sling Set, CM Test Vehicle	Time-share B-12 Downey
H14-9006	Sling Set, Weight and Balance	Time-share BP-1 Downey (basic) B-13 AMR (101)

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Table 9. Boilerplate 15 Ground Support Equipment (Cont)

GSE Model Number	Nomenclature	Remarks
H14-9015(2)	Jack Set, Weight and Balance	Time-share BP-1 Downey B-13 AMR (101)
H14-9030(2)	Base Support, SM and Adapter	Shop-release
H14-9059	SM and SC Adapter, Weight and Balance Fixture	Time-share B-12 Downey
H14-9073	Spacecraft Boilerplate Sling	Time-share B-14 Downey B-13 AMR
H14-9076	General Purpose Dolly	Shop-released
H14-9077	Sling, Access Door, SM	Time-share B-23 Downey B-13 AMR
S14-015(3)	Battery Charging Unit	Time-share B-14 Downey B-13 AMR
S14-034	Fluid Distribution System	Time-share B-13 Downey B-13 AMR
S14-036	Fluid Distribution System	Time-share B-13 AMR (Hangar AF)
S14-052	Water-Glycol Cooling Unit	Shop-released Downey (basic) Time-share B-13 AMR (101)
S14-078	Mobile Pressure Leak Test, LES Motor	Time-share B-13 AMR only
S14-082	Fluid Distribution System	Shop-release

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16.0 REFERENCES

1. Apollo Measurement Requirements Boilerplate 15. NAA S&ID, SID 63-565.

2. Apollo Electrical Umbilical Requirements Flight Research and Development Vehicle Lists. NAA S&ID, SID 63-619-1.

3. Apollo Spacecraft Requirement Specification. NAA S&ID, SID 62-700-2.

4. Weight, Balance, and Inertia for the Boilerplate Configurations. NAA S&ID, SID 62-1434.

5. General Test Plan, Research and Development for Project Apollo Spacecraft, Volumes I and V. NAA S&ID, SID 62-109-1 and 62-109-5.

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3.3 BOILERPLATE 18 DETAILED TEST PLAN

3.3.1 Introduction

3.3.1.1 Purpose

This document presents the detailed test plan for Boilerplate 18 and is to be utilized for testing at Downey and AMR until superseded by the NASA Project Apollo Flight Mission Directive for Boilerplate 18.

3.3.1.2 Scope

The scope of this detailed test plan is to specify test objectives, describe vehicle configuration, establish system priorities, present flight trajectories and describe the instrumentation requirements for Boilerplate 18 testing as well as the S&ID method of qualifying the test vehicle for the mission.

3.3.1.3 Precedence of Reports

The detailed test plan for Boilerplate 18 shall take precedence over all other reports and documents concerned with Boilerplate 18 testing except the NASA Project Apollo Flight Mission Directive for Boilerplate 18. The NASA mission directive, when published, shall supersede the detailed test plan.

3.3.1.4 Amendments

This document shall be revised quarterly or as often as necessary to reflect changes in the test plan and to provide additional information that is not available at time of publication.

3.3.1.5 Definition of Objective Terminology

The definition of terms used in connection with the objectives are as follows:

1. Demonstrate. Denotes the occurrence of an action or an event during a test. The accomplishment of an objective of this type requires a qualitative answer. The answer will be derived through the relation of this action or event to some other known information or occurrence. This category of objective implies a minimum of airborne instrumentation, and/or that the information be obtained external to the spacecraft.

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2. Determine. Denotes the measurement of performance of any system or subsystem. This category implies a quantitative investigation of overall operation which includes, generally, instrumentation for measuring basic inputs and outputs of the system or subsystem. The information obtained should indicate to what extent the system is operating as designed. The instrumentation should allow performance deficiencies to be isolated to either the system or to the system inputs.

3. Evaluate. Denotes the measurement of performance of any system or subsystem as well as the performance and/or interaction of its components that are under investigation. The accomplishment of objectives of this type requires quantitative data on the performance of both the system or subsystems and its components. The performance levels will then be analyzed for their contribution toward performance of the system. This category will provide the most detailed information of any of these categories.

4. Obtain Data. Denotes gathering engineering information which is to be measured to augment the general knowledge required in the development of the overall spacecraft. This category may also be used for supplemental investigation such as environmental studies, ground equipment studies, etc. The degree of instrumentation is not implied by this definition.

5. Establish. Denotes gathering engineering information for the development of ground procedures and operating techniques. Objectives in this category are not necessarily dependent on analytic studies.

3.3.1.6 Definition of Objectives

Test objectives are described as being Apollo first-order or Apollo second-order. These categories are defined as follows:

1. Apollo First-Order Test Objectives. Apollo first-order test objectives must be achieved to make the flight successful. Any malfunction of the S/C systems, G.S.E. or instrumentation which would jeopardize the attainment of first-order objectives shall be justification for initiating a hold during the countdown or postponement of the flight until the malfunction has been rectified.

[redacted]

2. Apollo Second-Order Test Objectives. Apollo second-order test objectives are those desired to support future Apollo flights or to supply supplementary data for overall spacecraft evaluation. Malfunction of the S/C systems, G. S. E. or instrumentation which would jeopardize the attainment of second-order objectives will not require a hold after start of countdown. Correction thereafter may be made at the discretion of the NASA test conductor.

3. 3. 1. 7 Definition of Systems Priorities

The Spacecraft systems are assigned either primary (P) or secondary (S) priorities. During the initial test program, when incomplete systems are tested, this definition will apply to the subsystem and component level.

3. 3. 1. 7. 1 Primary System (P). Primary systems are those functionally required for the S/C to successfully complete its planned mission or to accomplish first-order objectives. A hold or scrub will be mandatory if any of the primary systems indicate improper operation. Positive indication of satisfactory operation of all primary systems must be available for launch.

3. 3. 1. 7. 2 Secondary System (S). Secondary systems are those systems not functionally required for the S/C to complete its planned mission. Malfunction of secondary systems will not require a mandatory countdown hold or scrub. Corrections thereafter may be made at the discretion of the NASA Test Director or the NAA Project Engineer.

3. 3. 2 Test Objectives and System Priorities

The purpose of the third orbital spacecraft is to demonstrate the launch vehicle-spacecraft compatibility, to qualify the adapter and service module structures, and to evaluate the launch vehicle emergency detection and spacecraft-to-launch-vehicle separation systems. The Apollo Boilerplate 18 will be utilized for the test.

3. 3. 2. 1 Test Objectives

3. 3. 2. 1. 1 First-Order Objectives. The first order test objectives are:

1. To demonstrate satisfactory separation of the spacecraft from the Saturn I launch vehicle after S-IV burnout

[redacted]

[redacted]

2. To evaluate the structural integrity of the adapter and S/M structures under actual flight loading conditions

3. To evaluate the operation of the spacecraft crew safety system circuitry, displays, and controls in relation to the closed-loop flight test of the launch vehicle emergency detection system (EDS)

3.3.2.1.2 Second-Order Objectives. The second order test objective is to demonstrate satisfactory launch escape tower jettison.

3.3.2.2 System Priorities

1. Launch escape system (LES)

a. Tower jettison motor	Primary
b. Launch escape motor	Secondary
c. Pitch control motor	Secondary
d. Tower separation system	Primary
e. Tower sequencer	Primary

2. Electrical power system (EPS) partial

a. Battery power system	Primary
b. Mission sequencer	Primary

3. Communications and instrumentation system

a. Telemeter and antenna system	Primary
b. C-band transponder	Primary
c. Instrumentation	(See measurements list)

4. Environmental control system

Temperature control	Primary

[redacted]

5. Spacecraft separation systems

   a. S-IV to S/M adapter separation system — Primary

   b. S/M to S/M adapter separation system — Primary

   c. C/M to S/M separation system — Secondary

6. Service module reaction control system—partial, motor only (-x) — Primary

7. Emergency detection system — Primary

3.3.3 Mission Description

3.3.3.1 General Flight Plan

This test flight will be one of a series for qualification of the Saturn I launch vehicle to place the spacecraft into a low earth orbit and to demonstrate the physical and flight compatibility of the launch vehicle and spacecraft. The L/V-spacecraft separation system will be demonstrated. Provisions will be made to accommodate a closed-loop flight test of the emergency detection system (EDS).

The test vehicle will be launched in December 1964, by a Saturn I from pad 37B at an azimuth of 090 degrees rolling to a flight azimuth of 105 degrees prior to the pitch maneuver. The Saturn I launch vehicle (SA-10) will consist of a Saturn I first stage and an S-IV second stage. The spacecraft will consist of a live LES, command module (Boilerplate 18), service module, and a spacecraft adapter. During the first 146.9 seconds of powered flight, the Saturn I's eight H-1 engines will propel the test vehicle to an altitude of 200,220 feet; at this point the four inboard S-I engines will cut off. Six seconds later, the remaining S-I engines will cut off and the Saturn I will be jettisoned. S-IV ignition will occur at 155.9 seconds at an altitude of 231,166 feet. After 10 seconds of S-IV powered flight, the launch escape tower will be jettisoned at 265,188 feet. The inertial guidance system (ST 124) in the instrumentation unit will control the flight trajectory throughout the S-I powered flight.

The C/M, S/M, spacecraft adapter, and S-IV will be injected into a 100-mile circular orbit at T + 629.7 and an altitude of 607,612 feet. At injection, the S-IV engines are cut off and the spacecraft is separated from the S-IV. This separation operation involves firing the service module RCS motors (all four -x jets) followed by activation of the adapter shaped charges which simultaneously split the adapter into four free panels and separate the

[redacted]

S/M from the launch vehicle just above the instrumentation unit. Separation will be completed at T + 630.2. Orbital lifetime is estimated to be two to three days. No recovery is planned.

3.3.3.2 Sequence of Events and Flight Parameters

The sequence of events and flight parameters are shown in Table 3-1.

3.3.3.3 Flight Trajectories

Trajectory information for Boilerplate 18 is presented in Figures 3-1 through 3-7.

3.3.3.4 Flight Constraints

Flight constraints define the minimum, mandatory qualifications tests that must be completed on each major vehicle system prior to launch. Failure to satisfactorily complete these tests shall cause a flight hold. The flight constraints for BP-18 are presented in Table 3-2 and the status of these constraints will be determined monthly. Final constraint review will normally occur during the test vehicle acceptance data package review at the Florida facility after boilerplate/launch vehicle mating.

3.3.4 Description of Test Vehicle

The test vehicle (BP-18) configuration will consist of a complete LES, C/M, S/M (spacecraft type) and an adapter (spacecraft type) mounted on a Saturn I launch vehicle (IU, S-IV and S-I). The complete test vehicle configuration is presented in Figure 3-8.

3.3.4.1 Spacecraft Weight and Balance

Spacecraft weight and balance are shown in Table 3-3.

3.3.4.2 Launch Escape System (LES)

The Launch Escape System consists of live pitch control, tower jettison and launch escape motors. The LES also includes a structural skirt and launch escape tower equipped with separation system, instrumentation sensors, gauges and wiring. Mounted within the nose cone is a Q-ball pressure sensing system. Major components are as follows:

1. Q-ball assembly (NASA supplied)

2. Ballast enclosure

Table 3-1. Sequence of Events and Flight Parameters (B-18)

Time (sec)	Event	Altitude (ft)	Range (naut mi)	Relative Velocity (ft/sec)	Dynamic Pressure (psf)	Mach No.	Flight Path Angle (deg)	Inclination (deg)
T - 3.42	S-I ignition	0	0	0	0	0	90.0	
T - 0	Lift-off	0	0	0	0	0	90.0	
T + 72	Max Q	38,000		1500.0	690.0	1.52	55.25	
T + 146.9	S-I inboard engine cutoff	200,220	45.0	8383.6	21.33		24.36	
T + 152.9	S-I burnout	221,188	51.91	8899.28	10.89	9.10	23.39	
T + 155.9	S-IV ignition	231,166	55.90	8861.66	7.0	9.37	22.92	
T + 165.9	LET jettison	265,188	69.31	8942.67	1.4		21.34	
T + 437.9	Peak altitude	658,045	556.19	14806.63			0	
T + 629.7	Circular orbit insertion	607,612	1136.79	24245.40			0	31.1
	S-IV cutoff							
	Start separation timer							
	S/M RCS ignition (all 4 jets)							
T + 630.2	Initiate spacecraft adapter jettison		1250					
T + 637	Separation completed							
T + 749.7	T/M's turned off							

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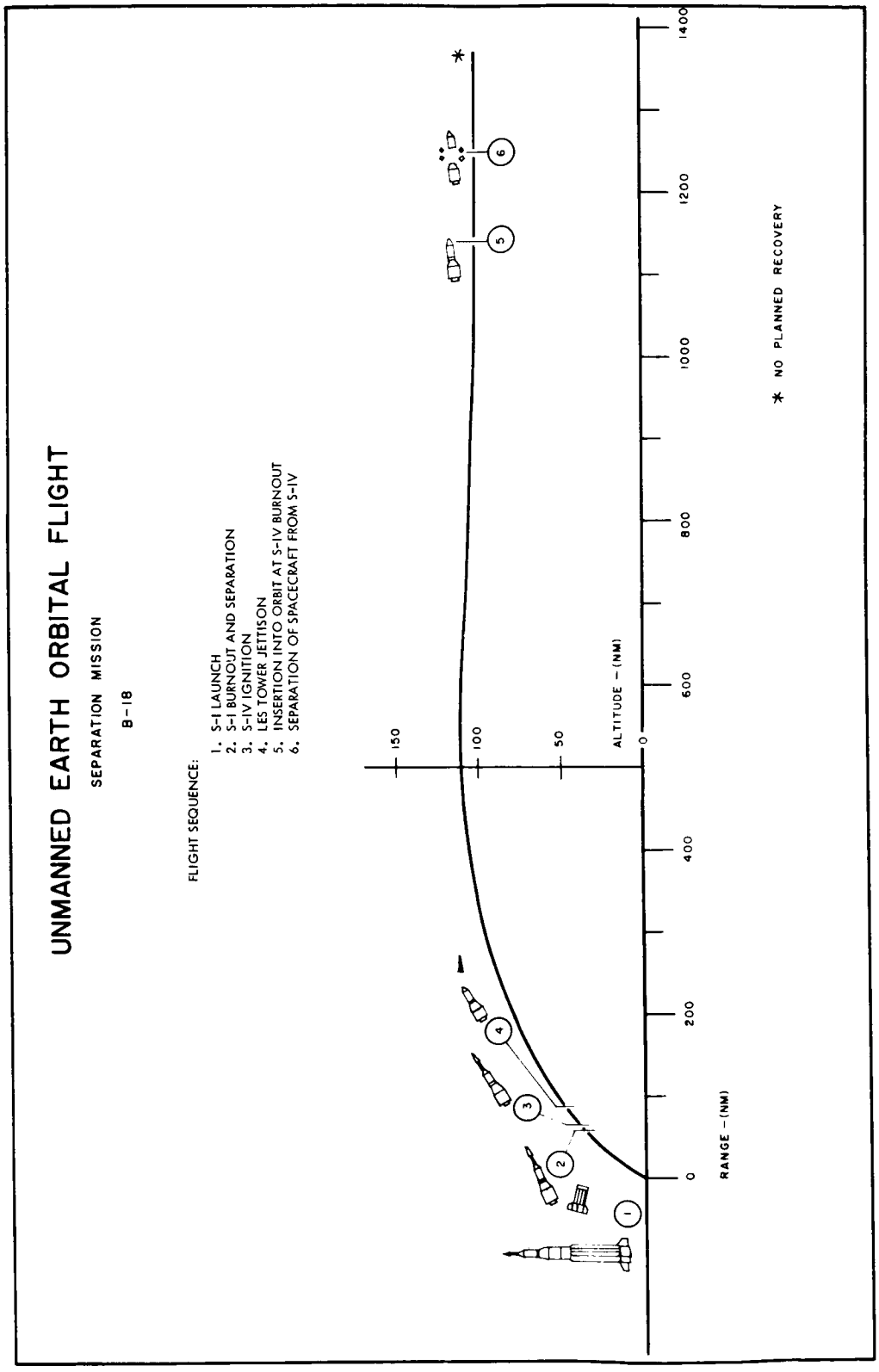

Figure 3-1. Boilerplate 18 Mission Launch Profile

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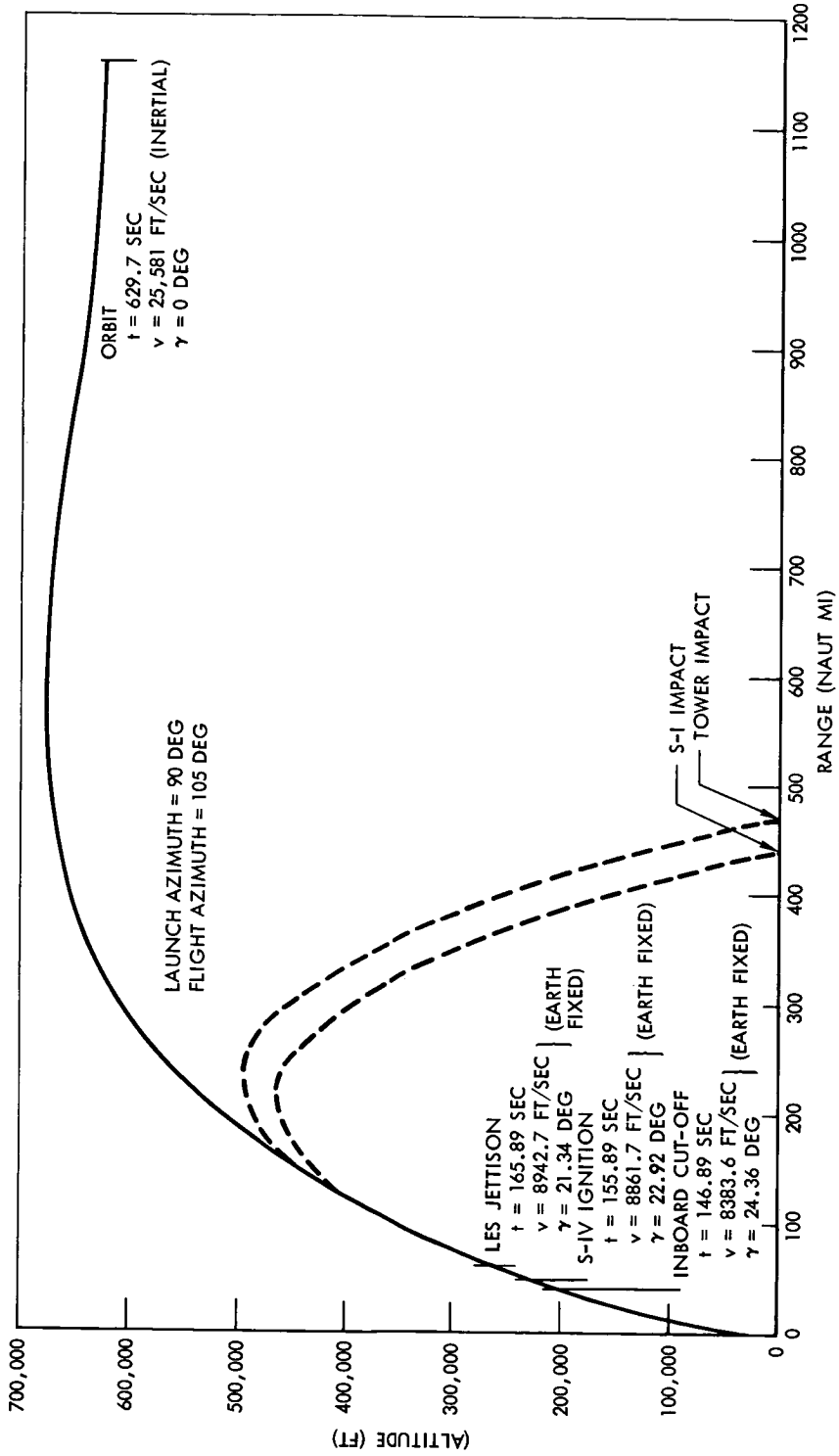

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Figure 3-2. Boilerplate 18 Altitude-Range Profile to Orbit Injection

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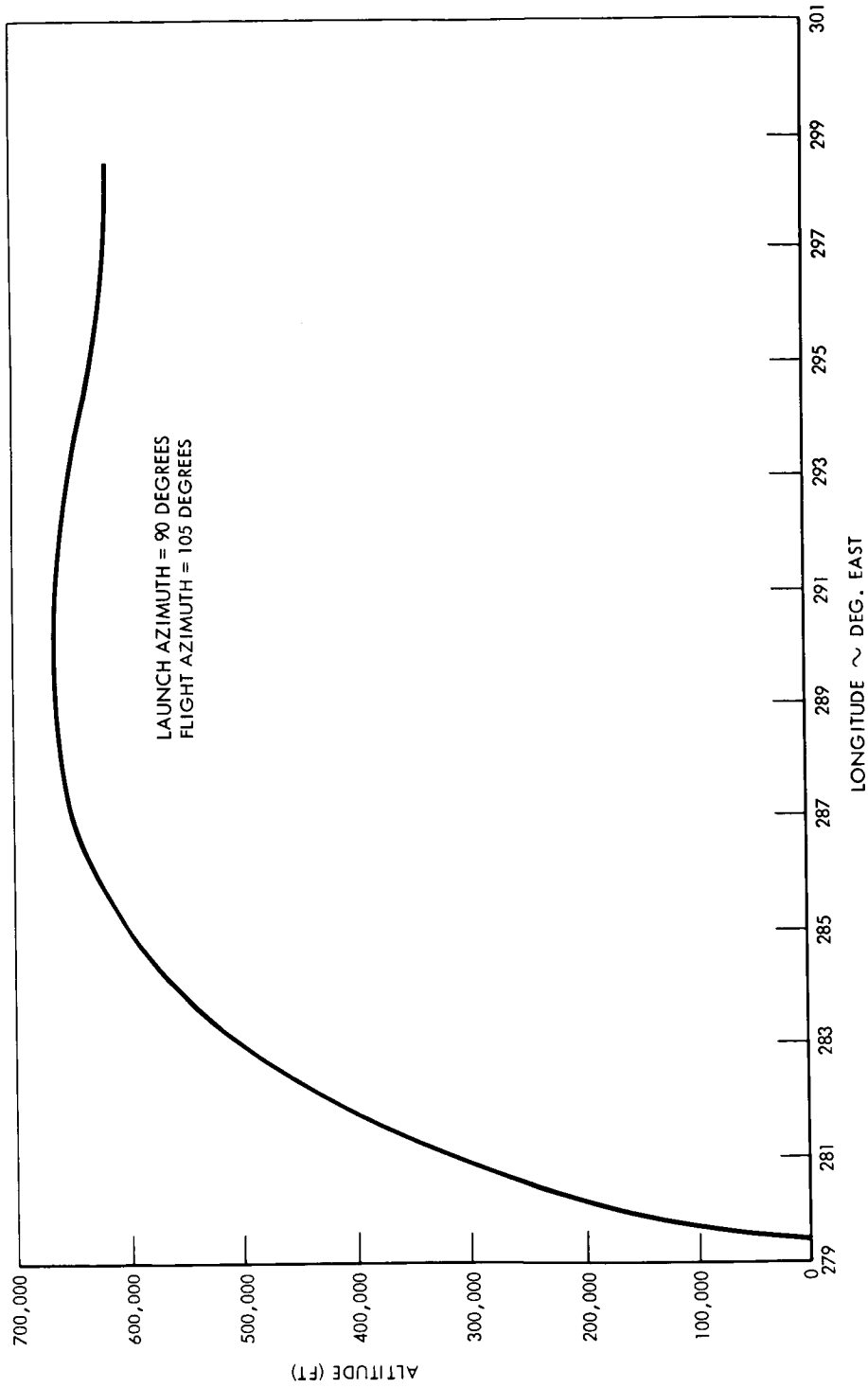

Figure 3-3. Boilerplate 18 Altitude-Longitude Profile to Orbit Injection

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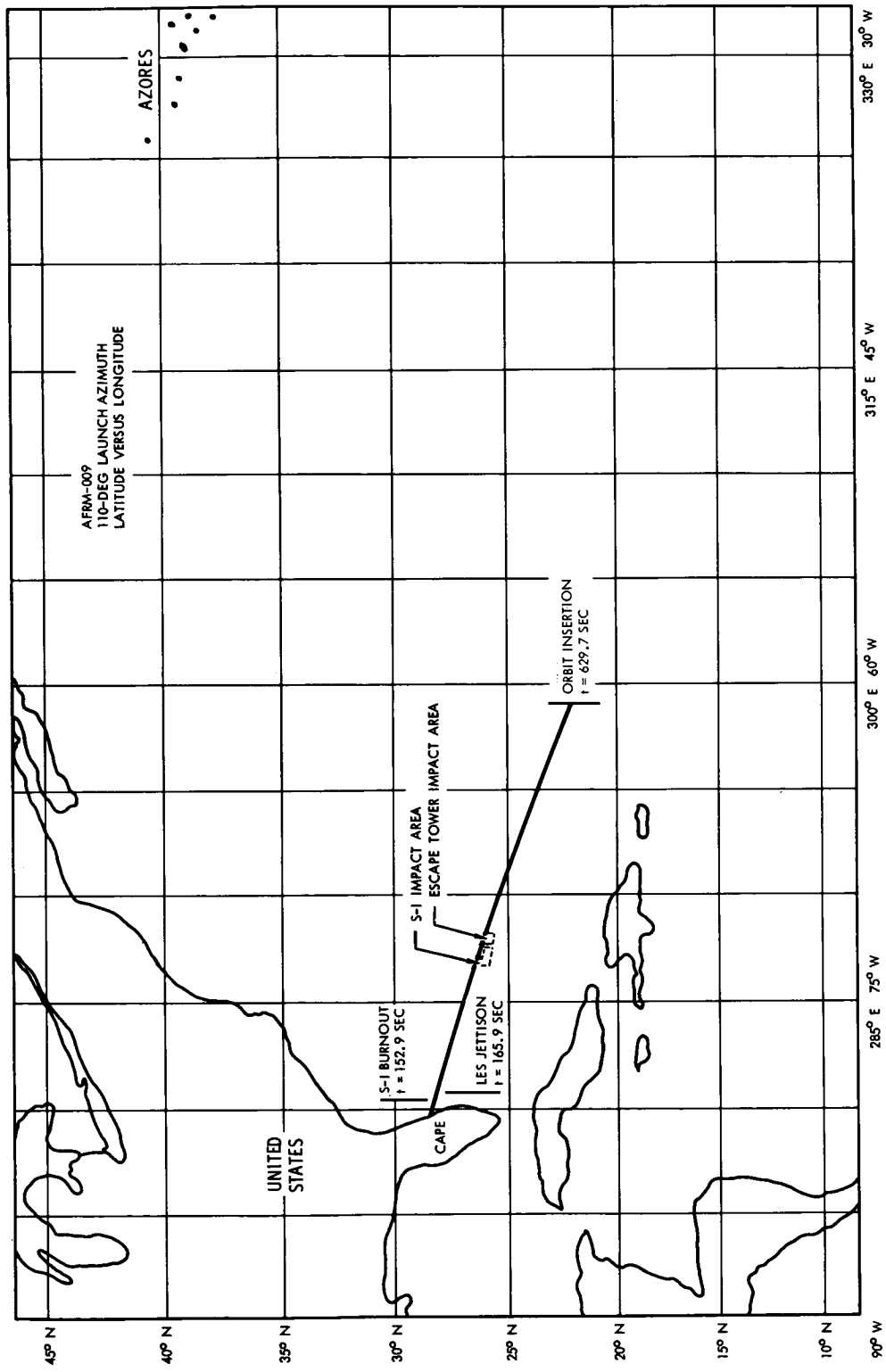

Figure 3-4. Boilerplate 18 Boost Earth Trace

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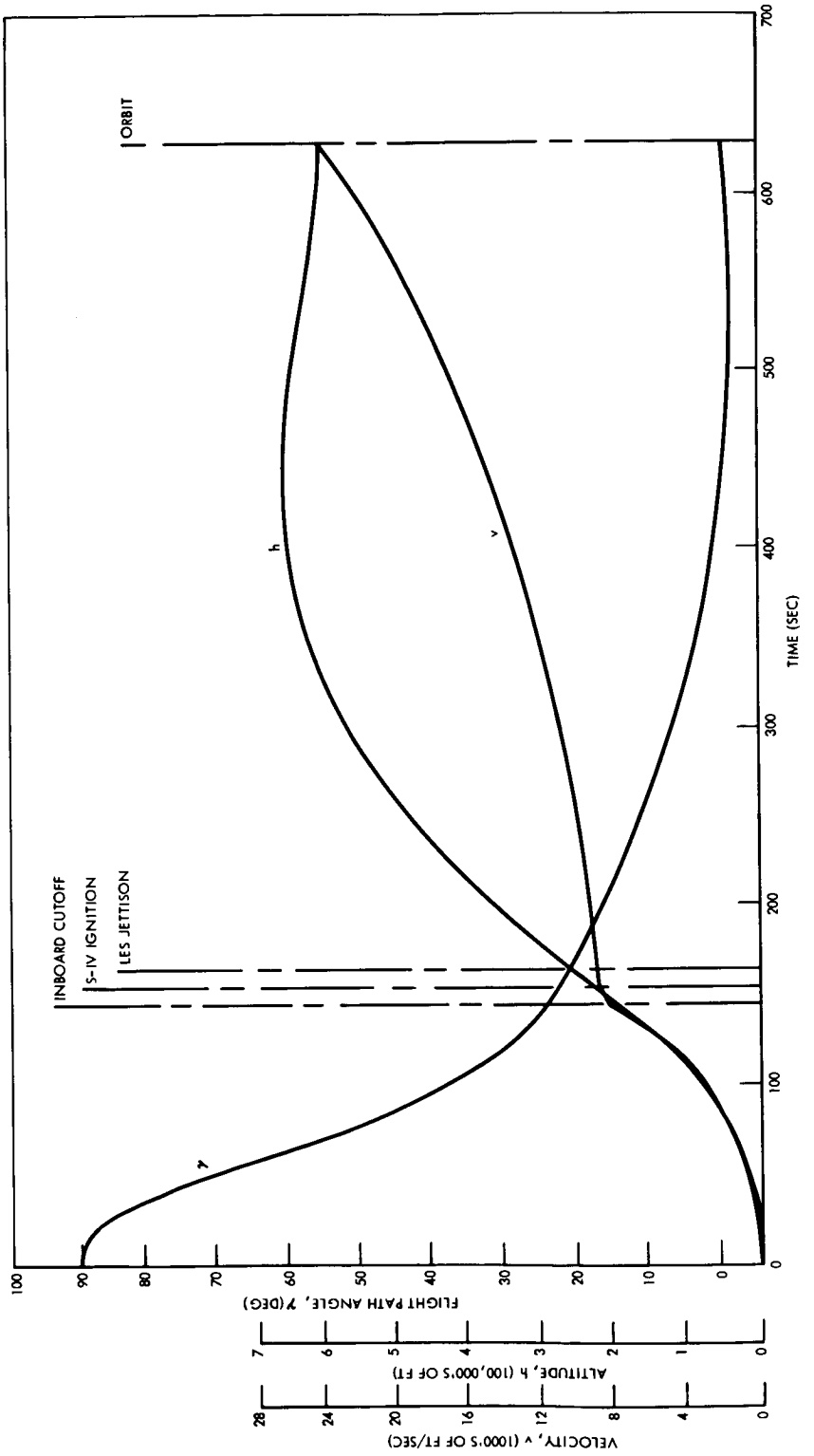

Figure 3-5. Boilerplate 18 Velocity, Altitude, and Flight Path Angle Time Histories (Earth-Fixed Geocentric Coordinates)

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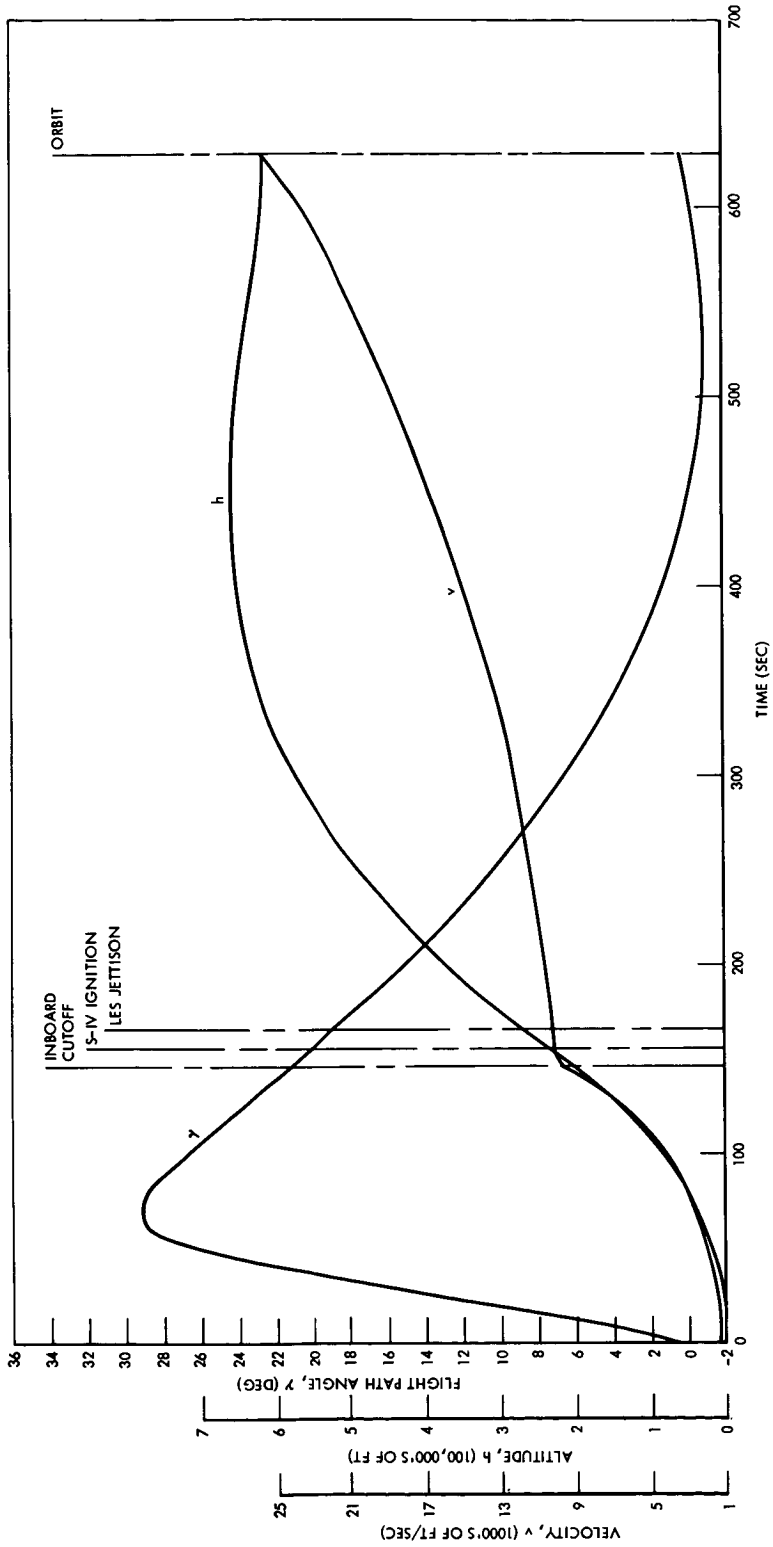

Figure 3-6. Boilerplate 18 Velocity, Altitude, and Flight Path Angle Time Histories (Inertial Geocentric Coordinates)

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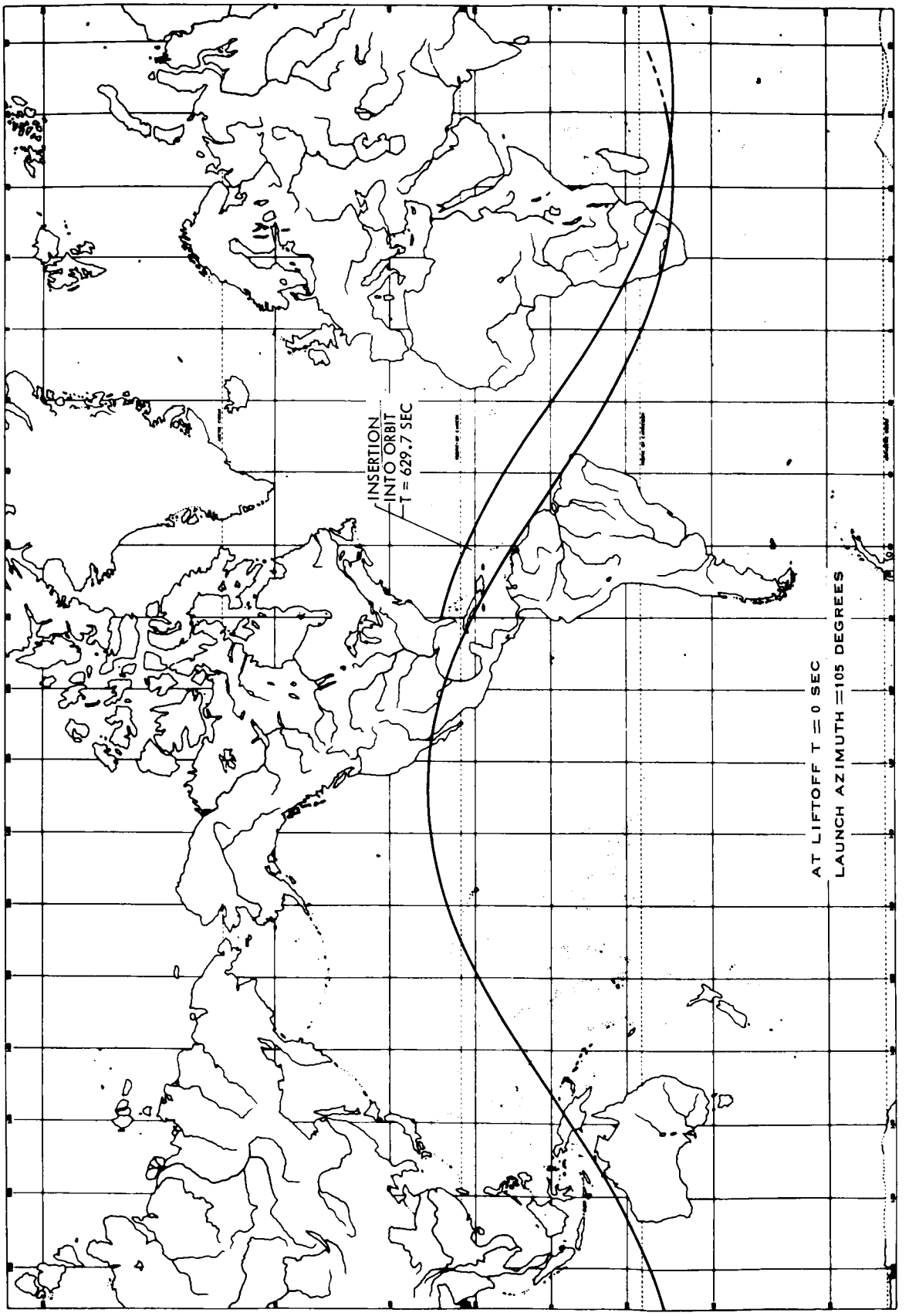

Figure 3-7. Boilerplate 18 Earth Orbital Trace

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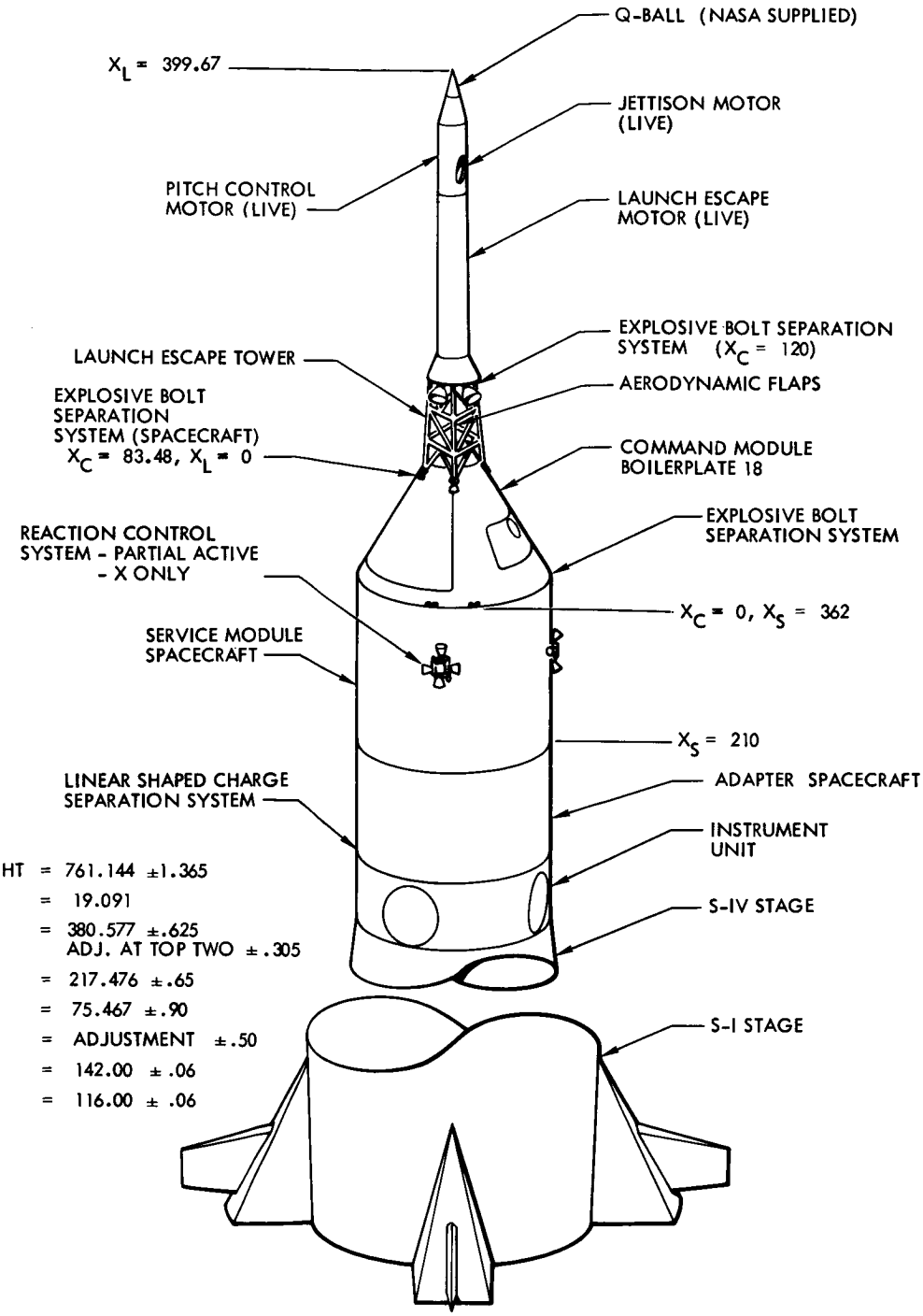

Figure 3-8. Boilerplate 18 and Saturn I Booster

[redacted]

Table 3-2. Boilerplate 18 Flight Constraints

Hardware	Constraint	Completion Date*
C/M tower release system	Completion of separation system tests per ATR 102B	
Tower sequencer and Mission sequencer	Satisfactory completion of flight worthiness tests	
C/M-S/M release system	Completion of separation systems tests, ATR 100A	
S/C-LV release system	Completion of separation systems tests, ATR 101	
S/M RCS	Partial completion of SM RCS tests on breadboard mockup	
AFRM-S/M structure	Completion of static structural tests on AFRM 004 and 006 vibration tests	
AFRM-adapter structure	Completion of static structural tests on AFRM 004 and 006 vibration tests	
BP-13 and BP-15	No unexplained failures	

*Completion date required to proceed with AMR integrated systems test on schedule

[redacted]

3. Pitch control motor (live)
4. Tower jettison motor (live)
5. Launch escape motor (live)
6. Structural skirt
7. Tower structure including aerodynamic (tower) flaps
8. Tower sequencer
9. CM - tower separation system

Table 3-3. Boilerplate Weight and Balance Parameters

Item	Weight (lb)	Center of Gravity (in.)			Moment of Inertia (slug ft^2)		
		X	Y	Z	Roll (X)	Pitch (Y)	Yaw (Z)
Launch escape system	6,410 (166)*	1,297.0	0.0	0.0	208	8,109	8,109
Command module	9,000 (3241)*	1,042.0	1.0	7.5	5,230	4,094	4,255
Service module	12,675 (8895)*	903.4	5.2	-2.5	8,752	12,202	12,738
Adapter	825	780.0	0.0	0.0	1,029	752	752
Total lift-off payload	28,910	1,030.3	2.6	1.2	15,370	179,115	179,728
Total in-orbit payload (lift-off minus LES)	22,500	954.3	3.3	1.6	15,148	44,743	45,349

*Weights in parentheses represent ballast which is included as part of the individual module weights

3.3.4.2.1 Q-Ball. The "Q-Ball" is a dynamic pressure sensor that provides pitch, yaw and dynamic pressure signals to the instrument unit for trajectory control during the boost phase. The "Q-Ball" is 19 inches long weighs approximately 23 pounds and is attached to the ballast enclosure.

3.3.4.2.2 Ballast Enclosure. The ballast enclosure forms the structure between the "Q-Ball" and the pitch control motor. It has a truncated-cone shape and is capable of accommodating 1500 pounds of lead ballast.

3.3.4.2.3 Pitch Control Motor. The pitch control motor is a live solid-propellant motor providing a thrust of 3400 pounds with a burn time of 0.5 seconds. The motor is 9 inches in diameter, 22 inches long and weighs 35 pounds. The housing for the motor forms the structure between the ballast enclosure and the tower jettison motor.

3.3.4.2.4 Tower Jettison Motor. The tower jettison motor is a solid propellant motor 26 inches in diameter, 47 inches long and weighs 550 pounds. Two unequal exhaust area thrust nozzles are positioned 30 degrees from the motor mean center line to provide a resultant thrust axis of 2.5 degrees (±0.5 degrees) from the motor mean centerline in the pitch plane. Nominal thrust is 33,000 pounds for a burning time of 1.2 seconds.

3.3.4.2.5 Launch Escape Motor. The launch escape motor is a solid-fuel motor 26 inches in diameter, 183 inches in length and weighs approximately 4826 pounds. Four fixed exhaust nozzles are canted so as to minimize impingement of jet blast on the C/M. Resultant nominal thrust is 155,000 pounds at 36,000 feet altitude at 70 F.

3.3.4.2.6 Structural Skirt. The structural skirt assembly provides the intermediate structure between the launch escape motor case and the launch escape tower. The structural skirt is a welded assembly consisting of a forged ring, longerons, and a shear skin which transfers loads from the launch escape motor to the tower legs. The structural skirt is attached to the tower by means of the tower-to-skirt separation systems.

3.3.4.2.7 Tower Structure. The launch escape tower is a truncated rectangular cross-section pyramid made of welded tubular titanium alloy. The tower is approximately 120 inches high with a base 46 x 50 inches. The tower forms the intermediate structure between the C/M and the launch escape motor. The tower structure is covered with an ablative material and is attached to the C/M with explosive bolts with redundant shaped-cutter charges. Aerodynamic flaps are mechanically attached near the top of the tower directly beneath the structural skirt separation plane. The

aerodynamic flaps, in conjunction with the tower, are used to ensure stabilization of the C/M blunt end forward during aborts between 30,000 and 220,000 feet.

3.3.4.2.8 Tower Sequencer. Dual sequencer units (channel A and B) are provided for the LES and are located on the tower structure. Each unit consists of one motor switch. An output voltage from the mission sequencer (located in the command module) drives each motor switch to the "arm" position. The switches then allow electrical power from the pyro bus to simultaneously fire the tower separation explosive bolts and shaped charge squibs, and the launch escape and pitch control motor ignition squibs.

3.3.4.2.9 C/M-Tower Separation System. The LES on Boilerplate 18 provides for automatic tower separation and jettison using the launch escape and pitch control motors. Tower jettison will be initiated 10 seconds after S-IV ignition by a signal from the instrument unit to the mission sequencer. The mission sequencer, in turn, energizes the dual tower sequencer motor switches, which allow electrical power from the pyro batteries to simultaneously energize the tower separation explosive bolt, the shaped charge squibs, and the launch escape and pitch control motor ignition squibs. The tower assembly is separated and propelled clear of the C/M trajectory by the launch escape and pitch control motors.

3.3.4.3 Command Module

The command module is a boilerplate structure simulating the size, shape, weight, and c.g. of the spacecraft configuration. It is a semi-monocoque type aluminum structure approximately 141 inches high and 154 inches in diameter at the base.

3.3.4.3.1 Crew Compartment. The boilerplate compartment uses the frame stiffeners of the exterior shell structure to attach mountings for the instrumentation electrical power system and any ballast required to maintain the proper weight and c.g. Also included are a main hatch of aluminum alloy structure bolted to the C/M structure for access to forward compartment shell and a forward access way (tubular structure of aluminum) welded to the forward bulkhead. The forward bulkhead is provided with a bolted-on cover.

3.3.4.3.2 Forward Compartment Cover. The forward compartment cover consists of aluminum skin and stiffeners utilizing riveted and bolted construction and a fibre glass honeycomb radome nose cone.

[redacted]

3.3.4.3.3 Aft Heat Shield. The boilerplate heat shield is similar to the spacecraft heat shield. It is composed of an inner and outer layer of laminated glass over an aluminum honeycomb core and is attached to the C/M by four adjustable struts.

3.3.4.3.4 Command Module Systems. Command module systems are as follows:

1. Communications and Instrumentation Systems. An R&D communications system is provided which consists of four FM/FM telemetry packages and two C-band beacon transponders and associated antenna equipment. Details of this equipment are described in Section 3.3.7. An R&D instrumentation system, designed to satisfy the test objectives, is provided. This system includes such end instruments as linear and vibration accelerometers, pressure transducers, strain gauges, commutators, and timers.

2. Environmental Control System. The Boilerplate 18 cooling system provides cool air in a continuous flow to maintain the C/M ambient temperature at 85 ± 10 F level. The system consists of a storage tank, accumulator pump, coldplate, heat exchanger, fan, thermal control valves, system interconnecting lines and quick disconnect valves. Power for this unit is supplied by the electrical power system.

3. Electrical Power System. An R&D electrical power system consisting of GFE instrumentation, logic, pyrotechnic batteries, power control and junction box, and essential circuitry is provided to accommodate the onboard electrical load requirements.

4. Emergency Detection System (EDS) Display Panel. The EDS display panel located in the C/M is composed of 22 event lights (redundancy for 11 functions). The following functions, normally displayed to the astronauts, will be displayed in Boilerplate 18 and their signals will be telemetered.

    a. S-I stage engine chamber pressure: 16 indicators to monitor 8 engines; amber colored to indicate failure

    b. S-IV stage engine chamber pressure: 12 of the above 16 indicators to monitor 6 engines; amber colored to indicate failure

[redacted]

[redacted]

c. Launch vehicle rates: 2 indicators to monitor 1 function; red colored to indicate excessive rates

d. Instrument unit power failure: 2 indicators to monitor 1 function; red colored to indicate power failure

e. LV guidance failure lights: 2 indicators to monitor 1 function; red colored to indicate LV guidance failure

There will be an automatic abort capability which is independent of the EDS display panel. Malfunction of certain critical functions will initiate the LES sequence.

5. Mission Sequencer. The mission sequencer is a solid-state switching device located in the C/M. It initiates the following events during flight.

EDS outputs
Fire tower separation squibs and ignite jettison motor arm S/M to S-IV stage adapter separation system
Activate S/M reaction control system
Activate C/M to S/M adapter separation system
Fire S-IV to S/M adapter separation system
Signal to instrumentation after orbit injection

In addition to the firing circuitry, the unit contains provisions for safe-arm control from the GSE hard-line monitoring and telemetry monitoring.

3.3.4.4 Service Module

The service module is a spacecraft structure approximately 155 inches long and 154 inches in diameter. The structure is a bonded-aluminum honeycomb shell with six radial shear webs dividing the interior cylinder area into six unequal equipment and tank areas. Equipment installed in the S/M, in addition to the umbilical system, instrumentation sensors and associated cabling, is described in the following paragraphs.

3.3.4.4.1 C/M to S/M Separation System. A live C/M to S/M separation system is provided. The system incorporates an explosive-bolt tension device with dual elements at each of the three C/M to S/M compression-pad attach points.

[redacted]

3.3.4.4.2 S/M Reaction Control System (RCS). A partial service module RCS is installed in the S/M. The system consists of four individual modules. Each module consists of four engines with only the aft thrusting engine (-x RCS) of each module operable. The remaining engines are nonfunctional and are installed to preserve aerodynamic configuration.

3.3.4.4.3 Service Propulsion System. A dummy service propulsion system nozzle extension is provided for evaluation of the complete separation sequence of the spacecraft adapter from the S/M. The simulated nozzle extension which is attached to the S/M with appropriate brackets and fittings duplicates the nozzle extension envelope.

3.3.4.4.4 EPS and ECS Radiators. Spacecraft EPS and ECS radiators, which form an integral part of the S/M structure, are provided. These radiators are inoperable and are installed for the purpose of preserving the structural integrity of the S/M.

3.3.4.5 Spacecraft Adapter

The adapter that mates the S/M to the S-IV instrument unit of the Saturn I launch vehicle is a cylinder approximately 116 inches long and 154 inches in diameter. The adapter is a spacecraft structure consisting of bonded-aluminum honeycomb construction. Included in the adapter, in addition to instrumentation sensors and associated wiring, are an air-conditioning barrier and a separation system. The separation system, which literally cuts the adapter away from the S-IV and the S/M, incorporates flexible, linear-shaped-charge explosive devices.

3.3.4.6 Instrument Unit (IU)

The instrument unit is a cylindrical section attached to the forward end of the S-IV stage and contains the guidance and control system, flight sequencers, telemetry system, tracking system, electrical power system, and emergency detection system logic circuitry.

3.3.4.7 Launch Vehicle (L/V)

The launch vehicle (L/V) for Boilerplate 18 is a Saturn I, designated SA-10, consisting of a first stage S-I, second stage S-IV, and an instrument unit. The S-I generates a nominal sea-level thrust of 1,500,000 pounds, using eight Rocketdyne H-1 engines burning liquid oxygen (LOX) and kerosene (RP-1). The S-IV generates a nominal vacuum thrust of 90,000 pounds, using six Pratt & Whitney RL-10-43 engines using LOX and liquid hydrogen (LH_2).

[redacted]

3.3.5 Structural Design Criteria. BP-18 is designed to the spacecraft's expected environment in the prelaunch, lift-off, boost, and earth orbit phases of the mission. Structural design criteria are available in SID-700-2.

3.3.6 Aerodynamic Stability. The aerodynamic stability characteristics are identical to those presented for Boilerplate 15.

3.3.7 Instrumentation Requirements. Boilerplate 18 requires 204 measurements to satisfy flight test objectives. The different types of measurements are summarized as 7 acceleration, 19 pressure, 49 temperature, 1 heat flux, 1 current, 51 strain, 20 voltage, 8 vibration, 33 step, and 15 position.

3.3.7.1 On-Board Instrumentation

A block diagram of the on-board instrumentation system is presented in Figure 3-9. Figures 3-10 through 3-23 show the various measurement locations. The measurement list for B/P 18 is presented in Table 3-4. The umbilical requirements are tabulated in Tables 3-5 and 3-6.

3.3.7.2 Data Acquisition System

Four FM/FM telemetry systems operating in the VHF band between 216 and 266 megacycles are used to transmit data acquired on board the flight vehicle. Each telemetry (T/M) system consists of a subcarrier oscillator package and transmitter unit. One of the four T/M's will include a 90-channel by 10 sample-per-second commutator, and another will include a 90-channel by a 1-1/4 sample-per-second commutator. The two other T/M's will have 13 continuous channels without commutation. The transmitter frequencies are as follows:

T/M	A	228.2 mc	T/M	C	247.3 mc
T/M	B	237.8 mc	T/M	D	257.3 mc

3.3.7.2.1 Signal Conditioner Package. A signal conditioner unit is used to adapt all signals received from transducers to the required T/M input signal and to direct this conditioned signal to the respective T/M. All range (R) and zero (Z) calibration circuitry is included in the unit. Z and R equal 15 and 85 percent of a full-scale (0 to 5 volts) signal respectively.

3.3.7.2.2 C-Band Transponder. Dual radar beacon transducers used to provide for tracking in a near earth condition and metric data generation by ground tracking stations are installed in the C/M. Each transponder is an AN/DPN-66 (SST-102A) beacon. The beacons operate in the C-band 5395-5905 megacycle range, transmitting at 5.765 mc with a

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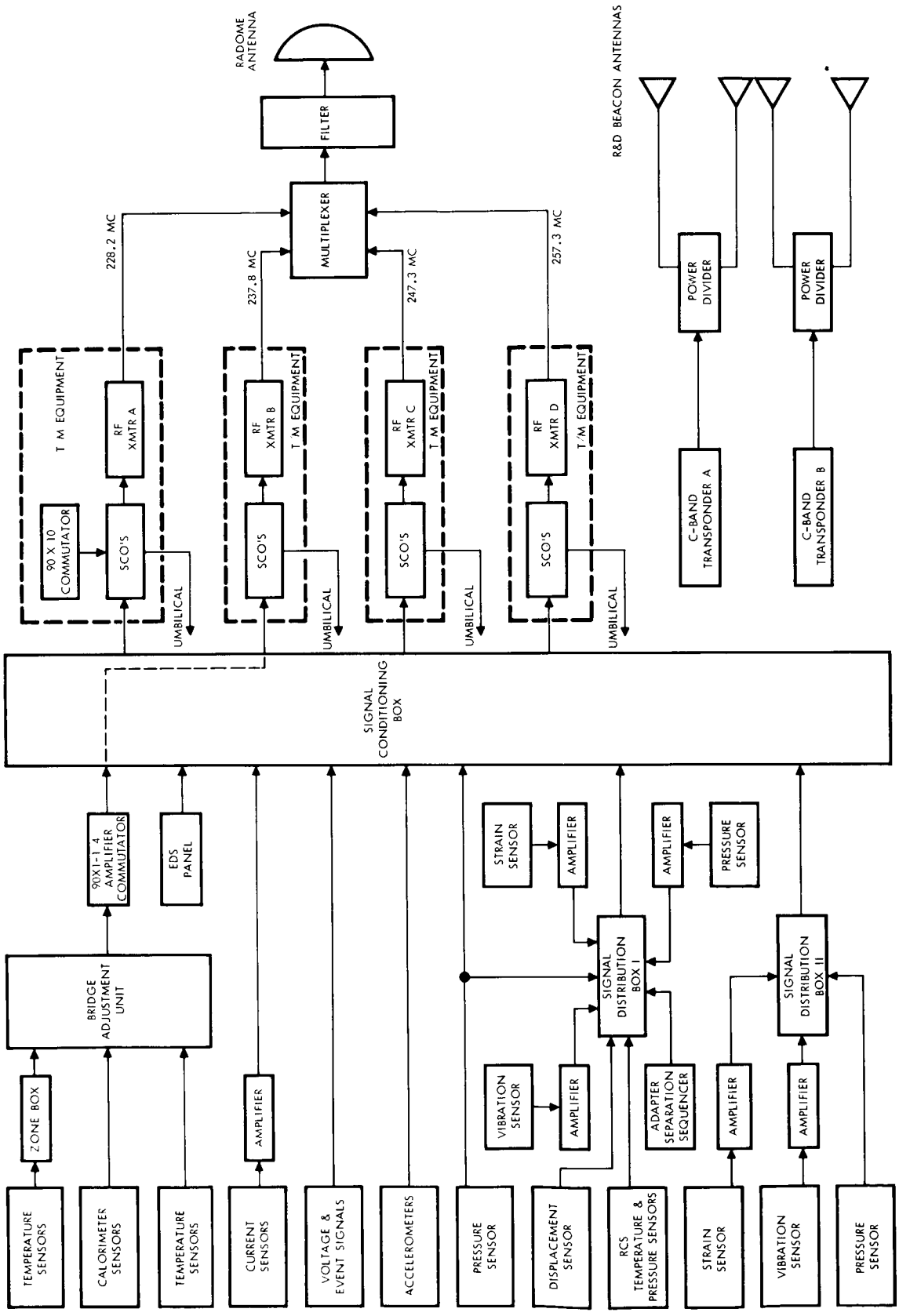

Figure 3-9. Instrumentation Block Diagram

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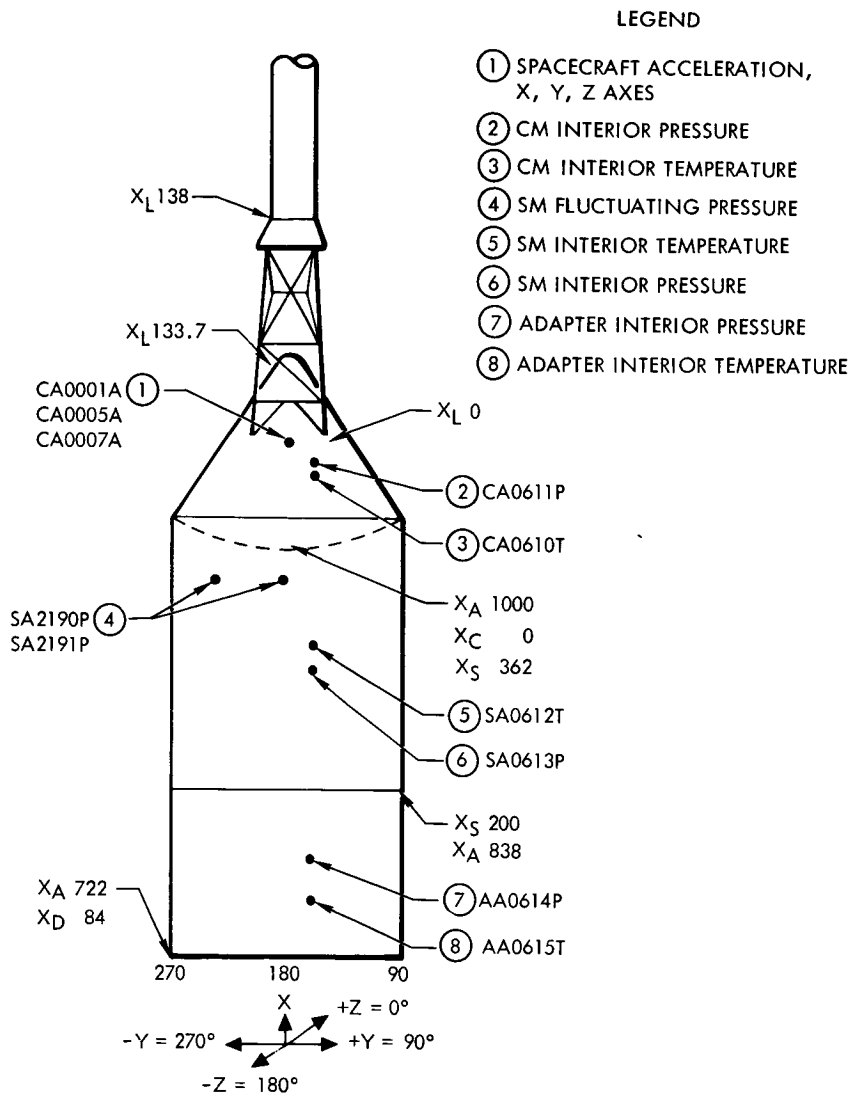

Figure 3-10. Spacecraft Measurement Locations

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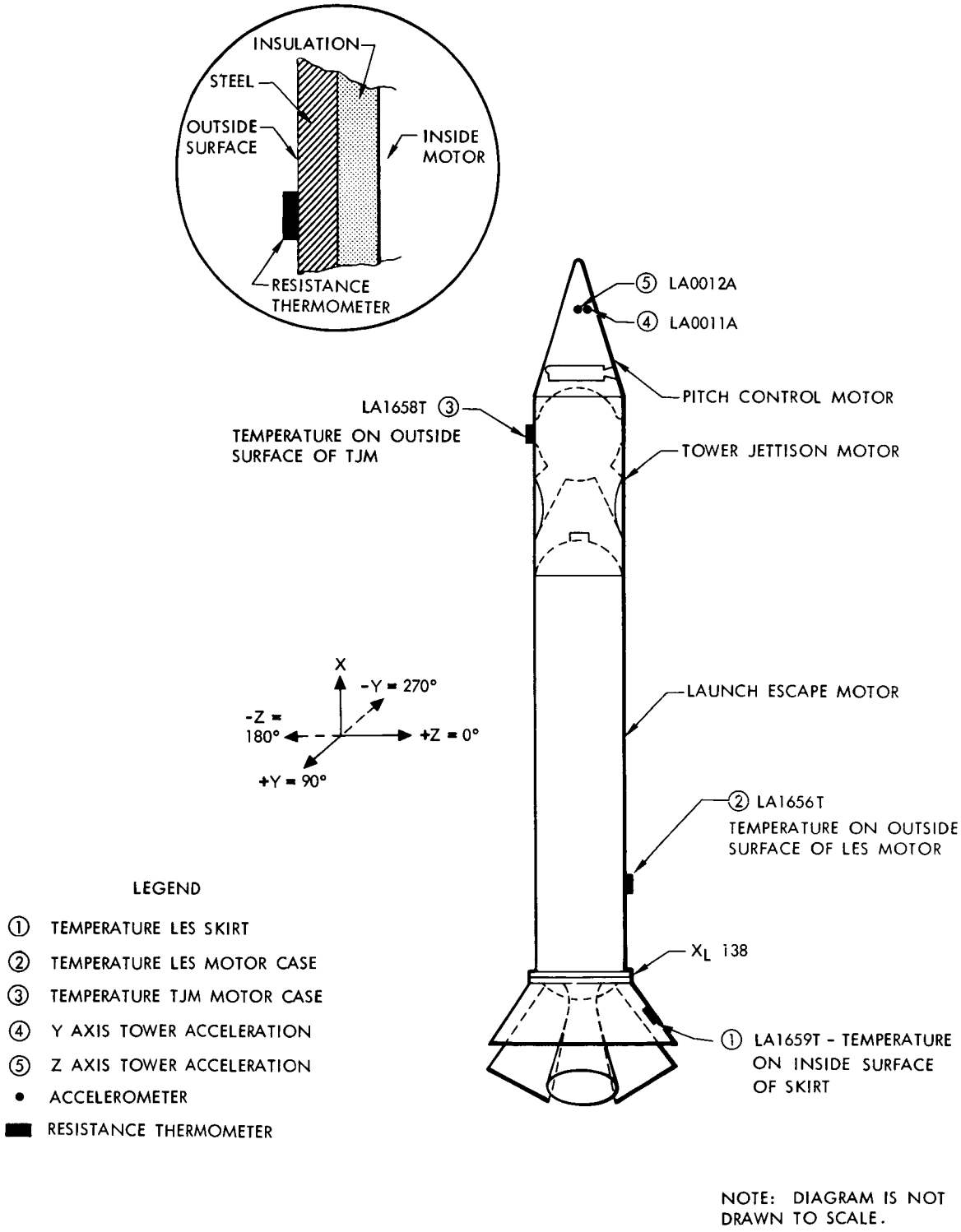

Figure 3-11. Launch Escape System Measurement Locations

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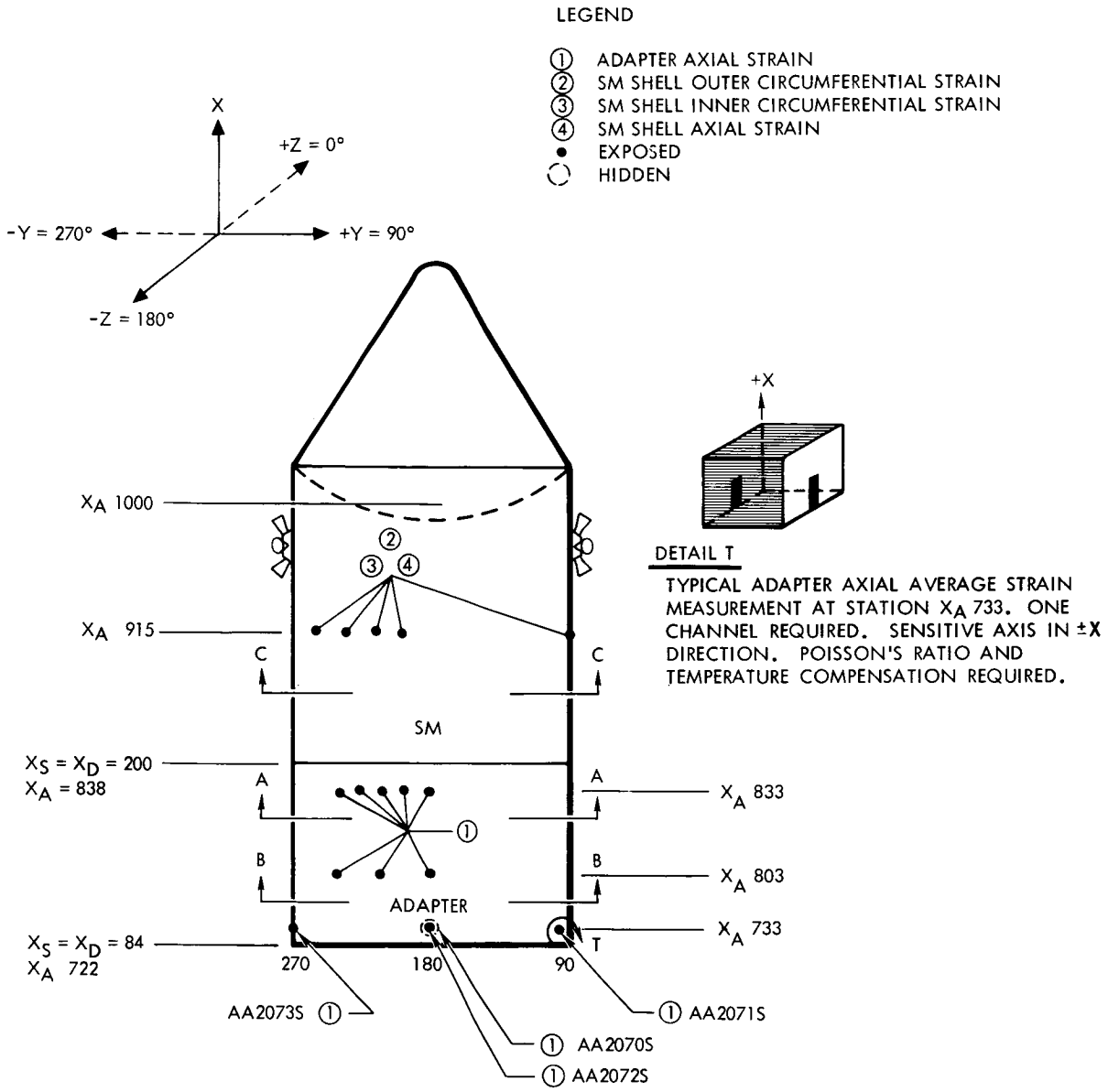
[redacted]



NOTE: DIAGRAM IS NOT DRAWN TO SCALE.

Figure 3-12. Adapter and Service Module Strain Measurement Locations (Sheet 1 of 3)

[redacted]

[redacted]

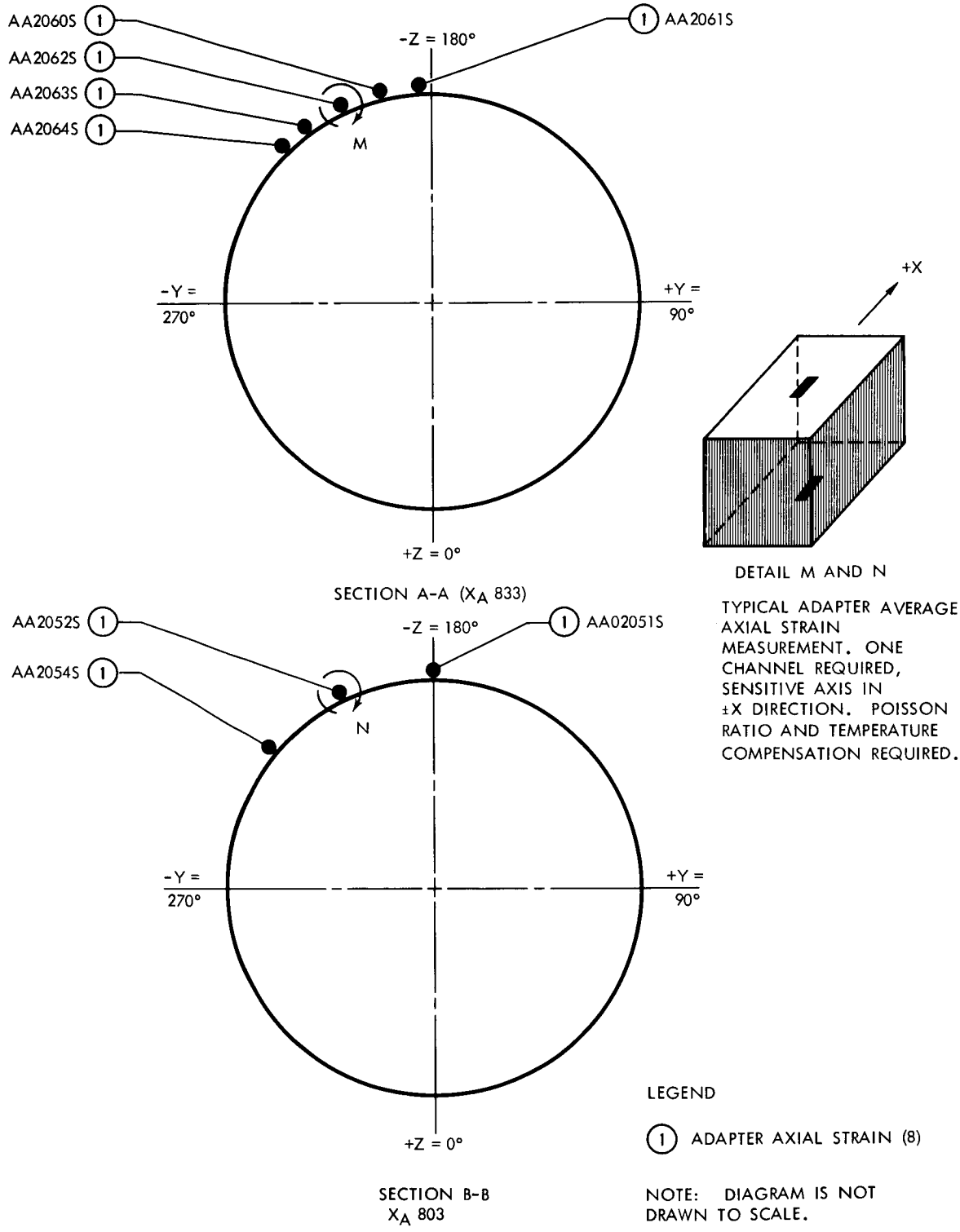
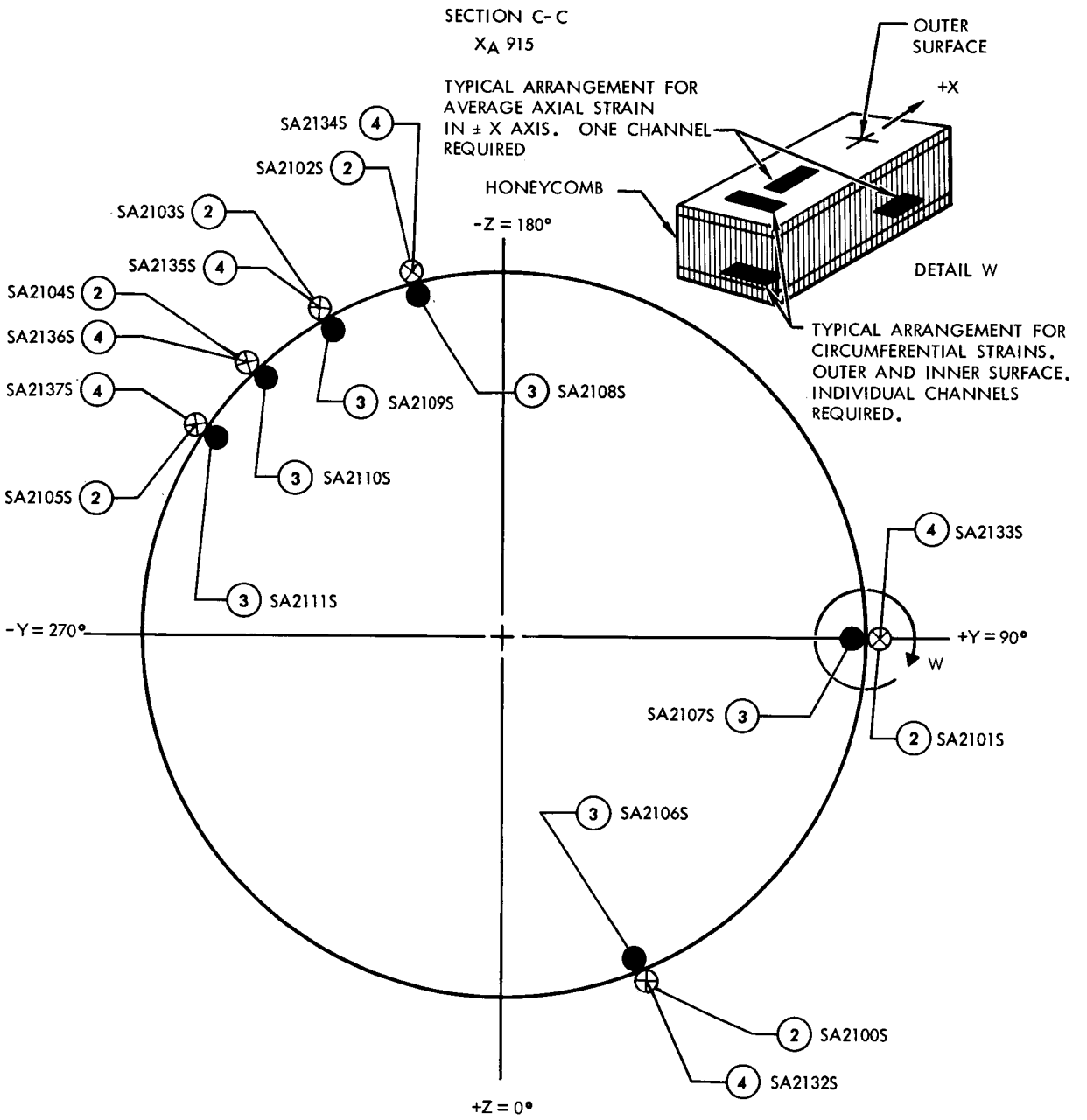


Figure 3-12. Adapter and Service Module Strain Measurement Locations (Sheet 2 of 3)

[redacted]

[redacted]



LEGEND

(2) SM SHELL OUTER CIRCUMFERENTIAL STRAIN (6)
(3) SM SHELL INNER CIRCUMFERENTIAL STRAIN (6)
(4) SM SHELL AXIAL STRAIN (6)

NOTE: DIAGRAM IS NOT DRAWN TO SCALE.

Figure 3-12. Adapter and Service Module Strain Measurement Locations (Sheet 3 of 3)

[redacted]

[redacted]

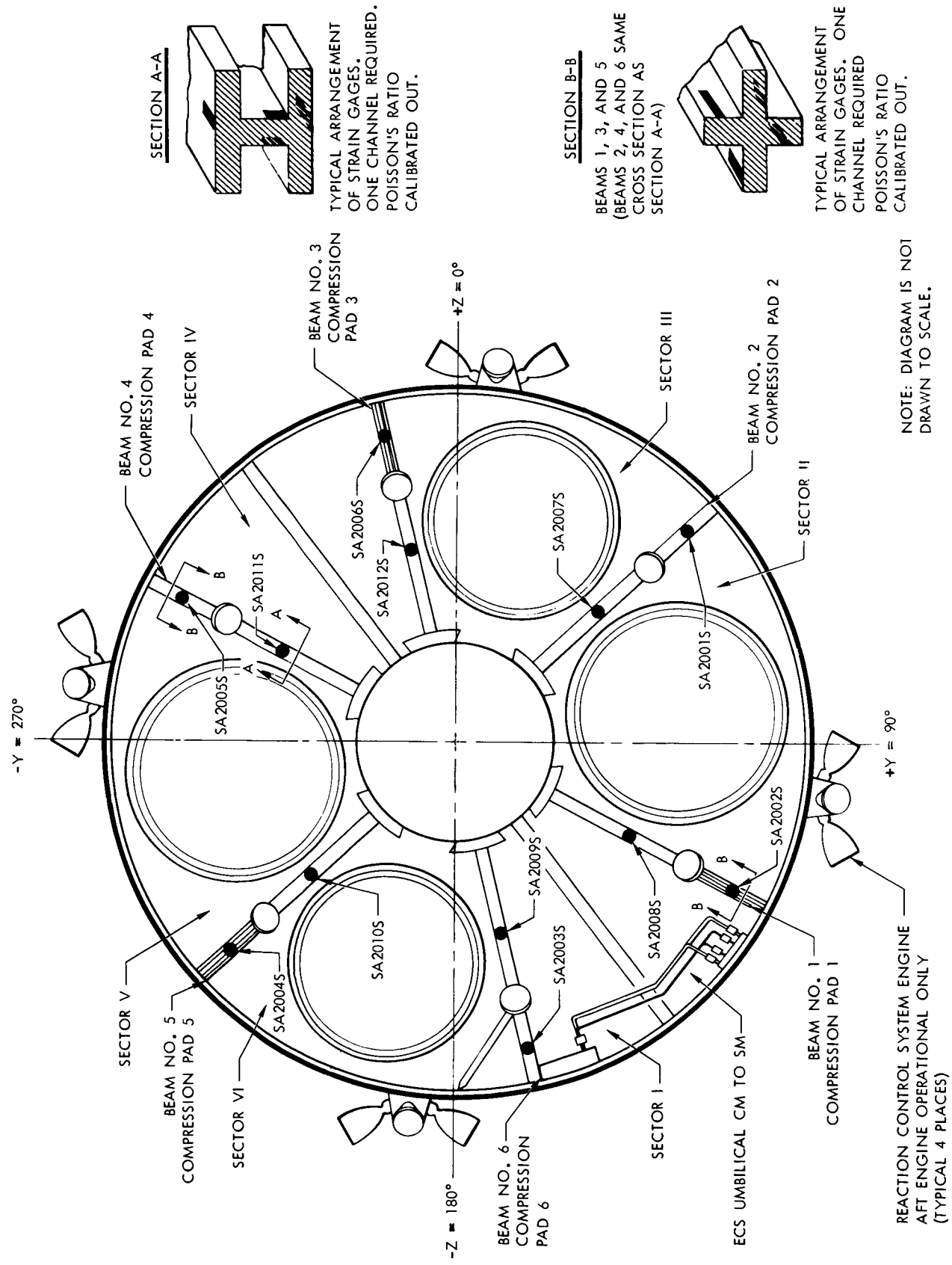


Figure 3-13. Compression Pad Axial Strain Measurement Locations

[redacted]

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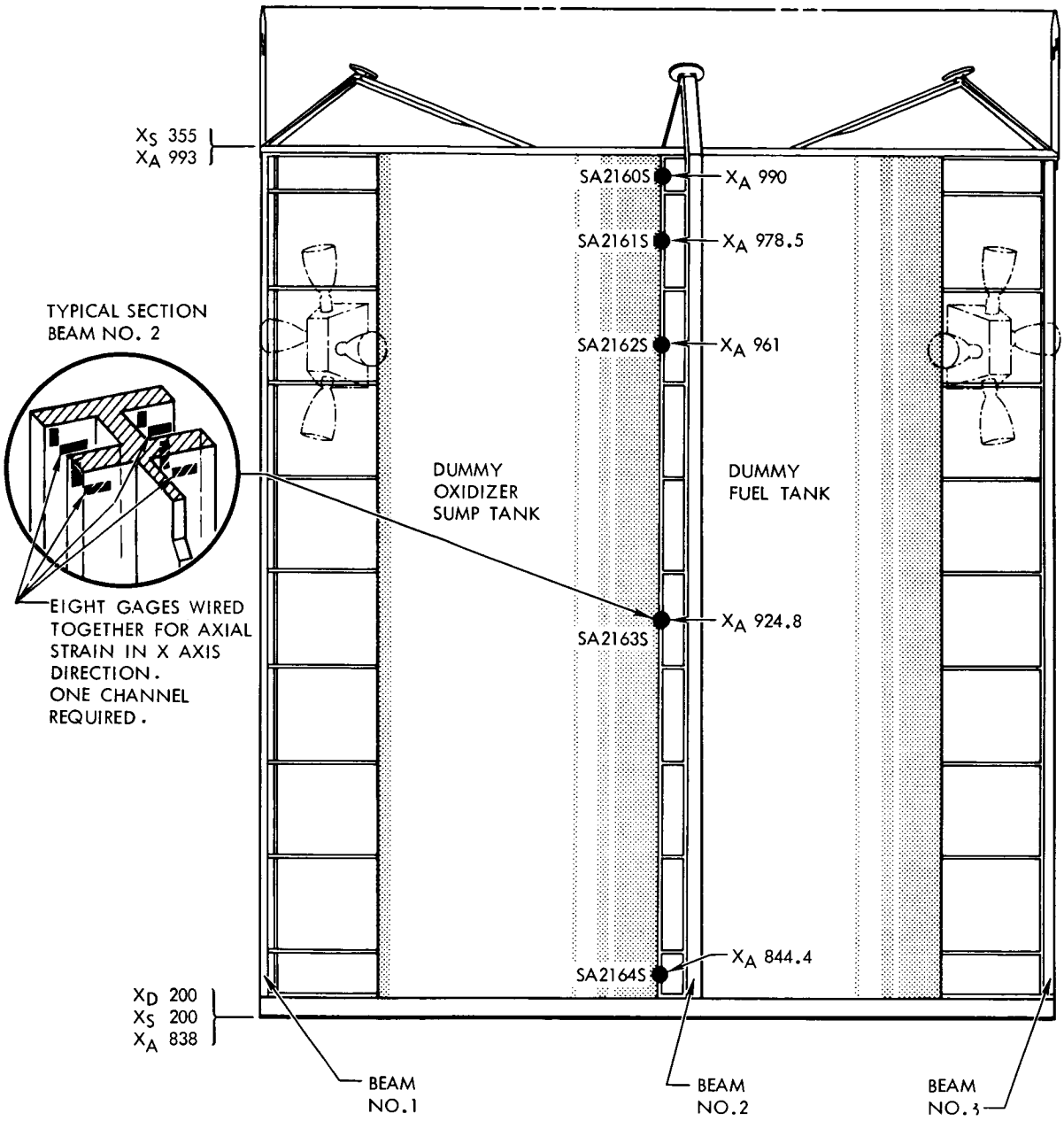

NOTE: DIAGRAM IS NOT DRAWN TO SCALE

Figure 3-14. Service Module Beam Inner Cap Axial Strain Measurement Locations

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[redacted]

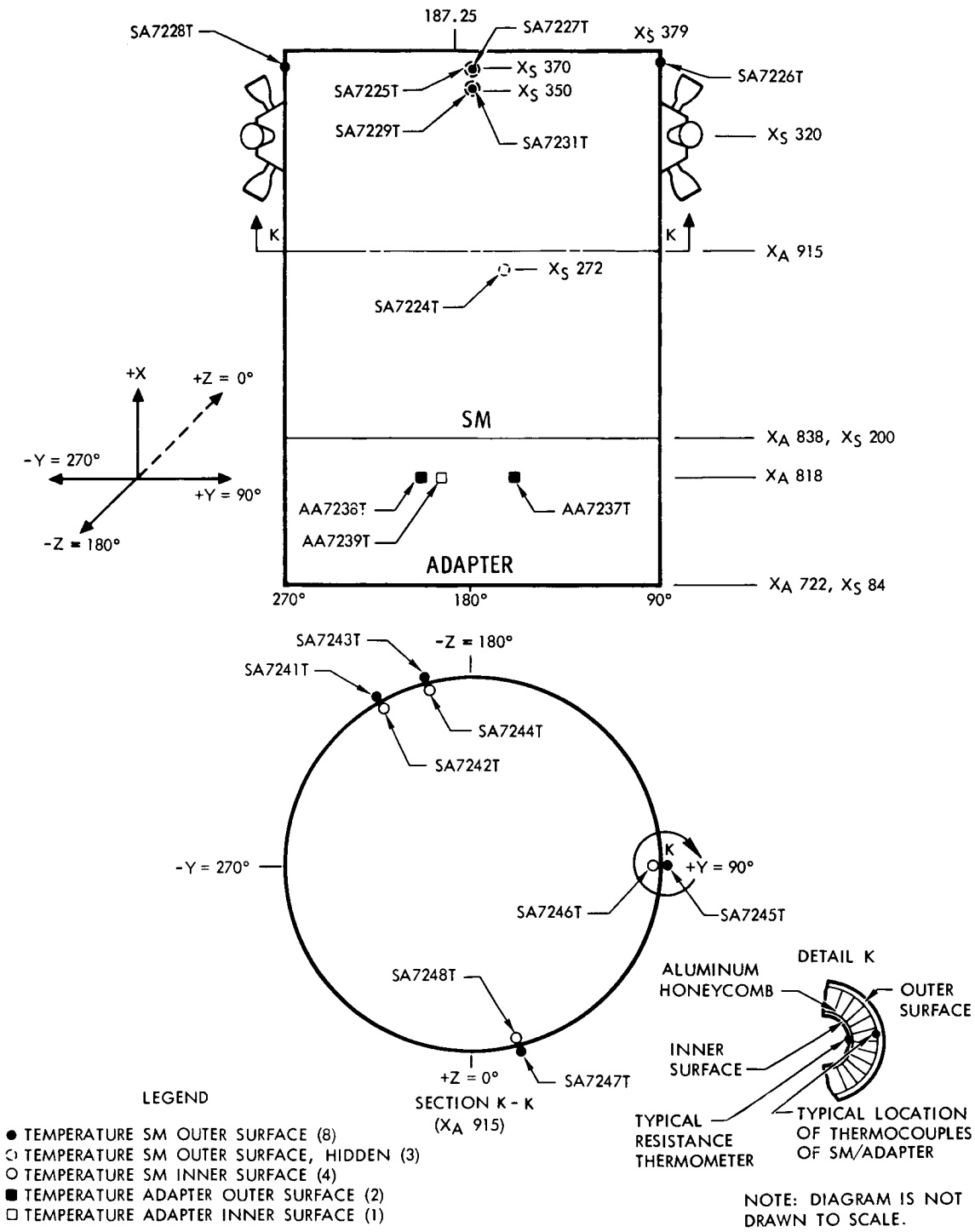

Figure 3-15. Service Module and Adapter Temperature Measurement Locations

[redacted]

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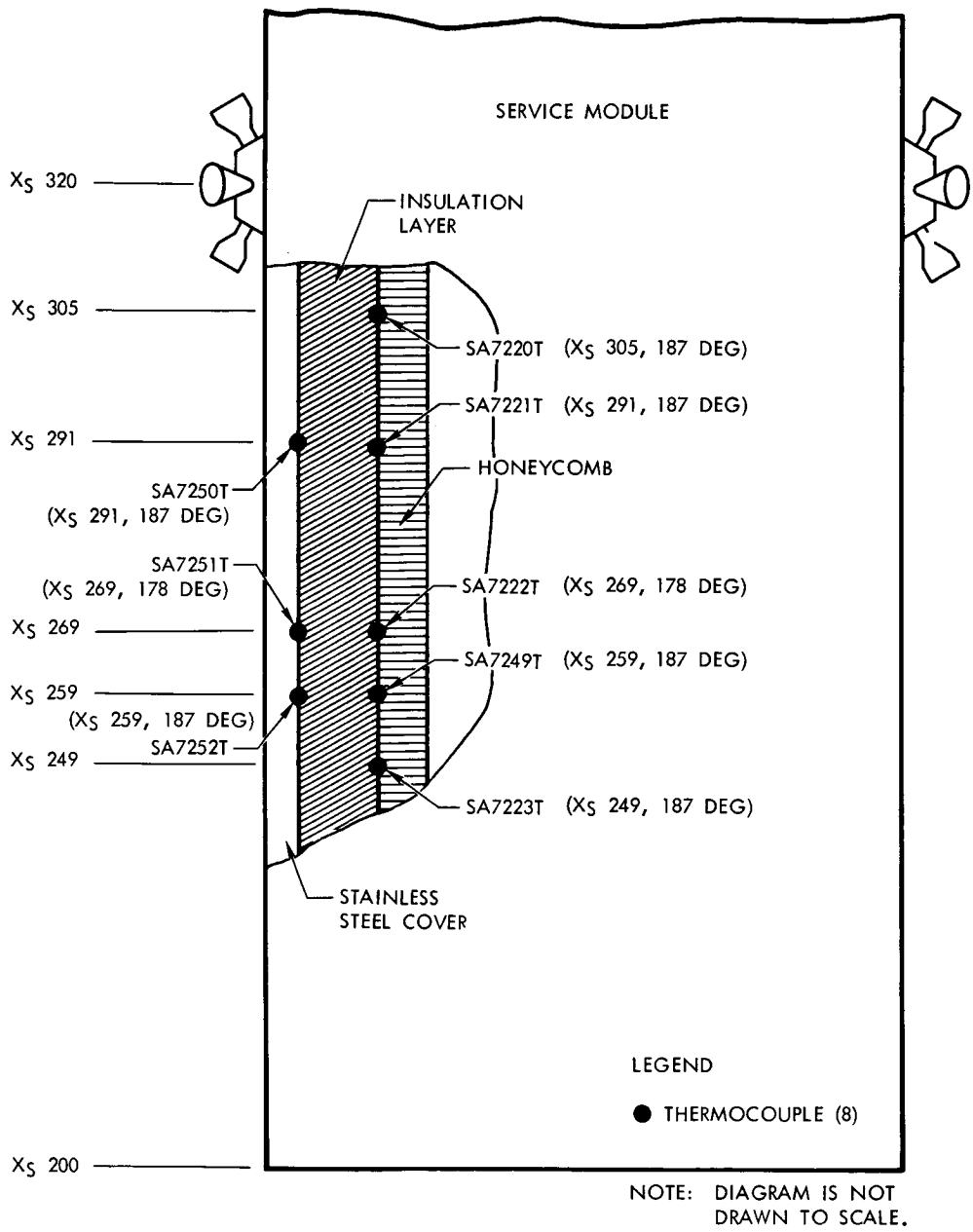

Figure 3-16. Reaction Control System Plume Temperature Measurement Locations

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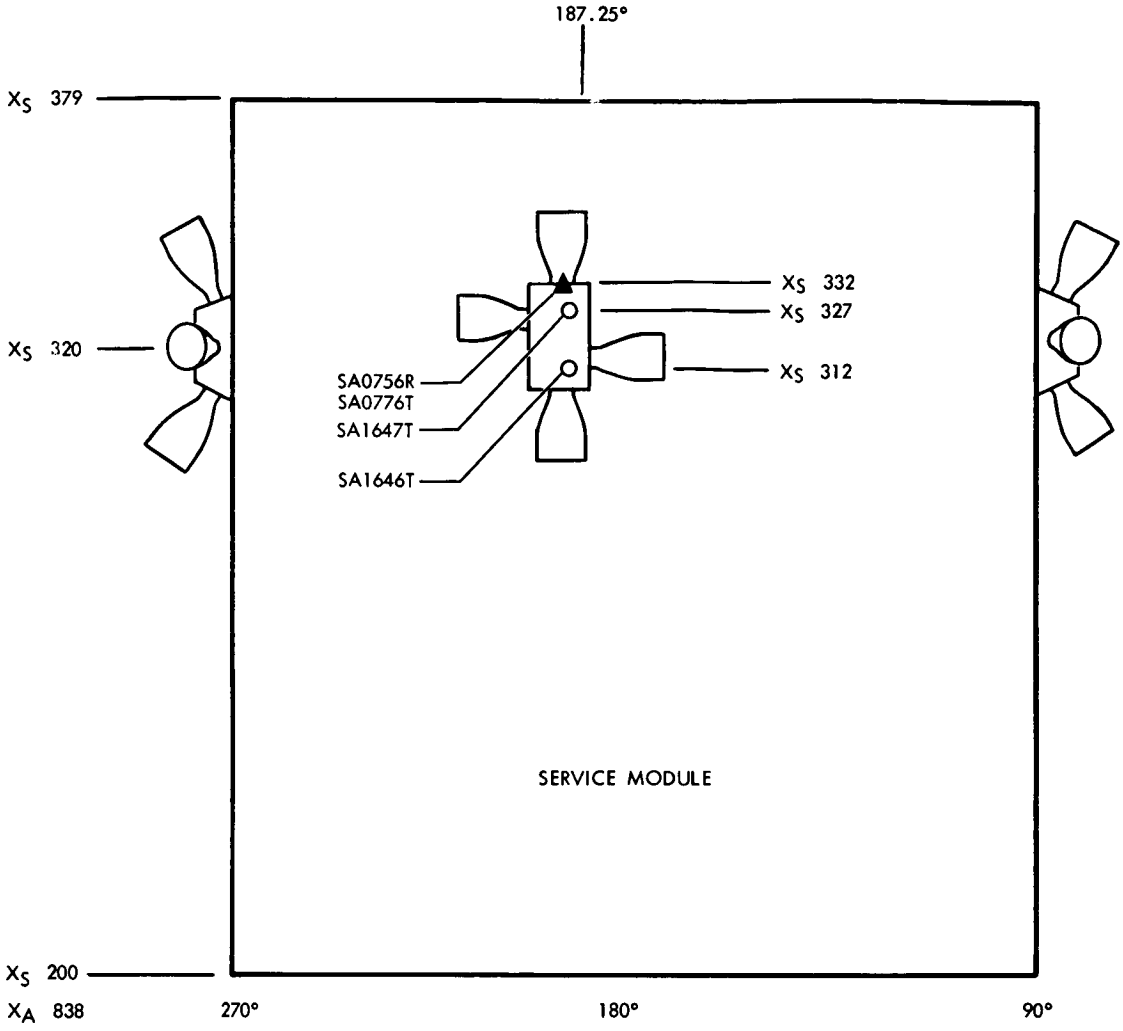
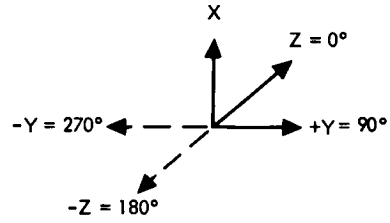
[redacted]





LEGEND

▲ HEAT FLUX (1) CALORIMETER BODY TEMPERATURE (1)

O TEMPERATURE SM RCS SUPPORT (2)

NOTE:
DIAGRAM IS NOT DRAWN TO SCALE.

Figure 3-17. Service Module Temperature Measurement Locations

[redacted]

[redacted]

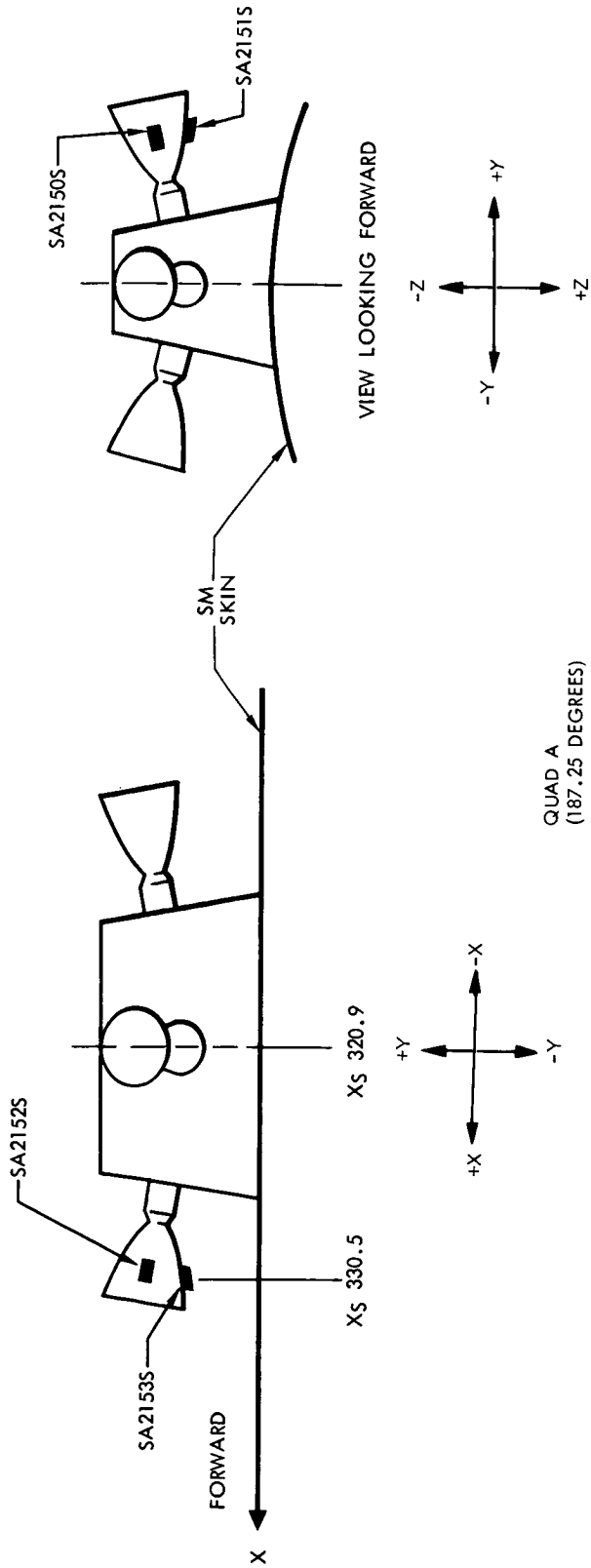


Figure 3-18. Reaction Control System Engine Strain Gauge Measurement Locations

[redacted]

[redacted]

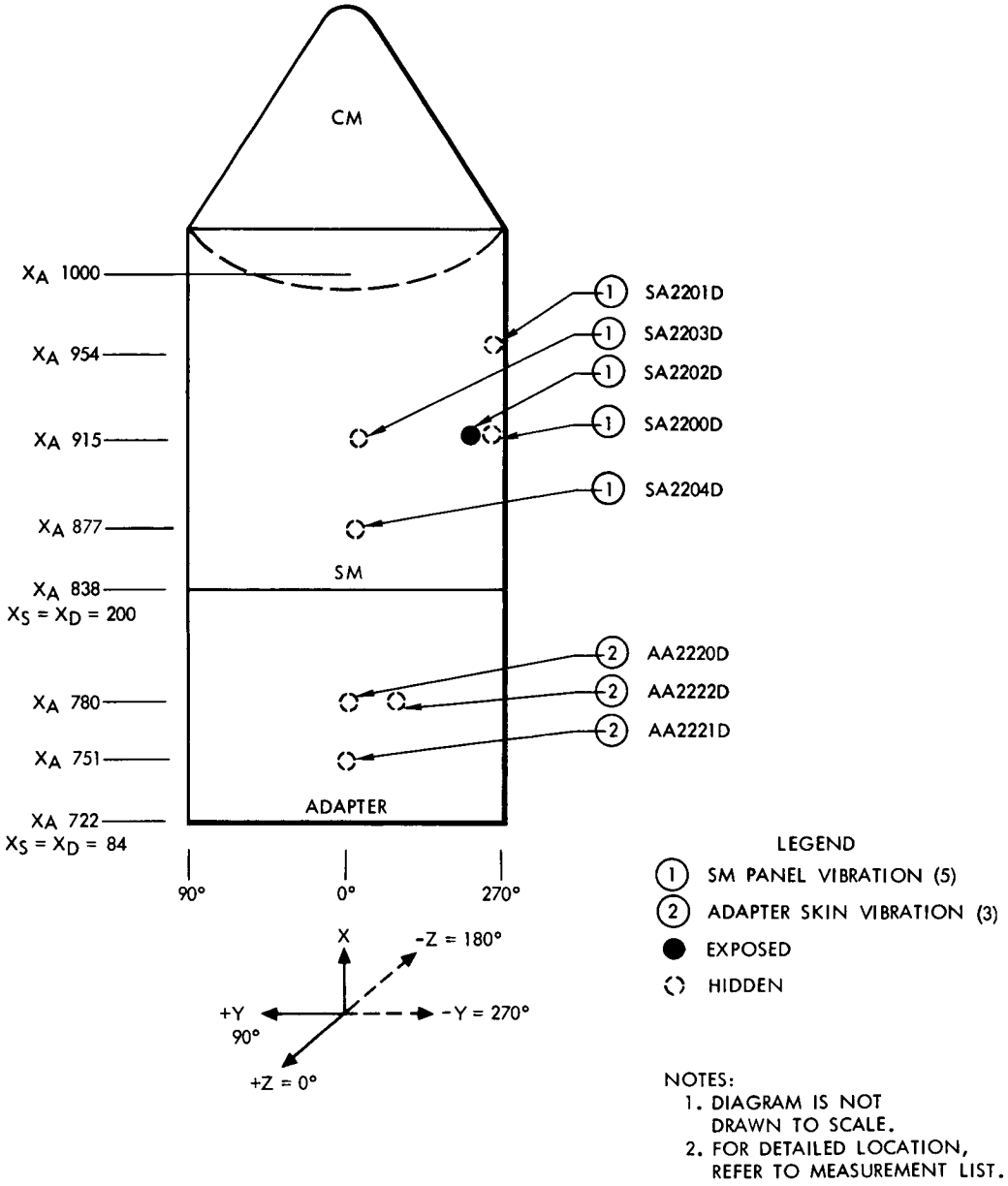
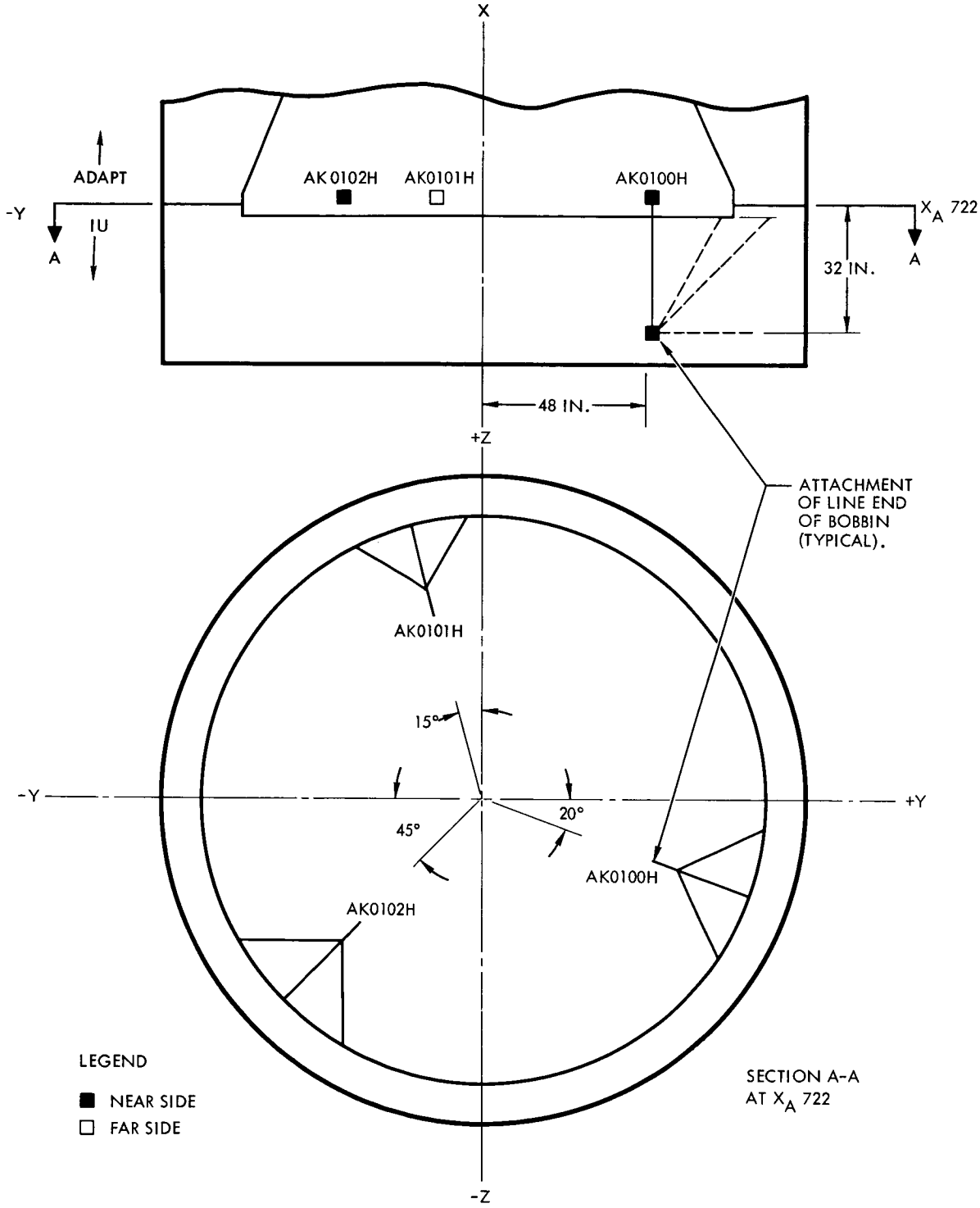


Figure 3-19. Vibration Measurement Locations

[redacted]

[redacted]



NOTE: DIAGRAM IS NOT DRAWN TO SCALE.

Figure 3-20. S-IV/Spacecraft Separation Measurement Locations

[redacted]

[redacted]

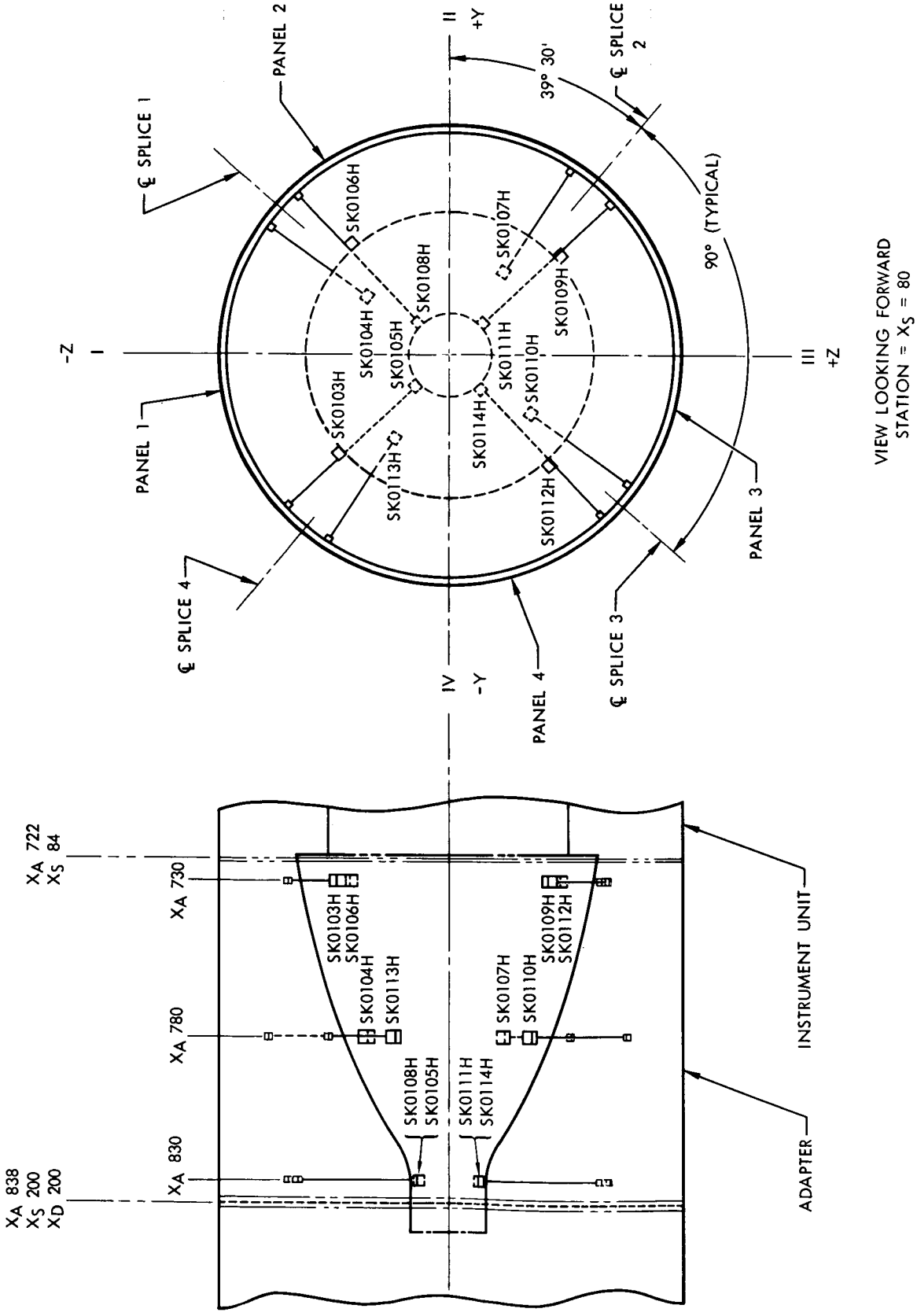
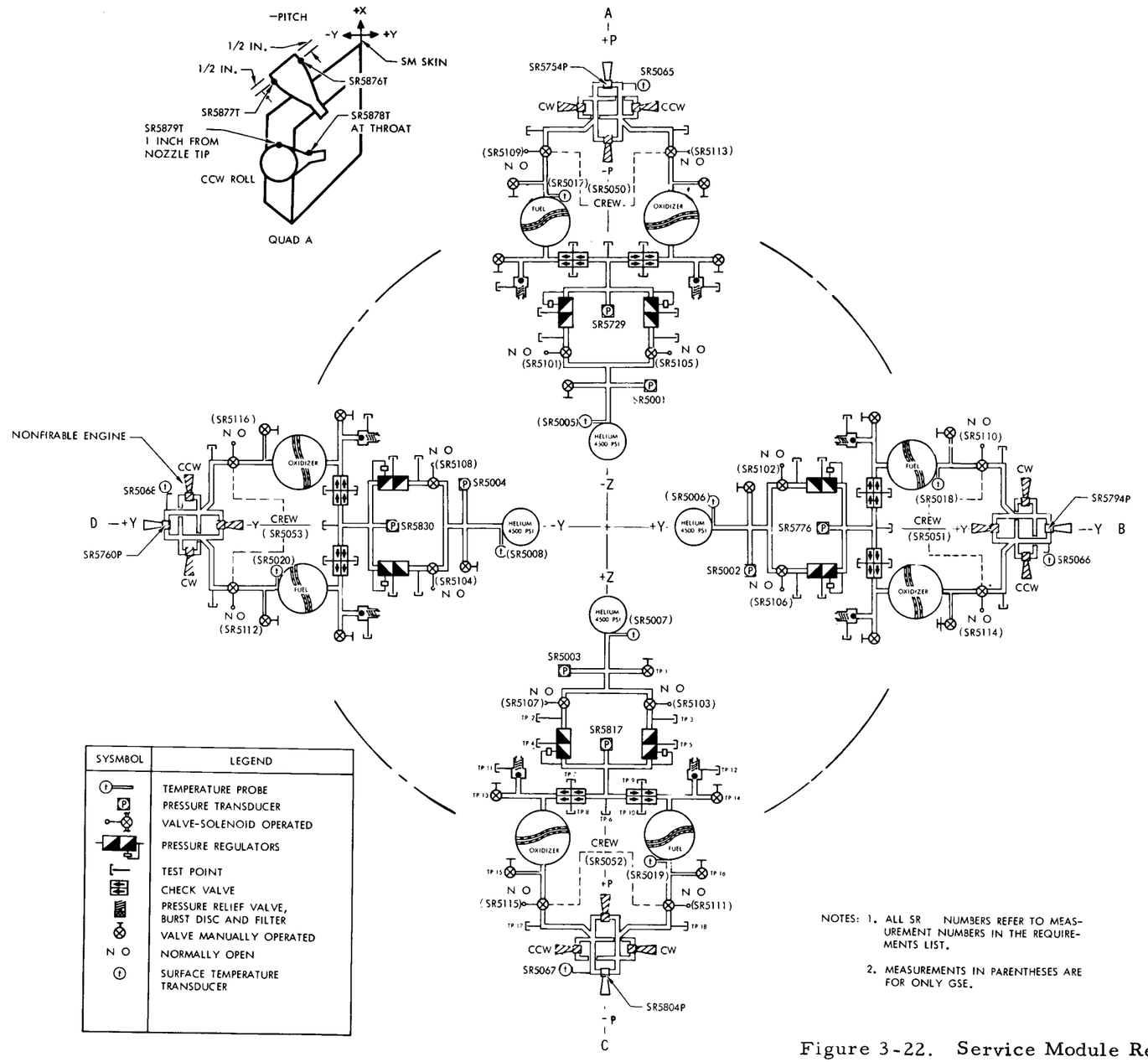


Figure 3-21. Service Module/Adapter Panel Bobbin Measurement Locations

[redacted]

[redacted]



SYSMBOL	LEGEND
(T)	TEMPERATURE PROBE
(P)	PRESSURE TRANSDUCER
	VALVE-SOLENOID OPERATED
	PRESSURE REGULATORS
	TEST POINT
	CHECK VALVE
	PRESSURE RELIEF VALVE, BURST DISC AND FILTER
	VALVE MANUALLY OPERATED
N O	NORMALLY OPEN
(T)	SURFACE TEMPERATURE TRANSDUCER

GSE TEST POINT MEASUREMENT NUMBERS				
TEST POINT	MODULE A	B	C	D
TP 1	SR6080	SR6081	SR6082	SR6083
TP 2	SR6010	SR6012	SR6014	SR6016
TP 3	SR6011	SR6013	SR6015	SR6017
TP 4	SR6020	SR6022	SR6024	SR6026
TP 5	SR6021	SR6023	SR6025	SR6027
TP 6	SR6050	SR6051	SR6052	SR6053
TP 7	SR6054	SR6056	SR6058	SR6060
TP 8	SR6055	SR6057	SR6059	SR6061
TP 9	SR6062	SR6064	SR6066	SR6068
TP10	SR6063	SR6065	SR6067	SR6069
TP11	SR6030	SR6032	SR6034	SR6036
TP12	SR6031	SR6033	SR6035	SR6037
TP13	SR6070	SR6071	SR6072	SR6073
TP14	SR6074	SR6075	SR6076	SR6077
TP15	SR6084	SR6085	SR6086	SR6087
TP16	SR6088	SR6089	SR6090	SR6091
TP17	SR6092	SR6093	SR6094	SR6095
TP18	SR6096	SR6097	SR6098	SR6099

NOTES: 1. ALL SR NUMBERS REFER TO MEASUREMENT NUMBERS IN THE REQUIREMENTS LIST.

2. MEASUREMENTS IN PARENTHESES ARE FOR ONLY GSE.

Figure 3-22. Service Module Reaction Control System Measurement Locations

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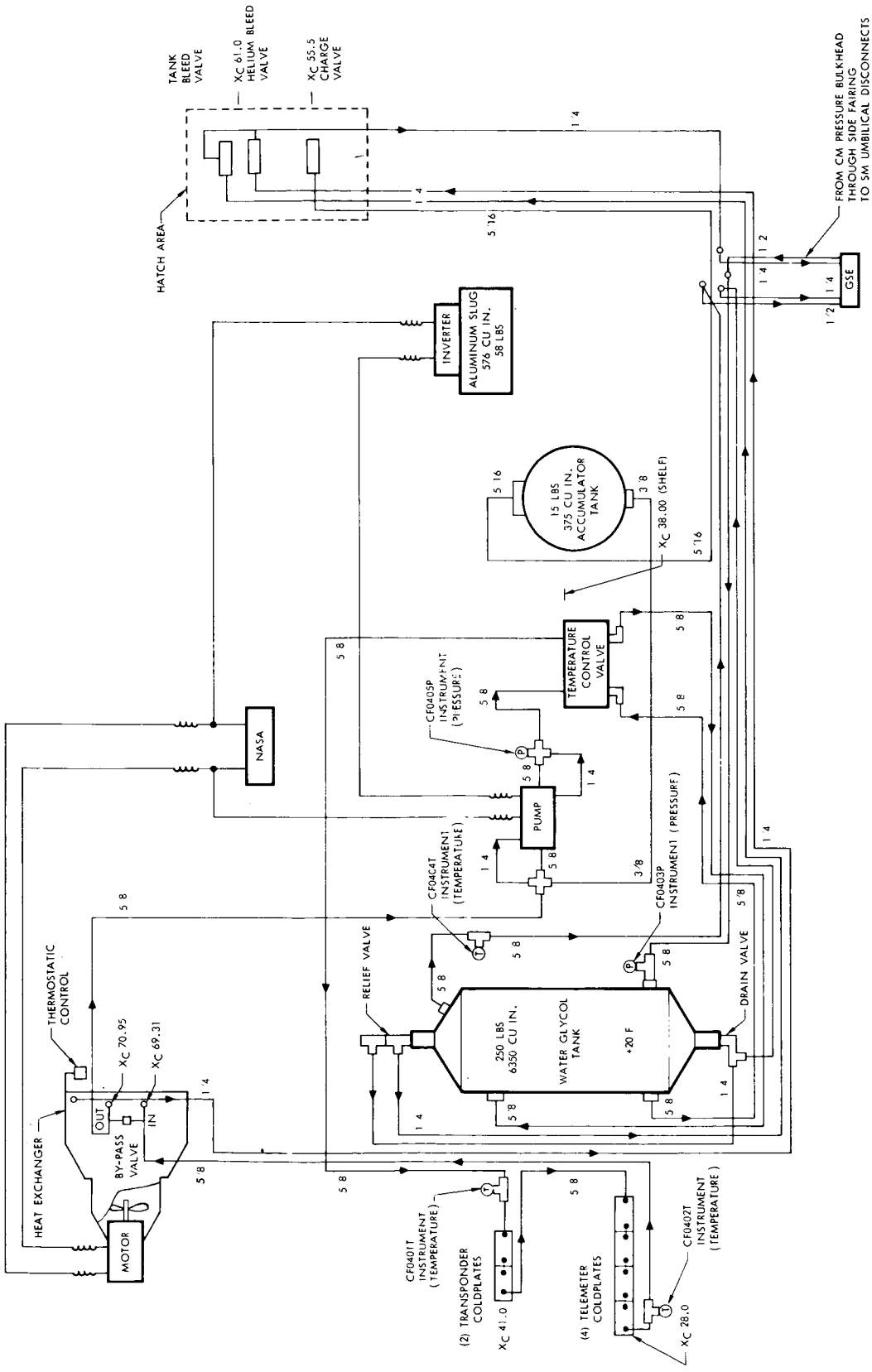

Figure 3-23. Environmental Control System Schematic Diagram—GSE Test Points

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[redacted]

Table 3-4. Boilerplate 18 Measurement List

SYSTEM
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NOVEMBER 8, 1963 L- 4
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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION	GSE
C A0001	A X AXIS SPACECRAFT ACCEL HIGH	A- 6	-2	+10	G		0-30	CPS	XC78,YC0,ZC21	
C A0005	A Y AXIS SPACECRAFT ACCEL	B- 5	-0.5	+0.5	G		0-30	CPS	XC78,YC0,ZC21	
C A0007	A Z AXIS SPACECRAFT ACCEL	B- 6	-0.5	+0.5	G		0-30	CPS	XC78,YC0,ZC21	
L A0011	A Y AXIS TOWER ACCEL	D- 6	-2	+2	G		0-30	CPS	XL380,YL0,ZL6	
L A0012	A Z AXIS TOWER ACCEL	A- 5	-2	+2	G		0-30	CPS	XL380,YL6,ZL0	
C A0610	T CM INTERIOR TEMP	B-13- 4	+32	+302	DEG F		1.25	S/S	CM INTERIOR	
C A0611	P CM INTERIOR PRESS	A-E- 14	+0	+15	PSIA		10	S/S	CM INTERIOR	
S A0612	T SM INTERIOR TEMP	B-13- 5	+32	+302	DEG F		1.25	S/S	SM INTERIOR	
S A0613	P SM INTERIOR PRESS	A-E- 15	+0	+15	PSIA		10	S/S	SM INTERIOR	
A A0614	P ADAPT INTERIOR PRESS	A-E- 16	+0	+15	PSIA		10	S/S	ADAPTER INTERIOR	
A A0615	T ADAPT INTERIOR TEMP	B-13- 6	+32	+302	DEG F		1.25	S/S	ADAPTER INTERIOR	
S A0756	R HEAT FLUX 17 (FWD FACE ENG PKG)	B-13-52	+0	+25	B/F/S		1.25	S/S	ENGINE PKG,187.2DEG	
S A0776	T SM CALORIMETER BODY TEMP 17	B-13-53	+32	+572	DEG F		1.25	S/S	ENGINE PKG,187.2DEG	
S A1646	T TEMP SM RCS SUPPORT LOC 1	B-13-24	+32	+2192	DEG F		1.25	S/S	XS312,187DEG	
S A1647	T TEMP SM RCS SUPPORT LOC 2	B-13-25	+32	+2192	DEG F		1.25	S/S	XS327.3,187DEG	
L A1656	T TEMP LES MTR CASE LOC 1	B-13-17	+32	+392	DEG F		1.25	S/S	XL200,0 DEG	
L A1658	T TEMP TJM MTR CASE LOC 1	B-13-18	+32	+392	DEG F		1.25	S/S	XL330,180 DEG	

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Table 3-4. Boilerplate 18 Measurement List (Cont)

SYSTEM
STRUCTURES

NOVEMBER 8 , 1963 L- 4
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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION	GSE
L A1659 T	TEMP LES SKIRT	B-13-19	+32	+482	DEG F		1.25	S/S	XL120,0 DEG	
S A2001 S	COMP PAD 2 BEAM AXIAL STRAIN 1	D-10	-7000	+7000	UI/IN		0-35	CPS	XC3,YC45.7,ZC43.5	
S A2002 S	COMP PAD 1 BEAM AXIAL STRAIN 1	A-E- 17	-7000	+7000	UI/IN		10	S/S	XA1000,YA61,ZA-31	
S A2003 S	COMP PAD 6 BEAM AXIAL STRAIN 1	A-E- 18	-7000	+7000	UI/IN		10	S/S	XC3,YC14,ZC-61.3	
S A2004 S	COMP PAD 5 BEAM AXIAL STRAIN 1	A-E- 19	-7000	+7000	UI/IN		10	S/S	XA1000,YA-49.5,ZA-47	
S A2005 S	COMP PAD 4 BEAM AXIAL STRAIN 1	A-E- 20	-7000	+7000	UI/IN		10	S/S	XC3,YC-55.3,ZC28.5	
S A2006 S	COMP PAD 3 BEAM AXIAL STRAIN 1	A-E- 21	-7000	+7000	UI/IN		10	S/S	XA1000,YA-25,ZA66.5	
S A2007 S	COMP PAD 2 BEAM AXIAL STRAIN 2	C- 6	-7000	+7000	UI/IN		0-35	CPS	XA1000,YA24.5,ZA23.8	
S A2008 S	COMP PAD 1 BEAM AXIAL STRAIN 2	A-E- 22	-7000	+7000	UI/IN		10	S/S	XA1000,YA30.5,ZA-15.5	
S A2009 S	COMP PAD 6 BEAM AXIAL STRAIN 2	A-E- 23	-7000	+7000	UI/IN		10	S/S	XA1000,YA8,ZA-33.5	
S A2010 S	COMP PAD 5 BEAM AXIAL STRAIN 2	A-E- 24	-7000	+7000	UI/IN		10	S/S	XA1000,YA-24.5,ZA-24	
S A2011 S	COMP PAD 4 BEAM AXIAL STRAIN 2	A-E- 25	-7000	+7000	UI/IN		10	S/S	XA1000,YA-30.5,ZA15.5	
S A2012 S	COMP PAD 3 BEAM AXIAL STRAIN 2	A-E- 26	-7000	+7000	UI/IN		10	S/S	XA1000,YA-8,ZA33.5	
A A2051 S	ADAPT AXIAL STRAIN 2	A-E- 27	-7000	+7000	UI/IN		10	S/S	XA803,YA-2.8,ZA-77	
A A2052 S	ADAPT AXIAL STRAIN 3	A-E- 28	-7000	+7000	UI/IN		10	S/S	XA803,YA-22.5,ZA-73.5	
A A2054 S	ADAPT AXIAL STRAIN 5	A-E- 29	-7000	+7000	UI/IN		10	S/S	XA803,YA-56,ZA-53	
A A2060 S	ADAPT AXIAL STRAIN 6	A-E- 30	-7000	+7000	UI/IN		10	S/S	XA833,YA-17.5,ZA-75	

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Table 3-4. Boilerplate 18 Measurement List (Cont)

SYSTEM
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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION	GSE
A A2061 S	ADAPT AXIAL STRAIN 7	A-E- 31	-7000	+7000	UI/IN		10	S/S	XA833,YA-2.8,ZA-77	
A A2062 S	ADAPT AXIAL STRAIN 8	A-E- 32	-7000	+7000	UI/IN		10	S/S	XA833,YA-22.5,ZA-73.5	
A A2063 S	ADAPT AXIAL STRAIN 9	A-E- 33	-7000	+7000	UI/IN		10	S/S	XA833,YA-40.5,ZA-65.5	
A A2064 S	ADAPT AXIAL STRAIN 10	A-E- 34	-7000	+7000	UI/IN		10	S/S	XA833,YA-56,ZA-53	
A A2070 S	ADAPT AXIAL STRAIN 11	D- 5	-7000	+7000	UI/IN		0-25	CPS	XA733,YA0,ZA77	
A A2071 S	ADAPT AXIAL STRAIN 12	A- 4	-7000	+7000	UI/IN		0-25	CPS	XA733,YA77,ZA0	
A A2072 S	ADAPT AXIAL STRAIN 13	B- 4	-7000	+7000	UI/IN		0-25	CPS	XA733,YA0,ZA-77	
A A2073 S	ADAPT AXIAL STRAIN 14	C- 5	-7000	+7000	UI/IN		0-25	CPS	XA733,YA-77,ZA0	
S A2100 S	SM SHELL OUTER CIR STRAIN 1	D-14	-7000	+7000	UI/IN		0-500	CPS	XA915,YA31.3,ZA70.5	
S A2101 S	SM SHELL OUTER CIR STRAIN 2	D-11	-7000	+7000	UI/IN		0-500	CPS	XA915,YA77.0,ZA0.0	
S A2102 S	SM SHELL OUTER CIR STRAIN 3	B-11	-7000	+7000	UI/IN		0-500	CPS	XA915,YA-22.5,ZA-73.5	
S A2103 S	SM SHELL OUTER CIR STRAIN 4	D-13	-7000	+7000	UI/IN		0-500	CPS	XA915,YA-31.3,ZA-70.5	
S A2104 S	SM SHELL OUTER CIR STRAIN 5	A-14	-7000	+7000	UI/IN		0-500	CPS	XA915,YA-40.5,ZA-65.5	
S A2105 S	SM SHELL OUTER CIR STRAIN 6	C-14	-7000	+7000	UI/IN		0-500	CPS	XA915,YA-48.4,ZA-60	
S A2106 S	SM SHELL INNER CIR STRAIN 7	A-12	-7000	+7000	UI/IN		0-500	CPS	XA915,YA31.0,ZA69.0	
S A2107 S	SM SHELL INNER CIR STRAIN 8	A-11	-7000	+7000	UI/IN		0-500	CPS	XA915,YA76.0,ZA0.0	
S A2108 S	SM SHELL INNER CIR STRAIN 9	A-10	-7000	+7000	UI/IN		0-500	CPS	XA915,YA-22,ZA-72.5	

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Table 3-4. Boilerplate 18 Measurement List (Cont)

SYSTEM
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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION	GSE
S A2109	S SM SHELL INNER CIR STRAIN 10	D-12	-7000	+7000	UI/IN		0-500	CPS	XA915,YA-31,ZA-69	
S A2110	S SM SHELL INNER CIR STRAIN 11	A-13	-7000	+7000	UI/IN		0-500	CPS	XA915,YA-40,ZA-64	
S A2111	S SM SHELL INNER CIR STRAIN 12	B-14	-7000	+7000	UI/IN		0-500	CPS	XA915,YA-47.5,ZA-59	
S A2132	S SM SHELL AXIAL STRAIN 1	B-10	-7000	+7000	UI/IN		0-500	CPS	XA915,YA31.5,ZA70.5	
S A2133	S SM SHELL AXIAL STRAIN 2	C-11	-7000	+7000	UI/IN		0-500	CPS	XA915,YA77.0,ZA0.0	
S A2134	S SM SHELL AXIAL STRAIN 3	C-10	-7000	+7000	UI/IN		0-500	CPS	XA915,YA-22.5,ZA-73.5	
S A2135	S SM SHELL AXIAL STRAIN 4	B-12	-7000	+7000	UI/IN		0-500	CPS	XA915,YA-31.3,ZA-70.5	
S A2136	S SM SHELL AXIAL STRAIN 5	C-13	-7000	+7000	UI/IN		0-500	CPS	XA915,YA-40.5,ZA-65.5	
S A2137	S SM SHELL AXIAL STRAIN 6	C-12	-7000	+7000	UI/IN		0-500	CPS	XA915,YA-48.4,ZA-60	
S A2150	S SM RCS NOZZLE STRAIN 1	B-15	-2000	+2000	UI/IN		0-500	CPS	SIDE NOZ COMBUS CHAMB	
S A2151	S SM RCS NOZZLE STRAIN 2	C-15	-2000	+2000	UI/IN		0-500	CPS	SIDE NOZ COMBUS CHAMB	
S A2152	S SM RCS NOZZLE STRAIN 3	D-15	-2000	+2000	UI/IN		0-500	CPS	FWD NOZ COMBUS CHAMB	
S A2153	S SM RCS NOZZLE STRAIN 4	A-15	-2000	+2000	UI/IN		0-500	CPS	FWD NOZ COMBUS CHAMB	
S A2160	S SM BEAM 2 INNER CAP AX STRAIN 1	A-E- 35	-7000	+7000	UI/IN		10	S/S	XA990,YA15,ZA15	
S A2161	S SM BEAM 2 INNER CAP AX STRAIN 2	A-E- 36	-7000	+7000	UI/IN		10	S/S	XA978.5,YA15,ZA15	
S A2162	S SM BEAM 2 INNER CAP AX STRAIN 3	A-E- 37	-7000	+7000	UI/IN		10	S/S	XA961,YA15,ZA15	
S A2163	S SM BEAM 2 INNER CAP AX STRAIN 4	A-E- 38	-7000	+7000	UI/IN		10	S/S	XA924.8,YA15,ZA15	

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Table 3-4. Boilerplate 18 Measurement List (Cont)

SYSTEM
STRUCTURES

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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION	GSE
S A2164 S	SM BEAM 2 INNER CAP AX STRAIN 5	A-E- 39	-7000	+7000	UI/IN		10	S/S	XA844.4,YA15,ZA15	
S A2190 P	SM FLUCTUATING PRESS 1	B-16	+0	+15	PSIA		20-1K	CPS	XA930,187.25DEG	
S A2191 P	SM FLUCTUATING PRESS 2	D-16	+0	+15	PSIA		20-1K	CPS	XA930,232.25DEG	
S A2200 D	SM PANEL VIBRATION 1	D-18	-50	+50	G		20-1K	CPS	XA915,YA-76.9,ZA-2.5	
S A2201 D	SM PANEL VIBRATION 2	A-16	-50	+50	G		20-1K	CPS	XA954,YA-76.9,ZA-2.5	
S A2202 D	SM PANEL VIBRATION 3	D-17	-50	+50	G		20-1K	CPS	XA915,YA-76,ZA14.5	
S A2203 D	SM PANEL VIBRATION 4	B-17	-50	+50	G		20-1K	CPS	XA915,YA0,ZA-77	
S A2204 D	SM PANEL VIBRATION 5	B-18	-50	+50	G		20-1K	CPS	XA877,YA0,ZA-77	
A A2220 D	ADAPT SKIN VIBRATION 1	C-16	-50	+50	G		20-1K	CPS	XA780,YA0,ZA-77	
A A2221 D	ADAPT SKIN VIBRATION 2	C-17	-50	+50	G		20-1K	CPS	XA751,YA0,ZA-77	
A A2222 D	ADAPT SKIN VIBRATION 3	C-18	-50	+50	G		20-1K	CPS	XA780,YA-20,ZA-74.5	
S A7220 T	TEMP SM OUTER SURFACE LOC 1	B-13-26	+32	+482	DEG F		1.25	S/S	XS305.0,187DEG	
S A7221 T	TEMP SM OUTER SURFACE LOC 2	B-13-27	+32	+482	DEG F		1.25	S/S	XS291.0,187DEG	
S A7222 T	TEMP SM OUTER SURFACE LOC 3	B-13-28	+32	+482	DEG F		1.25	S/S	XS269.0,178DEG	
S A7223 T	TEMP SM OUTER SURFACE LOC 4	B-13-29	+32	+482	DEG F		1.25	S/S	XS249.0,187DEG	
S A7224 T	TEMP SM OUTER SURFACE LOC 5	B-13-30	+32	+482	DEG F		1.25	S/S	XS272.0,7 DEG	
S A7225 T	TEMP SM OUTER SURFACE LOC 6	B-13-31	+32	+482	DEG F		1.25	S/S	XS370,0DEG	

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Table 3-4. Boilerplate 18 Measurement List (Cont)

SYSTEM
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NOVEMBER 8, 1963 L- 4
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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION	GSE
S A7226	T TEMP SM OUTER SURFACE LOC 7	B-13-32	+32	+482	DEG F		1.25	S/S	XS370,90DEG	
S A7227	T TEMP SM OUTER SURFACE LOC 8	B-13-33	+32	+482	DEG F		1.25	S/S	XS370,180DEG	
S A7228	T TEMP SM OUTER SURFACE LOC 9	B-13-34	+32	+482	DEG F		1.25	S/S	XS370,270DEG	
S A7229	T TEMP SM OUTER SURFACE LOC 10	B-13-35	+32	+482	DEG F		1.25	S/S	XS350,0DEG	
S A7231	T TEMP SM OUTER SURFACE LOC 12	B-13-36	+32	+482	DEG F		1.25	S/S	XS350,180DEG	
A A7237	T TEMP ADAPTER OUTER SURF LOC 18	B-13-37	+32	+482	DEG F		1.25	S/S	XA818,YA17.5,ZA-75	
A A7238	T TEMP ADAPTER OUTER SURF LOC 19	B-13-38	+32	+482	DEG F		1.25	S/S	XA818,YA-22.5,ZA-73	
A A7239	T TEMP ADAPTER INNER SURF LOC 20	B-13-39	+32	+482	DEG F		1.25	S/S	XA818,YA-21,ZA-72	
S A7241	T TEMP SM OUTER SURF LOC 22	B-13-40	+32	+482	DEG F		1.25	S/S	XA915,YA-48.4,ZA-60	
S A7242	T TEMP SM INNER SURF LOC 23	B-13-41	+32	+482	DEG F		1.25	S/S	XA915,YA-48.0,ZA-59	
S A7243	T TEMP SM OUTER SURF LOC 24	B-13-42	+32	+482	DEG F		1.25	S/S	XA915,YA-31.3,ZA-70	
S A7244	T TEMP SM INNER SURF LOC 25	B-13-43	+32	+482	DEG F		1.25	S/S	XA915,YA-31,ZA-69	
S A7245	T TEMP SM OUTER SURF LOC 26	B-13-44	+32	+482	DEG F		1.25	S/S	XA915,YA77,ZA 0	
S A7246	T TEMP SM INNER SURF LOC 27	B-13-45	+32	+482	DEG F		1.25	S/S	XA915,YA76,ZA 0	
S A7247	T TEMP SM OUTER SURF LOC 28	B-13-46	+32	+482	DEG F		1.25	S/S	XA915,YA31.3,ZA70.5	
S A7248	T TEMP SM INNER SURF LOC 29	B-13-47	+32	+482	DEG F		1.25	S/S	XA915,YA31,ZA70	
S A7249	T TEMP SM OUTER SURF LOC 30	B-13-48	+32	+482	DEG F		1.25	S/S	XS259.0,187DEG	

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Table 3-4. Boilerplate 18 Measurement List (Cont)

SYSTEM
STRUCTURES

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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION	GSE
S A7250	T TEMP SM HS SURF LOC 31	B-13-49	+32	+1022	DEG F		1.25	S/S	XS291,187DEG	
S A7251	T TEMP SM HS SURF LOC 32	B-13-50	+32	+1022	DEG F		1.25	S/S	XS269,178DEG	
S A7252	T TEMP SM HS SURF LOC 33	B-13-51	+32	+1022	DEG F		1.25	S/S	XS259,187DEG	

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Table 3-4. Boilerplate 18 Measurement List (Cont)

SYSTEM
ELECTRICAL

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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION	GSE
C C0001	V DC VOLTAGE MAIN BUS A	A-E- 3	+22	+32	VDC		10	S/S	PWR CONTROL BOX	U
C C0002	V DC VOLTAGE MAIN BUS B	A-E- 4	+22	+32	VDC		10	S/S	PWR CONTROL BOX	U
C C0003	V DC VOLTAGE LOGIC BUS A	A-E- 12	+0	+40	VDC		10	S/S	LES SEQUENCER	U
C C0004	V DC VOLTAGE LOGIC BUS B	A-E- 13	+0	+40	VDC		10	S/S	LES SEQUENCER	U
C C0005	C TOTAL DC CURRENT	A-E- 5	+0	+50	AMPS		10	S/S	PWR CONTROL BOX	UC
S C0010	V DC VOLTAGE ADAPTER PYRO BUS A	A-E- 6	+0	+36	VDC		10	S/S	SM ADAPTER SEQ	U
S C0011	V DC VOLTAGE ADAPTER PYRO BUS B	A-E- 7	+0	+36	VDC		10	S/S	SM ADAPTER SEQ	U
C C0030	X REGULATED PWR SUPPLY (5VDC)	GSE			EVENT					UC
S C0031	X UMBILICAL SEPARATION	GSE			EVENT					U
C C0032	V BATTERY A MONITOR AND BLEED	GSE	+0	+36	VDC					U
C C0033	V BATTERY B MONITOR AND BLEED	GSE	+0	+36	VDC					U
C C0034	X BUS A POWER TRANSFER	GSE			EVENT					U
C C0035	X BUS B POWER TRANSFER	GSE			EVENT					U

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Table 3-4. Boilerplate 18 Measurement List (Cont)

SYSTEM
LAUNCH ESCAPE

NOVEMBER 8, 1963 L- 4
PAGE NO. 9 F- 5

MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION	GSE
B D0001 X	S-1 LIFT OFF SIGNAL	A-E- 55			STEP		10	S/S	SIG COND BOX	
C D0005 V	DC VOLTAGE LES PYRO BUS A	A-E- 8	+0	+36	VDC		10	S/S	LES SEQUENCER	U
C D0006 V	DC VOLTAGE LES PYRO BUS B	A-E- 9	+0	+36	VDC		10	S/S	LES SEQUENCER	U
C D0023 X	CM-SM SEP RELAY CLOSE A	A-E- 62			STEP		10	S/S	LES SEQUENCER	
C D0024 X	CM-SM SEP RELAY CLOSE B	A-E- 62			STEP		10	S/S	LES SEQUENCER	
L D0033 X	TWR JETT AND SEP RELAY CLOSE A	A-E- 58			STEP		10	S/S	TWR LES SEQUENCER	
L D0034 X	TWR JETT AND SEP RELAY CLOSE B	A-E- 58			STEP		10	S/S	TWR LES SEQUENCER	
C D0078 X	IU TWR JETT SIGNAL A	A-E- 56			STEP		10	S/S	LES SEQUENCER	
C D0079 X	IU TWR JETT SIGNAL B	A-E- 56			STEP		10	S/S	LES SEQUENCER	
C D0084 X	FIRING MTR SW IND SAFE A	GSE			EVENT				LES SEQUENCER	U
C D0085 X	FIRING MTR SW IND SAFE B	GSE			EVENT				LES SEQUENCER	U
C D0090 X	MISSION SEQUENCER PYRO ARM A	GSE			EVENT				LES SEQUENCER	UB
C D0091 X	MISSION SEQUENCER PYRO SAFE A	GSE			EVENT				LES SEQUENCER	UB
C D0092 X	MISSION SEQUENCER PYRO ARM B	GSE			EVENT				LES SEQUENCER	UB
C D0093 X	MISSION SEQUENCER PYRO SAFE B	GSE			EVENT				LES SEQUENCER	UB
C D0094 X	SEQUENCER LOGIC READY A	GSE			EVENT				LES SEQUENCER	UB
C D0095 X	SEQUENCER LOGIC READY B	GSE			EVENT				LES SEQUENCER	UB

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Table 3-4. Boilerplate 18 Measurement List (Cont)

SYSTEM
LAUNCH ESCAPE

NOVEMBER 8, 1963 L- 4
PAGE NO. 10 F- 5

MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION	GSE
C D0096 X	SEQUENCER LOGIC SAFE A	GSE			EVENT				LES SEQUENCER	UB
C D0097 X	SEQUENCER LOGIC SAFE B	GSE			EVENT				LES SEQUENCER	UB
S D0125 X	S-IV/ADAPT/SM SEP RELAY CLOSE A	A-E- 60			STEP		10	S/S	SM ADAPTER SEQ	
S D0126 X	S-IV/ADAPT/SM SEP RELAY CLOSE B	A-E- 60			STEP		10	S/S	SM ADAPTER SEQ	
B D0160 X	S-IV CUTOFF SIGNAL A	A-E- 59			STEP		10	S/S	IU LES SEQUENCER	
B D0161 X	S-IV CUTOFF SIGNAL B	A-E- 59			STEP		10	S/S	IU LES SEQUENCER	
L D0185 V	DC VOLTAGE TWR PYRO BUS A	A-E- 10	+0	+36	VDC		10	S/S	TWR LES SEQUENCER	
L D0186 V	DC VOLTAGE TWR PYRO BUS B	A-E- 11	+0	+36	VDC		10	S/S	TWR LES SEQUENCER	
L D0190 X	LES/PITCH CONT MTR FIRE RLY CL A	A-E- 57			STEP		10	S/S	TWR LES SEQUENCER	
L D0191 X	LES/PITCH CONT MTR FIRE RLY CL B	A-E- 57			STEP		10	S/S	TWR LES SEQUENCER	
C D0286 X	FIRING MTR SW IND FIRE A	GSE			EVENT				LES SEQUENCER	U
C D0287 X	FIRING MTR SW IND FIRE B	GSE			EVENT				LES SEQUENCER	U
C D0320 X	EDS SAFE IND SAFE A	GSE			EVENT				LES SEQUENCER	UB
C D0321 X	EDS SAFE IND SAFE B	GSE			EVENT				LES SEQUENCER	UB
C D0322 X	EDS ENABLE ON A AND B	GSE			EVENT				LES SEQUENCER	UB
C D0350 X	SM RCS FIRE RELAY CLOSE A	A-E- 61			STEP		10	S/S	LES SEQUENCER	
C D0351 X	SM RCS FIRE RELAY CLOSE B	A-E- 61			STEP		10	S/S	LES SEQUENCER	

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Table 3-4. Boilerplate 18 Measurement List (Cont)

SYSTEM
ENVIRONMENTAL CONTROL

NOVEMBER 8, 1963 L- 4
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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION	GSE
C F0400 T R/D	ECS CM INTERIOR TEMP	GSE	+0	+150	DEG F				CM INTERIOR	UC
C F0401 T R/D	ECS COLD PLATE INLET TEMP	GSE	+0	+100	DEG F				COLD PLATE INLET	UC
C F0402 T R/D	ECS COLD PLATE OUTLET TEMP	GSE	+0	+100	DEG F				COLD PLATE OUTLET	UC
C F0403 P R/D	ECS TANK INLET PRESS	GSE	+0	+50	PSID				COOL TANK INLET	UC
C F0404 T R/D	ECS TANK OUTLET TEMP	GSE	+0	+100	DEG F				COOL TANK OUTLET	UC
C F0405 P R/D	ECS PUMP OUTLET PRESS	GSE	+0	+50	PSID				COOL PUMP OUTLET	UC

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Table 3-4. Boilerplate 18 Measurement List (Cont)

SYSTEM
FLIGHT TECHNOLOGY

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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION	GSE
A K0100 H	S-IV/SC SEPARATION BOBBIN D	A-E- 40	-10	+80	IN		10	S/S	XA720,YA46,ZA-16.5	
A K0101 H	S-IV/SC SEPARATION BOBBIN E	A-E- 41	-10	+80	IN		10	S/S	XA720,YA-12.4,ZA46.3	
A K0102 H	S-IV/SC SEPARATION BOBBIN F	A-E- 42	-10	+80	IN		10	S/S	XA720,YA-34,ZA-34	
S K0103 H	SM/ADAPT PANEL 1 BOBBIN A	A- 7	-10	+80	IN		0-35	CPS	XA730,YA-33,ZA-35	
S K0104 H	SM/ADAPT PANEL 1 BOBBIN B	A- 8	-10	+80	IN		0-35	CPS	XA780,YA20,ZA30	
S K0105 H	SM/ADAPT PANEL 1 BOBBIN C	A- 9	-10	+80	IN		0-35	CPS	XA830,YA-10,ZA-10	
S K0106 H	SM/ADAPT PANEL 2 BOBBIN A	B- 7	-10	+80	IN		0-35	CPS	XA730,YA34,ZA-33	
S K0107 H	SM/ADAPT PANEL 2 BOBBIN B	B- 8	-10	+80	IN		0-35	CPS	XA780,YA29,ZA20	
S K0108 H	SM/ADAPT PANEL 2 BOBBIN C	B- 9	-10	+80	IN		0-35	CPS	XA830,YA10,ZA-10	
S K0109 H	SM/ADAPT PANEL 3 BOBBIN A	C- 7	-10	+80	IN		0-35	CPS	XA730,YA33,ZA35	
S K0110 H	SM/ADAPT PANEL 3 BOBBIN B	C- 8	-10	+80	IN		0-35	CPS	XA780,YA-20,ZA-30	
S K0111 H	SM/ADAPT PANEL 3 BOBBIN C	C- 9	-10	+80	IN		0-35	CPS	XA830,YA10,ZA10	
S K0112 H	SM/ADAPT PANEL 4 BOBBIN A	D- 7	-10	+80	IN		0-35	CPS	XA730,YA-34,ZA33	
S K0113 H	SM/ADAPT PANEL 4 BOBBIN B	D- 8	-10	+80	IN		0-35	CPS	XA780,YA-29,ZA-20	
S K0114 H	SM/ADAPT PANEL 4 BOBBIN C	D- 9	-10	+80	IN		0-35	CPS	XA830,YA-10,ZA10	

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Table 3-4. Boilerplate 18 Measurement List (Cont)

SYSTEM
REACTION CONTROL

NOVEMBER 8, 1963 L- 4
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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION	GSE
S R5001 P	HE PRESS TANK A	A-E- 43	+0	+5K	PSIA		10	S/S	XA963,YA-11,ZA-81	UC
S R5002 P	HE PRESS TANK B	A-E- 44	+0	+5K	PSIA		10	S/S	XA963,YA81,ZA-11	UC
S R5003 P	HE PRESS TANK C	A-E- 45	+0	+5K	PSIA		10	S/S	XA963,YA11,ZA81	UC
S R5004 P	HE PRESS TANK D	A-E- 46	+0	+5K	PSIA		10	S/S	XA963,YA-81,ZA11	UC
S R5005 T	HE TEMP TANK A	GSE	-100	+200	DEG F				XA963,YA-11,ZA-81	UC
S R5006 T	HE TEMP TANK B	GSE	-100	+200	DEG F				XA963,YA81,ZA-11	UC
S R5007 T	HE TEMP TANK C	GSE	-100	+200	DEG F				XA963,YA11,ZA81	UC
S R5008 T	HE TEMP TANK D	GSE	-100	+200	DEG F				XA963,YA-81,ZA11	UC
S R5017 T	TEMP FUEL LINE A	GSE	+0	+200	DEG F					UC
S R5018 T	TEMP FUEL LINE B	GSE	+0	+200	DEG F					UC
S R5019 T	TEMP FUEL LINE C	GSE	+0	+200	DEG F					UC
S R5020 T	TEMP FUEL LINE D	GSE	+0	+200	DEG F					UC
S R5050 X	COMBINED PROP ISO VLV MON SYS A	GSE			EVENT					U
S R5051 X	COMBINED PROP ISO VLV MON SYS B	GSE			EVENT					U
S R5052 X	COMBINED PROP ISO VLV MON SYS C	GSE			EVENT					U
S R5053 X	COMBINED PROP ISO VLV MON SYS D	GSE			EVENT					U
S R5065 T	TEMP ENGINE PACKAGE A1	B-13-11	+32	+302	DEG F		1.25	S/S	XA963,YA-11,ZA-81	

Table 3-4. Boilerplate 18 Measurement List (Cont)

SYSTEM
REACTION CONTROL

NOVEMBER 8, 1963 L- 4
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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION	GSE
S R5066 T	TEMP ENGINE PACKAGE B1	B-13-12	+32	+302	DEG F		1.25	S/S	XA963,YA-81,ZA11	
S R5067 T	TEMP ENGINE PACKAGE C1	B-13-13	+32	+302	DEG F		1.25	S/S	XA963,YA11,ZA81	
S R5068 T	TEMP ENGINE PACKAGE D1	B-13-14	+32	+302	DEG F		1.25	S/S	XA963,YA81,ZA-11	
S R5101 X	HE ISOLATION VLV A1 POSITION	GSE	OPEN	CLOSE	EVENT					U
S R5102 X	HE ISOLATION VLV B1 POSITION	GSE	OPEN	CLOSE	EVENT					U
S R5103 X	HE ISOLATION VLV C1 POSITION	GSE	OPEN	CLOSE	EVENT					U
S R5104 X	HE ISOLATION VLV D1 POSITION	GSE	OPEN	CLOSE	EVENT					U
S R5105 X	HE ISOLATION VLV A2 POSITION	GSE	OPEN	CLOSE	EVENT					U
S R5106 X	HE ISOLATION VLV B2 POSITION	GSE	OPEN	CLOSE	EVENT					U
S R5107 X	HE ISOLATION VLV C2 POSITION	GSE	OPEN	CLOSE	EVENT					U
S R5108 X	HE ISOLATION VLV D2 POSITION	GSE	OPEN	CLOSE	EVENT					U
S R5109 X	FUEL ISOLATION VLV A1 POSITION	GSE	OPEN	CLOSE	EVENT					U
S R5110 X	FUEL ISOLATION VLV B1 POSITION	GSE	OPEN	CLOSE	EVENT					U
S R5111 X	FUEL ISOLATION VLV C1 POSITION	GSE	OPEN	CLOSE	EVENT					U
S R5112 X	FUEL ISOLATION VLV D1 POSITION	GSE	OPEN	CLOSE	EVENT					U
S R5113 X	OX ISOLATION VLV A2 POSITION	GSE	OPEN	CLOSE	EVENT					U
S R5114 X	OX ISOLATION VLV B2 POSITION	GSE	OPEN	CLOSE	EVENT					U

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Table 3-4. Boilerplate 18 Measurement List (Cont)

SYSTEM
REACTION CONTROL

NOVEMBER 8, 1963 L- 4
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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION	GSE
S R5115 X 0X	ISOLATION VLV C2 POSITION	GSE	OPEN	CLOSE	EVENT					U
S R5116 X 0X	ISOLATION VLV D2 POSITION	GSE	OPEN	CLOSE	EVENT					U
S R5729 P A	HE MANIFOLD PRESS	A-E- 47	+0	+400	PSIA		10	S/S	XA963,YA-11,ZA-81	
S R5754 P A	CHAMBER PRESS ENG +P	A-E- 54	+0	+250	PSIA		10	S/S	XA963,YA-11,ZA-81	
S R5760 P D	CHAMBER PRESS ENG +Y	A-E- 52	+0	+250	PSIA		10	S/S	XA963,YA-81,ZA11	
S R5776 P B	HE MANIFOLD PRESS	A-E- 48	+0	+400	PSIA		10	S/S	XA963,YA81,ZA-11	
S R5794 P B	CHAMBER PRESS ENG -Y	A-E- 51	+0	+250	PSIA		10	S/S	XA963,YA81,ZA-11	
S R5804 P C	CHAMBER PRESS ENG -P	A-E- 53	+0	+250	PSIA		10	S/S	XA963,YA11,ZA81	
S R5817 P C	HE MANIFOLD PRESS	A-E- 49	+0	+400	PSIA		10	S/S	XA963,YA11,ZA81	
S R5830 P D	HE MANIFOLD PRESS	A-E- 50	+0	+400	PSIA		10	S/S	XA963,YA-81,ZA11	
S R5876 T	TEMP A ENG NOZZLE WALL 1 -P	B-13-20	+32	+2192	DEG F		1.25	S/S	XS336,187DEG	
S R5877 T	TEMP A ENG NOZZLE WALL 2 -P	B-13-21	+32	+2192	DEG F		1.25	S/S	XS336,187DEG	
S R5878 T	TEMP A CCW ROLL ENG NOZ WALL 1	B-13-22	+32	+2192	DEG F		1.25	S/S	XS321,187DEG	
S R5879 T	TEMP A CCW ROLL ENG NOZ WALL 2	B-13-23	+32	+2192	DEG F		1.25	S/S	XS321,187DEG	
S R6010 P	PRESS SYS A TEST POINT 2	GSE	+C	+5K	PSIG					T
S R6011 P	PRESS SYS A TEST POINT 3	GSE	+0	+5K	PSIG					T
S R6012 P	PRESS SYS B TEST POINT 2	GSE	+0	+5K	PSIG					T

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Table 3-4. Boilerplate 18 Measurement List (Cont)

SYSTEM
REACTION CONTROL

NOVEMBER 8, 1963 L- 4
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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION	GSE
S R6013	P PRESS SYS B TEST POINT 3	GSE	+0	+5K	PSIG					T
S R6014	P PRESS SYS C TEST POINT 2	GSE	+0	+5K	PSIG					T
S R6015	P PRESS SYS C TEST POINT 3	GSE	+0	+5K	PSIG					T
S R6016	P PRESS SYS D TEST POINT 2	GSE	+0	+5K	PSIG					T
S R6017	P PRESS SYS D TEST POINT 3	GSE	+0	+5K	PSIG					T
S R6020	P PRESS SYS A TEST POINT 4	GSE	+0	+300	PSIG					T
S R6021	P PRESS SYS A TEST POINT 5	GSE	+0	+300	PSIG					T
S R6022	P PRESS SYS B TEST POINT 4	GSE	+0	+300	PSIG					T
S R6023	P PRESS SYS B TEST POINT 5	GSE	+0	+300	PSIG					T
S R6024	P PRESS SYS C TEST POINT 4	GSE	+0	+300	PSIG					T
S R6025	P PRESS SYS C TEST POINT 5	GSE	+0	+300	PSIG					T
S R6026	P PRESS SYS D TEST POINT 4	GSE	+0	+300	PSIG					T
S R6027	P PRESS SYS D TEST POINT 5	GSE	+0	+300	PSIG					T
S R6030	P PRESS SYS A TEST POINT 11	GSE	+0	+300	PSIG					T
S R6031	P PRESS SYS A TEST POINT 12	GSE	+0	+300	PSIG					T
S R6032	P PRESS SYS B TEST POINT 11	GSE	+0	+300	PSIG					T
S R6033	P PRESS SYS B TEST POINT 12	GSE	+0	+300	PSIG					T

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Table 3-4. Boilerplate 18 Measurement List (Cont)

SYSTEM
REACTION CONTROL

NOVEMBER 8, 1963 L- 4
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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION	GSE
S R6034	P PRESS SYS C TEST POINT 11	GSE	+0	+300	PSIG					T
S R6035	P PRESS SYS C TEST POINT 12	GSE	+0	+300	PSIG					T
S R6036	P PRESS SYS D TEST POINT 11	GSE	+0	+300	PSIG					T
S R6037	P PRESS SYS D TEST POINT 12	GSE	+0	+300	PSIG					T
S R6050	P PRESS SYS A TEST POINT 6	GSE	+0	+300	PSIG					T
S R6051	P PRESS SYS B TEST POINT 6	GSE	+0	+300	PSIG					T
S R6052	P PRESS SYS C TEST POINT 6	GSE	+0	+300	PSIG					T
S R6053	P PRESS SYS D TEST POINT 6	GSE	+0	+300	PSIG					T
S R6054	P PRESS SYS A TEST POINT 7	GSE	+0	+300	PSIG					T
S R6055	P PRESS SYS A TEST POINT 8	GSE	+0	+300	PSIG					T
S R6056	P PRESS SYS B TEST POINT 7	GSE	+0	+300	PSIG					T
S R6057	P PRESS SYS B TEST POINT 8	GSE	+0	+300	PSIG					T
S R6058	P PRESS SYS C TEST POINT 7	GSE	+0	+300	PSIG					T
S R6059	P PRESS SYS C TEST POINT 8	GSE	+0	+300	PSIG					T
S R6060	P PRESS SYS D TEST POINT 7	GSE	+0	+300	PSIG					T
S R6061	P PRESS SYS D TEST POINT 8	GSE	+0	+300	PSIG					T
S R6062	P PRESS SYS A TEST POINT 9	GSE	+0	+300	PSIG					T

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Table 3-4. Boilerplate 18 Measurement List (Cont)

SYSTEM
REACTION CONTROL

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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION	GSE
S R6063	P PRESS SYS A TEST POINT 10	GSE	+0	+300	PSIG					T
S R6064	P PRESS SYS B TEST POINT 9	GSE	+0	+300	PSIG					T
S R6065	P PRESS SYS B TEST POINT 10	GSE	+0	+300	PSIG					T
S R6066	P PRESS SYS C TEST POINT 9	GSE	+0	+300	PSIG					T
S R6067	P PRESS SYS C TEST POINT 10	GSE	+0	+300	PSIG					T
S R6068	P PRESS SYS D TEST POINT 9	GSE	+0	+300	PSIG					T
S R6069	P PRESS SYS D TEST POINT 10	GSE	+0	+300	PSIG					T
S R6070	P PRESS SYS A TEST POINT 13	GSE	+0	+300	PSIG					T
S R6071	P PRESS SYS B TEST POINT 13	GSE	+0	+300	PSIG					T
S R6072	P PRESS SYS C TEST POINT 13	GSE	+0	+300	PSIG					T
S R6073	P PRESS SYS D TEST POINT 13	GSE	+0	+300	PSIG					T
S R6074	P PRESS SYS A TEST POINT 14	GSE	+0	+300	PSIG					T
S R6075	P PRESS SYS B TEST POINT 14	GSE	+0	+300	PSIG					T
S R6076	P PRESS SYS C TEST POINT 14	GSE	+0	+300	PSIG					T
S R6077	P PRESS SYS D TEST POINT 14	GSE	+0	+300	PSIG					T
S R6080	P PRESS SYS A TEST POINT 1	GSE	+0	+5K	PSIG					T
S R6081	P PRESS SYS B TEST POINT 1	GSE	+0	+5K	PSIG					T

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Table 3-4. Boilerplate 18 Measurement List (Cont)

SYSTEM
REACTION CONTROL

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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION	GSE
S R6082	P PRESS SYS C TEST POINT 1	GSE	+0	+5K	PSIG					T
S R6083	P PRESS SYS D TEST POINT 1	GSE	+0	+5K	PSIG					T
S R6084	P PRESS SYS A TEST POINT 15	GSE	+0	+300	PSIG					T
S R6085	P PRESS SYS B TEST POINT 15	GSE	+0	+300	PSIG					T
S R6086	P PRESS SYS C TEST POINT 15	GSE	+0	+300	PSIG					T
S R6087	P PRESS SYS D TEST POINT 15	GSE	+0	+300	PSIG					T
S R6088	P PRESS SYS A TEST POINT 16	GSE	+0	+300	PSIG					T
S R6089	P PRESS SYS B TEST POINT 16	GSE	+0	+300	PSIG					T
S R6090	P PRESS SYS C TEST POINT 16	GSE	+0	+300	PSIG					T
S R6091	P PRESS SYS D TEST POINT 16	GSE	+0	+300	PSIG					T
S R6092	P PRESS SYS A TEST POINT 17	GSE	+0	+300	PSIG					T
S R6093	P PRESS SYS B TEST POINT 17	GSE	+0	+300	PSIG					T
S R6094	P PRESS SYS C TEST POINT 17	GSE	+0	+300	PSIG					T
S R6095	P PRESS SYS D TEST POINT 17	GSE	+0	+300	PSIG					T
S R6096	P PRESS SYS A TEST POINT 18	GSE	+0	+300	PSIG					T
S R6097	P PRESS SYS B TEST POINT 18	GSE	+0	+300	PSIG					T
S R6098	P PRESS SYS C TEST POINT 18	GSE	+0	+300	PSIG					T

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Table 3-4. Boilerplate 18 Measurement List (Cont)

SYSTEM
REACTION CONTROL

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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION	GSE
S R6099 P	PRESS SYS D TEST POINT 18	GSE	+0	+300	PSIG					T
S R7145 T	+P ENG FUEL VLV SOLENOID SYS A	B-13-15	+32	+302	DEG F		1.25	S/S	XA963,YA-11,ZA-81	
S R7200 T	TEMP OXID VLV BODY +P ENG SYS A	B-13-16	+32	+302	DEG F		1.25	S/S	XA963,YA-11,ZA-81	

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Table 3-4. Boilerplate 18 Measurement List (Cont)

SYSTEM
CREW SAFETY

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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION	GSE
B S0016 X	LAUNCH VEH GUIDANCE FAIL A	A-E- 82		STEP		10	S/S	INSTRUMENT UNIT	
B S0017 X	LAUNCH VEH GUIDANCE FAIL B	A-E- 82		STEP		10	S/S	INSTRUMENT UNIT	
B S0020 X	LAUNCH VEH RATE EXCESSIVE A	A-E- 83		STEP		10	S/S	INSTRUMENT UNIT	
B S0021 X	LAUNCH VEH RATE EXCESSIVE B	A-E- 83		STEP		10	S/S	INSTRUMENT UNIT	
B S0025 X	INSTRUMENT UNIT PWR FAIL A	A-E- 84		STEP		10	S/S	INSTRUMENT UNIT	
B S0026 X	INSTRUMENT UNIT PWR FAIL B	A-E- 84		STEP		10	S/S	INSTRUMENT UNIT	
B S0030 X	ENG NO 1 OUT A	A-E- 74		STEP		10	S/S	INSTRUMENT UNIT	
B S0031 X	ENG NO 1 OUT B	A-E- 74		STEP		10	S/S	INSTRUMENT UNIT	
B S0032 X	ENG NO 2 OUT A	A-E- 75		STEP		10	S/S	INSTRUMENT UNIT	
B S0033 X	ENG NO 2 OUT B	A-E- 75		STEP		10	S/S	INSTRUMENT UNIT	
B S0034 X	ENG NO 3 OUT A	A-E- 76		STEP		10	S/S	INSTRUMENT UNIT	
B S0035 X	ENG NO 3 OUT B	A-E- 76		STEP		10	S/S	INSTRUMENT UNIT	
B S0036 X	ENG NO 4 OUT A	A-E- 77		STEP		10	S/S	INSTRUMENT UNIT	
B S0037 X	ENG NO 4 OUT B	A-E- 77		STEP		10	S/S	INSTRUMENT UNIT	
B S0038 X	ENG NO 5 OUT A	A-E- 78		STEP		10	S/S	INSTRUMENT UNIT	
B S0039 X	ENG NO 5 OUT B	A-E- 78		STEP		10	S/S	INSTRUMENT UNIT	
B S0040 X	ENG NO 6 OUT A	A-E- 79		STEP		10	S/S	INSTRUMENT UNIT	

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Table 3-4. Boilerplate 18 Measurement List (Cont)

SYSTEM
CREW SAFETY

NOVEMBER 8, 1963 L- 4
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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION	GSE
B S0041 X	ENG NO 6 OUT B	A-E- 79			STEP		10	S/S	INSTRUMENT UNIT	
B S0042 X	ENG NO 7 OUT A	A-E- 80			STEP		10	S/S	INSTRUMENT UNIT	
B S0043 X	ENG NO 7 OUT B	A-E- 80			STEP		10	S/S	INSTRUMENT UNIT	
B S0044 X	ENG NO 8 OUT A	A-E- 81			STEP		10	S/S	INSTRUMENT UNIT	
B S0045 X	ENG NO 8 OUT B	A-E- 81			STEP		10	S/S	INSTRUMENT UNIT	
B S0080 X	ABORT REQUEST A	A-E- 85			STEP		10	S/S	INSTRUMENT UNIT	
B S0081 X	ABORT REQUEST B	A-E- 85			STEP		10	S/S	INSTRUMENT UNIT	
B S0082 V	EDS ABORT LOGIC IN NO 1	A-E- 86	+0	+40	VDC		10	S/S	INSTRUMENT UNIT	
B S0083 V	EDS ABORT LOGIC IN NO 2	A-E- 87	+0	+40	VDC		10	S/S	INSTRUMENT UNIT	
B S0084 V	EDS ABORT LOGIC IN NO 3	A-E- 88	+0	+40	VDC		10	S/S	INSTRUMENT UNIT	
C S0088 V	EDS ABORT LOGIC OUT A	C- 4	+0	+40	VDC		0-10	CPS	LES SEQUENCER	
C S0089 V	EDS ABORT LOGIC OUT B	D- 4	+0	+40	VDC		0-10	CPS	LES SEQUENCER	
C S0095 V	DC VOLTAGE SC EDS BUS NO 1	A-E- 73	+0	+40	VDC		10	S/S		
C S0096 V	DC VOLTAGE SC EDS BUS NO 2	A-E- 72	+0	+40	VDC		10	S/S		
C S0097 V	DC VOLTAGE SC EDS BUS NO 3	A-E- 71	+0	+40	VDC		10	S/S		

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Table 3-4. Boilerplate 18 Measurement List (Cont)

SYSTEM
COMMUNICATIONS AND INSTRUMENTATION

NOVEMBER 8, 1963 L- 4
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MEAS. ID	MEASUREMENT DESCRIPTION	CHANNEL L SC COM K NO SEG	DATA RANGE LOW	HIGH	UNIT	P R	RESPONSE RATE	UNIT	LOCATION	GSE
C T0007	X R AND Z CALIBRATION MONITOR	GSE			EVENT				SIG COND BOX	U
C T0202	T TM RF AMP A TEMP	B-13- 7	+32	+302	DEG F		1.25	S/S	TM RF AMP A	
C T0204	T TM RF AMP B TEMP	B-13- 8	+32	+302	DEG F		1.25	S/S	TM RF AMP B	
C T0207	T TM RF AMP C TEMP	B-13- 9	+32	+302	DEG F		1.25	S/S	TM RF AMP C	
C T0209	T TM RF AMP D TEMP	B-13-10	+32	+302	DEG F		1.25	S/S	TM RF AMP D	
C T0430	F TM COMPOSITE VIDEO A	GSE			RF					U
C T0431	F TM COMPOSITE VIDEO B	GSE			RF					U
C T0432	F TM COMPOSITE VIDEO C	GSE			RF					U
C T0433	F TM COMPOSITE VIDEO D	GSE			RF					U

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Table 3-5. Umbilical Functions, B-18

GSE S/M Umbilical	Function	Voltage Range (volts dc)	Wire Gage	Origin	Connector and Pin
1. Instrumentation bus OFF	Holding	28	20	PCB	*
2. External power bus A	Power		16		
3. External power bus A	Power				
4. External power bus A	Power				
5. External power bus A	Power				
6. External power bus B	Power				
7. External power bus B	Power				
8. External power bus B	Power				
10. External power ground	Power				
11. External power ground	Return				
12. External power ground	Return				
13. External power ground	Return				
14. External power ground	Return				
15. External power ground	Return				
16. External power ground	Return				
17. External power ground	Return		16		
18. Main bus A monitor and regulation (+)	Meter		20		
19. Main bus A monitor and regulation (-)	Meter				
20. Main bus B monitor and regulation (+)	Meter				
21. Main bus B monitor and regulation (-)	Meter			PCB	
22. Regulated power supply (5-v dc)	Monitor	28		SCB	
23. Main battery current total	Monitor	0 to 5		Signal conditioner	
24. Umbilical separation	Monitor	28		Umbilical	
25. Umbilical separation	Monitor	28		Umbilical	
26. ECS inlet temperature (+)	Monitor	0 to 5		ECS	
27. T/M A RF transmitter, OFF	Holding	28		JB2	
28. T/M A RF transmitter, OFF	Holding			JB2	
29. T/M B RF transmitter, OFF	Holding			JB2	
30. T/M C RF transmitter, OFF	Holding			JB2	
31. T/M calibration enable control	Holding			JB2	
32. T/M calibration auto-manual control	Holding			PCB	
33. C-band transponder, OFF 1	Holding			PCB	
34. C-band transponder, OFF 2	Holding			PCB	
35. Gyro erection, attitude	Momentary			JB2	
36. TM RF power amplifier, ON (latching relay)	Momentary	28	20	JB2	*

*Information to be presented at a later date.

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Table 3-5. Umbilical Functions, B-18 (Cont)

GSE S/M Umbilical	Function	Voltage Range (volts dc)	Wire Gage	Origin	Connector and Pin
71. Helium temperature B	Monitor	0 to 5	20	RCS	*
72. Helium temperature C	Monitor				
73. Helium temperature D	Monitor				
74. Oxidizer temperature A	Monitor				
75. Oxidizer temperature B	Monitor				
76. Oxidizer temperature C	Monitor				
77. Oxidizer temperature D	Monitor				
78. Helium pressure A	Monitor				
79. Helium pressure B	Monitor				
80. Helium pressure C	Monitor				
81. Helium pressure D	Monitor	0 to 5		RCS	
82. Logic bus A	Monitor	28		Sequencer	
83. Logic bus B	Monitor	28		Sequencer	
84. Pyro bus A	Monitor	28		Sequencer	
85. Pyro bus B	Monitor	28		Sequencer	
86. Logic battery A	Monitor	28		Sequencer	
87. Logic battery B	Monitor	28		Sequencer	
88. Pyro battery A	Monitor	28		Sequencer	
89. Pyro battery B	Monitor	28	20	Sequencer	*

*Information to be presented at a later date.

Table 3-5. Umbilical Functions, B-18 (Cont)

GSE S/M Umbilical	Function	Voltage Range (volts dc)	Wire Gage	Origin	Connector and Pin
37. T/M RF power amplifier, OFF (latching relay)	Momentary	28	20	PCB	*
38. T/M calibration control manual step	Momentary	28	20	JB2	
39. R calibrate	Momentary	28	20	Signal conditioner	
40. Z calibrate	Momentary	28	20	Signal conditioner	
41. Erection monitor, pitch, roll	Light	28	20	JB2	
42. Erection monitor, roll, yaw	Light	28	20	JB2	
43. ECS external control	Holding	28	16	ECS	
44. Signal common to GSE	Return	28	16	Signal conditioner	
45. Signal common to GSE	Return	28	16	Signal conditioner	
46. ECS and RCS instrumentation power	Power	28	16	ECS and RCS	
47. ECS and RCS instrumentation common	Return	28	16	ECS and RCS	
48. ECS pump output pressure	Monitor	5	20	ECS	
49. C/M interior temperature	Monitor	0 to 5	20	ECS	
50. Battery A, monitor and bleed	Monitor	28	20	PCB	
51. Battery B, monitor and bleed	Monitor	28	20	PCB	
52. Sequencer initiate A	Momentary	28	20	Sequencer	
53. Sequencer initiate A	Return	28	20	Sequencer	
54. Sequencer initiate B	Momentary	28	20	Sequencer	
55. Sequencer initiate B	Return	28	20	Sequencer	
56. Shield	As required				
57. Shield	As required				
58. Shield	As required				
59. Shield	As required				
60. T/M heater power (+)	Power	28	16	JB2	
61. T/M heater power (-)	Return	28	16	JB2	
62. T/M heater power (+)	Power	28	16	JB2	
63. T/M heater power (-)	Return	28	16	JB2	
64. GSE relay power (+)	Power	28	20	GSE	
65. GSE relay power (-)	Return	28	20	GSE	
66. T/M composite video A	Monitor	*	Coax	*	
67. T/M composite video B	Monitor	*	Coax	*	
68. T/M composite video C	Monitor	*	Coax	*	
69. T/M composite video D	Monitor	*	Coax	*	
70. Helium temperature A	Monitor	0 to 5	20	RCS	*

*Information to be presented at a later date.

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Table 3-6. B-18 Adapter Wiring

Adapter/S-I Interfaces	Function	Voltage Range (volts dc)	Wire Gage	Origin	Connector and Pin
CONNECTOR A15J1					
1. LET jettison command power B					A15J1-v
2. LET jettison command B					A15J1-a
3. Shield terminate					A15J1-b
4. LES logic bus A safe command					A15J1-e
5. LES logic bus B safe command					A15J1-d
6. LES logic switches indicate safe					A15J1-c
7. LES logic buses arm command					A15J1-z
8. LES logic switches indicate arm					A15J1-Y
9. LES logic bus A indicate ON					A15J1-X
10. LES logic bus B indicate ON					A15J1-V
11. All engines shutdown power A					A15J1-h
12. All engines shutdown power A					A15J1-g
13. Shield					A15J1-f
14. Confidence loop power IN					A15J1-FF
15. Confidence loop signal OUT					A15J1-EE
16. Spacecraft EDS bus 1					A15J1-i
17. EDS auto abort 1		—To be presented when available—			A15J1-n
18. L/V-EDS +8D91 power					A15J1-u
19. No. 1 cutoff L/V engines					A15J1-k
20. S-I two-engine out auto abort deactivate					A15J1-q
21. L/V rate excessive auto abort deactivate					A15J1-s
22. S-I or S-IV engine No. 1 OUT A					A15J1-NN
23. S-I or S-IV engine No. 2 OUT A					A15J1-MM
24. S-I or S-IV engine No. 3 OUT A					A15J1-LL
25. S-I or S-IV engine No. 4 OUT A					A15J1-KK
26. S-I or S-IV engine No. 5 OUT A					A15J1-JJ
27. S-I or S-IV engine No. 6 OUT A					A15J1-HH
28. S-I engine No. 7 OUT					A15J1-GG
29. S-I engine No. 8 OUT					A15J1-AA
30. Abort request A					A15J1-z
31. L/V rate excessive A					A15J1-y
32. IU power fail A					A15J1-x
33. L/V guidance fail A					A15J1-w

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Table 3-6. B-18 Adapter Wiring (Cont)

Adapter/S-I Interface	Function	Voltage Range (volts dc)	Wire Gage	Origin	Connector and Pin
CONNECTOR A15J2					
1. Q-ball electronic power (+)	Power	28	20	Instrument unit	A15J2-LL
2. Q-ball electronic power common (-)	Return	0		Instrument unit	A15J2-MM
3. Q-ball electronic power shield terminate	Shield	0		Q-ball	A15J2-NN
4. Q-ball heater power (+)	Power	115		S-I GSE	A15J2-JJ
5. Q-ball heater power (-)	Return	115		S-I GSE	A15J2-HH
6. Q-ball heater power shield terminate	Shield	0		Q-ball	A15J2-KK
7. Q-ball alpha-q yaw output (-)	Signal	0 to 30		Q-ball	A15J2-GG
8. Q-ball alpha-q yaw output (+)	Signal	0 to 30		Q-ball	A15J2-AA
9. Q-ball alpha-q pitch output (-)	Signal	0 to 30		Q-ball	A15J2-z
10. Q-ball alpha-q pitch output (+)	Signal	0 to 30		Q-ball	A15J2-y
11. Q-ball dynamic pressure T/M Ref (-)	Return	0 to 5		Instrument unit	A15J2-x
12. Q-ball dynamic pressure T/M Ref (+)	Signal	0 to 5		Q-ball	A15J2-w
13. Q-ball surface temperature T/M Ref (-)	Return	0		Instrument unit	A15J2-v
14. Q-ball surface temperature T/M Ref (+)	Signal	0 to 5		Q-ball	A15J2-h
15. Q-ball simulate command	Power	28		S-I GSE	A15J2-g
16. Q-ball alpha-q yaw T/M Ref (-)	Return	0		Instrument unit	A15J2-f
17. Q-ball alpha-q yaw T/M (+)	Signal	0 to 5		Q-ball	A15J2-e
18. Q-ball alpha-q pitch T/M Ref (-)	Return	0 to 5		Instrument unit	A15J2-d
19. Q-ball alpha-q pitch T/M (+)	Signal	0 to 5		Q-ball	A15J2-c
20. Q-ball signal shield terminate	Shield	0		Q-ball	A15J2-b
21. Spacecraft EDS bus No. 2					A15J2-i
22. EDS auto abort No. 2					A15J2-n
23. L/V - EDS +8D92 power					A15J2-u
24. No. 1 cutoff L/V engines					A15J2-k
25. S-I two engine out auto abort deactivate					A15J2-q
26. L/V rate excessive auto abort deactivate	—To be presented when available—				A15J2-r
27. Liftoff indicate power					A15J2-a
28. Liftoff indicate power					A15J2-Z
29. Instrument main bus B battery power off command					A15J2-B
30. Common					A15J2-A
31. Instrument main bus A battery power off command					A15J2-C
32. Confidence loop power IN					A15J2-EE
33. Confidence loop signal OUT					A15J2-DD

Table 3-6. B-18 Adapter Wiring (Cont)

Adapter/S-I Interface	Function	Voltage Range (volts dc)	Wire Gage	Origin	Connector and Pin
CONNECTOR A15J3					
1. LES pyro Bus A safe command					A15J3-e
2. LES pyro Bus B safe command					A15J3-d
3. LES pyro switches indicate safe					A15J3-c
4. LES pyro buses arm command					A15J3-z
5. LES pyro switches indicate arm					A15J3-Y
6. LES pyro bus indicate ON					A15J3-X
7. LES pyro Bus B indicate ON					A15J3-V
8. LES indicate power					A15J3-S
9. LES sequencer common					A15J3-N
10. LET jettison command power A					A15J3-v
11. LET jettison command A					A15J3-a
12. Shield terminate					A15J3-b
13. All engines shutdown power A					A15J3-h
14. All engines shutdown power A					A15J3-g
15. Shield					A15J3-f
16. Confidence loop power IN					A15J3-DD
17. Confidence loop signal OUT					A15J3-CC
18. Spacecraft EDS Bus No. 3		—To be presented when available—			A15J3-i
19. EDS auto abort No. 3					A15J3-n
20. L/V-EDS +8D93 power					A15J3-u
21. No. 2 cutoff					A15J3-k
22. S-I two engine out auto abort deactivate					A15J3-q
23. L/V rate excessive auto abort deactivate					A15J3-s
24. S-I or S-IV engine No. 1 OUT B					A15J3-NN
25. S-I or S-IV engine No. 2 OUT B					A15J3-MM
26. S-I or S-IV engine No. 3 OUT B					A15J3-LL
27. S-I or S-IV engine No. 4 OUT B					A15J3-KK
28. S-I or S-IV engine No. 5 OUT B					A15J3-JJ
29. S-I or S-IV engine No. 6 OUT B					A15J3-HH
30. S-I engine No. 7 OUT B					A15J3-GG
31. S-I engine No. 8 OUT B					A15J3-AA
32. Abort request B					A15J3-z
33. L/V rate excessive B					A15J3-y
34. IU power fail B					A15J3-x
35. L/V guidance fail B					A14J3-w

power output of 2.5 kw and receiving at 5690 mc. The system can accommodate up to three identical serial interrogation pulses.

3.3.7.2.3 Telemetry Antenna. The telemetry antenna system consists of a multiplexer, filter, and VHF omni antenna. The antenna on Boilerplate 18 is located under a radome on the nose or forward compartment apex of the C/M.

3.3.7.2.4 C-Band Antennas. The C-band antenna system will consist of four flush-mounted, circularly-polarized antennas and two power dividers. Each C-band transponder will utilize one power divider and two antennas. The antennas will be located 90 degrees apart around the lower portion of the command module ($X_C = 77$). The C-band antennas will be used to receive interrogation pulses and to transmit the radar beacon reply.

3.3.8 Tracking and Support Data Requirements

3.3.8.1 General

Detailed tracking and support data requirements are included in the AMR Program Requirements documents. These requirements include parameters, coverage intervals, accuracies, and data disposition. This section will briefly outline the types of coverage to be provided by AMR.

3.3.8.2 Metric Trajectory Data

Metric trajectory data on the spacecraft are required from launch through orbital injection. The three types of data acquisition systems utilized are fixed optical, tracking cinetheodolite optical, and electronic tracking. During the initial phase of boost, the primary data source will be the optical tracking systems with the radar beacon tracking system as the primary source thereafter. The tracking systems are required to provide C/M position velocity, acceleration and attitude and other data as specified in the AMR Program Requirements document. AMR support will consist of continuous tracking during the boost phase and through orbit insertion (approximately 15 minutes total). If the radar transponders remain operative after orbit insertion, the AMR will also be requested to track the spacecraft during the next pass over the AMR. Tracking assignments and times are shown in Figure 3-24.

3.3.8.3 Photographic Data

3.3.8.3.1 Documentary Photographic Coverage. A complete photographic documentary record of all key events associated with the test is required. The following activities will be covered:

[redacted]

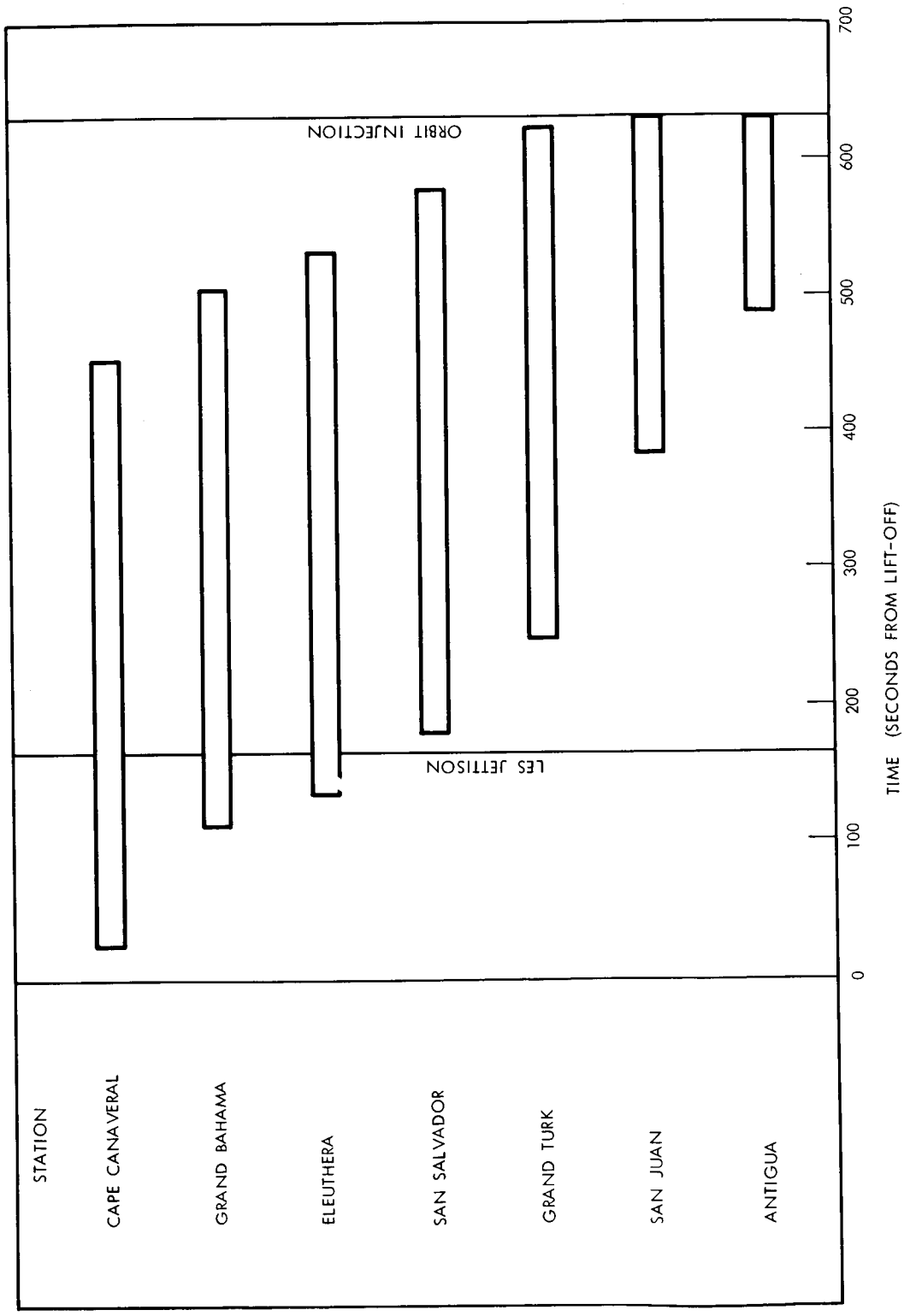

Figure 24. Tracking Intervals in Seconds From Lift-Off for Boilerplate 18

[redacted]

Transportation
Preflight preparations and checkout
Flight operations
Postflight activity and events

3.3.8.3.2 Engineering Sequential Photographic Coverage. Visible events data coverage from before launch through the midcourse boost phase of the flight is required. This events coverage will be provided by engineering sequential optical systems and will include the following:

1. Fixed motion picture coverage

   a. Prelaunch phase - a continuous emergency surveillance from T - 2 hours to T + 5 seconds at two frames per second

   b. Launch phase - lift-off coverage at 200 frames per second for structural surveillance of Apollo spacecraft interface areas

2. Tracking motion picture coverage

   Launch phase - S-I staging, S-IV ignition, and escape tower separation coverage with 500-inch lenses at 20 frames per second

3.3.8.4 Timing

The following time codes indicating time of day referenced to Greenwich Mean Time are required when recording data:

1. AMR B-2 Time Code - 1-pps, 17-digit binary width amplitude modulated (10 cps)

2. AMR D-5 Time Code - 100-pps, 17-digit binary width code amplitude modulated (1000 cps)

All magnetic tape recordings should contain the time codes specified in items 1 and 2. All other data recordings, such as strip charts and oscillograms, should contain the time code specified in item 1.

A common time reference will be used for correlation of data from all data acquisition systems. All time distribution equipment will be furnished by the AMR at all test sites.

3.3.8.5 Meteorological Data

A forecast of T - 0 conditions required at T - 1 hours shall include surface and upper air observations at 500-foot intervals from sea level to

[redacted]

250,000 feet. These observations, obtained from Rawinsonde and Rocketsonde, will include altitude, temperature, wind direction and velocity, and relative humidity data.

3.3.8.6 Telemetry Data

It is required that all four telemetry data links be received by the AMR from just prior to liftoff and continuously through orbit injection. At present, there are no requirements for additional telemetry reception thereafter.

3.3.8.7 Data Disposition

The disposition of data shall be as follows:

1. Trajectory data in tab form and in the BMD format on magnetic tape are required within three working days.

2. Engineering sequential film copies and event times are required within 24 hours.

3. Final meteorological data of launch conditions are required within 24 hours.

4. Trajectory data in tabulated form for a quick look are required within two calendar days.

3.3.9 Prelaunch Operations

3.3.9.1 Test Preparation - NAA, Downey

The initial spacecraft test sequence will be accomplished in the spacecraft test preparation area at the NAA, Downey Facility, prior to shipping the boilerplate to AMR. The sequence of test operations consists of five phases and is presented in block diagram form in Figure 3-25.

3.3.9.1.1 Phase One - Spacecraft and GSE Preparation. The spacecraft which is composed of the launch escape tower, C/M, S/M, and spacecraft adapter will be received by test preparation from manufacturing. A receiving inspection will be conducted on the boilerplate and associated GSE during the Manufacturing close out. The vehicle system and subsystems will be examined to ensure compliance with the latest configuration requirements and any necessary updating of the boilerplate and GSE will be accomplished. Instrumentation packages will be installed which have not previously been installed by Manufacturing. During this phase the GSE will

[redacted]

[redacted]

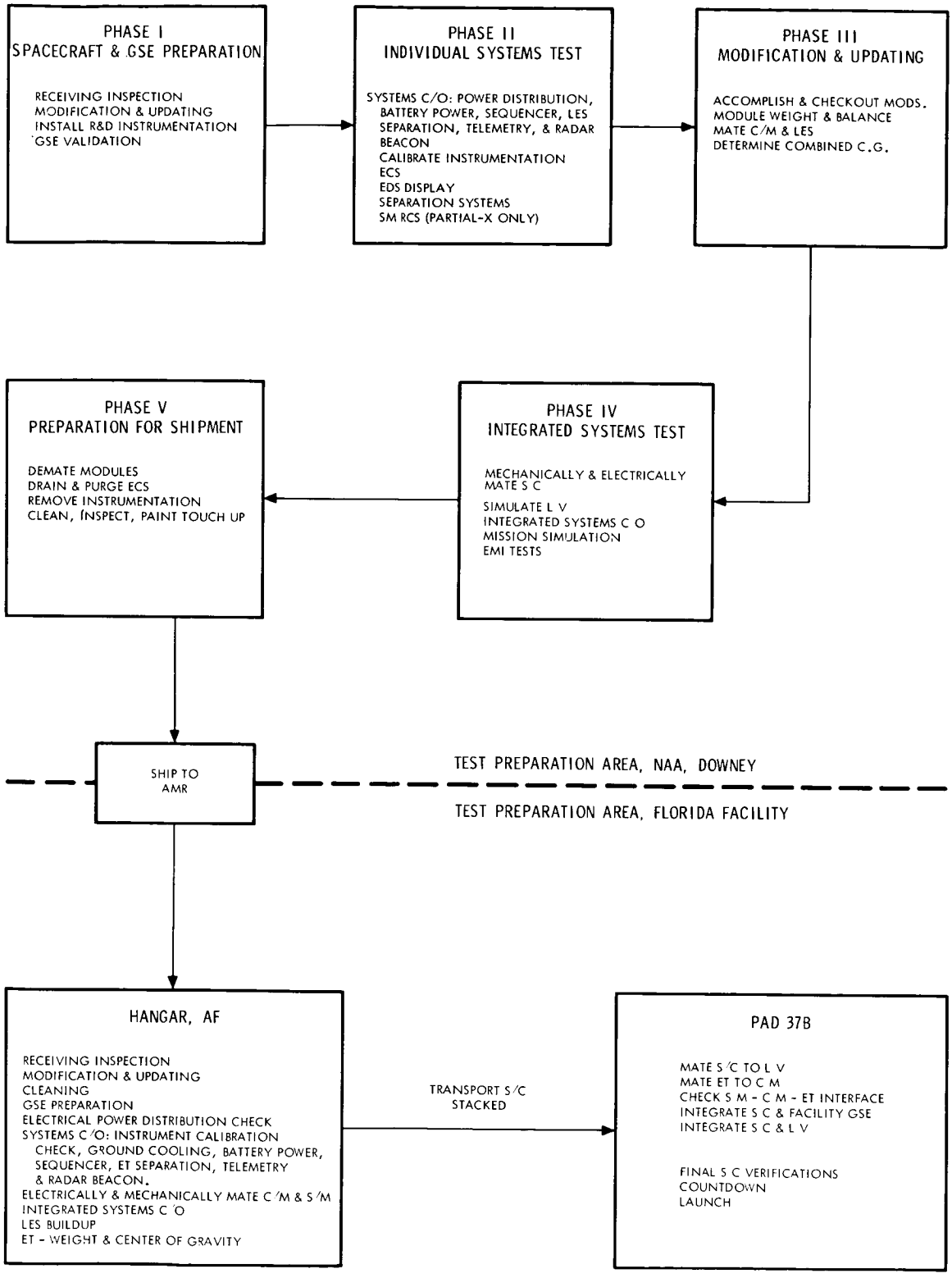

Figure 3-25. Boilerplate 18 Test Preparation Flow Diagram

[redacted]

[redacted]

be installed, facility interface checked, and GSE validation of all individual checkout consoles accomplished. After individual validation, the GSE will be integrated and verified for proper operation as a system. The GSE will then be connected to the vehicle systems through umbilicals, and interconnecting electrical cables will be continuity checked and connected to their respective modules. Modules will be physically unmated in the test preparation area. During this period the LES sequencer will be bench checked with the LES BME, verified for proper operation, and installed in the boilerplate spacecraft.

3.3.9.1.2 Phase Two - Individual Systems Check. The second phase of the test preparation will be individual systems tests to verify operational capability systems to be checked and will include the following:

1. Electrical Power System. A wiring test on the electrical power distribution will be performed to verify continuity of the system and will be followed by an electrical system test to verify operation of the system from ground and internal battery power, power switching, and activation of spacecraft subsystems.

2. Telemetry Instrumentation System. Measurements will be made of the VCO's frequency and the transmitter frequency power input and deviations. Proper adjustments will be made to correct any deviations from present valves. Calibration verifications will be made on all measurements. Any special Government-furnished (GFE) instruments will be functionally tested with the checkout GSE, either on the bench or while installed in the spacecraft.

3. Radar Beacon and Antenna System. A check on the voltage standing wave ratio (VSWR) and attenuation at all operating frequencies will be conducted. The average power of the beacon will be measured and the peak power computed. The frequency of the transmitter, the sensitivity of the receiver, and the transmitter delay will be measured. The receiver will be tested for proper operation when interrogated with the proper code pulses.

4. Separation Systems. Mechanical and electrical tests on the separation system and electrical tests on the mission sequencer will be conducted to verify proper signaling of all sequences, including separation and rocket motor ignition.

5. Environmental Control System. The system will be gas-leak checked at operational pressure. Thermo switches, valves, pump, and fan will be functionally checked. The system will be serviced with a water-glycol solution; then a complete system operational checkout will be made.

[redacted]

6. Emergency Detection System Display. A functional verification of the parameter display portion of the emergency detection system will be performed. Simulators for the launch escape system and explosive devices will be used to provide circuit loading and to give proper responses. Both the proper phasing and timing of functions and redundant functions will be tested. During the test, the explosive device circuits will be monitored to determine that no interaction exists which might cause premature operation.

7. Service Module Reaction Control System. The S/M reaction control engines will be aligned, and a leak and functional check will be made on the propellant feed system. The timing and synchronization of the valves and the propellant gaging will be determined.

All of the above system tests will be performed in accordance to detailed operational test procedures designed to penetrate to the component level. During each test, data will be recorded via hardline and airlink to substantiate the test results.

3.3.9.1.3 Phase Three - Modification and Updating. Modifications and updating of the flight hardware and GSE will be accomplished and checked out. Weight and balance checks will be conducted on the individual modules of the spacecraft. The C/M and LES will be mated, weighed, and center of gravity determined.

3.3.9.1.4 Phase Four - Integrated Systems Test. The B/P spacecraft modules will be vertically mated, mechanically and electrically, to flight configuration and their alignment requirements will be verified. GSE handling equipment will be used and evaluated during this operation. An integrated systems test will be conducted in this configuration. This test will consist of all systems being activated individually to verify their compatibility with each other while operating. The conclusion of this test will consist of a flight simulation which will include a sequence of operations duplicating the entire flight mission. In addition, electromagnetic interference tests will be conducted to determine effects during systems operations. The monitoring and control of the vehicle will be via the telemetry link and transmittal control consoles respectively.

3.3.9.1.5 Phase Five - Preparation for Shipment. This is the final preparation prior to shipment to AMR. The B/P spacecraft modules will be demated and individual modules and associated GSE will be prepared for shipment to the field. This phase will include cleaning, painting as required, purging of the ECS, and final close-out in compliance with transportation requirements. It is to be noted that the techniques and procedures used in

[redacted]

the test preparation area will approximate field site techniques and procedures, consistent with the limitations of the Downey facilities.

3.3.9.2 Test Preparation at AMR, Hangar AF

Upon arrival at AMR, the test vehicle components and GSE will be positioned in checkout stations, and all access covers and doors will be removed. A receiving inspection will be performed to determine the extent, if any, of shipping damage. All components will be visually inspected, and part numbers and serial numbers will be compared with the workbook configuration. A review of all existing design paperwork, by NAA-AMR personnel in conjunction with Downey personnel, will determine any updating required. Any work necessary to clear workbook discrepancies will be accomplished. Any changes in the instrumentation will be followed by a complete calibration of affected instruments. A one-point calibration check will be made on all other instruments. The GSE will be revalidated as required. The GSE will then be connected to the systems and detailed functional checks performed on each individual system. The temperature control system will be gas-leak checked at operational pressure. A pump rotational check will be made. Thermoswitches, valves, pump, and fan will be functionally checked. The system will be filled and bled with a 40-percent water, 60-percent glycol solution. The complete system and fan will then be operationally checked out. The LES sequencer will be checked with power off and then functionally checked with power on. The LES will be completely built up, with the exception of pyro-initiators. Telemetry and radar beacon checks will include: frequencies, power output levels, calibration, and tuning. Power system checks will include monitoring the load current under simulated operating conditions for a specified length of time to verify the capabilities of the batteries. Ground cooling will be required for all of the above checks to maintain an acceptable equipment temperature. All checks will utilize detailed checkout procedures designed to penetrate to the component level. Integrated system checks will include simulated countdown and flight. A weight and center of gravity check on the boilerplate C/M will be made only if configuration changes warrant it. The module will then be transported to Pad 37B.

3.3.9.3 Combined Systems Check, Launch Pad 37B

3.3.9.3.1 Preparations. The boilerplate components will be mated. A hydra-set will be used for all mating operations. The spacecraft will be mated with the launch vehicle and the alignment verified. The escape tower will be installed on the spacecraft. All GSE will be connected, and the launch facilities will be validated. The launch-complex checkout will follow including: control center, launch vehicle, and spacecraft. A ground cooling cart will be used to maintain acceptable equipment temperatures.

[redacted]

[redacted]

3.3.9.3.2 Prelaunch. Ground tests of the telemeter and the radar beacon will include frequencies, power output levels, calibration, and tuning. Prelaunch checkout of the electrical power system will consist of final circuit verification of the electrical distribution system and monitoring of the instrumentation battery system voltage and current. Operation with internal power is limited to an as yet undetermined number of minutes. LES prelaunch checkout requires the installation of hot bridge wire simulators that are connected to an event recorder. Checkout will consist of exercising the logic and pyro-bus-arm-safe relays, initiating the sequencer (either locally or from the blockhouse), recording the sequenced events, and monitoring the logic and pyro-batteries during sequencer operation. The hot bridge wire simulators will verify adequate firing energy and monitor for inadvertent transients. A telemetry recording of the above sequences will be made to verify proper LES instrumentation operation.

3.3.9.4 Operational Test Procedure (OTP)

Operational Test Procedures are prepared for the detailed checkout of each individual system. The operational test procedures for Boilerplate 18 applicable to test preparation, NAA, Downey and AMR will be presented when available.

3.3.9.5 Launch Day Activities

By the start of countdown, Boilerplate 18 will have been mated and installed upon the launch vehicle. The on-board systems will have been checked and tested to assure that the systems are in operative condition. The LES system will have been installed with pyrotechnics shorted. Batteries will have been installed, checked, and unloaded.

3.3.9.5.1 Countdown Activities. The official countdown is the responsibility of MSC/MSFC and LOC and will be coordinated and written at AMR. Countdown activities will be presented when available.

3.3.10 Test Management and Organization

3.3.10.1 Downey Test Preparation Organization

The Downey Test Preparation Organization is depicted in Figure 3-26.

Major responsibilities of the B-18 Test Preparation Team are as follows:

1. Boilerplate 18 Test Project Engineering

   a. To plan, schedule and conduct all tests performed on Boilerplate 18 after manufacturing completion and prior to shipment to AMR

[redacted]

[redacted]

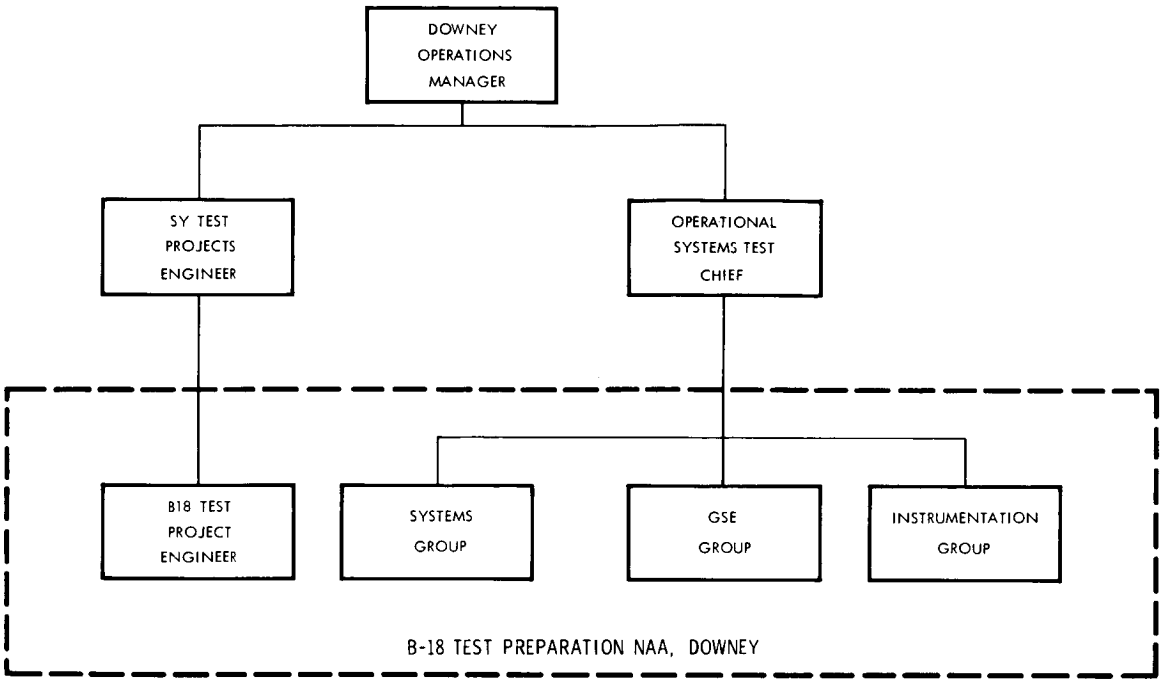

Figure 3-26. Test Preparation, Downey

b. Review and approve operational test procedures

c. Review and approve test preparation work schedules

2. Systems Group

a. Initiate and implement individual systems detailed checkout procedures and evaluate test results

b. Conduct individual and integrated systems checkout and operating procedures

3. GSE Group

a. Prepare and conduct GSE Operational Test Procedures

b. Direct GSE maintenance and review GSE support manuals

c. Coordinate GSE requirements and GSE instrumentation calibration.

[redacted]

[redacted]

4. Instrumentation Group

   a. Establish special instrumentation installation, calibration, and checkout procedures

   b. Coordinate the Measurement List and OTP engineering data requirements

   c. Direct instrumentation test activities

3.3.10.2 AMR Checkout and Launch Operations

The Florida Facility test organization is shown in Figure 3-27.

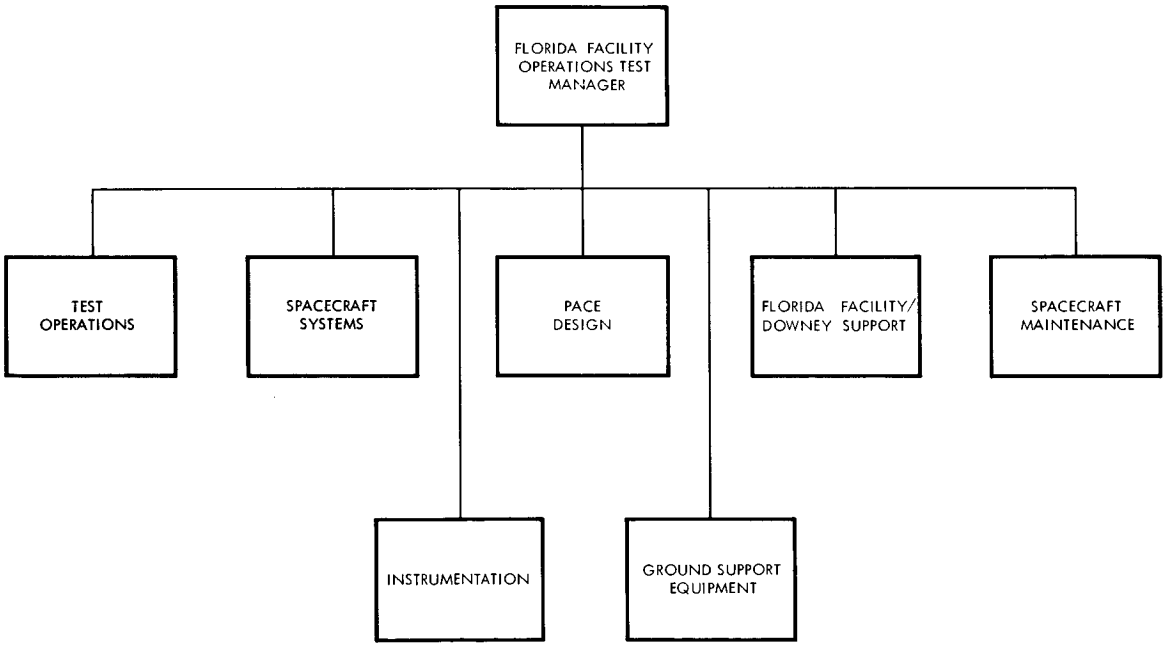

Figure 3-27. Test Preparation, Florida

The AMR Florida Facility checkout and launch group responsibilities are as follows:

1. Florida Facility Apollo Operations Manager

   a. Provide over-all direction of Apollo operation at AMR

[redacted]

[redacted]

b. Be responsible to Downey Test and Operations Director, Florida Facility General Manager, and NASA for interpreting and implementing the policies and directions of Apollo test program at AMR

c. Be responsible for establishing effective working relations with NASA-POD and associate contractors

2. Test Operations Group

a. Coordinate and schedule all S&ID activities at AMR

b. Provide over-all planning to ensure completion of tests in accordance with test schedules

c. Coordinate with NASA, Downey, and associate contractors at AMR

d. Prepare all schedules and review test plans and procedures

e. Direct and control all systems checkout and launch operations

3. Systems Group

a. Ensure readiness of spacecraft system for all checkout and flight operations

b. Operate system monitor and control equipment during checkout operations under the direction of Test Operation Group

c. Be responsible for the acceptance and preparation of the test vehicle and for checkout of all systems prior to launch operations

d. Prepare individual system checkout procedures for test operation approval

e. Acquire and process the data in accordance with the test plan and perform preliminary data analysis as required to support test operations

4. Instrumentation Group

a. Direct all instrumentation calibrations, checkouts, and test activities

[redacted]

b. Coordinate the instrumentation measurements and OTP Engineering data requirements

c. Coordinate quick-look and calibration data with data groups

5. Ground Support Equipment Group

a. Develop checkout and maintenance procedures for all GSE

b. Ensure readiness of GSE to support spacecraft system checkout and launch operations and evaluate GSE adequacy and performance during ground operations.

c. Ensure facility-GSE compatibility and readiness to support all spacecraft operations

d. Provide design and drafting support for test operations

6. Florida Facility/Downey Support Group

a. Provide technical support of all tasks associated with the Florida Facility field operations

b. Prepare and publish detail test plans for each test vehicle

c. Assist in the preparation of Florida Facility support requirements and publish program requirements documents.

7. Spacecraft Maintenance

a. Provide technicians for test operations

b. Provide administration and supervision of all technicians

3.3.11 Recovery Requirements

3.3.11.1 General

There are no recovery requirements for Boilerplate 18.

3.3.12 Launch Day Requirements

3.2.12.1 Weather Requirements for Launch

The following minimum weather requirements for launch will be monitored from L-3 days until launch:

[redacted]

[redacted]

1. Ambient temperature must be between +20 and +140 F.

2. No ground level icing is allowable.

3. Launch must take place from sunrise to one hour before sunset.

4. The cloud cover must permit optical tracking to 300,000 feet.

5. Winds at a 100-foot elevation may not exceed 22.5 knots steady state.

6. Winds at a 200-foot elevation may not exceed 25.9 knots steady state.

A gust factor of 1.4 is allowable for wind readings.

3.3.13 Pad and Range Safety Requirements

3.3.13.1 Pad Safety

Pad safety is under the direction of the pad safety supervisor. All provisions of the General Range Safety Plan, Volume I AFMTC Pamphlet No. 80-2, are applicable unless specifically excepted, modified, or supplemented.

3.3.13.2 Range Safety

Range safety is the responsibility of the range safety officer. All critical or potentially hazardous operations must be cleared with him prior to accomplishment. Range safety requirement shall be in accordance with the General Range Safety Plan, Volume II, AFMTC Phamphlet No. 80-2. This document supplements the general safety policies and procedures prescribed in AFMTC regulation 80-9.

3.3.14 Data Handling, Analysis, and Reporting

3.3.14.1 Data Handling and Processing

Data Engineering will support Downey preparation testing, field prelaunch testing, and launch flight operations of Boilerplate 18 by rapid data processing and presentation for analysis and evaluation of system performance. They will maintain instrumentation calibration curves, monitor real-time data displays, assist in determining areas of data playback, and submit the test data in report forms for analysis. During the launch operation, spacecraft-generated data will be transmitted via RF Link to AMR acquisition sites and recorded on magnetic tapes. Selected data will

be displayed at the sites in real time on oscillograms or strip charts for monitoring purposes. Subsequent to the flight, other data will be processed at the field data processing station for additional preliminary analysis. A copy of each magnetic tape, containing the data acquired during the flight operation, will be transmitted to Apollo Data Engineering within 24 hours after the flight. These tapes will then be processed and the data presented in the appropriate forms for detailed analysis and reporting. The data to be provided by the AMR and the time periods required will be specified in the B-18 Operations Requirements document. The AMR-acquired tracking data (radar and optical) will be reduced at the range processing center and submitted to Apollo Data Engineering as follows:

3.3.14.1.1 Preliminary Data. Preliminary data in the launch-pad-centered rectangular coordinate system are required within 48 hours after the flight. If the above data requirements cannot be fulfilled, radar data containing time, azimuth, elevation, and slant range from each tracking station will be required within the same time period. Also required will be the coordinates of each radar and the calibration correction. All data are required on magnetic tapes and in tabular form.

3.3.14.1.2 Final Data. The tracking data will be processed into the required outputs as specified in the PRD. These data will be required on magnetic tape in BCD format compatible with IBM 700-series computers and in tabular form. The data are required within three working days following the mission. Copies of all engineering sequential film and their tabulated event times are required within 24 to 48 hours after launch. The meteorological data will be required in tabular form and on IBM cards within 24 hours after launch.

3.3.14.2 Calibration Data

System calibration checks on each parameter will be conducted in the Downey test preparation area. The results obtained from the calibrations will be run through an IBM 7090 computer to determine the best curve fit of the values. These data will be plotted and transported with the vehicle to the field test site. The field test site personnel will perform calibration checks on each measurement and compare the results with the Downey calibrations. Transducer measurements found outside acceptable limits will be rechecked and replaced as required to bring these measurements within acceptable tolerances. When a transducer or the signal conditioning is changed, a new calibration will be made. After plotting to verify the calibration, the information will be forwarded to Downey.

[redacted]

3.3.14.3 Data Analysis and Test Evaluation

The detailed analysis of all test data for systems and over-all test evaluation will be accomplished jointly by Test Integration, the various engineering design groups, Test and Operations, and Data Engineering. In the field, personnel will view the quick-look evaluation flight data to determine preliminary operating performance of the spacecraft and to verify that the test objectives were fulfilled. Questionable areas will be verified with additional playbacks made at the field data processing station. This preliminary information will be distributed in the field reports. At Downey the telemetry tapes will be processed and the data presented in preliminary format on oscillograph records. The records will be annotated and validated, and a chronology of major events will be determined and checked for proper sequence. A preliminary evaluation of the flight performance will be conducted during a data review with Apollo Test and Operations, Test Integration, and the design groups. Specific areas of interest arising from this review will be further investigated. After the preliminary data review has been completed, the telemetry data will be processed into a final format (digitized) and presented in report form. Specific areas of interest arising from the preliminary review will be noted in greater detail. The final data will be qualified for consistency with the preliminary data and inspected for accuracy. Preliminary tracking data may be further processed through computers at Downey into the required outputs. This data will be reviewed for consistency and completeness and released to the appropriate groups. All final tracking data will be forwarded to Downey, edited, further processed if necessary, and presented in report form. The processed telemetry and tracking data will then be compiled into data reports and released to Test Integration, the various engineering design groups, and Test and Operations for a detailed system analysis and over-all flight performance evaluation and for inclusion in the NAA final test report.

3.3.14.4 NAA Test Reporting

3.3.14.4.1 T + 5 Day Data Submittal Report. This report will contain all processed telemeter data presented in analog form of function value versus time and will be required for submittal five days after receipt of the tapes in Downey. No analysis will be required in this report.

3.3.14.4.2 T + 30 Day Spacecraft Flight Report. This report will contain the detailed systems analysis, and be due 30 calendar days after receipt of the tapes in Downey.

[redacted]

[redacted]

3.3.15 Ground Support Equipment

3.3.15.1 General

Items of GSE are either shop-released for BP-18, in which case they are normally assigned to the spacecraft at Downey and remain with the vehicle through launch operations, or are time shared, as designated, with other vehicles. After launch, GSE utilized at the Florida Facility will be recycled to Downey for updating and reassignment if major modification is required. Otherwise, the equipment will remain at Florida for time sharing with subsequent vehicles. GSE current planning and requirements are presented in SID 62-564.

Four general groups of GSE will be utilized in the various areas of checkout and testing:

1. Checkout equipment (systems control and monitoring devices, interconnecting cables, and power distribution systems)

2. Handling equipment (sling, dollies, supports, etc.)

3. Auxiliary equipment (protective covers, dummy motors, simulators, etc.)

4. Servicing equipment (battery chargers, fluid transfer and booster units, etc.)

3.3.15.2 Ground Support Equipment List

The ground support equipment assigned to Boilerplate 18 will be presented when available.

3.4 AIRFRAME 009 DETAILED TEST PLAN

3.4.1 Introduction

3.4.1.1 Purpose

This section is included in the General Test Plan to describe in detail the over-all plan for accomplishing those tests required to ensure test vehicle readiness for flight operations.

[redacted]

[redacted]

3.4.1.2 Scope

The specific purposes of the detailed test plan are to:

1. Designate the test objectives; describe the vehicle configuration, instrumentation, and mission; and list the data required for accomplishment of the test objectives

2. Designate preliminary checkout and test procedures of the vehicle

3. Provide information required by the AMR for flight test support planning

The detailed range facilities requirements, logistics support requirements, and range contractor requirements are beyond the scope of this report and will be contained in the NASA program requirements document.

3.4.1.3 Precedence of Reports

The NASA flight mission directive, when published, shall take precedence over this detailed test plan.

3.4.1.4 Amendments

The detailed test plan will be revised and updated, as additional information is made available, in each quarterly revision of the General Test Plan.

3.4.1.5 Definition of Priorities

The objectives for this test are either first order or second order. These categories are defined in the following paragraphs.

3.4.1.5.1 First-Order Test Objectives (Mandatory). These test objectives must be achieved for the mission to be successful and define the main purpose for conducting the test. Malfunction of spacecraft systems, ground support equipment, or instrumentation, which jeopardizes the attainment of first-order objectives, will require a countdown hold or launch scrub until such time as a fix can be made.

3.4.1.5.2 Second-Order Test Objectives. Second-order test objectives are those desired to support future Apollo flights or to supply supplementary data for over-all spacecraft evaluation. Malfunction of spacecraft systems, ground support equipment, or instrumentation, which jeopardizes the attainment of second-order objectives, will not require a hold after start of

countdown. Correction thereafter may be made at the discretion of the NASA Test Director or the Project Engineer.

3.4.1.6 Systems Priorities

The spacecraft systems are assigned either primary or secondary priorities. During the initial test program, when incomplete systems are tested, this definition will apply at the subsystem and component level.

3.4.1.6.1 Primary Systems. Primary Systems are those systems functionally required for the spacecraft to successfully complete its planned mission or to accomplish first-order test objectives. A hold or scrub will be mandatory if any of the Primary Systems indicate improper operation. A positive indication of satisfactory operation must be available for launch.

3.4.1.6.2 Secondary Systems. Secondary Systems are those systems not functionally required for the spacecraft to complete its planned mission. Malfunction of secondary systems will not require a mandatory hold or scrub. Corrections thereafter may be made at the discretion of the NASA Test Director or the Project Engineer.

3.4.2 Test Objectives and System Priorities

3.4.2.1 Test Objectives

3.4.2.1.1 First-Order Test Objectives. The first-order test objectives are:

1. Demonstrate the physical compatibility of the launch vehicle and production spacecraft including EDS operation in the launch and flight environments

2. Evaluate the structural integrity of the spacecraft in suborbital flight environments, including boost, zero g, entry, water impact, and recovery

3. Determine operational characteristics of the production spacecraft systems under unmanned suborbital flight conditions

4. Evaluate the operation of the S/M SPS and RCS under zero g conditions, including the SPS restart capability

5. Determine the C/M trajectory and aerodynamic stability characteristics during a lifting entry

[redacted]

6. Evaluate the thermal protection system at conditions approaching orbital entry

7. Demonstrate satisfactory separation of the spacecraft from the launch vehicle and the S/M from the C/M

8. Evaluate performance of the spacecraft instrumentation and communications system and compatibility with the launch vehicle systems

9. Demonstrate satisfactory performance of the complete Apollo recovery operation

3.4.2.1.2 Second-Order Test Objectives. The second-order test objectives are:

1. Evaluate the launch countdown operation

2. Evaluate the operation of the attitude control programer sequencer and up-command system.

3.4.2.2 Systems Priorities

1. Launch escape system

a. Launch escape motor	Secondary
b. Tower jettison motor	Primary
c. Pitch control motor	Secondary
d. Tower separation system	Primary

2. Electrical power system

a. Battery power system	Primary
b. Fuel cell	Primary
c. Mission sequencer	Primary

[redacted]

3. Communications and instrumentation system.	
a. Telemetry and antenna system	Primary
b. Radar beacon	Primary
c. Instrumentation	(See Measurement List)
d. Command control system	Primary
4. Environmental control system	Secondary
5. Spacecraft separation systems	
a. S-IV to S/M adapter separation system	Primary
b. S/M to S/M adapter separation system	Primary
c. C/M to S/M separation system	Primary
6. Reaction control systems	
a. Service module RCS system	Primary
b. Command module RCS system	Primary
7. Emergency detection system	Primary
8. Service propulsion system	Primary
9. Stabilization and control system	Primary
10. Earth landing system	Primary

3.4.3 Mission Description

3.4.3.1 Flight Plan

The Saturn I launch vehicle (SA-111) will boost the Apollo spacecraft from a launch azimuth of 100 degrees into a suborbital trajectory terminating near Ascension Island. The trajectory selected will be designed to insert a payload into a 100-nautical-mile earth orbit; however, following normal S-IV ignition and jettison of the launch escape tower, the S-IV will be prematurely shutdown at a velocity of 24,659 fps in order to ensure suborbital flight. The spacecraft/S-IV separation sequence will be initiated

[redacted]

at S-IV shutdown by firing the service module +X RCS, followed two seconds later by adapter jettison. The service module +X RCS will continue thrusting for a period of six seconds to ensure a safe spacecraft/S-IV separation distance.

Following S-IV separation the service module RCS will be used to rotate the spacecraft in pitch approximately 113 degrees (nose upward) and will maintain the spacecraft in this attitude through two firings of the SPS. Prior to the first SPS firing, the S/M -X RCS will be thrusted for 20 seconds to unsettle SPS fuel. After a 41-second coast period, a ullage maneuver will be performed to resettle SPS fuel by thrusting the +X service module RCS. The SPS will be fired for 25 seconds, shut down for 50 seconds, and then refired for 10 seconds. A ullage maneuver will be performed prior to the second SPS firing with the service module +X RCS.

Following the second SPS shutdown, the spacecraft will be oriented for S/M separation by pitching -76 degrees (nose downward) and a separation initiated. The -X S/M RCS will be fired to ensure separation of S/M from C/M. The command module RCS will damp out separation transients, and rotate the C/M approximately 52 degrees in pitch and 180 degrees in roll to achieve the desired attitude for a lifting entry. The roll attitude will remain fixed until drogue chute deployment at 25,000 feet. The main chutes will deploy at 15,000 feet, and the flight will terminate upon impact of the command module in the Atlantic Ocean near Ascension Island. RCS propellant will be jettisoned after main chute deployment.

3.4.3.2 Sequence of Events

The sequence of events will be as follows:

Event	Time (sec)
S-I ignition	-3.4
Lift-off	0
S-I inboard engines shutdown	146
S-I outboard engines shutdown	152
S-IV ignition	155
LES jettison	165
S-IV shutdown	615
Fire +X S/M RCS	615
S-IV - spacecraft separation	617
Shutdown S/M RCS	621
Initiate pitch maneuver	621
Complete pitch maneuver	658
Initiate de-ullage (-X S/M RCS)	658
Complete de-ullage	678
Initiate ullage (+X S/M RCS)	719

[redacted]

Event	Time (sec)
Complete ullage	739
Fire S/M SPS	739
Shutdown S/M SPS	764
Initiate ullage (+X S/M RCS)	794
Complete ullage	814
Fire S/M SPS	814
Shutdown S/M SPS	824
Initiate separation orientation	828
Initiate C/M - S/M separation	850
Initiate entry orientation	859
Entry	1148
Drogue chute deployment	1905
Main chute deployment	1935
Impact	2420

3.4.3.3 Flight Parameters

Pertinent flight parameters are presented in Figures 3-28 through 3-31.

3.4.3.4 Flight Trajectories

Trajectory profiles are presented in Figures 3-32 and 3-33 for the two S/M SPS thrust durations. Figure 3-34 presents an earth trace of the ballistic trajectory.

3.4.3.5 Flight Constraints

Flight constraints define the minimum mandatory tests that must be completed on each major vehicle system prior to launch. Failure to satisfactorily complete these tests will cause a flight hold. The status of these constraints will be determined on a monthly basis. A final flight constraint review will normally be conducted during the test vehicle acceptance data package review, at AMR after spacecraft-launch vehicle mating operations. The flight constraints for Airframe 009 are as follows:

1. Satisfactory completion of first-order mission objectives in flight of B-18
2. Completion of AFRM 004 limit pressurization tests, limit load tests, and boost environment stack tests (S/M - C/M)
3. Completion of AFRM 006 acoustic tests C/M with all systems and heat shield)

[redacted]

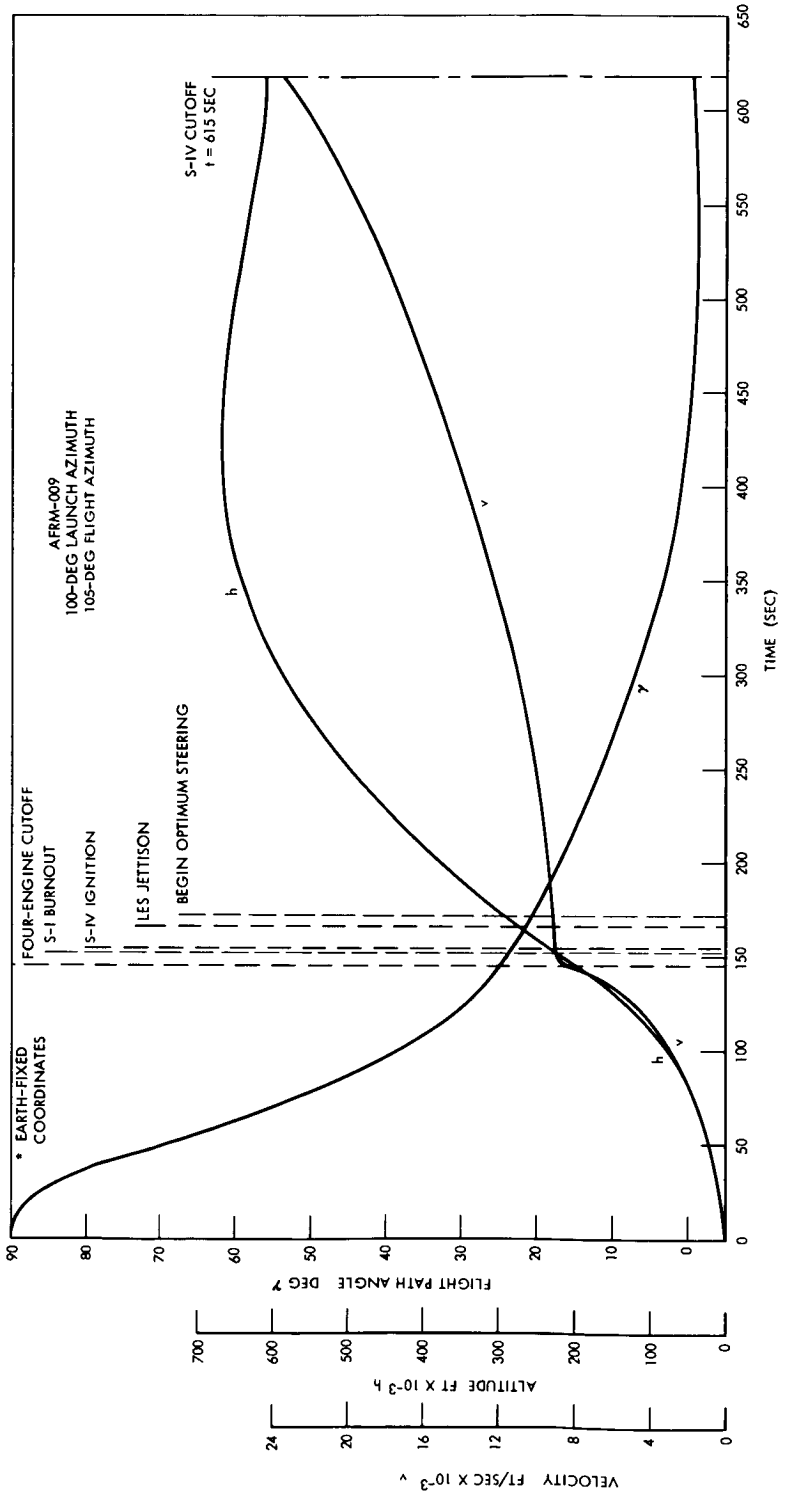

Figure 3-28. Airframe 009 Boost Phase Velocity, Altitude, and Flight Path Angle Versus Time (Earth-Fixed Coordinates)

[redacted]

[redacted]

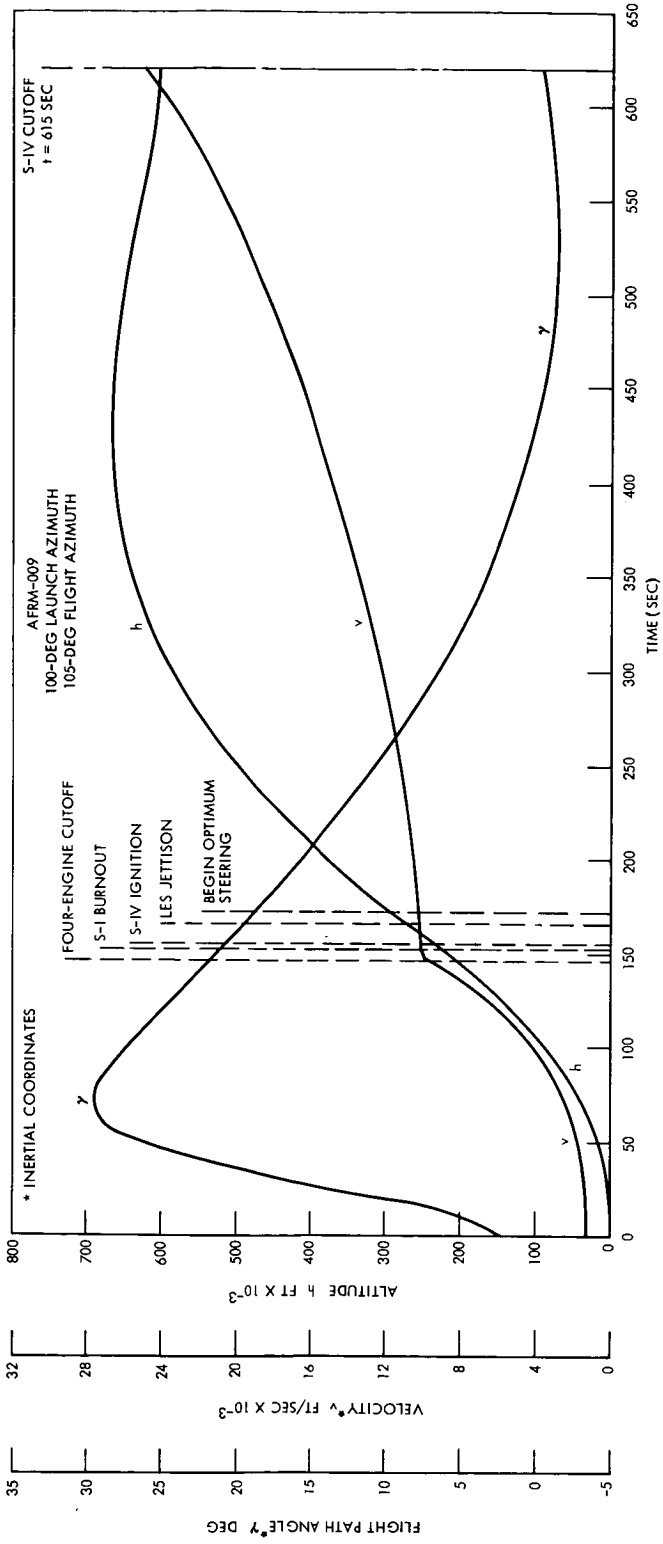

Figure 3-29. Airframe 009 Boost Phase Velocity, Altitude, and Flight Path Angle Versus Time (Inertial Coordinates)

[redacted]

[redacted]

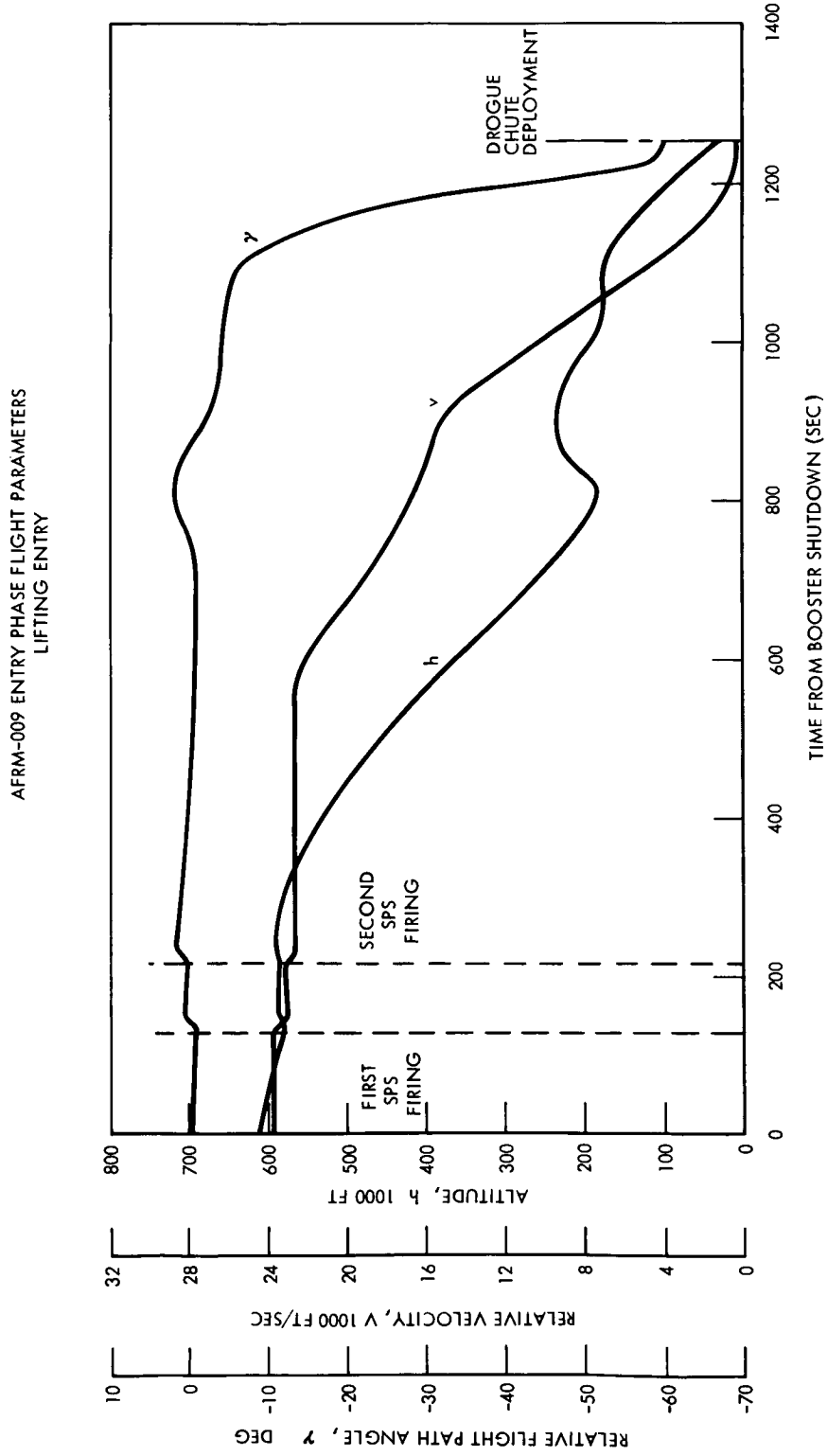

Figure 3-30. Airframe 009 Entry Phase Velocity, Altitude, and Flight Path Angle Versus Time

[redacted]

[redacted]

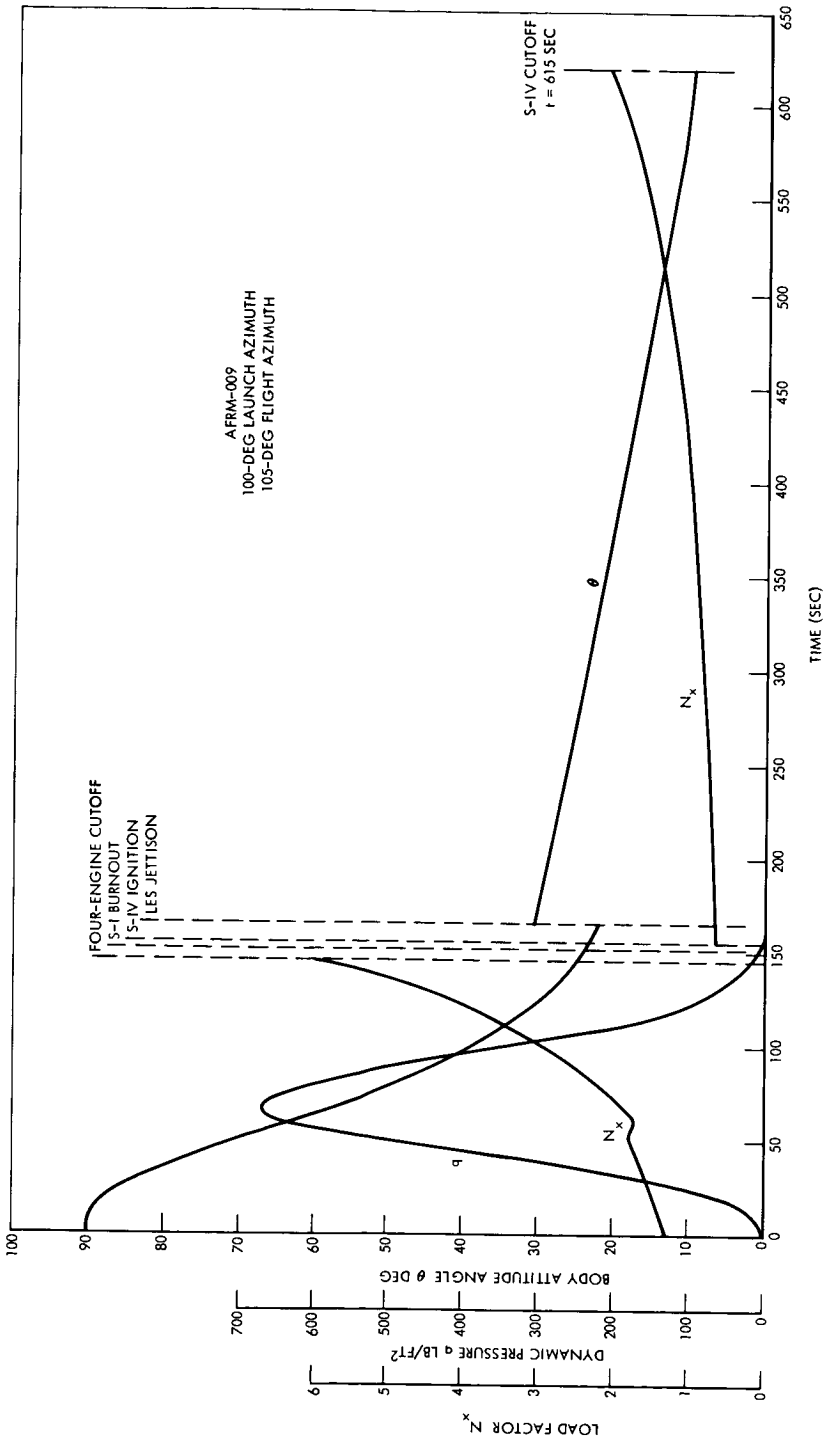

Figure 3-31. Airframe 009 Boost Acceleration Versus Time

[redacted]

[redacted]

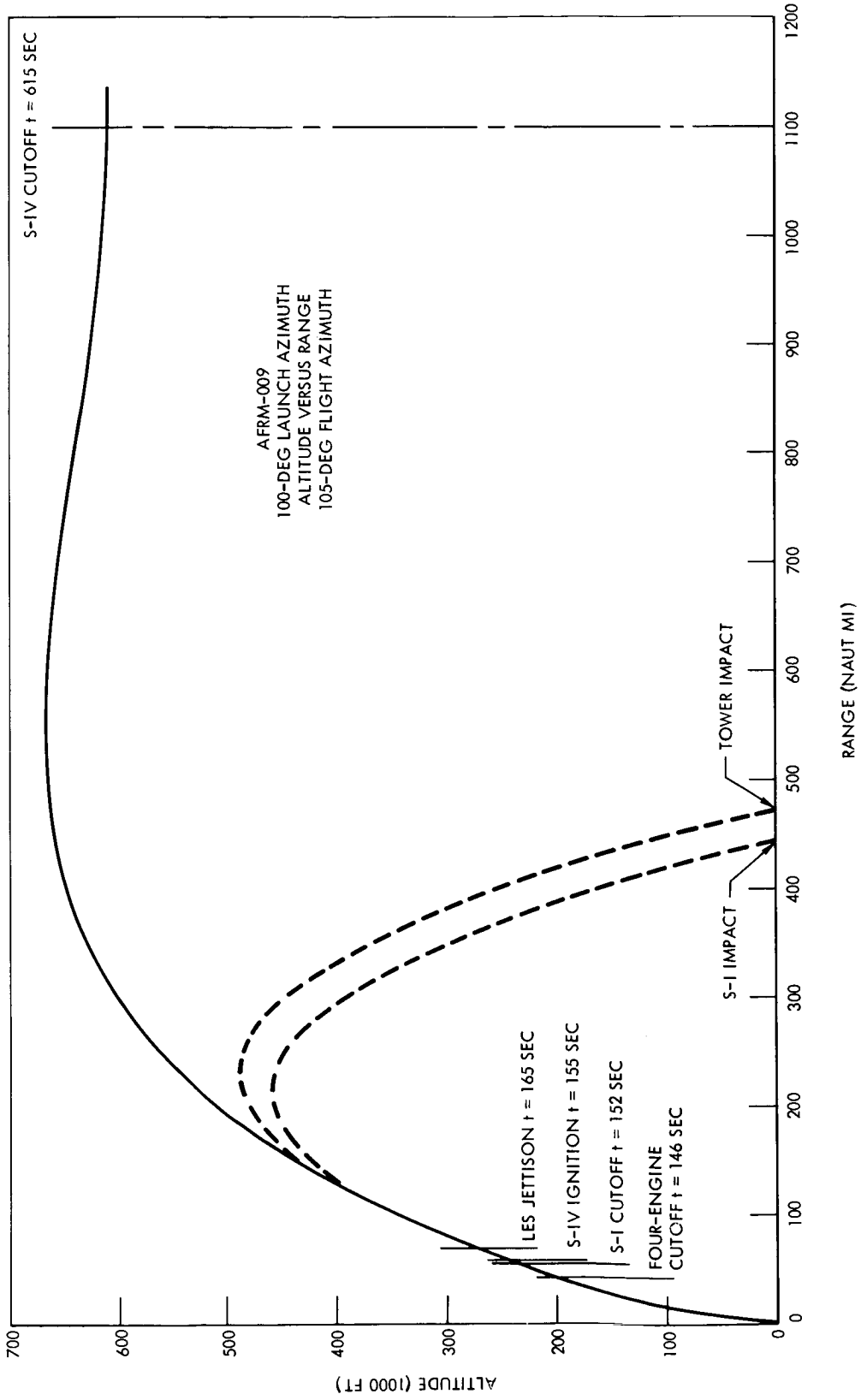

Figure 3-32. Airframe 009 Boost Phase Range Versus Altitude

[redacted]

[redacted]

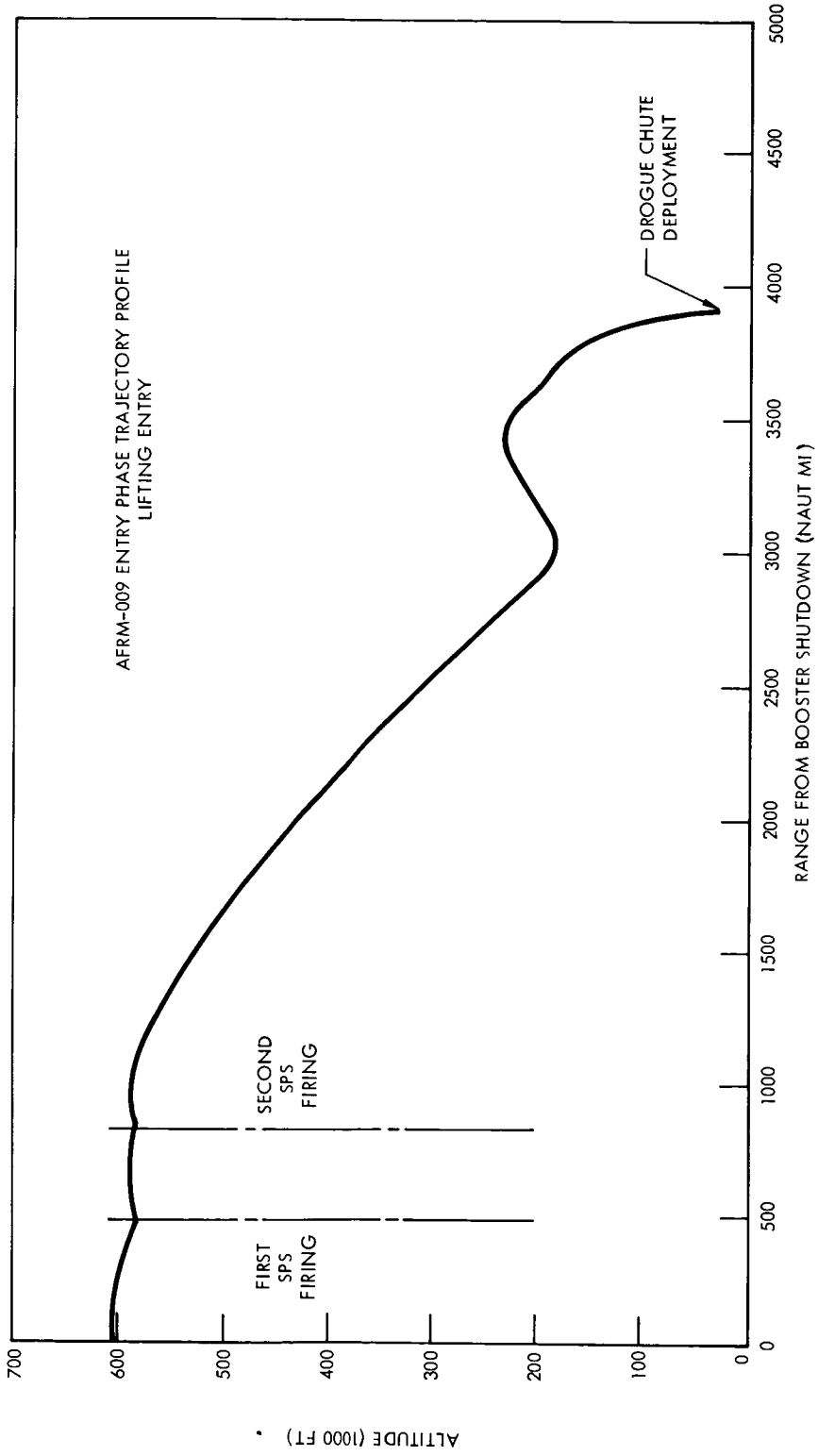

Figure 3-33. Airframe 009 Entry Phase Range Versus Altitude

[redacted]

[redacted]

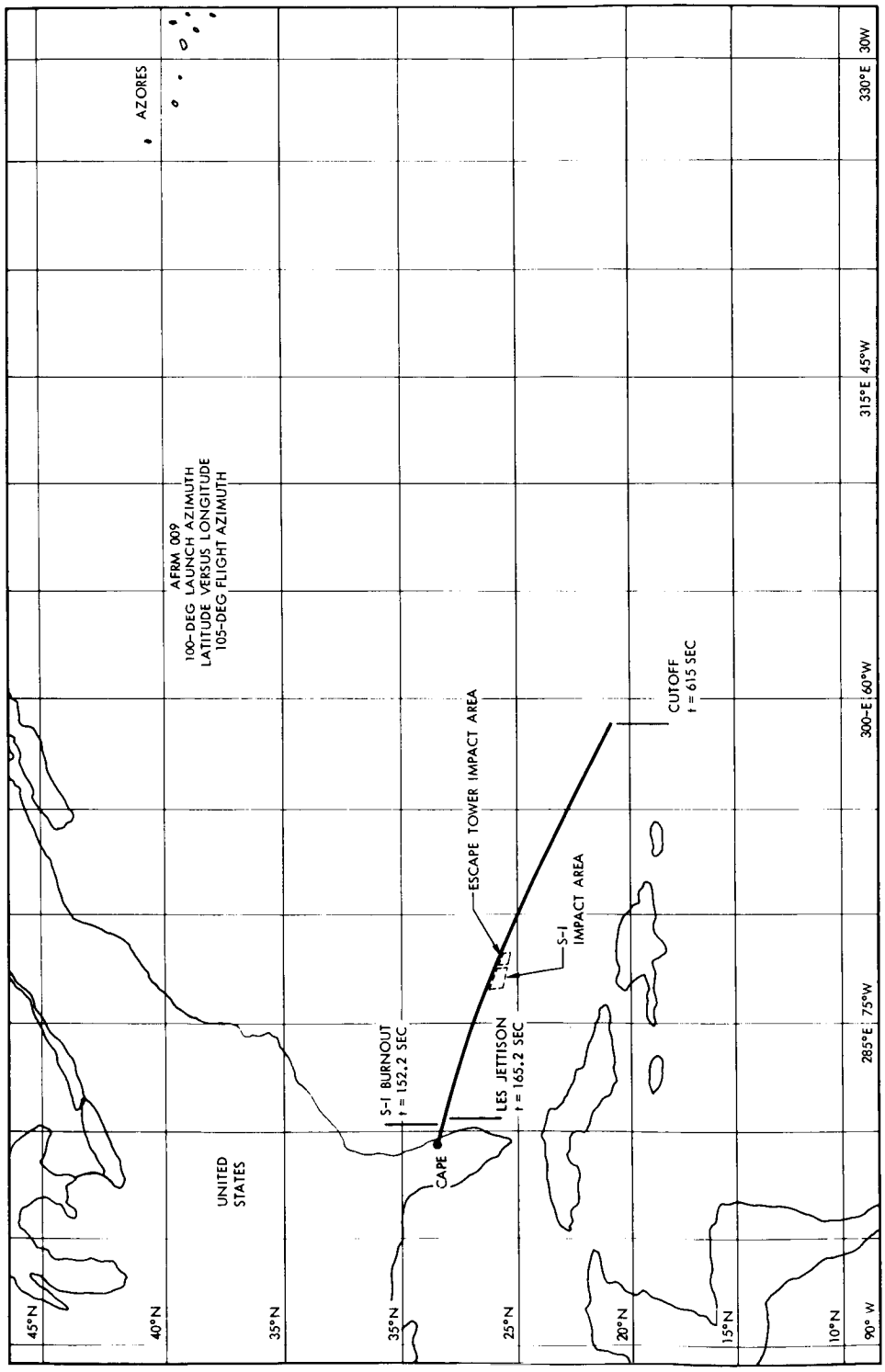

Figure 3-34. Airframe 009 Earth Trace

[redacted]

4. Completion of AFRM 005 thermal structural tests

5. Completion of AFRM 001 S/M-SPS and RCS normal performance tests (SPS-450 seconds, RCS-450 seconds)

6. Completion of C/M-RCS (functional mock-up) normal performance test (approximately 400 seconds)

7. Completion of AFRM 006 vibration tests (ground handling and transportation)

8. Completion of simulators 1 and 2 mission profile studies (spacecraft dynamics during boost abort, suborbital coast, and suborbital entry flight phases)

9. Completion of AFRM 007 water impact tests (two drops)

10. Completion of partial qualification tests of applicable spacecraft systems to support AFRM 009

11. Completion of partial AFRM 007 flotation tests

3.4.4 Description of Test Vehicle

Airframe 009 configuration will consist of a prototype spacecraft structure equipped with all systems except those in the following list.

1. Two fuel cells

2. One cryogenic system

3. Waste management system

4. Water management system (partial)

5. Guidance and navigation system

6. Battery charger

7. In-flight test system

8. Up-data link

9. Television camera

10. Audio panel, that portion not required to exercise the VHF transmitter

11. Crew provisions (including couches)

12. Astro-sextant door mechanism

13. LioH packages

14. Scientific equipment

15. Suit and backpack storage

16. S-band antenna

17. Hand controllers

18. Radiation detection system

3.4.4.1 Spacecraft Weight and Balance

Airframe 009 estimated weights are as follows:

Spacecraft Component	Weight (lb)
Launch escape system	6560
Command module	9398
Service module	8662
Adapter S-IV	830

3.4.4.2 Launch Escape System (LES)

The prototype launch escape system for Airframe 009 consists of the following major components:

1. Q-ball assembly

2. Ballistic enclosure

3. Pitch control support assembly

4. Pitch control motor (live)

5. Tower jettison motor assembly (live motor)

[redacted]

6. Launch escape motor assembly (live motor)

7. Structural skirt assembly

8. Launch escape tower

9. Aerodynamic flap

10. LES tower sequencer system

11. LES tower skirt sequencer system

3.4.4.2.1 Q-Ball Assembly. The Q-ball is a dynamic pressure sensing unit that provides pitch, yaw, and dynamic pressure signals to the S-IV booster instrumentation unit for trajectory control during the boost phase. The Q-ball is 19 inches long, weighs approximately 23 pounds, and is located in the apex of the LES.

3.4.4.2.2 Ballistic Enclosure. The ballistic enclosure forms the structure between the Q-ball and the pitch control motor structure and houses the LES lead ballast.

3.4.4.2.3 Pitch Control Motor. The pitch control motor is a live, solid propellant rocket motor providing a thrust of approximately 3400 pounds for a duration of 0.5 seconds. The pitch control motor is fired simultaneously with the launch escape motor for thrust vector control. The motor housing forms the structure between the ballistic enclosure and the tower jettison motor. The PCM ignitor employs redundant hot-wire initiators.

3.4.4.2.4 Tower Jettison Motor. The tower jettison motor is a live, solid propellant motor employed for the removal of the launch escape system from the command module. The motor is 26 inches in diameter, 47 inches long, and weighs approximately 550 pounds. Two unequal exhaust area thrust nozzles are positioned 30 degrees from the motor mean centerline to provide a resultant thrust axis of 2.5 degrees ±0.5 degrees from the motor mean centerline. The motor provides a thrust of 33,000 pounds for 1.2 seconds. It is equipped with an ignitor using redundant hot-wire initiators.

3.4.4.2.5 Launch Escape Motor. The launch escape motor is a solid propellant rocket motor used for safe removal of the command module from the remainder of the spacecraft in the event of a mission abort during the initial boost phase. The motor is 26 inches in diameter, 183 inches in length, and weighs approximately 4826 pounds. Four fixed nozzles are canted to minimize impingement of the rocket blast on the command module.

[redacted]

The motor provides 155,000 pounds of thrust at 36,000 feet altitude and 70 F. The motor ignitor employs redundant hot wire initiators.

3.4.4.2.6 Structural Skirt. The structural skirt assembly provides the intermediate structure between the launch escape motor case and the launch escape tower. The structural skirt is a welded assembly consisting of a forged ring, longerons, and a shear skin which transfers loads from the launch escape motor to the tower legs. The structural skirt is attached to the tower by means of the tower to skirt separation systems.

3.4.4.2.7 Tower Structure. The launch escape tower is a truncated rectangular cross-section pyramid structure constructed of a welded tubular titanium alloy. The tower forms the intermediate structure between the C/M and the structural skirt assembly and is approximately 120 inches long with a base 46 x 50 inches. The structure is covered with an ablative material and is attached to the C/M with explosive bolts with redundant shaped cutter charges. An aerodynamic flap is mechanically attached near the top of the tower directly beneath the structural skirt separation plane.

3.4.4.2.8 Aerodynamic Flap. An aerodynamic flap is mechanically attached near the top of the tower structure directly beneath the structural skirt separation plane. The aerodynamic flap, in conjunction with the tower, is used to stabilize the command module blunt end forward, during aborts occurring between the altitudes of approximately 30,000 feet and 220,000 feet.

3.4.4.2.9 Tower Sequencer. Dual tower sequencer systems (channels A and B) provide input signals to the following pyrotechnics.

1. Tower jettison motor squibs

2. Tower base separation shaped charge squibs

3. Tower base separation explosive bolts squibs

3.4.4.2.10 Tower Skirt Sequencer. Dual tower skirt sequencer systems (channels A and B) provide input signals to the following pyrotechnics.

1. Pitch control motor squibs

2. Tower jettison motor squibs

3. Launch escape motor squibs

4. Tower skirt separation shaped charge squibs

5. Tower skirt separation explosive bolts squibs

3.4.4.3 Command Module

The command module will be a prototype spacecraft structure conforming to the production design and consisting of two structural elements: the inner structure which forms the pressurized environmentally controlled crew compartment; and the outer structure which provides the aerodynamic shape of the command module and provides environmental protection for the inner structure. The C/M is a symmetrical blunt conical shape, approximately 141 inches high and 154 inches in diameter. Ballast will be installed to duplicate, as closely as possible, the weight, moment of inertia, and center of gravity of AFRM 011.

3.4.4.4 Service Module

The service module will be a prototype spacecraft structure conforming to the production design and consisting of six radial shear beams dividing the interior cylinder into six unequal equipment areas. The S/M is approximately 155 inches in length and 154 inches in diameter.

3.4.4.5 Spacecraft Adapter

The spacecraft adapter will be a prototype structure conforming to production design constructed on two-inch-thick bonded aluminum honeycomb.

3.4.5 Structural Design Criteria

3.4.6 Aerodynamic Stability

3.4.6.1 Spacecraft Plus Escape Tower

3.4.6.2 Spacecraft Alone

3.4.6.3 Symbols

3.4.7 Instrumentation Requirements

3.4.7.1 On-Board Instrumentation

3.4.7.2 Data Acquisition System

3.4.8 Tracking and Support Data Requirements

3.4.8.1 General

3.4.8.2 Phototheodolite Data

3.4.8.3 Radar Tracking Data

3.4.8.4 Photographic Data

3.4.8.5 Meteorological Data

3.4.9 Prelaunch Operations

3.4.9.1 Acceptance Tests, NAA

3.4.9.2 Arrival and Receiving Inspection, Test Site

3.4.9.3 Combined Systems Check, Launch Pad

3.4.9.4 Test Procedures

3.4.9.5 Launch Day Activities

3.4.10 Test Management and Organization

3.4.10.1 Acceptance Tests

3.4.10.2 Checkout Tests

3.4.10.3 Launch and Recovery

3.4.11 Recovery Requirements

3.4.11.1 Requirements

3.4.11.2 Recovery Forces

3.4.11.3 Recovery Concept

3.4.11.4 Location Aids

3.4.12 Launch Day Requirements

3.4.13 Pad and Range Safety Requirements

3.4.13.1 Pad Safety

3.4.13.2 Range Safety

3.4.14 Data Handling, Analysis, and Reporting

3.4.14.1 Data Handling and Processing

3.4.14.2 Calibration Data

3.4.14.3 Data Analysis and Test Evaluation

3.4.14.4 Test Reporting

3.4.15 Ground Support Equipment

3.5 AIRFRAME 011 DETAILED TEST PLAN

3.5.1 Introduction

3.5.1.1 Purpose

This document presents the detailed test plan for Airframe 011 and is to be utilized for testing at Downey and AMR until superseded by the NASA Project Apollo Flight Mission Directive for Airframe 011.

3.5.1.2 Scope

The scope of this detailed test plan is to specify test objectives, describe vehicle configuration, establish system priorities, present flight trajectories, and describe the instrumentation requirements for Airframe 011 testing, as well as the S&ID method of qualifying the test vehicle for the mission.

3.5.1.3 Precedence of Reports

The detailed test plan for Airframe 011 shall take precedence over all other reports and documents concerned with Airframe 011 testing except the NASA Project Apollo Flight Mission Directive. The NASA mission directive, when published, shall supersede the detailed test plan.

3.5.1.4 Amendments

This document shall be revised quarterly or as often as necessary to reflect changes in the test plan and to provide additional information that is not available at time of publication.

3.5.1.5 Definition of Objectives

Test objectives are described as being Apollo first order or second order. These categories are defined in the following paragraphs.

[redacted]

3.5.1.5.1 Apollo First-Order Test Objectives. These test objectives must be achieved for the mission to be successful and define the main purpose for conducting the test. Malfunction of spacecraft systems, GSE or instrumentation which jeopardize the attainment of first-order test objectives will require a countdown hold or launch scrub until such time as a fix can be made.

3.5.1.5.2 Apollo Second-Order Test Objectives. Second-order test objectives are those desired to support future Apollo flights or to supply supplementary data for over-all spacecraft evaluation. Malfunction of S/C Systems, GSE or instrumentation which jeopardize the attainment of second-order test objectives will not require a hold after start of countdown. Corrections thereafter may be made at the discretion of the NASA Test Director or the Project Engineer.

3.5.1.6 Definition of Systems Priorities

The spacecraft systems are assigned either primary (P) or secondary (S) priorities. During the initial test program, when incomplete systems are tested, this definition will apply at the subsystem and component level.

3.5.1.6.1 Primary Systems (P). Primary systems are those systems functionally required for the spacecraft to successfully complete its planned mission or to accomplish first-order test objectives. A hold or scrub will be mandatory if any of the primary systems indicate improper operation. A positive indication of satisfactory operation must be available for launch.

3.5.1.6.2 Secondary Systems (S). Secondary systems are those systems not functionally required for the S/C to complete its planned mission. Malfunction of secondary systems will not require a mandatory countdown hold or scrub. Corrections therafter may be made at the discretion of the NASA Test Director or the Project Engineer.

3.5.2 Test Objectives and System Priorities

3.5.2.1 Test Objectives

3.5.2.1.1 First-Order Test Objectives. The first-order test objectives are:

1. Demonstrate the structural integrity of the spacecraft in the orbital flight environments, including boost, earth orbit, entry, water impact and recovery.

[redacted]

2. Demonstrate the aerodynamic stability, trajectory, and maneuverability of the C/M during lifting entry.

3. Demonstrate satisfactory operation of spacecraft systems under manned orbital flight conditions.

4. Demonstrate the compatibility of the manned spacecraft with the GOSS, including recovery operations.

5. Demonstrate satisfactory separation of the S/M from the C/M.

3.5.2.1.2 Second-Order Test Objectives. The second-order test objectives are:

1. Evaluate crew performance under orbital flight conditions

2. Evaluate start and restart capabilities of the service module SPS and RCS under orbital flight conditions

3. Evaluate the operational characteristics of the spacecraft systems under orbital flight conditions

4. Evaluate guidance and navigation system closed-loop operation and inflight navigational sighting techniques

5. Evaluate the operation of the ECS during manned orbital flight

6. Evaluate the launch countdown operation

3.5.2.2 System Priorities

1. Launch escape system	
a. Launch escape motor	Primary
b. Tower jettison motor	Primary
c. Pitch control motor	Primary
d. Tower separation system	Primary
e. Abort sequencer	Primary
2. Electrical power system	
a. Battery power system	Primary
b. Fuel cells	Primary
3. Communications and instrumentation system	
a. Telemetry and antenna system	Primary
b. Radar beacon	Primary
c. Instrumentation	(see Measurement List)

4. Environmental control system	Primary
5. Spacecraft separation systems	
a. S-IV to S/M adapter separation system	Primary
b. S/M to S/M adapter separation system	Primary
c. C/M to S/M separation system	Primary
6. Reaction control systems	
a. Service module RCS system	Primary
b. Command module RCS system	Primary
7. Emergency detection system	Primary
8. Service propulsion system	Primary
9. Stabilization and control system	Primary
10. Guidance and navigation system	Secondary
11. Earth landing system	
a. Parachutes	Primary
b. Sequence controller	Primary
c. Recovery aids	Primary
12. Crew safety system	Primary

3.5.3 Mission Description

3.5.3.1 Flight Plan

The Saturn I launch vehicle will boost the manned spacecraft into a near-circular, 100-nautical-mile earth orbit from a launch azimuth of 100 degrees from pad 34, with a programmed roll to a flight azimuth of 72 degrees. The spacecraft will be separated from the S-IV stage in orbit and the S/M adapter jettisoned. During the orbital flight phase, the crew will perform designated tasks to fully test the various spacecraft systems. While on the third orbit, the spacecraft will be oriented to the proper attitude for the SPS deorbit firing. Shortly after the spacecraft leaves the coastline of the Australian continent, retro fire will be initiated. Upon SPS cutoff, the crew will orient the spacecraft for CSM separation and jettison the S/M, then reorient the C/M for entry. The entry phase will consist of a 45-degree modulated lifting trajectory. The flight will terminate with command module touchdown in the Pacific Ocean west of the Hawaiian Islands.

3.5.3.2 Sequence of Events

The sequence of events will be as follows:

Event	Time (sec)
S-I ignition	-3.4
Lift-off	0.0
Max-Q	72.0
S-I inboard engine cut-off	146.2
S-I outboard engine burn-out	152.2
Ullage rocket ignition	153.0
S-IV ignition	155.2
LES jettison	165.2
Peak altitude	436.0
Orbit	628.9
S-IV-spacecraft separation	630.0
Spacecraft orientation for deorbit	
SPS deorbit maneuver	14,925.0
Spacecraft orientation for separation	
C/M-S/M separation	15,025.0
C/M orientation for entry	15,163.0
C/M entry (400,000 feet)	15,345.0
Apex cover jettison (25,000 feet)	16,660.0
Drogue chute deployment	16,660.0
Main chute deployment (15,000 feet)	16,690.0
Water impact	17,160.0

3.5.3.3 Flight Parameters

Pertinent boost phase flight parameters are presented in Figures 3-35, 3-36, and 3-37. Figures 3-38 and 3-39 present the entry phase flight parameters for a C/M 45-degree bank entry.

3.5.3.4 Flight Trajectories

The boost phase trajectory profile and earth trace are presented in Figures 3-40 and 3-41. In addition, an orbital earth trace is provided in Figure 3-42. Figures 3-43 and 3-44 present a plan view and a profile for the nominal entry trajectories.

3.5.3.5 Flight Constraints

Flight constraints define the minimum mandatory tests which must be completed on each major vehicle system prior to launch. Failure to

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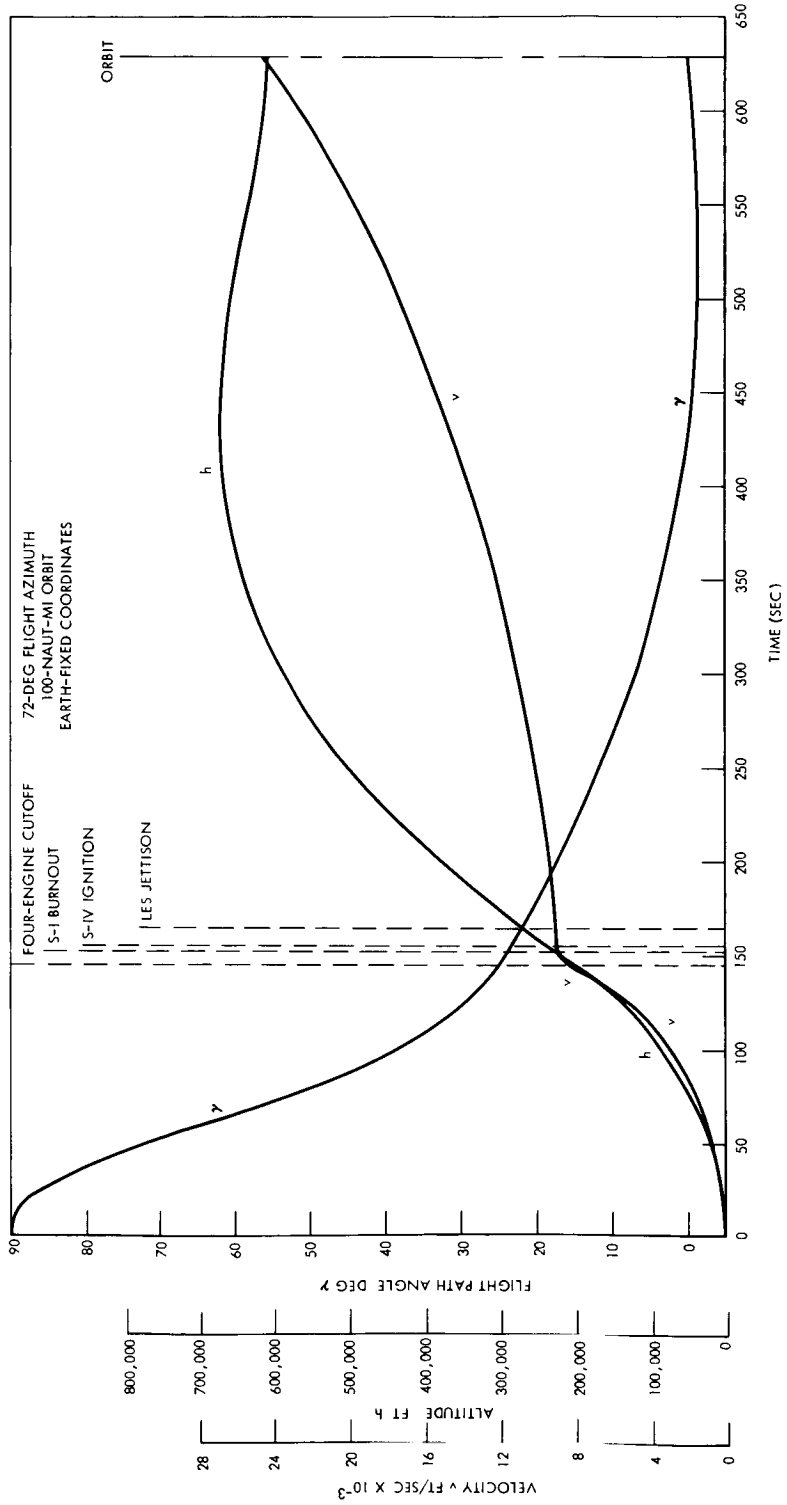

Figure 3-35. Airframe 011 Boost Phase Velocity, Altitude, and Flight Path Angle Versus Time (Earth-Fixed Coordinates)

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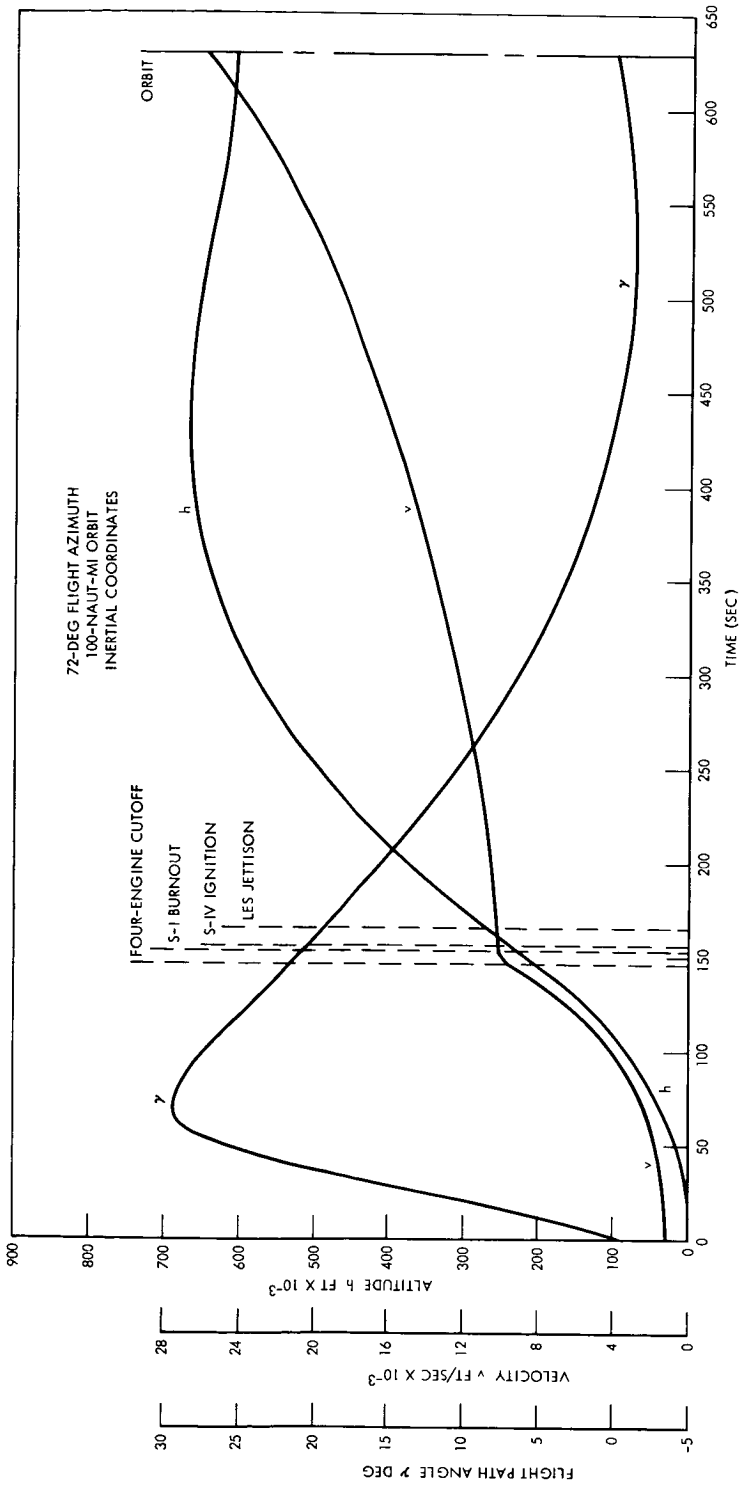

Figure 3-36. Airframe 011 Boost Phase Velocity, Altitude, and Flight Path Angle Versus Time (Inertial Coordinates)

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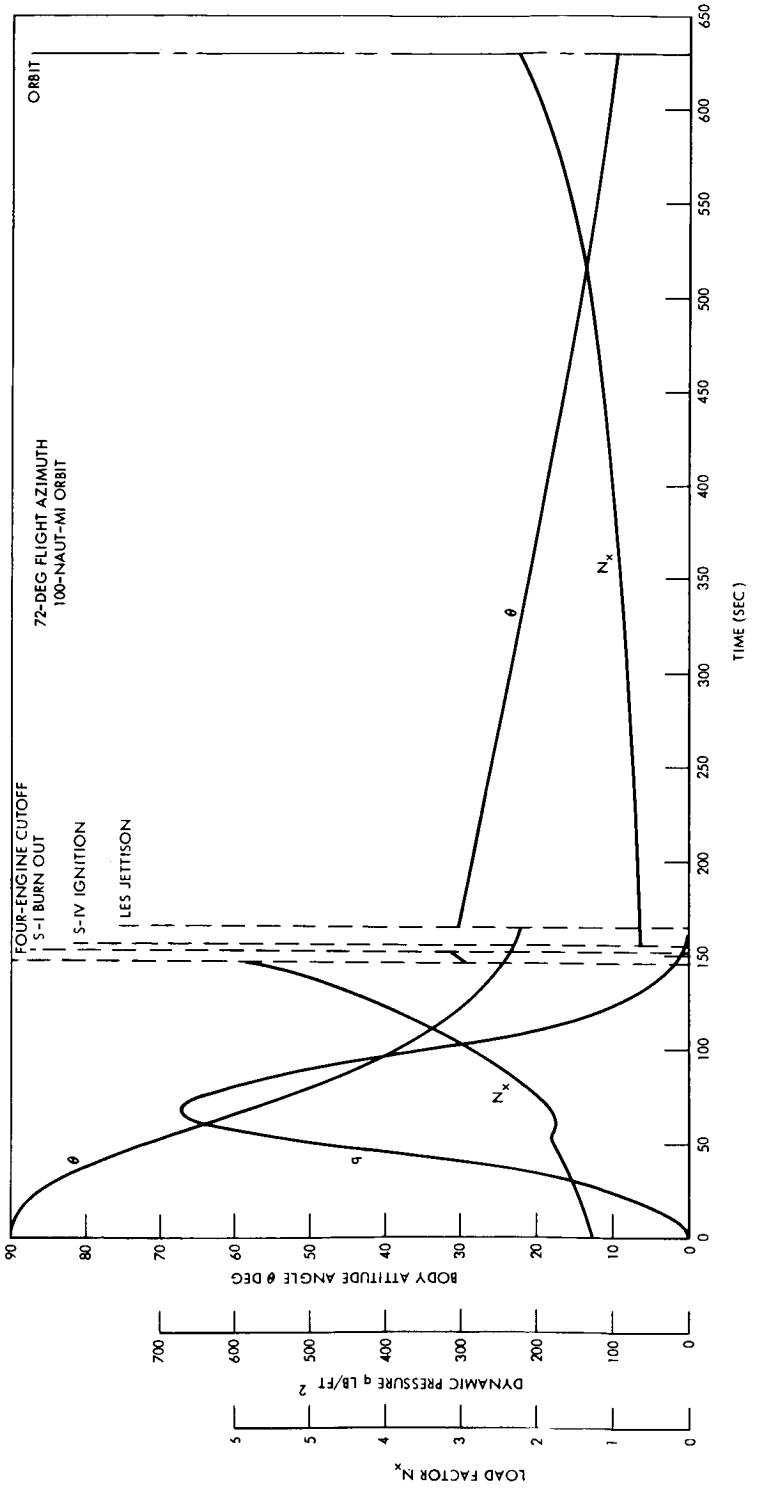

Figure 3-37. Airframe 011 Boost Phase Load Factor, Dynamic Load Pressure, and Attitude Angle Versus Time

[redacted]

[redacted]

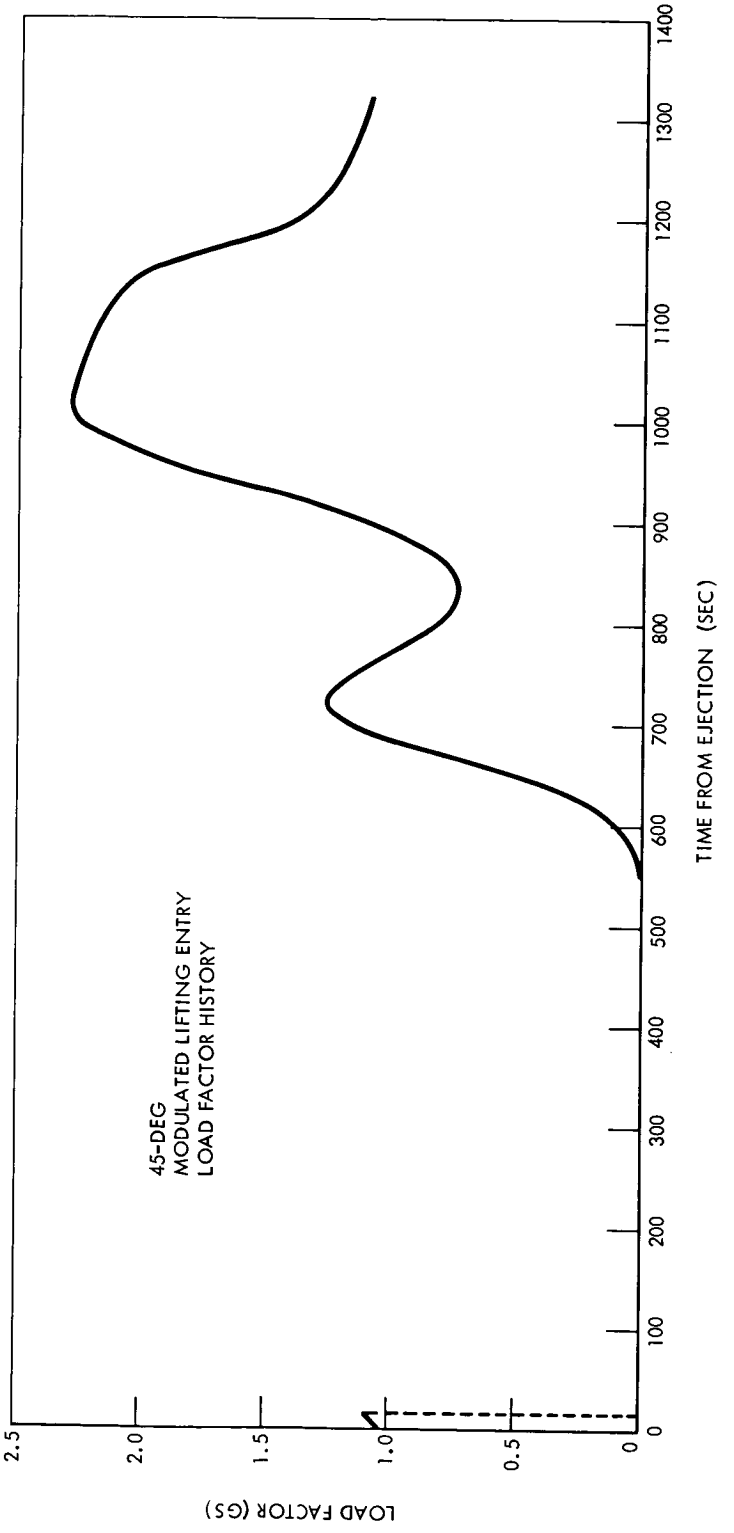

Figure 3-38. Airframe 011 Entry Phase Load Factor Versus Time

[redacted]

[redacted]

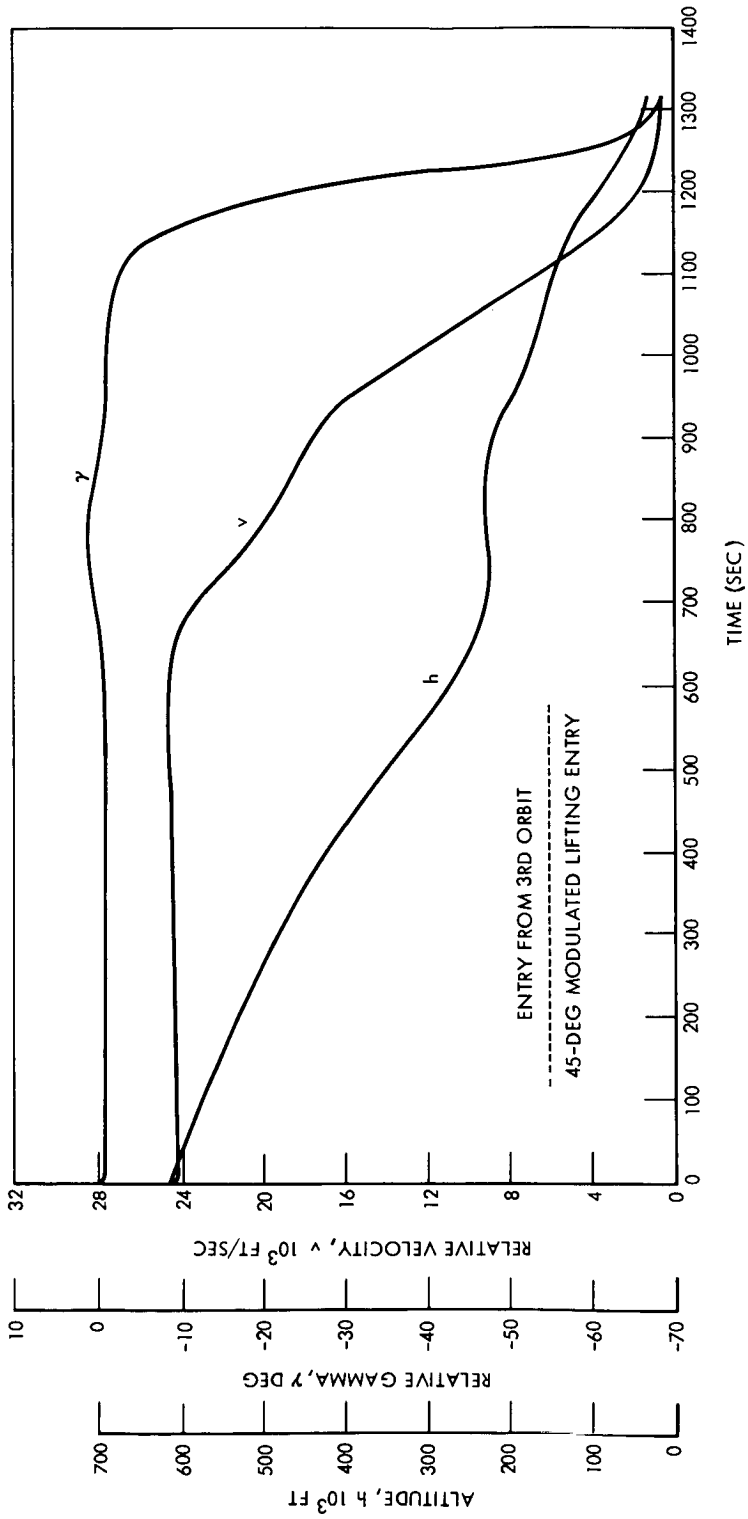

Figure 3-39. Airframe 011 Entry Phase Velocity, Altitude, and Flight Path Angle Versus Time

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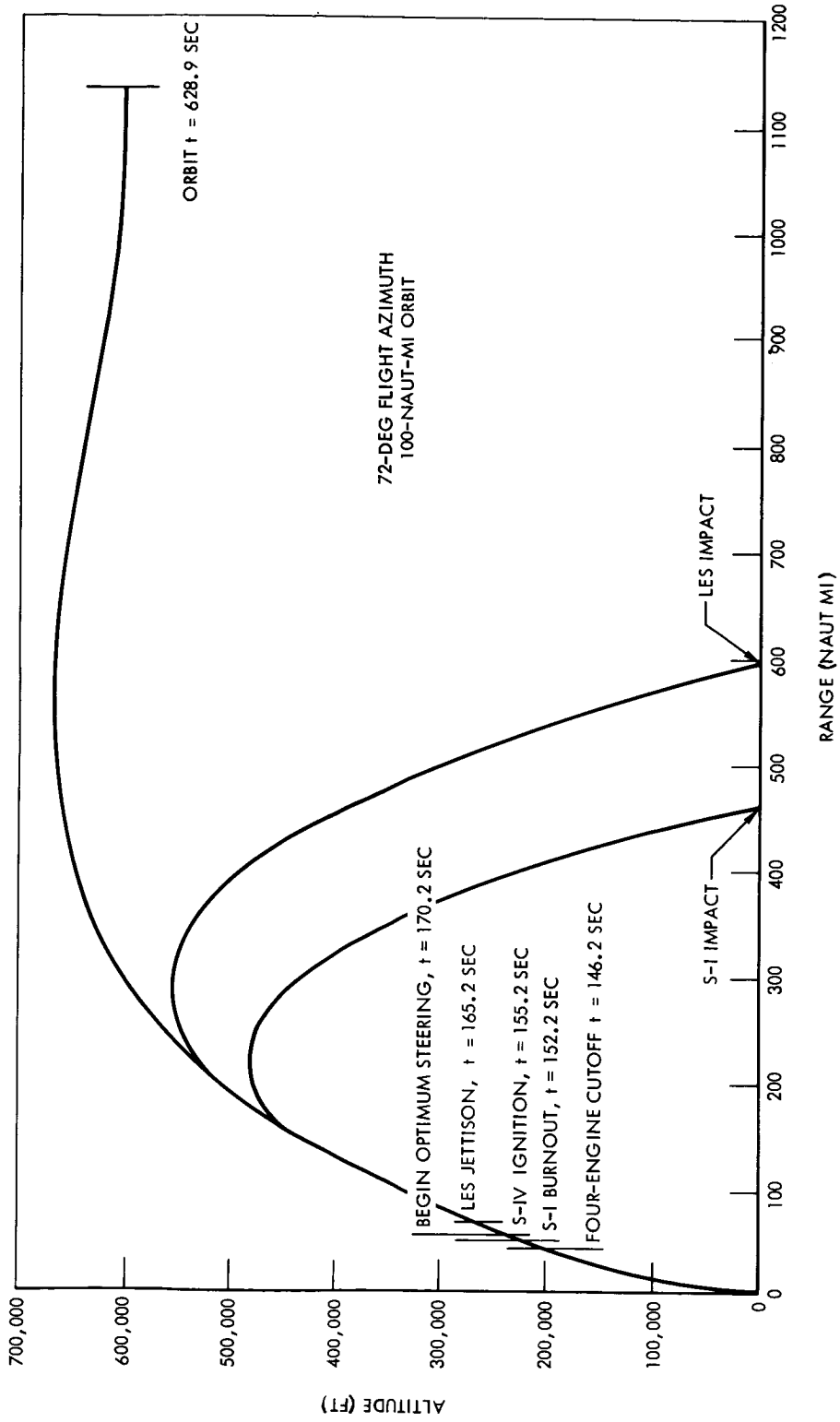

Figure 3-40. Airframe 011 Boost Phase Altitude Versus Range

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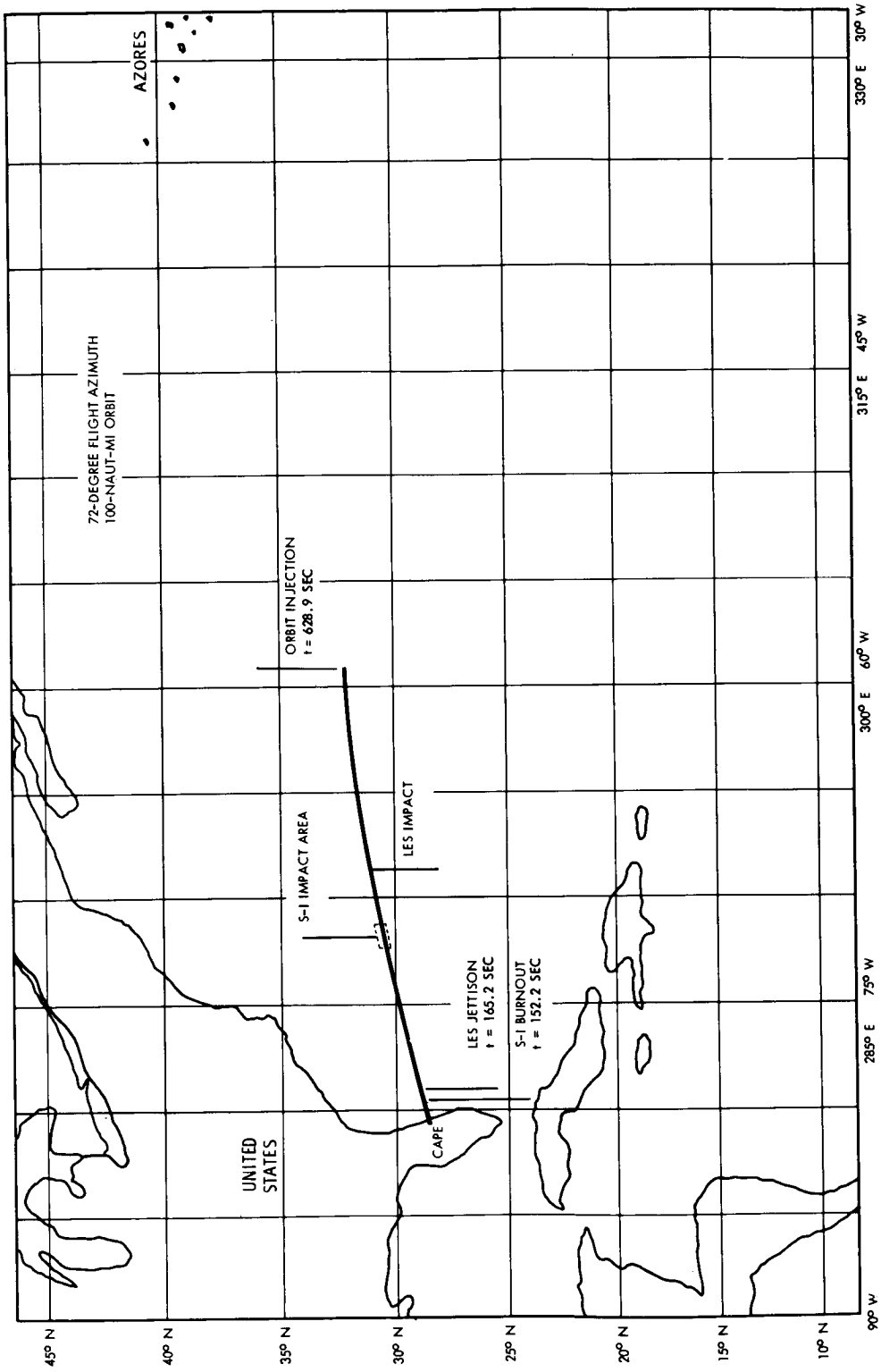

Figure 3-41. Airframe 011 Boost Trajectory Earth Trace (Latitude Versus Longitude)

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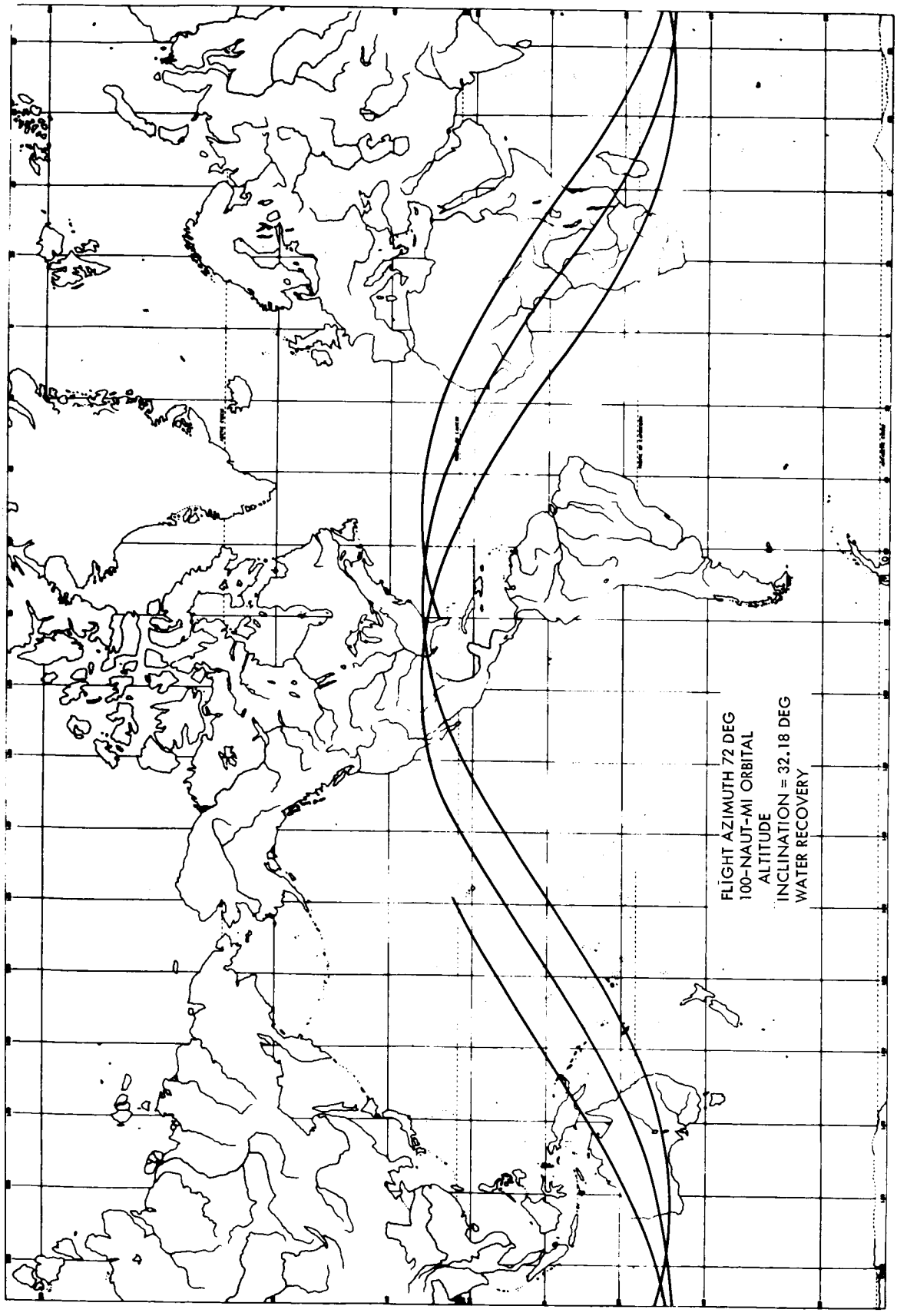

Figure 3-42. Airframe 011 Orbital Earth Trace

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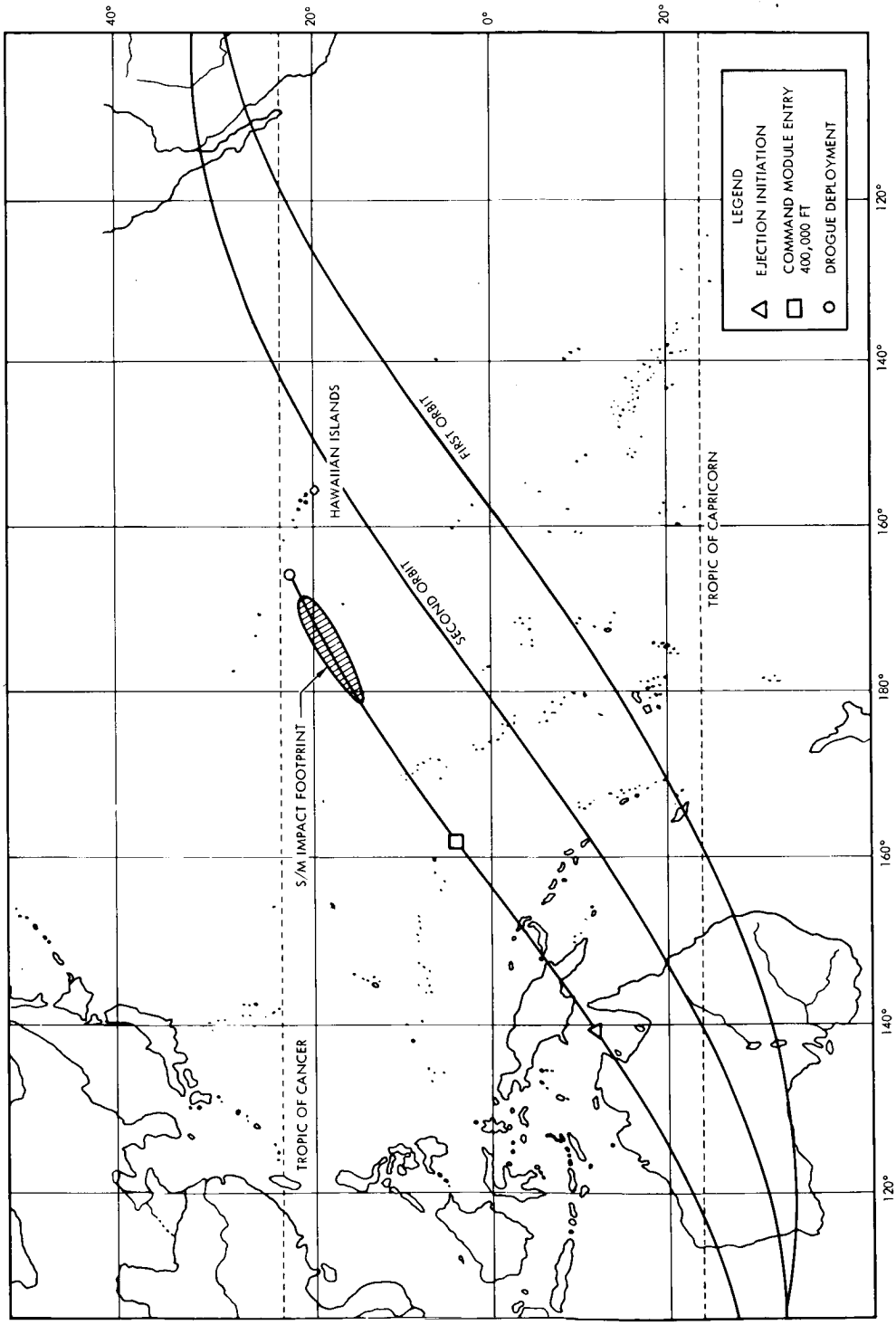

Figure 3-43. Recovery From Third Orbit-Earth Trace (45-Degree Modulated Lifting Entry)

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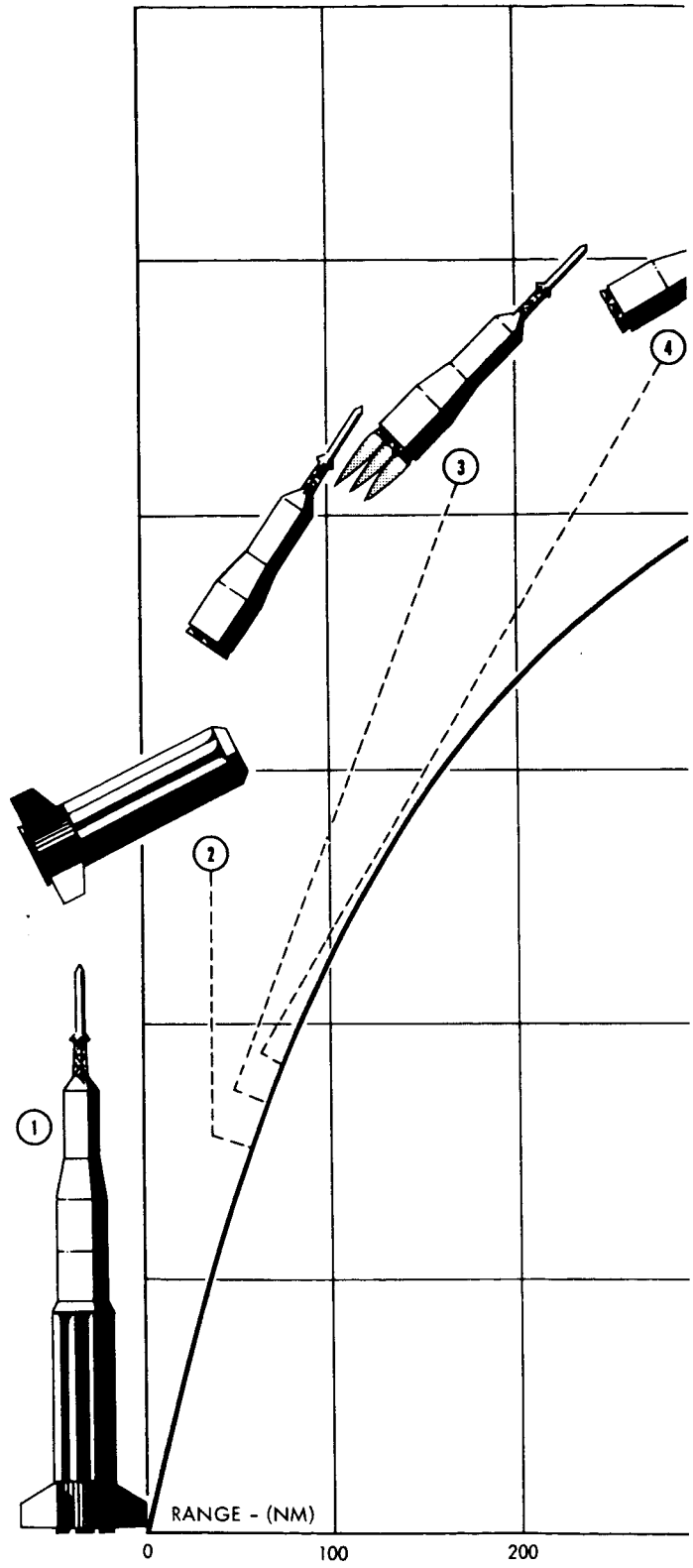
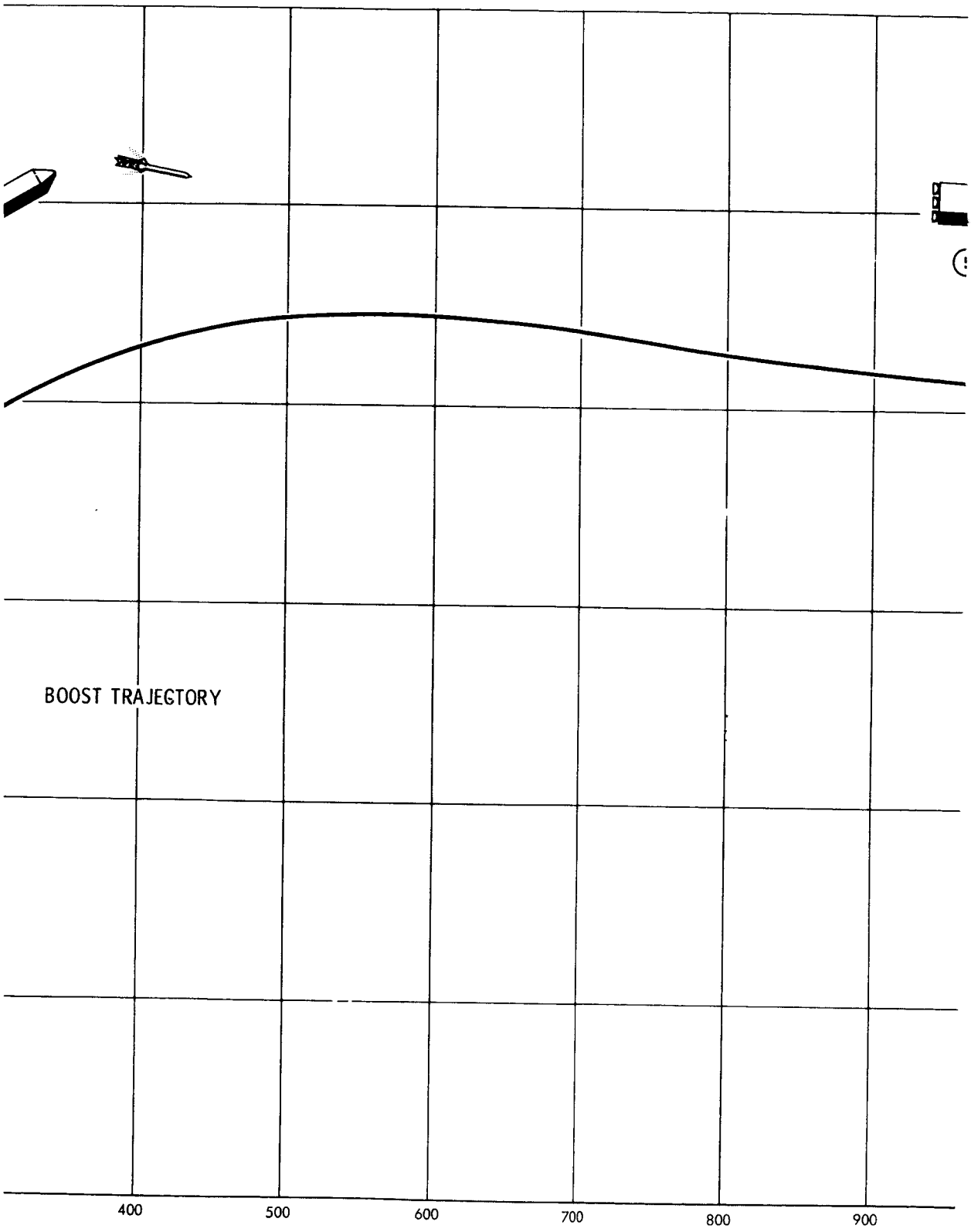
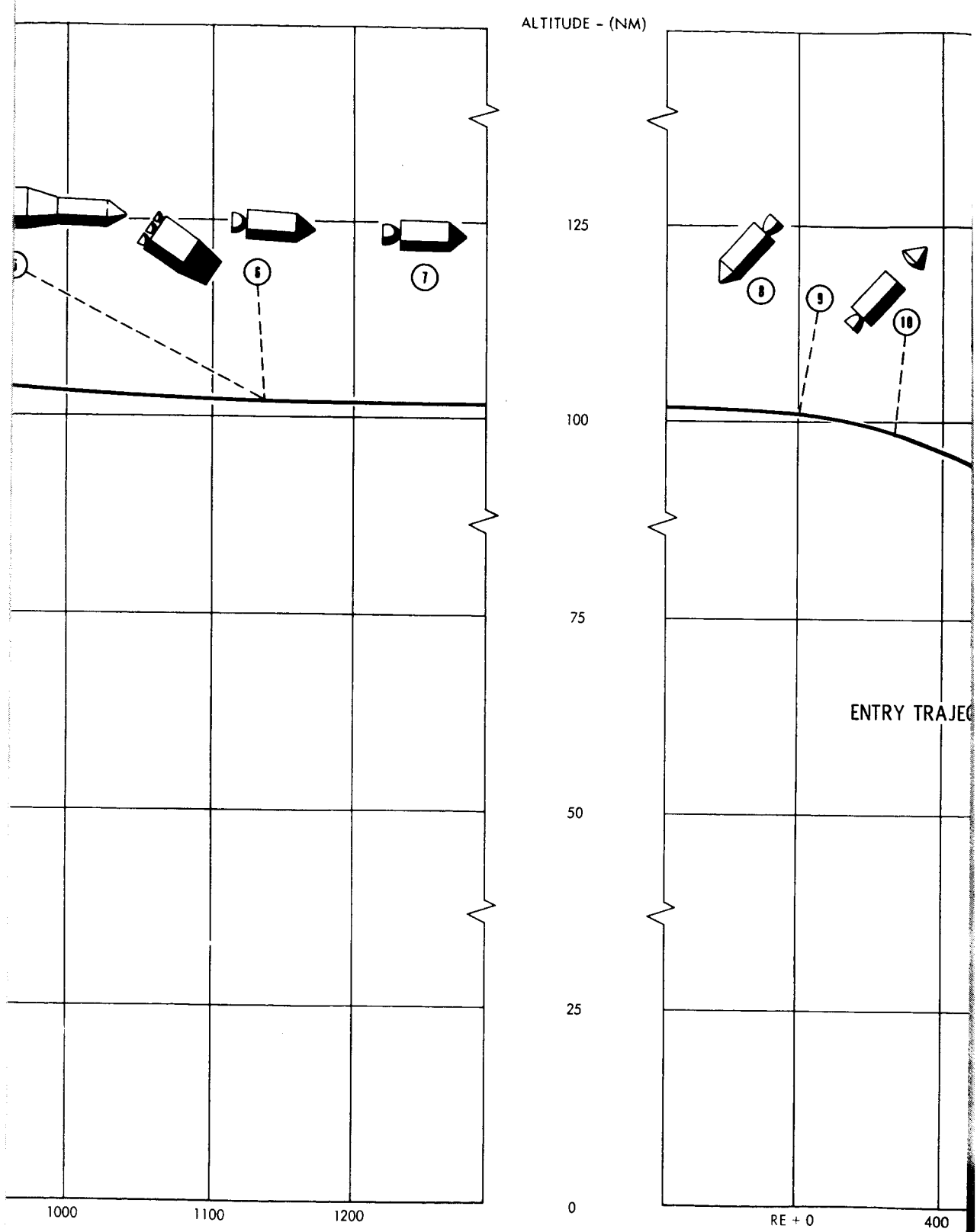
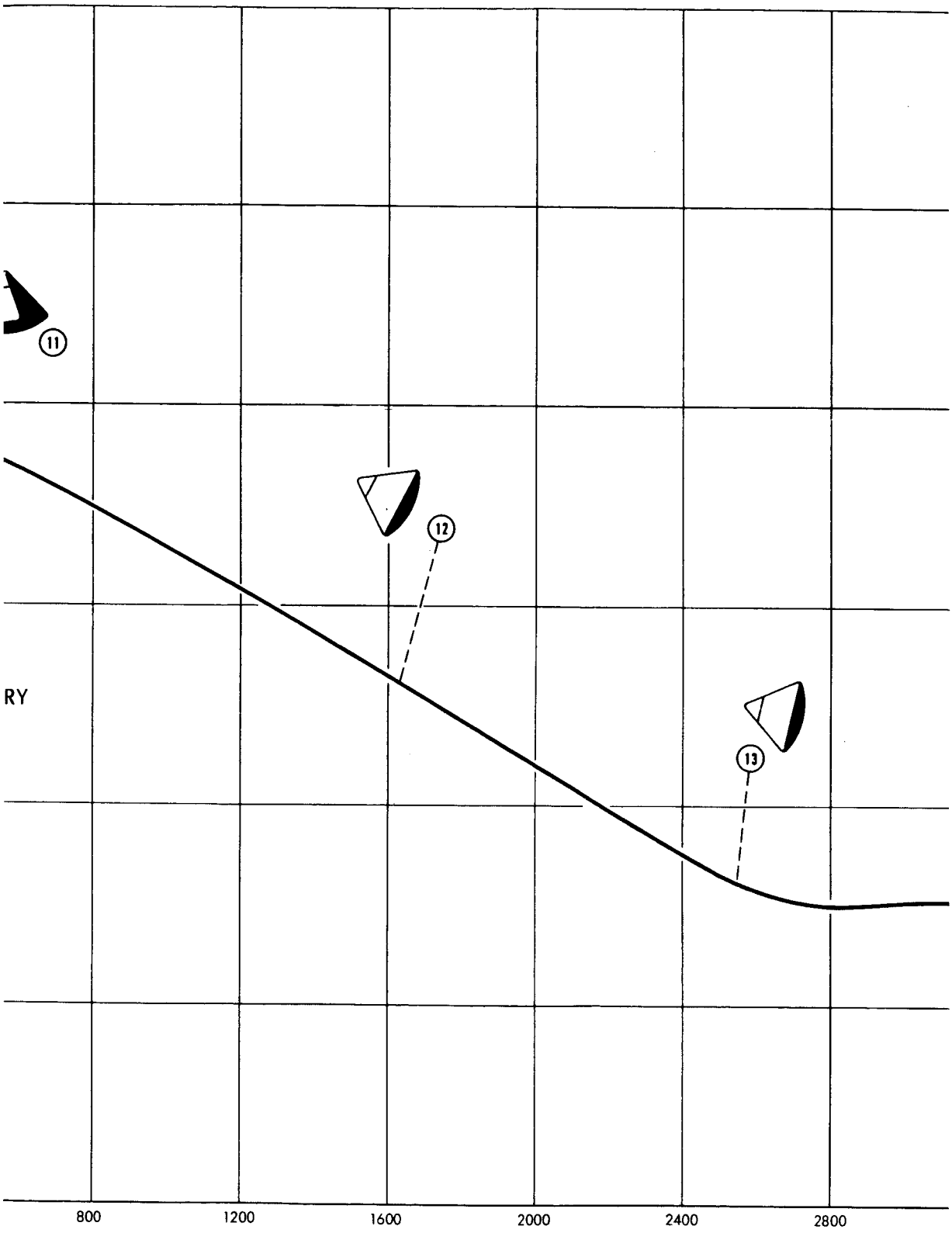

1
2
3
4
RANGE - (NM)
0
100
200


BOOST TRAJECTORY
400
500
600
700
800
900


ALTITUDE - (NM)
125
100
75
50
25
0
6
7
8
9
10
ENTRY TRAJEC
1000
1100
1200
RE + 0
400

NORTH /



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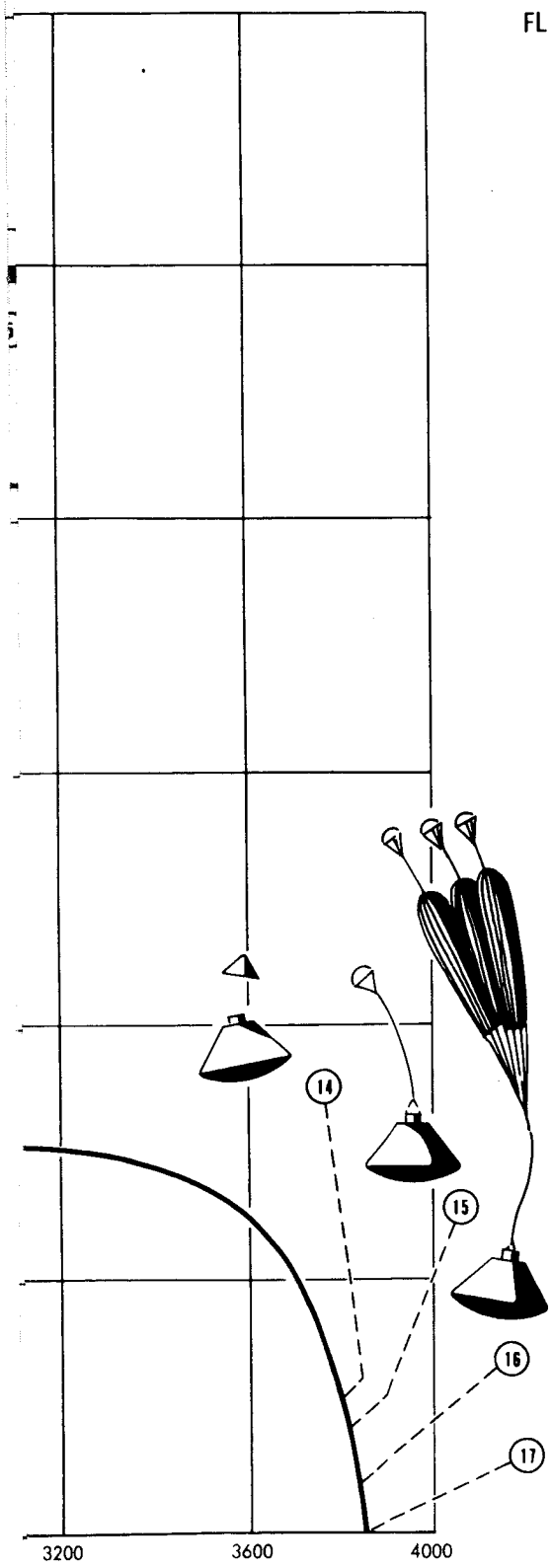

FLIGHT SEQUENCE:

1. SATURN - I LAUNCH
2. S-I BURNOUT AND SEPARATION
3. S-IV IGNITION
4. LES TOWER JETTISON
5. INITIATION OF ORBIT, S-IV BURNOUT
6. S-IV SPACECRAFT SEPARATION
7. ORBITAL PHASE
8. SPACECRAFT ORIENTATION
9. EJECTION FROM ORBIT
10. COMMAND MODULE - SERVICE MODULE SEPARATION
11. COMMAND MODULE ORIENTATION
12. ENTRY AT 400,000 FT
13. INITIATE LIFTING MANEUVER ~ 260,000 FT
14. COMMAND MODULE APEX COVER EJECTED
15. DROGUE PARACHUTE DEPLOYED
16. MAIN PARACHUTES DEPLOYED
17. LANDING AND RECOVERY

Figure 3-44. Mission Schematic (Manned Earth Orbital)

satisfactorily complete these tests shall cause a flight hold. The status of these constraints will be determined on a monthly basis. Final constraint review will normally occur during the test vehicle acceptance data package review at the AMR after boilerplate launch vehicle mating. The flight constraints for Airframe 011 are as follows:

1. Satisfactory completion of first-order mission test objectives in flight of AFRM-009 (9-15-65)

2. Completion of AFRM-004 ultimate load tests (11-1-65)

3. Completion of AFRM-006 vibration test (flight environment 9-1-65; reference IOL 693-220-050-63-103)

4. Completion of AFRM-005 land impact test (one drop, 10-15-65)

5. Completion of AFRM-001 normal performance, off-limit performance and five mission cycles tests (7-1-65; SPS - 4600 seconds; S/M RCS - 3600 seconds)

6. Completion of C/M RCS (functional mock-up) normal performance, off-limit performance, and five mission cycles test (7-1-65; C/M RCS - 3500 seconds)

7. Completion of ECS qualification tests (5-1-65)

8. Completion of qualification tests of applicable spacecraft systems to support AFRM-011 (7-15-65; prior to shipment of AFRM-011 from Downey)

9. Completion of AFRM-008 environmental proof tests (manned thermal-vacuum normal mission simulation, manned thermal-vacuum mission simulating malfunction, and emergency modes, 11-15-65)

10. Satisfactory completion of first-order mission objectives in flights of AFRM-002, AFRM-010, and B-22 (8-1-65, 9-1-65, 3-1-65)

11. Completion of simulators 1 and 2 mission profile studies (3-15-65, spacecraft dynamics during boost, abort, earth orbit, and entry from orbit flight phases; reference SID 63-1040-1)

12. Completion of B-15 flight test (6-15-64, launch escape motor jettisoning of the launch escape tower)

13. Completion of AFRM-007 flotation and crew survivability test (11-15-65)

3.5.4 Description of Test Vehicle

3.5.4.1 Spacecraft Weights

3.5.4.2 Launch Escape System

A complete launch escape system will be provided and will include the following:

Tower
Escape motor
Jettison motor
Pitch control motor
Tower release device

3.5.4.3 Command Module

The command module will be a spacecraft structure complete with all systems to support a manned earth orbital mission. A descriptive list of the individual systems will be included in the test plan as the information becomes available.

3.5.4.4 Service Module

The service module will be a spacecraft structure complete with spacecraft systems conforming to an earth orbital mission. A descriptive list of those systems to be installed in the service module will be incorporated in the test plan as information becomes available.

3.5.5 Structural Design Criteria

3.5.6 Aerodynamic Stability

3.5.6.1 Spacecraft Plus Escape Tower

3.5.6.2 Spacecraft Alone

3.5.6.3 Symbols

3.5.7 Instrumentation Requirements

3.5.7.1 On-Board Instrumentation

3.5.7.2 Data Acquisition System

3.5.8 Tracking and Support Data Requirements

3.5.8.1 General

3.5.8.2 Phototheodolite Data

3.5.8.3 Radar Tracking Data

3.5.8.4 Photographic Data

3.5.8.5 Meteorological Data

3.5.8.6 Data Disposition

3.5.9 Prelaunch Operations

3.5.9.1 Test Preparation- NAA, Downey

3.5.9.2 Test Preparation - Florida Facility

3.5.9.3 Combined Systems Check, Launch Pad

3.5.9.4 Operational Test Procedures

3.5.9.5 Launch Day Activities

3.5.10 Test Management and Organization

3.5.10.1 Test Preparation, S&ID, Downey

3.5.10.2 Florida Facility, Checkout and Launch Organization

3.5.10.3 Launch and Recovery

3.5.11 Recovery Requirements

3.5.11.1 Requirements

3.5.11.2 Recovery Forces

3.5.11.3 Recovery Concept

3.5.11.4 Location Aids

3.5.12 Launch Day Requirements

3.5.13 Pad and Range Safety Requirements

3.5.13.1 Pad Safety

3.5.13.2 Range Safety

3.5.14 Data Handling, Analysis, and Reporting

3.5.14.1 Data Handling and Processing

3.5.14.2 Calibration Data

3.5.14.3 Data Analysis and Test Evaluation

3.5.14.4 S&ID Test Reporting

3.5.15 Ground Support Equipment

3.5.15.1 General

3.5.15.2 Ground Support Equipment List

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4.0 PROPULSION SYSTEM DETAILED TEST PLANS*

4.1 TEST FIXTURE F-2 DETAILED TEST PLAN**

4.1.1 Introduction

4.1.1.1 Purpose

The Apollo Program General Test Plan, Volume V, provides the S&ID plan governing implementation and conduct of individual major test programs.

4.1.1.2 Scope

This section details the requirements for the test program to be conducted at the propulsion system development facility at White Sands Missile Range. The information presented in this test plan includes the definition of the over-all test objectives, the over-all test plan, a description of the test vehicle, and the spacecraft systems to be tested.

4.1.1.3 Precedence of Reports

This document shall take precedence over all other S&ID documents governing implementation and conduct of this detailed test plan.

4.1.1.4 Amendments

This test plan will be revised to reflect approved changes and to provide additional information that is unavailable at this time.

4.1.1.5 Definition of Priorities

4.1.1.5.1 Test Objectives

4.1.1.5.1.1 Primary Test Objectives. Primary test objectives must be obtained. Tests will not proceed until such time as the primary measurements are obtainable. A rerun of a test will be required if a primary objective is not obtained during the initial test operation.

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* Entire section reissued

** Section 4.1 is unchanged for the 30 December 1963 issue of this document. A major revision of the F-2 detailed test plan will be made in the 30 March 1964 issue.

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4.1.1.5.1.2 Secondary Objectives. Secondary objectives will be met, when possible, without cancellation or excessive delay of a test. Decisions to proceed without obtaining an objective will be made by the test conductor. Apollo Engineering will determine whether the test must be rerun if secondary objectives are not obtained. However, no test will be started if it is apparent that more than 1/4 of the secondary objectives assigned to that test cannot be obtained.

4.1.1.5.2 Systems Priorities

4.1.1.5.2.1 Primary Systems. Primary systems provide functions vital to the start and completion of the planned test. A hold or scrub is mandatory if any one of the primary systems is not functioning. These systems include GSE needed to complete the test mission profile.

4.1.1.5.2.2 Secondary Systems. Secondary systems are not functionally required to maintain the test vehicle in the planned test.

4.1.1.6 Definition of Objective Terminology

The definitions of the following terms used in conjunction with objectives for this report are given in Definition of Terms, page 7-1.

1. Demonstrate
2. Determine
3. Evaluate
4. Obtain Data
5. Establish

4.1.2 Test Program

4.1.2.1 General Test Description

The F-2 test fixture will be available prior to spacecraft 001 for ground test evaluation and certification of the service propulsion system. The F-2 fixture will simulate the dimension and functions of the spacecraft service propulsion system, but it is of "battleship" construction and utilizes both spacecraft and boilerplate hardware. This propulsion system basically consists of propellant and pressurant storage containers, an engine, and a pressure-fed transfer system. Evaluation and certification of the facility, propellant servicing system, maintenance equipment, and checkout and operating ground support equipment also will be accomplished.

Procedures for operation, maintenance servicing, and checkout of the service propulsion system will be developed. Evaluation and development tests involving mandatory risk to the system will first be performed on the

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battleship test fixture, thereby reducing the risk to spacecraft 001. After the primary objectives of the F-2 fixture have been accomplished, the fixture will continue to operate in support of the service propulsion test program.

4.1.2.2 Program Objectives and Test Sequence

4.1.2.2.1 General Objectives

1. Demonstrate the safe operation of the service propulsion pressurization system, propellant system, and engine system

2. Demonstrate the compatibility between the propellant, pressurization, and engine systems

3. Evaluate the performance of the propellant, pressurization, and engine systems

4. Demonstrate the safe operation of the service propulsion system checkout, operating, and servicing ground support equipment

5. Evaluate the performance of the service propulsion system checkout, operating, and servicing ground support equipment

6. Evaluate and develop procedures for servicing, checkout, maintenance, and operation of the service propulsion system

4.1.2.2.2 Test Series I. This series of tests covers the first complete evaluation of the service propulsion system to be performed with the F-2 test fixture. Subsequent test series will cover verification tests using flight qualified hardware, improved systems design, and problem analysis in support to spacecraft 001 and the flight program.

The sequence of tests indicated in the following paragraphs is not necessarily the order in which the tests will be accomplished in the field. The sequence and numbers of tests are also subject to change as definitive test requirements are evolved.

4.1.2.2.2.1 Block I, System Operations (Nonfiring). This block of tests will include significant engineering tests for evaluation of the SPS and GSE systems. They will be performed during the initial prefiring checkout period. Specific tests to be accomplished will be as follows:

1. Leak test of all liquid systems using gaseous nitrogen and of all helium systems using helium.

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2. Functional checkout of valves, components, and control systems to verify proper operation and correct hook-up of control circuitry

3. Calibration of propellant tank sight gauges

4. Load-unload propellants to verify proper operation of servicing GSE

4.1.2.2.2.2 Block II, Propellant Systems Calibration. The SPS propellant systems contain trim orifices to provide proper propellant flow and pressure to the SPS engine. A series of tests must be performed to develop a family of curves for use in selecting orifice sizes to produce normal conditions required for the test program. In addition, tests will be performed in this block to calibrate the flow meters installed in the propellant systems. The sight gauges on the sides of the propellant tanks will be utilized in this effort. Three separate sets of orifices will be used for the tests in this block. The test series is as follows:

1. Twelve firings of 10-second duration each. Orifice set number 1 will be installed.

2. Twelve firings of 10-second duration each. Orifice set number 2 will be installed.

3. Twelve firings of 10-second duration each. Orifice set number 3 will be installed.

4. Four firings of 10-second duration each to calibrate flow meters.

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4.1.2.2.2.3 Block III, Normal Performance Evaluation. The service propulsion system performance will be evaluated under normal system operating conditions. The tests will provide the data needed to evaluate the system performance during start, shutdown, restart, steady-state, and intermittent cycling, including gimbal operation. Base-line data will be established for subsequent design limit condition evaluations. The test items are:

1. One firing of 10-second duration for verification of proper operation of systems and components under hot firing conditions. This will be the initial firing, and similar systems shakedown tests will be performed after each major hardware change.

2. Two firings of 30-second duration each, with large propellant tank ullage volume and a 5-minute off-time between firings

3. Two firings of 30-second duration each, with small propellant tank ullage volume and 5-minute off-time between firings

4. Intermittent firings as follows:

   a. Four firings of 5-second duration each, with a 10-second off-time between firings

   b. One firing of 90-second duration, followed by a 5-minute off-time

   c. Four firings of 5-second duration each, with a 10-second off-time between firings

5. Three firings of 30-second duration each, with a 10-second off-time between firings. Engines will be gimbaled during the second and third firing.

6. Three firings of 20-second duration each. Allow sufficient off-time between firings to investigate results and evaluate data. Readjust pressure regulators to achieve 160-psig oxidizer and 163-psig fuel pressures at engine inlet. Gimbal during first and second firings.

7. One firing of 90-second duration. Allow a 10-minute off-time; then, one firing of 30-second duration. Gimbal during both firings.

8. One firing of 200-second duration, with fast gimbal cyclic rate.

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[redacted]

This completes 480 seconds of planned operation of this engine. The remaining 240 seconds may be used for tests which must be repeated or for new test requirements which arise as a result of information gained from the preceding tests. In any event, this engine must be replaced, since each of the next three tests require essentially full engine life firing.

9. Fifty firings of random duration from 5 to 60 seconds. Total firing time to be 730 seconds, with random off-times from 1- to 30-minute duration each.

4.1.2.2.2.4 Block IV, Simulated Mission Evaluation. Two simulated mission tests will be performed in this block. Evaluation of SPS engine performance during mission duty cycles will be accomplished as extensively as possible in the atmospheric conditions existing at PSDF. Total seconds of firing in this block will be approximately 1340. The test items are:

1. One continuous test to simulate a lunar orbital mission with firings, durations, and off-times as follows:

Number of Firings	Duration of Firings (sec)	Off-time
1	17	30 min
1	7	30 min
1	7	30 min
1	400	12 hrs
19	5	1 min
1	5	1 hr
1	120	8 hrs
1	5	30 min
1	2	30 min
1	2	---

2. One continuous test to simulate an aborted lunar mission with firings, durations, and off-times as follows:

Number of Firings	Duration of Firings (sec)	Off-time
1	18	30 min
1	635	8 hrs
1	2	30 min
1	5	---

4.1.2.2.2.5 Block V, Malfunction Tests. Tests in this block are for the purpose of obtaining data on various actual and simulated modes

of system or component malfunctions. Modes of failure - such as high and low propellant pressure, propellant valve failure, oxidizer and fuel depletion, helium ingestion, low voltage, and high and low propellant temperatures - will be investigated. The test items are as follows:

1. Two firings of 20-second duration each, with propellant tank pressures near relief valve settings. There will be sufficient off-time between firings to permit checks for propellant leaks.

2. Two firings of 20-second duration each, with high propellant pressures and a 30-minute off-time between firings.

3. Two firings of 20-second duration each, with low propellant pressures and a 30-minute off-time between firings.

4. Two firings of 20-second duration each, with very low propellant pressures and a 30-minute off-time between tests.

5. Four firings of 5-second duration each and one firing of 30 seconds with off-times of 10 seconds between firings. Engine valve bank "A" shall remain closed. Gimbaling will occur during 30-second firings.

6. Four firings of 5-second duration each and one firing of 30 seconds with off-times of 10 seconds between firings. Engine valve bank "B" shall remain closed. Gimbaling will occur during 30-second firings.

7. One firing of 30-second duration, with a 10-minute off-time; then three firings of 5-second duration with a 30-second off-time between firings. Low control voltage will be supplied to propellant valves during each firing.

8. Two firings of 30-second duration each, with a 10-minute off-time between firings. Low voltage will be supplied to gimbal actuator motors during each firing.

9. Three firings of 30-second duration each, with off-times of 30 minutes; then 3 firings of 5 seconds with off-times of 5 seconds. These firings will be conducted with high propellant temperatures.

10. Three firings of 30-second duration each, with off-times of 30 minutes; then 3 firings of 5 seconds with off-times of 5 seconds. These firings will be conducted with low propellant temperatures.

[redacted]

11. One firing of undetermined duration. Start with oxidizer pressure at 210 psig, fuel pressure at 205 psig, 75-percent propellant load, and helium isolation valves closed. Fire engine until inlet pressures reach 140 psig.

12. One firing of undetermined duration. Start with oxidizer pressure at 161 psig, fuel pressure at 156 psig, 50-percent propellant load, and helium isolation valves closed. Fire engine until inlet pressures reach 145 psig.

13. Helium ingestion test for which conditions and program have not been determined.

14. One firing of undetermined duration. Oxidizer load will be 2700 lb; fuel load will be 3000 lb. Fire engine until oxidizer is depleted.

15. One firing of unknown duration. Oxidizer load will be 4500 lb; fuel load will be 1350 lb. Fire engine until fuel is depleted.

4.1.2.2.3 Test Sequence. The general test schedule is presented in Section 4.1.10. This schedule reflects a logical sequence of propulsion system evaluation by test block, based on the information available at this time. As the testing progresses, schedule changes may be necessary.

4.1.2.3 Test Limitations

The static firing tests of the service module propulsion system are to be conducted at the propulsion system development facility at the White Sands Missile Range. Testing conducted under these conditions will be subject to the following deviations from the mission configuration.

1. Variable climatic conditions of temperature and humidity

2. Exposure to dust and sand

3. Test fixture rigidity (thus affecting vibration response of the propulsion system)

4. Earth surface gravity

5. Rocket engine firing without the full-expansion nozzle in place

Prior to the start of S/M propulsion system testing at WSMR, the following component and systems tests must be accomplished.

[redacted]

1. Design Information Testing. In accordance with Engineering Development Laboratory directives,

   a. Propellant transfer system bread-board tests with fluid flow

   b. Gas pressurization system bread-board with inert gases, helium and nitrogen

Data from these tests must be available before "hot" firing tests can be conducted at WSMR.

2. Rocket Engine Design Testing. In accordance with S&ID document SID 62-651, paragraph 3.2.3 (Aerojet Co., Rept 3865-13A), the main service propulsion engine must be developed to a prequalification level of 750 seconds of intermittent and/or continuous firing capability.

3. F-2 Fixture Tests at NAA, Los Angeles Division. In accordance with S&ID OTP-P-4000, the propellant tankage, transfer system, and pressurizing systems must be tested for leakage and function.

4.1.2.4 Test Implementation

The tests set forth in this test plan will be implemented in the field through the medium of Section 4.1.11, Detailed Test Descriptions, which will be considered test directives. Deviations from these directives, necessary to configuration or test requirement changes, will be implemented through a verification notice from S&ID to NASA-MSC-ASPO. This notice will verify specific schedule dates for individual tests and will contain information as to whether the detailed test description (latest revision) will be followed or whether deviations are necessary. If deviations are necessary, they will be described in detail for approval by NASA-MSC-ASPO.

4.1.3 Configuration

4.1.3.1 Test Fixture F-2

The test fixture F-2 simulates the spacecraft S/M main propulsion system but is of battleship construction, utilizing both spacecraft and boiler-plate hardware.

The spacecraft S/M main propulsion system, as installed in the spacecraft, is of the liquid propellant type, using earth storable hypergolic propellants. The fuel (MIL-P-27402) is a 50-50 blend of unsymmetrical

[redacted]

dimethylhydrazine (UDMH) and hydrazine (N_2H_4). The oxidizer is nitrogen tetroxide (N_2O_4). A 175-psia pressure-fed system supplies the propellants to the thrust chamber. The fuel supply is contained within two hemispherically ended cylindrical tanks with their inlet and outlet ports connected in series. The capacity of two fuel tanks is 15,738 pounds. The oxidizer supply is also contained in two hemispherically ended cylindrical tanks connected in series. The capacity of two oxidizer tanks is 31,620 pounds. A helium system is used to pressurize the propellant tanks. The helium supply is contained within eight spherical tanks with a capacity of 98 pounds of He pressurized to 4000 psig.

The main propulsion engine develops a nominal 21,900 pounds of thrust in space (vacuum) and has a specific impulse of 315 seconds. It is equipped with a 60:1 expansion ratio nozzle. The engine has a gimbal mechanism with excursions in Z of ±8.5 degrees and Y of ±6.0 degrees. For a more detailed breakdown of this system, refer to SID 62-700-2. Figure 4-1 shows the F-2 test fixture.

4.1.3.1.1 F-2 Fixture Description and Implementation. The following describes the F-2 fixture and defines the configuration.

1. Propellant tankage is to be of the same internal size, shape, and plumbing interfaces as the spacecraft flight configuration, but of boilerplate construction.

2. The pressure vessels are to be of boilerplate construction and spacecraft volume.

3. Component hardware, such as pressure regulators, is to be off-the-shelf, but spacecraft hardware will be employed as it becomes available.

4. Plumbing is to be boilerplate, but spacecraft hardware will be used as it becomes available.

5. The first engine is to be a prototype SPS engine without an operable gimbal mechanism. Qualified engines with operable gimbal mechanism will be used when they become available. The expansion bell will be removed from the thrust chamber, leaving the 6:1 expansion nozzle for sea-level operation.

6. Structural steel will be utilized to provide tankage support, stand tie-down, and engine mounting.

7. Instrumentation for the F-2 fixture will be as called out in Section 4.1.4.1.

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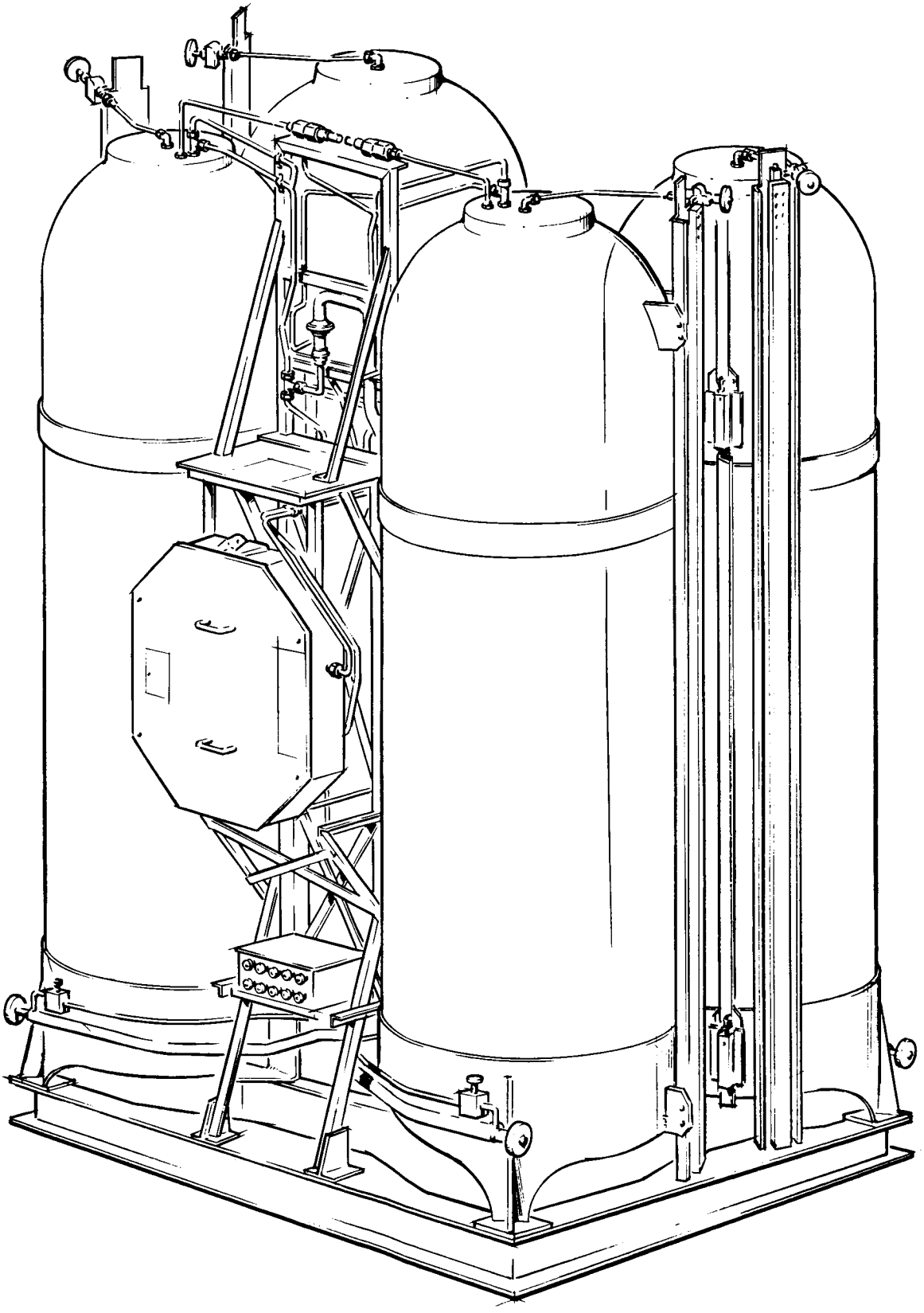

Figure 4-1. Propulsion System Test Fixture F-2

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The ground support equipment (GSE) concept for the Apollo program is not complete at this time. Items of GSE and their use are currently being completed. GSE will be listed under four groups:

Auxiliary equipment
Checkout and control equipment
Handling equipment
Servicing equipment

The present GSE requirements list is given in paragraph 4.1.3.2. For more detailed descriptions and up-to-date configurations (as they become available) refer to document SID 62-1014-2, Definitions and Objectives, Apollo Ground Support Equipment.

4.1.3.2 F-2 Fixture-GSE

Model	Nomenclature
A14-044	Nozzle Closure
A14-015	Nozzle Plug (140 psi)
A14-045	Control Crane Auxiliary
A14-056	Link Gimbal Locking Fixture S/M
A14-131	Nozzle Plug (10 psi)
A14-127	Nozzle Extension Inertia Simulator
C14-017	Service Propulsion Engine Alignment Set
C14-075	Propellant System Fluid C/O Unit
C14-075	Propellant System Fluid C/O Unit
C14-079	SPS Engine Electrical B/M Console
C14-163	S/M SPS Propulsion Quantity Gauging BME
C14-179	Cable Set, Electrical (-21)
C14-179	Cable Set, Electrical (-41)
C14-406	Electrical Terminal Distributor
C14-408	Thrust Chamber, B/M Alignment
C14-426	Calibration Unit, Pressure 6000 psig
C14-427	Calibration Unit, Fluid Flow Rate
C14-428	Calibration Unit, Temperature
C14-435	Electrical Terminal Distributor Terminal Room
C14-437	Electrical Terminal Distributor Control Center
C14-438	Electrical Terminal Distributor Test Stand
C14-439	Electrical Terminal Distributor Shelter
C14-444	Fluid Distributor Control Unit SPS Oxidizer
C14-445	Fluid Distributor Control Unit SPS Fuel
C14-454	Propulsion Quantity Gauging System C/O Euipment
C14-455	SPS C/O and Monitoring Remote Control Rack
C14-602	SPS C/O and Firing Console
C14-613	Test Direction Panel

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Model	Nomenclature
H14-021	GSE Handling Cart
H14-024	S/M Propulsion Motor Sling
H14-037	Propulsion Development Test Ground Adapter
H14-052	Position Trailer Narrow Base
H14-072	Mission Propulsion Engine Support
H14-100	B-2 Access Stand
H14-101	B-1 Access Stand
H14-106	Test Fixture and Ground Adapter Sling
H14-107	F-2 Support Stand
H14-120	SPS Engine Support
H14-132	SPS Engine Dolly
S14-002	N_2O_4 Transfer Unit (Int.)
S14-003	Mass Spec. Leak Tester He
S14-007	Pressure Contamination Prevention Unit
S14-008	UDMH and N_2H_4 Transfer Unit (Int.)
S14-022	Helium Booster Unit
S14-023	Pressure Maintenance Unit
S14-043	Fluid Distribution System (PSDF)
S14-058	Fuel Ready Storage Unit
S14-059	Oxidizer Ready Storage Unit
S14-060	Fuel Toxic Vapor Disposal Unit
S14-061	Oxidizer Toxic Vapor Disposal Unit
S14-069	Dewpoint Meter
S14-070	Decontamination Unit
S14-071	Brazing Unit, Portable
S14-075	Propulsion Detection System
S14-076	Mobile GN_2 Bottle Rack

4.1.3.3 Facilities

The propulsion test facility will consist of the following major areas to support both F-2 and S/C 001 test programs.

1. Test Stand 1—Supports F-2 fixture test program

2. Test Stand 2—Supports S/C 001 test program

3. Control Center (Common to both test stands)

   a. Control room

   b. Data acquisition room

   c. Observation room

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d. Electrical power and air conditioning room

4. Test Preparation Building

a. Photo laboratory

b. Viewing room

c. Calibration and standards laboratory

X-ray
Analytical laboratory
Hygiene
Hazardous test
Office
Filtration analysis
Precision tool room
Nonconformance report crib

d. Clean room

e. Fuel decontamination

f. Oxidizer decontamination

g. Scape Suit area

h. Reproduction

i. Tech files

j. Conference room

k. Office

l. First aid room

m. Machine shop

n. Mechanical shop

o. GSE storage

p. Checkout and maintenance bay

q. Electronics shop

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r. Tool room

s. Checkout room

t. Vehicle inspection

u. Mechanical and electrical equipment

5. Propellant Storage Area-Supports S/C 001 and F-2 for the following gases, liquids, and propellants

a. UDMH-N_2H_4—minimum capacity, 144,000 pounds

b. N_2O_4 tank—minimum capacity, 216,000 pounds

c. LH_2 tank—minimum capacity, 14,000 gallons

d. LO_2 tank—minimum capacity, 3500 gallons

e. He tank—2 tube bank trailers at 2200 psig to 400 psig

f. GN_2 tank—minimum capacity, 1000 cubic feet (water volume) at 2200 psi.

g. MMH tank—minimum capacity, 200 gallons (in drums)

h. LN_2 tank—minimum capacity, 4500 gallons

6. Propellant Transfer and Control Facility. This facility is in design stages. A description will be given when design effort is completed.

4.1.4 Instrumentation and Data Acquisition Requirements

4.1.4.1 Instrumentation System

The propulsion test program will require an instrumentation system to accomplish the test requirements. The system will be composed of the following types of equipment.

1. Transducers located on the test vehicles, test stands, and GSE

2. Signal conditioning equipment located on the test vehicles, test stands, and GSE terminal room

3. Excitation sources for the transducers

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4. Junction boxes and associated wiring from the test vehicles and test stands to the GSE terminal room data input patch panels

5. Closed-circuit TV cameras and associated equipment

6. Fastex photo cameras for engineering data

7. Monitoring cameras for documentation of hazardous operations

8. Six dual-channel potentiometer-type pen recorders

The transducer requirements are set forth in the equipment list.

4.1.4.2 Data Acquisition System

The data acquisition system will provide on-line instrumentation displays, quick-look playback capabilities, and magnetic-tape storage of all data from the instrumentation system.

4.1.4.2.1 System Description. The output of the instrumentation system will terminate at the data acquisition system input patch panels in the GSE terminal room. The high-frequency measurement will use frequency modulation and FM multiplexing to prepare the data for magnetic-tape storage. The high accuracy measurements will employ PCM techniques. The subcarrier oscillators and multiplex equipment for the analog system and the multiplexing and digitizing equipment for the digital system will be located in the GSE terminal room. Transmission from the GSE terminal room to the blockhouse will be by coaxial cables. Magnetic recorders will be located in the blockhouse. To provide playback and display, FM demodulation and PCM decommutation equipment will be required. The system will incorporate a timing system for time-code generation and system synchronization. The type of data output will be "quick-look": oscillographs, graphic recorders, event recorders, and motors. Detailed data analysis will be performed at Downey.

4.1.4.2.2 System Capacity. There will be 100-percent magnetic-tape recording of all data. On-line and playback capacity will be as follows:

1. Two 36-channel oscillographs

2. Two 18-channel Offner recorders

3. One 50-channel event recorder

4. One 100-channel CRT bar graph (part of PCM decommutation)

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4.1.5 Support Requirements

4.1.5.1 General

The details of support requirements that might apply to the static firing program are provided in SID 62-931. This section will summarize support requirements applicable to the static firing program.

4.1.6 Pretest Operations

The F-2 fixture test preparation program consists of planning, performing, and evaluating a series of engineering tests of the F-2 fixture. This program will be conducted at the NAA LAD, prior to shipping the F-2 fixture to PSDF.

Upon arrival at the PSDF test site, the F-2 fixture will be inspected and prepared for transportation to, and erection on, test stand 1.

In preparation for testing on the test stand, all systems will be checked for function, and the fluid systems will be qualified for testing by the application of pressure, leakage, and flow tests. All instrumentation will be checked out and calibrated with the readout instrumentation in the control center.

This program is intended to insure the satisfactory operation of the service module main propulsion system, represented by the F-2 fixture assembly. The objective of these preparation tests is to ready the F-2 fixture for the static firing test program.

4.1.6.1 Test Preparation - NAA Los Angeles Division

Manufacturing, acceptance, and preparation tests will be performed at the Los Angeles Division Engineering Research Laboratory. These tests will be performed per OTP-P-4000A-F-2, and include complete systems leak and functional checkout.

4.1.6.2 Receiving Inspection and Checkout at WSMR

The F-2 fixture will be shipped fully assembled to WSMR. A general familiarization and review of checkout procedures will precede the actual test program.

Gas-system and propellant-system tests will be performed to insure functional operation and to verify that the system integrity has not deteriorated during shipment. The tests will be performed in an interim test preparation area in building 1540 at WSMR.

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4.1.6.3 Installation - Test Stand

At the test stand, the fixture will be mounted and aligned. Instrumentation and control continuity will be established with the blockhouse equipment. Individual and combined-systems checkout tests will be conducted on the propellant-delivery, pressurization, and engine systems. Instrumentation throughout the test fixture will be calibrated with the data acquisition system. Fueling, defueling, purge, leak checks, and pressurization servicing tests will be performed. Simulated firings will be conducted to verify over-all systems operation and compatibilities for normal and emergency conditions.

4.1.6.4 Test Procedures

This section contains a listing of detail checkout procedures required for the conduct of all activity at the test areas. A procedure sequence chart depicting the time-phasing of all procedures in each test area will be established.

F-2 OPERATIONAL TEST PROCEDURES

Number	Procedure
OTP-P-4000A-F-2	Preparation of the F-2 service module propulsion system test fixture at the Los Angeles Division
OTP-S-3050-F-2	Storage of F-2 at WSMR building 1540
OTP-S-4106-F-2	Leakage and functional check of the F-2 service propulsion system at building 1540, WSMR
OTP-S-4100-F-2	F-2 service propulsion system leakage check
OTP-S-8091-F-2	Pressure and temperature transducer spot check while installed on F-2 at WSMR building 1540
OTP-S-4101-F-2	F-2 service propulsion system functional check
OTP-S-9043-F-2	A14-044 nozzle closure validation
OTP-S-9044-F-2	H14-024 service module propulsion engine sling validation
OTP-S-9045-F-2	H14-072 mission propulsion engine support validation
OTP-S-9046-F-2	H14-052 position trailer narrow base validation and operating instructions
OTP-S-9051-F-2	H14-106 F-2 test fixture and H14-037 adapter sling validation
OTP-S-3053-F-2	Handling of F-2 while inactive at PSDF
OTP-S-9052-F-2	H14-132 service propulsion system engine dolly validation
OTP-S-9054-F-2	C14-602 service propulsion system test unit validation
OTP-S-9056-F-2	C14-444 service propulsion system (oxidizer) fluid distribution control unit validation

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F-2 OPERATIONAL TEST PROCEDURES (cont)

Number	Procedure
OTP-S-9057-F-2	C14-613 test director console
OTP-S-9058-F-2	C14-445 service propulsion system (fuel) fluid distribution control unit validation
OTP-S-9059-F-2	C14-XXX ground relay control unit validation
OTP-S-9060-F-2	Combined C14-179 cable set and C14-435, C14-437, C14-438, C14-439 terminal strip electrical validation
OTP-S-9061-F-2	S14-907 pressure contamination prevention unit validation
OTP-P-9062-F-2	S 14-023 pressure maintenance unit validation
OTP-P-4104-F-2	S 14-022 helium booster unit, operation, validation and helium system pressurization
OTP-P-9064-F-2	S14-002 N_2O_4 (oxidizer) transfer unit validation
OTP-P-9053-F-2	S14-008 UMDH & N_2H_4 (fuel) transfer unit validation
OTP-P-9065-F-2	S14-043 fluid distribution (propellant) system validation
OTP-P-9066-F-2	S14-058 fluid ready storage unit validation
OTP-P-9067-F-2	S14-059 oxidizer ready storage unit validation
OTP-P-9068-F-2	S14-060 fuel toxic vapor disposal unit validation
OTP-P-9069-F-2	S14-061 oxidizer toxic vapor disposal unit validation
OTP-P-9070-F-2	S14-070 decontamination unit validation
OTP-P-9071-F-2	C14-408 thrust chamber bench maintenance alignment validation
OTP-P-3051-F-2	Shipment of F-2 from WSMR building 1540 to PSDF test stand No. 1
OTP-P-9006-F-2	A14-046 auxiliary crane control checkout and operating instructions
OTP-P-9040-F-2	Removal and installation of the PSDF test stand No. 1 removable enclosure (roof)
OTP-P-9041-F-2	Removal and installation of the PSDF test stand No. 1 removable platform (grating)
OTP-P-9042-F-2	Installation and removal of H14-037 test adapter on/from PSDF test
OTP-P-3052-F-2	Installation and removal of F-2 on/from PSDF test stand No. 1
OTP-P-9047-F-2	C14-017 service propulsion engine alignment set validation
OTP-P-4110-F-2	F-2 service propulsion engine handling, storage, and shipping
OTP-P-4111-F-2	Installation and removal of the service propulsion engine on/from the test fixture
OTP-P-9048-F-2	C14-426 calibration unit, high pressure, validation

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F-2 OPERATIONAL TEST PROCEDURES (cont)

Number	Procedure
OTP-P-9049-F-2	C14-427 calibration unit, flow rate, validation
OTP-P-9050-F-2	C14-428 calibration unit, temperature, validation
OTP-P-8082-F-2	F-2 instrumentation transducer and cabling installation and removal
OTP-P-8083-F-2	Continuity check of instrumentation wiring while F-2 is installed on the test stand
OTP-P-1041-F-2	Continuity check of F-2 control wiring
OTP-P-8084-F-2	F-2 transducer and signal conditioning functional check
OTP-P-8080-F-2	Temperature transducer calibration spot check on F-2 while on the test stand
OTP-P-8081-F-2	Pressure transducer calibration spot check on F-2 while on the test stand
OTP-P-8085-F-2	Vibration transducer (Gulton) calibration spot check on F-2 while on the test stand
OTP-P-8087-F-2	Baldwin-Lima-Hamilton Model U3XXA load cell (thrust) calibration
OTP-P-9073-F-2	A14-045 nozzle plug validation
OTP-P-9075-F-2	C14-O75 propulsion system fluid C/0 unit validation and operating instructions
OTP-P-9076-F-2	C14-079 electro-mechanical B/M console equipment validation end operating instructions
OTP-P-9077-F-2	H14-120 service propulsion system engine support
OTP-P-4112-F-2	F-2 service propulsion engine leakage and functional check
OTP-P-9078-F-2	Decontamination procedure for the facility propellant systems
OTP-P-4113-F-2	F-2 service propulsion engine decontamination
OTP-P-0013-F-2	GSE integration checkout procedure
OTP-P-8088-F-2	F-2 data acquisition system prerun checkout
OTP-P-9079-F-2	C14-163 service propulsion system quantity bench maintenance equipment validation
OTP-P-4102-F-2	F-2 oxidizer tank and detank
OTP-P-4103-F-2	F-2 fuel tank and detank
OTP-P-1042-F-2	Emergency power checkout
OTP-P-4114-F-2	Service propulsion engine prefire checkout
OTP-P-0011-F-2	F-2 prefire countdown
OTP-P-0012-F-2	F-2 firing countdown
OTP-P-4105-F-2	F-2 postfire check list
OTP-P-4115-F-2	Service propulsion engine postfire procedure
OTP-P-9081-F-2	S14-003 mass spectrometer leak tester validation and operating instructions

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F-2 OPERATIONAL TEST PROCEDURES (cont)

Number	Procedure
OTP-P-8090-F-2	F-2 Quantity transducer calibration validation
OTP-P-9063-F-2	A14-029 checkout system verification unit validation
OTP-P-9072-F-2	S14-069 dew point meter validation
OTP-P-9074-F-2	S14-075 propellant detection system validation
OTP-P-9080-F-2	S14-076 spacecraft GSE crossover distribution validation
OTP-P-9083-F-2	C14-454 propellant quantity gauging system checkout equipment validation
OTP-P-9082-F-2	C14-455 service propulsion system checkout monitor panel remote control rack validation

4.1.7 NAA Test Management and Organization

4.1.7.1 Program Management Relationships

The Apollo Program Manager, through the Apollo Engineering organization, is responsible for determining the requirements for tests, for proper utilization of data, and for controlling the configuration of test vehicles and associated GSE.

The division director of Test and Quality Assurance, through the director of Apollo Test and Operations, has direct responsibility for the conduct of all Apollo testing at WSMR.

The ATO-WSMR Manager, reporting directly to the director of Apollo Test and Operations, is responsible for all test and support functions at WSMR in keeping with established S&ID policies and procedures.

The ATO-WSMR Manager is responsible for interfaces with the NASA Resident Manager and the WSMR in consonance with policy guidance from S&ID and MSC.

4.1.7.2 ATO-WSMR

4.1.7.2.1 Basic Considerations. The S&ID Apollo Test and Operations concept for the conduct of the propulsion test program at PSDF is presented below. Included are the organizational charts, statements of functional responsibility, and relationships between the ATO-WSMR and the NASA Resident Manager and the WSMR.

4.1.7.2.2 Propulsion Tests. These tests will be conducted at the Apollo Propulsion System Development Facility on the west side of the WSMR.

NASA and the Corps of Engineers are responsible for site selection, preparation, and construction. NASA/S&ID will be responsible for the test article, test equipment, and GSE installation and checkout.

The administrative functions, shown in the attached organization charts, were designed to support both the propulsion and mission abort test groups with minimum overhead and maximum utilization of personnel and resources. The two test groups are also mutually self-supporting, and the movement of both technical and support personnel to WSMR, on either a trip or change of assignment, is time-phased to match peak test periods.

4.1.7.3 ATO-WSMR Organization

The lines of communications for the WSMR test organization are shown in Figure 4-2. For the F-2 test program and spacecraft 001 test program, ATO technical responsibility is combined under one group with formal conduct of the test operations being the responsibility of the respective test conductor.

4.1.7.3.1 ATO-WSMR Manager. The manager of ATO-WSMR is responsible to the director of the Apollo Test and Operations, S&ID, Downey, and to NASA for implementing and interpreting the directions and policies of the Apollo test program at WSMR. The ATO-WSMR Manager directs all S&ID activities at WSMR and is responsible for establishing effective working relations with the local NASA, WSMR, and associate contractor managers.

4.1.7.3.2 Service Propulsion Tests Chief. The service propulsion test chief is responsible to the ATO-WSMR Manager for the planning, preparation, coordination, conduct, and reporting of the service propulsion tests. This includes defining personnel requirements, facilities requirements and criteria, and instrumentation and data requirements; accepting and preparing propulsion test vehicles; the direct supervising of all tests conducted in the Apollo propulsion test area; maintaining, modifying, and operating all GSE associated with this program; and preparing and submitting test plans, procedures, and reports. The functional breakdown of this organization is presented in Figure 4-3.

4.1.7.3.3 Engineering Project Engineer. The S&ID Apollo Engineering project engineer represents the chief engineer in coordination of the effort on the propulsion test vehicles. This includes the following responsibilities:

1. Configuration of the test vehicle, GSE, and instrumentation

2. Approval of engineering orders, procurement specifications, schedules, test plans, etc.

3. Coordination of all aspects of each test vehicle activity to assure proper balance in concept, design, construction, and test

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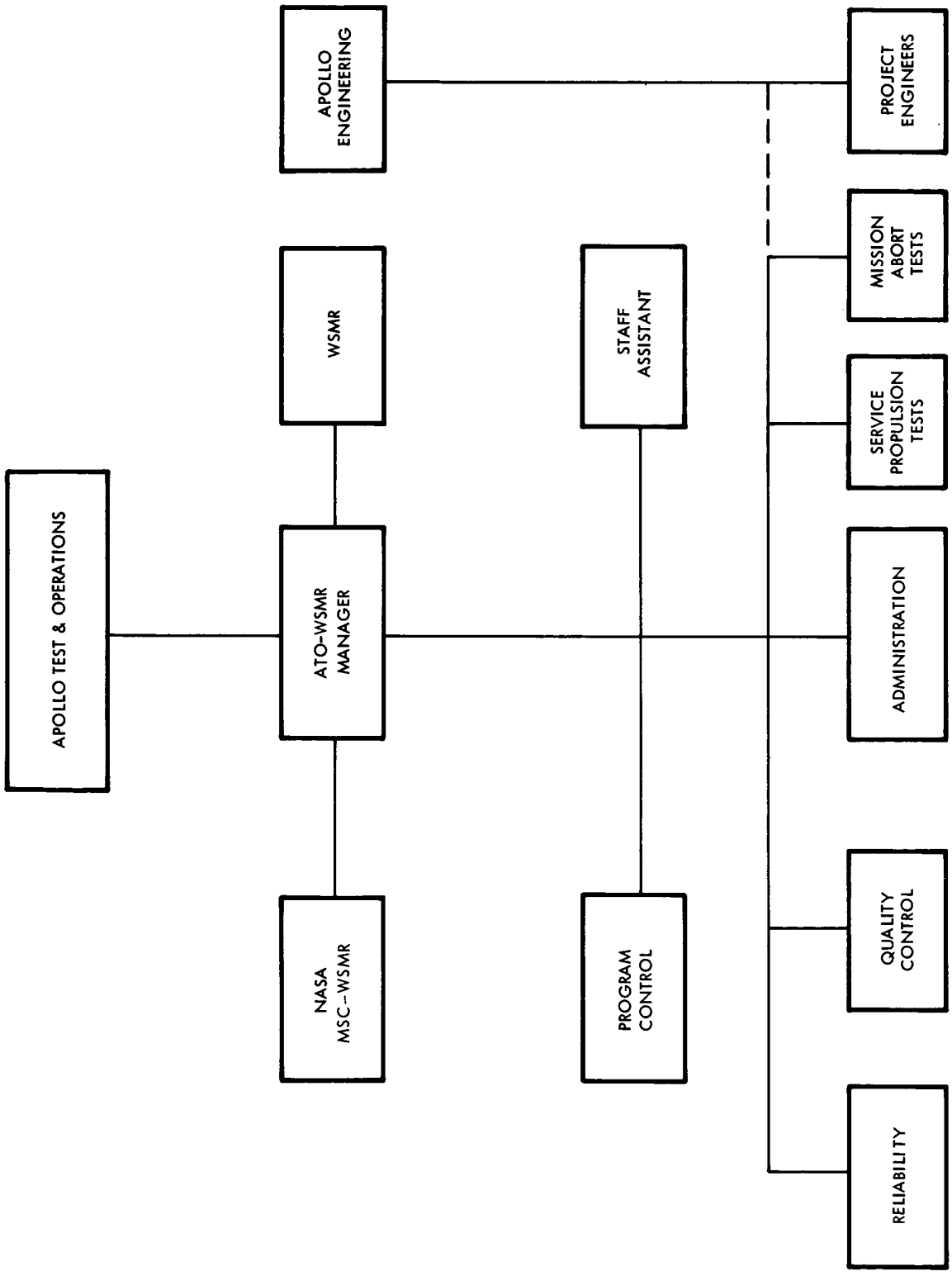

Figure 4-2. ATO-WSMR Organization

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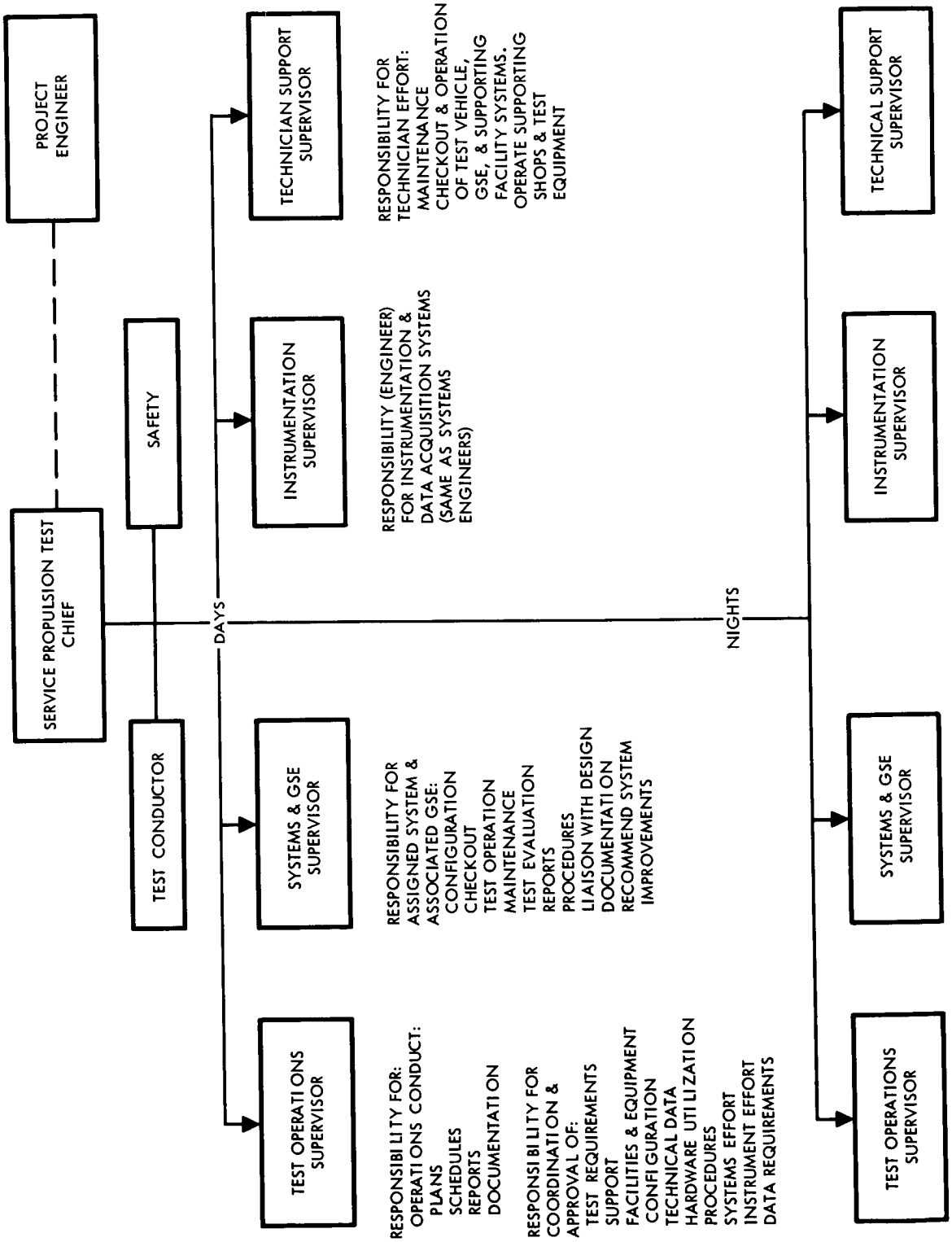

Figure 4-3. ATO Propulsion Test Functional Organization (WSMR)

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4.1.7.3.4 Test Conductor. The assigned F-2 test conductor will be directly responsible to the service propulsion test chief for the conduct of test operations and will approve all working documents pertinent to the test accomplishment. The ATO test operations conduct is depicted in Figure 4-4.

4.1.7.3.5 Administration. The administrative chief is responsible to the ATO-WSMR manager for all administrative and housekeeping functions associated with ATO testing at WSMR. He coordinates all administrative support furnished by WSMR for the mission abort tests and represents the ATO-WSMR manager on any boards, panels, and committees that may be required. He is responsible for the operation, maintenance, improvement, support, and modification of the propulsion, administrative, and test areas assigned to the NASA and S&ID. These responsibilities can be described as follows:

1. Personnel includes the supervisory and operating responsibility for employment, wage and salary review, employee relations, industrial hygiene and safety, medical and food service, and the preparation of all local operating procedures pertaining to these subjects.

2. Finance includes the supervisory and operating responsibility for timekeeping, disbursement, petty cash and payroll, and the preparation of all local operating procedures pertaining to these subjects.

3. Material includes the supervisory and operating responsibility for warehousing and supply, purchasing, property records and control, tool cribs, transportation, pool cars and leased vehicles, maintenance of mobile equipment, and preparation of all local operating procedures pertaining to these subjects.

4. Logistics includes the supervisory and operating responsibility for updating, operating, maintenance, checkout, and test procedures manuals; determination of spares and spares levels; reproduction and photographic support, including processing; and the preparation of all local operating procedures pertaining to these subjects.

5. Security includes the supervisory and operating responsibility for coordinating all security activities and investigations and maintaining police and fire protection, lock and key control, identification badges, communications, vehicle and visitor control, mail distribution, classified document control, and the preparation of local operating procedures pertaining to these subjects.

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6. Facilities includes the responsibility for operation, maintenance, and modification of NASA and S&ID facilities in the propulsion area; maintenance of industrial property records; and the preparation of all local operating procedures pertaining to these subjects.

4.1.7.3.6 Quality Control. The Quality Control Supervisor is responsible to the ATO-WSMR Manager for ensuring the S&ID products at WSMR meet the high standards required by NASA and NAA. This includes physical inspection and functional verification of test vehicles, GSE, and test facilities; the preparation of required historical records, inspection forms, and malfunction reports; the operation of laboratories and calibration standards; and the preparation of all local operating procedures pertaining to these subjects.

4.1.7.4 Configuration Control

The F-2 test vehicle, GSE, and instrumentation configuration will be controlled by engineering drawings and engineering orders. Incorporation of EO's will be authorized through workbook entry by ATO engineers. Change verification records will be maintained on all major hardware assemblies, so that completed EO change configurations are available at all times. A current test vehicle configuration control summary will be maintained. The S&ID project engineer will approve recommended changes required to facilitate updating of the configuration summary and its dissemination to S&ID Downey and the NASA. This general outline of configuration control procedures will be amplified when methods and procedures for the maintenance of documentation and communication channels are resolved.

4.1.7.4.1 TAIR Book. The test and inspection record (TAIR) book is a control and a record of all activities on the test vehicle and GSE. It remains with the hardware. Entries generating work will be entered in the TAIR book by ATO service propulsion test and quality control personnel.

4.1.7.5 Engineering Orders

The Apollo Test and Operations/Apollo Engineering working relationship with respect to engineering orders is depicted in Figures 4-5 and 4-6.

4.1.7.6 Procedure Preparation and Control

Checkout procedures will be prepared by Apollo Test and Operations in accordance with engineering process specifications. These procedures will be approved by engineering system integration prior to use by the ATO field organization. The assigned engineering project engineer will acquire this approval or approve the procedure in lieu of assigning engineering systems integration personnel to the field. The basic procedure flow diagram is shown in Figure 4-7.

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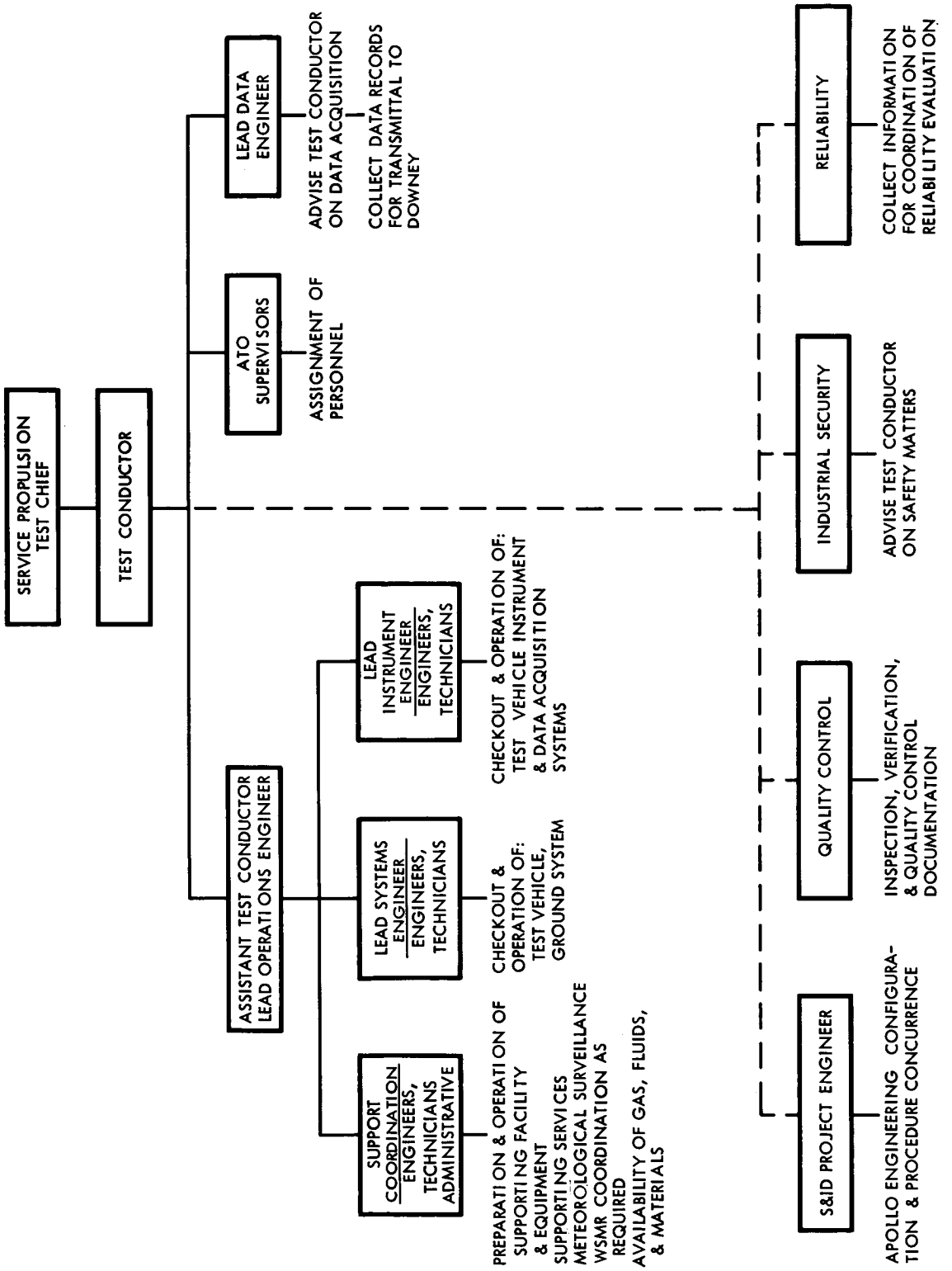

Figure 4-4. ATO-Test Operations Conduct Organization

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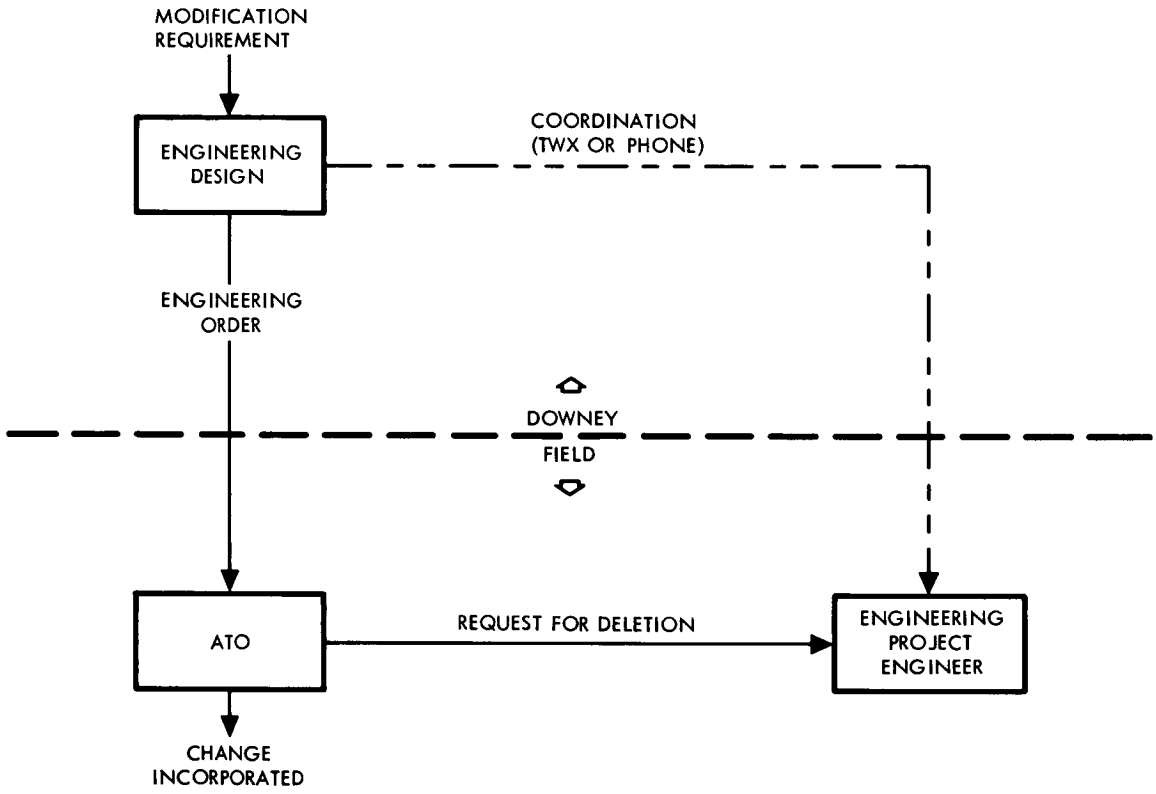

Figure 4-5. Downey-Originated Engineering Orders

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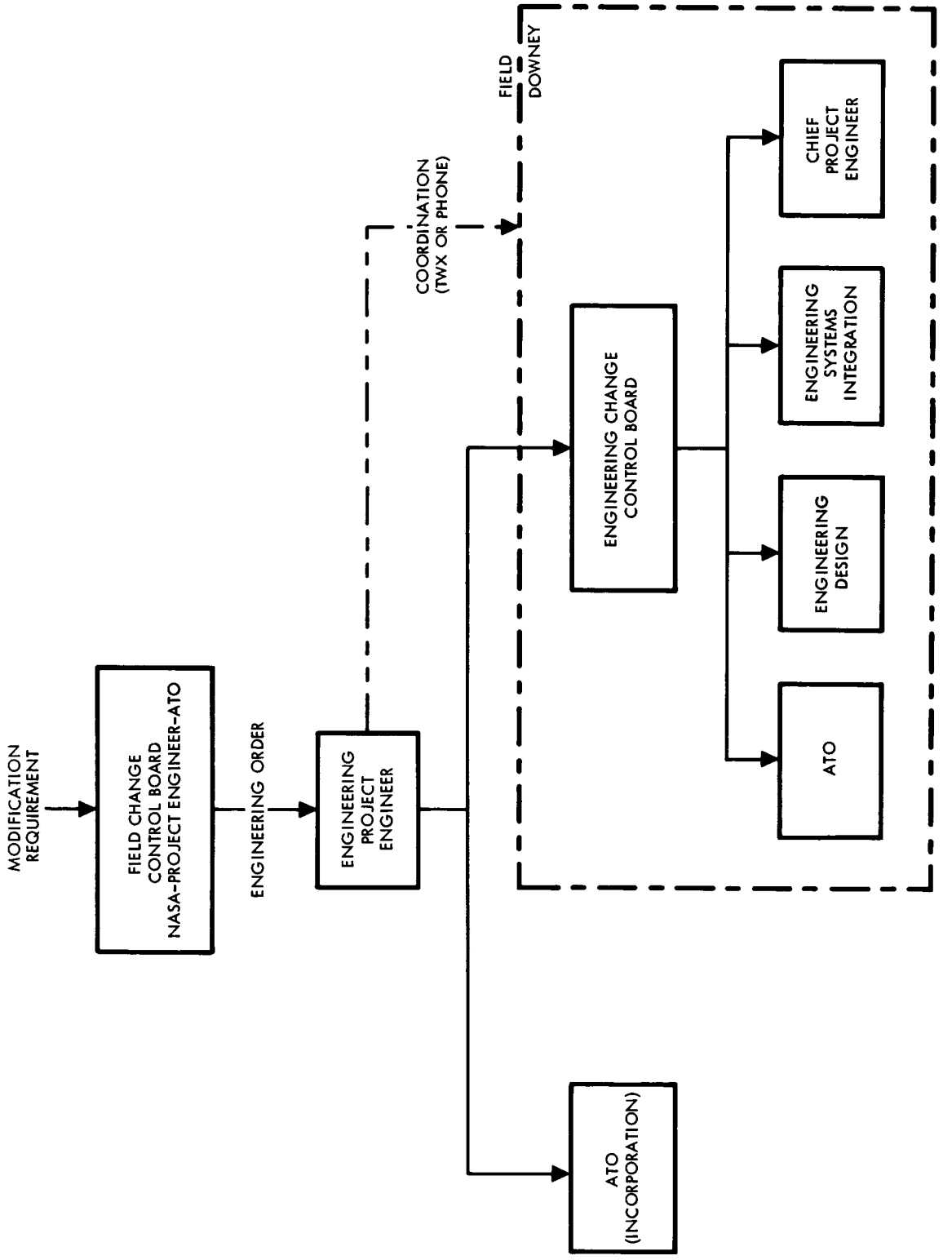

Figure 4-6. Field-Originated Engineering Orders

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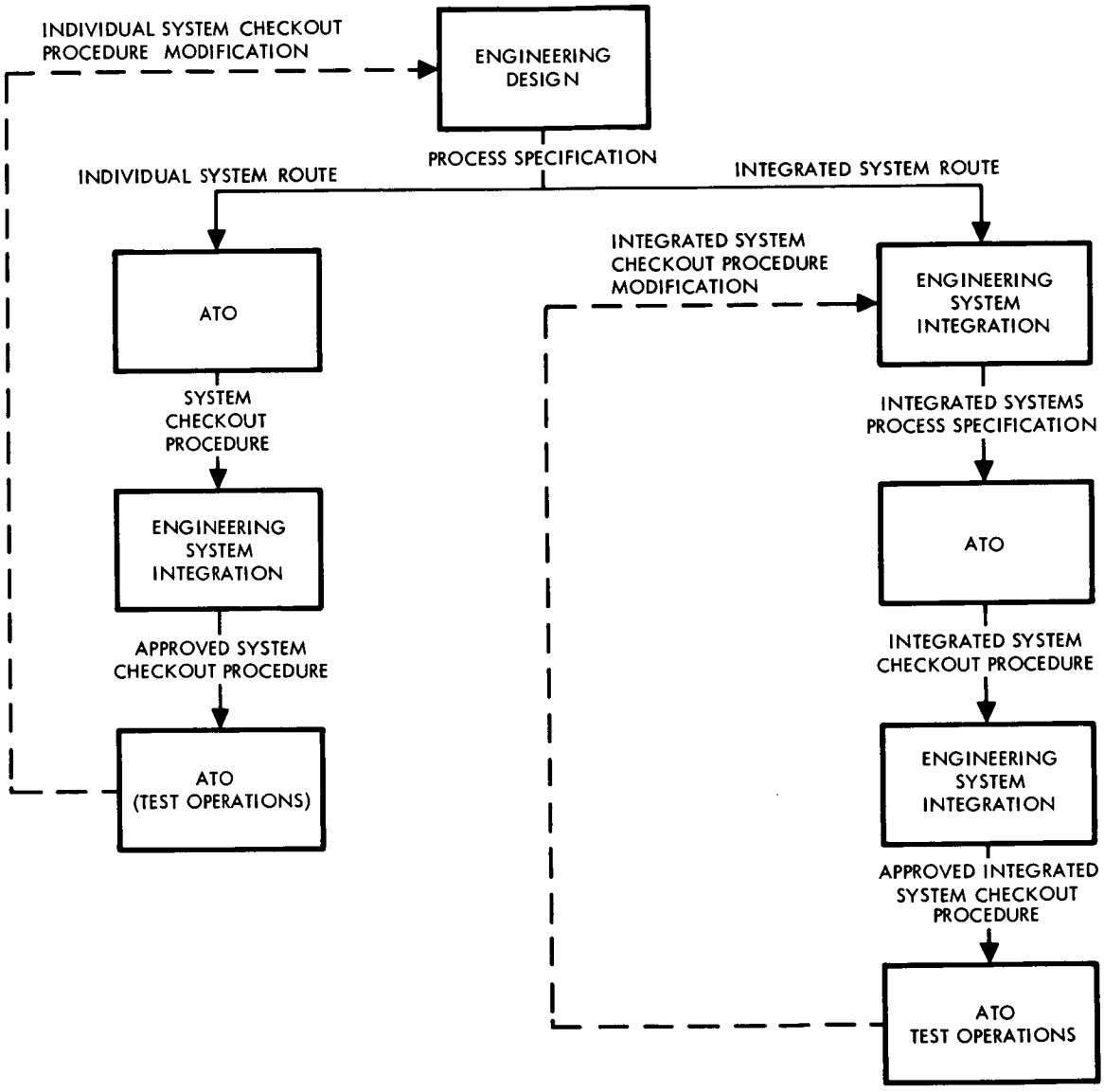

Figure 4-7. Checkout Procedures

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4.1.7.7 Test Plan Preparation and Control

The F-2 propulsion test plan is prepared by Apollo Test and Operations to satisfy test requirements generated by Apollo Engineering. The basic test plan flow diagram is shown in Figure 4-8. The NASA project engineer will approve the test plan.

4.1.7.8 Instrumentation Measurement List Preparation and Control

The F-2 instrumentation measurement list is prepared by engineering systems integration in coordinated effort with ATO and engineering instrumentation design. This list is primarily generated from individual data measurement required by the design units concerned with the test. The measurement list flow diagram is shown in Figure 4-9.

4.1.8 Safety Requirements

In general, WSMR test site safety regulations will reflect one or more of the following manuals and regulations:

1. All applicable NAA regulations, and Specifically Industrial Hygiene and Safety Manual for the NASA Propulsion Development Facility, WSMR, dated October 1962, and subsequent revisions

2. Air Force Manual 32-2, Accident Prevention Handbook

3. Corps of Engineers Manual, EM385-1-1, General Safety Requirements

4. Ordnance Corps ORD M7224 (T.O. 11A-1-40) Ordnance Safety Manual

5. Air Force T.O. 11C-1-6, General Safety Precautions for Missile Liquid Propellants

6. Safety Orders of the State of New Mexico

7. National Safety Council - Accident Prevention Manual for Industrial Operations

4.1.8.1 Pad Safety

4.1.8.1.1 Safety Signals. Both visual and audible warning signal devices will be installed on the test site to inform personnel of hazard status. The system will consist of green, amber, and red lights, klaxon horns, and a public address system.

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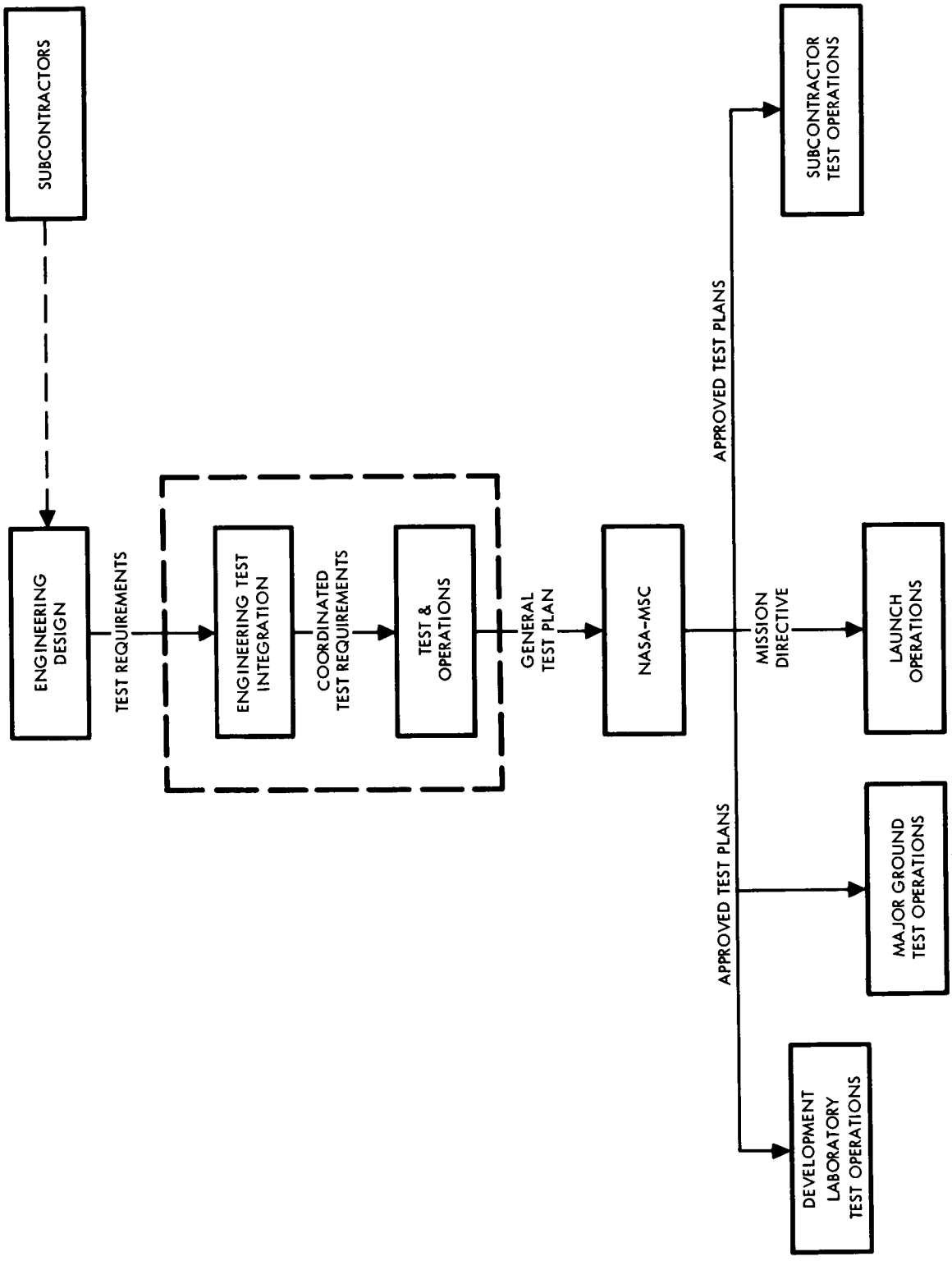

Figure 4-8. General Test Plan

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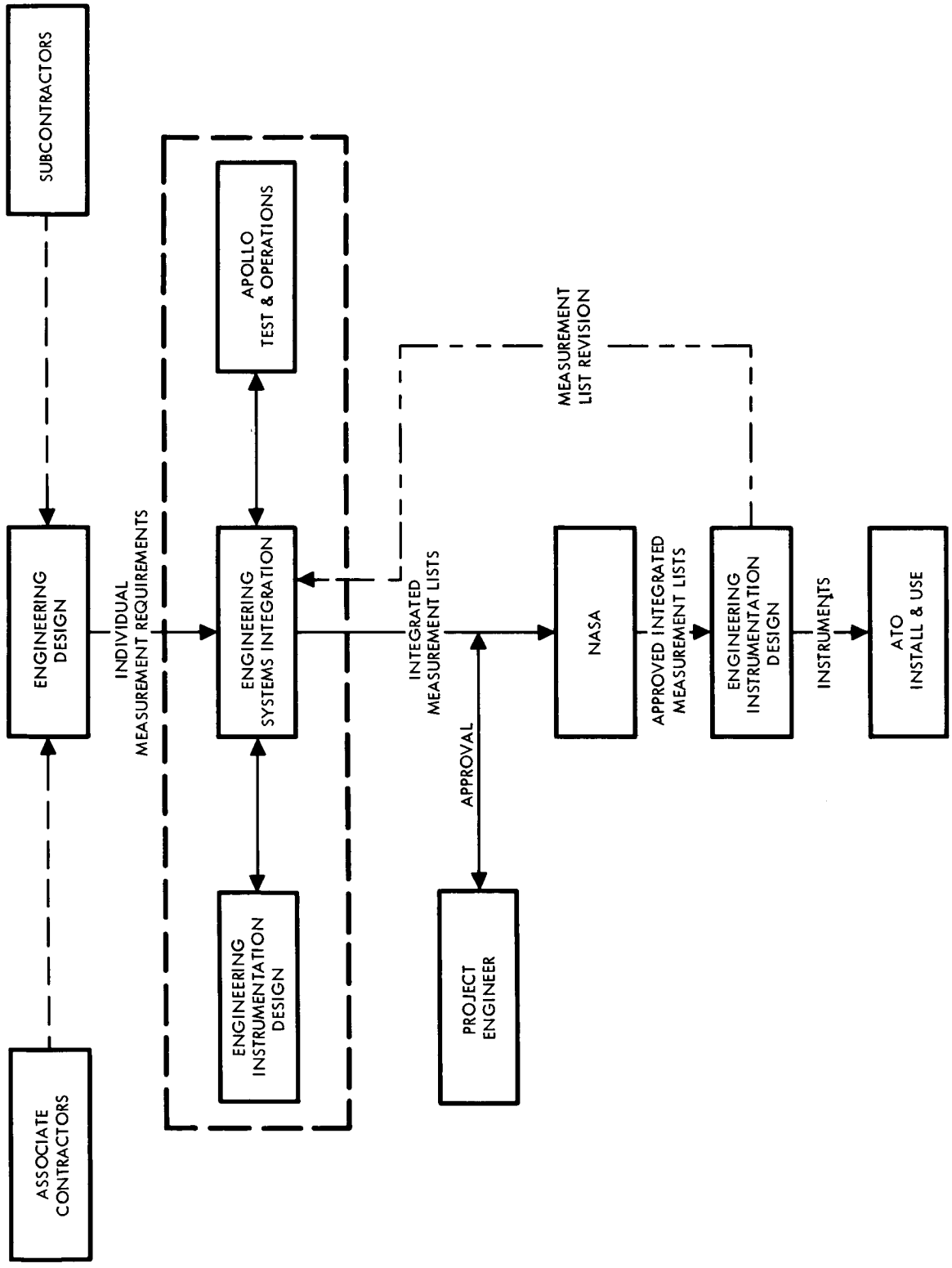

Figure 4-9. Instrumentation Measurement List Flow Diagram

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4.1.8.1.2 Damage Control. The following procedures will be effected:

1. A fire control system will provide sufficient water to combat a major fire or "spill."

2. A vapor detection system will provide the capability of measuring concentrations of either N_2O_4 or UDMH to between 0 and 50 PPM in air. Vapor detectors will be located at all points in the test sites where the possibility of vapor concentration exists. The detection system will activate visible and audible alarm systems. The fire and vapor detection system controllers will be located in the control center.

3. Self-contained breathing apparatus and Scape Suits will be provided for all personnel exposed to hazardous environments.

4. Secondary protection will be provided in the form of splash suits and air packs for use in atmospheres not exceeding 4-percent contamination.

5. Emergency protection for up to 10-minutes exposure in atmospheres of less than 2-percent contamination will be provided by an apron and full face-pieces with a canister mask.

6. Eye wash fountains and shower stalls will be provided at strategic locations throughout the test sites.

7. Safety belts and nets will be provided on and below all work platforms on the test sites.

8. During all operations hazardous to personnel, the "buddy system" will be used; a stand-by employee in full protective clothing will be assigned to each man working to monitor the operations and, if necessary, assist in evacuation.

4.1.8.1.3 Medical Program. First aid stations staffed with competent personnel will be maintained at both the test and administration areas. These stations will be equipped to provide full emergency medical service. Ambulance service will be available and hospital arrangements made for more serious treatment.

4.1.8.2 Test Operations

This data will be supplied when available.

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4.1.9 Data Handling, Analysis, and Reporting

4.1.9.1 Reports

Test reporting will consist of 4-hour, 24-hour, and final reports. The 4-hour report will be submitted within 4 hours following the test. These reports will contain pertinent information, objectives, configuration, procedures available at the time, and a qualitative description of the test. The 4-hour report will be followed by a comprehensive 24-hour report, detailing test conditions, observations, on-site evaluation by the test team, and other pertinent data. Final test reports will be prepared upon completion of a significant series of tests. The final report will contain a detailed engineering evaluation of the results of each test. Specific report flow and scheduling information will be included in this section when available.

4.1.9.2 Evaluation

Test evaluation will be accomplished in two areas. On-site evaluation at the propulsion system development facility, WSMR, will be accomplished, immediately following the test, to evaluate test objective accomplishment and to determine the quality of the data. This evaluation will be performed by the ATO systems engineers for the purpose of controlling test operations progress and providing adequate field reports to support engineering evaluation at Downey. Quantitative evaluation of the tests will be performed by Apollo Engineering utilizing the processed test data. Additional test evaluation methods and flow details will be included in this section when available.

4.1.9.3 Data Handling, Analysis, and Flow

S&ID will acquire and process all data obtained from the propulsion test program. The planned data system and data processing effort will (1) furnish the necessary data at the test site for operational requirements and (2) provide Apollo Engineering qualified data in tabular and plotted formats for evaluation and reporting of the tests. The handling and flow of data will be coordinated by ATO Data Engineering section.

4.1.9.3.1 On-Site Data Handling. This paragraph pertains to the control and physical movement of all site-generated test data. These data consist of calibration data, instrumentation configuration data, various playbacks (mentioned in paragraph 4.1.4.2), and magnetic tape. The transmittal of these data will be within the test site and between the site, S&ID, Downey, and NASA.

Calibration and instrumentation information available prior to testing will be transmitted to Downey by the test means available (e.g., FAX, hand-carry, or mail). All required quick-look playbacks will be produced

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by the site data acquisition system. After request and processing, site-generated quick-look and real-time test data will be transported from the recording area to a data review area. The data will be annotated, logged, and stored for on-site data review. The data essential to continued testing that require detailed processing by the Downey ground station will be stipulated. The required information will be sent back to the test site via TWX or FAX. After the site playback needs have expired, the physical data tape will be hand-carried or shipped to the Downey ground station for data verification, final data processing, and permanent storage.

4.1.9.3.2 Downey Data Processing. Test data required for preliminary and final data review and analyses will be processed by the S&ID Downey ground station. Coordination with the design and test areas will be maintained to determine the support requirements. When required, data essential to continued operations of the test group will be processed to appropriate formats and forwarded to the test site. Those data designated for detailed analyses by Apollo Engineering design groups will be processed to final formats. Methods of display include oscillograms, strip charts, plots, and tabulations. These data will have been edited, scaled, and grouped. Alternate processing methods include preparation of computer input tapes for complete data reduction and calculation. Final data inputs will be prepared for inclusion into test reports.

4.1.9.3.3 Downey Data Handling. This encompasses the distribution and maintenance of data generated through the S&ID Downey ground station. These data include calibration outputs, various processed displays, and magnetic tape. In addition, a variety of bulk data (e.g., motion picture film, test information, etc.) will be received from the test site to be maintained. The distribution will be between the test site and Downey and in-plant at S&ID, Downey.

Processed calibration outputs will be transmitted to the test site by FAX or mail. The historical calibration tapes will be maintained at S&ID, Downey, for automatic scaling of test data. Upon completion of processing, information required for test support will be transmitted to the test site. Playbacks designated for Downey use will be logged and make available for review and analysis. Systematic storage and control of test data will be maintained to insure the retrieval of test data for future review.

4.1.9.4 Calibration Data

The test vehicle instrumentation calibration data will be recorded in the quality control documentation. A record of calibration data and calibrating equipment will be maintained at the test site. A duplicate of the calibration data will be supplied to data engineering for computer processing in Downey. Computer output includes calibration plots and scale

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factors, up-dated calibration tape, and reading cards. Processed calibration outputs will be transmitted to the test site for use in quick-look evaluation. A permanent historical calibration tape will be maintained in Downey. This tape will reflect all valid instrumentation calibrations performed during the propulsion test program.

4.1.10 Detailed Test Objectives and Schedule

The F-2 test plan schedule is shown in Figure 4-10; the schedule of test objectives is shown in Tables 4-1 and 4-2.

4.1.11 Detailed Test Descriptions

For the decimal headings preceding test objectives, refer to Table 4-1.

4.1.11.1 Cold Tests

4.1.11.1.1 Test No. 1: Leak Checks

4.1.11.1.1.1 Test Objectives

1. Primary

1.1 Determine systems are leak free

1.2 Demonstrate systems function properly

2.1 Establish servicing procedures

2.2 Establish safety rules and procedures

2.3 Establish operating techniques — GSE and systems

4.1 Obtain data on ullage pressures

4.1.11.1.1.2 Test Configuration. The test will be conducted with F-2 test fixture in operational configuration, as defined by S&ID drawing B17-400050, with the following exceptions:

1. The rocket engine will be a fireable prototype engine.

2. The gas pressure regulators will be commercially available hardware.

3. Gaseous nitrogen will be used in place of helium to pressurize the propellant supply tanks.

[redacted]

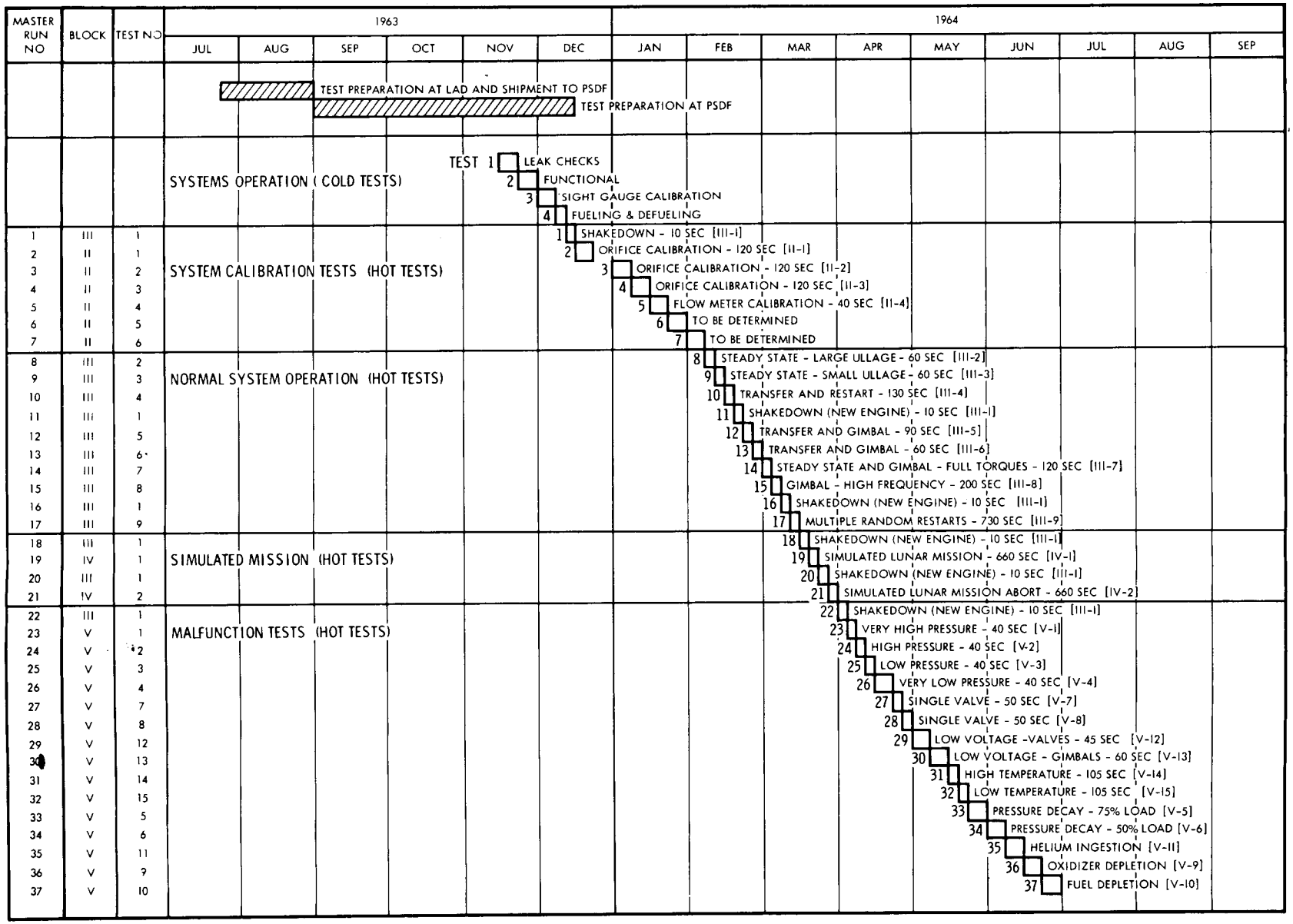

Figure 4-10. F-2 Test Plan

[redacted]

Table 4-1. Test Objectives for Fixture F-2

Test Objectives	COLD TESTS				HOT TESTS																																				
Block No.	I				III	II	II	II	II	II	II	III	III	III	III	III	III	III	III	III	III	III	IV	III	IV	III	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Test No.	1	2	3	4	1	1	2	3	4	5	6	2	3	4	1	5	6	7	8	1	9	1	1	1	2	1	1	2	3	4	7	8	12	13	14	15	5	6	11	9	10
Master Run No.	1	2	3	4	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.0 Demonstrate system integrity																																									
1.1 Determine systems are leak free	P	S	S	P	P	P	P	P	S	T	T				P	S						P	S	P	S	P	S														
1.2 Demonstrate systems function properly	P	P	S	P	P	P	P	P	S	T	T				P	S						P	S	P	S	P	S														
1.3 Systems shakedown - hot firing conditions					P	P	P	P	S	T	T				P	S						P	S	P	S	P	S														
2.0 Demonstrate operational procedures																																									
2.1 Establish servicing procedure	P	P	P	P	P	P	P	P	P	T	T	S	S	S	P							P		P		P															
2.2 Establish safety rules and procedures	P	P	P	P	P	P	P	P	S	T	T				P							P		P		P							P	P	S	S					
2.3 Establish operating techniques: GSE and systems	P	P	P	P	P	P	P	P	S	T	T	P	P	S	P							P	P	P	P	P	P	P	S	S											
3.0 Evaluate propellant system performance																																									
3.1 Obtain data on propellant temperature variation				P	S	S	S	S	S	T	T	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	P	P	S	S	S	S	S
3.2 Evaluate engine propellant inlet conditions					S	P	P	P	P	T	T	S	S	S	S	S	P	S	S	S	S	S	S	S	S	S	P	P	P	P	S	S	P	P	S	S	P	P	S	S	S
3.3 Obtain data on system resonant frequency					S	S	S	S	S	T	T	S	S	S	S	S	S	S	P	S	P	S	P	S	P	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
3.4 Evaluate mixture ratio control					S	S	S	S	S	T	T	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
3.5 Determine feed-line pressure surges					S	P	P	P	P	T	T	S	S	P	S	P	P	P	P	S	P	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	S	P	P
3.6 Evaluate PU system operation					S	S	S	S	S	T	T	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
3.7 Obtain data on propellant line vibration					S	S	S	S	S	T	T	P	P	S	S	S	S	S	S	S	P	S	P	S	P	S	S	P	S	S	S	S	S	S	S	S	S	S	S	S	S
3.8 Obtain data on propellant tank outlet pressures					S	S	S	S	S	T	T	S	S	P	S	P	S	P	P	S	P	S	S	S	S	S	S	S	P	P	P	P	P	P	S	S	S	S	S	P	P
4.0 Evaluate pressurization system performance																																									
4.1 Obtain data on ullage pressures	P	P		P	S	S	S	S	S	T	T	P	P	P	S	P	S	S	S	S	S	S	P	S	P	S	P	P	S	P	S	S	P	P	S	S	P	P	S	S	S
4.2 Determine helium system pressure surges					P	P	P	P	P	T	T	P	P	S	P	P	P	S	S	P	S	P	P	P	P	P	P	P	P	S	S	S	S	S	P	P	P	P	S	P	P
4.3 Obtain data on helium system temperatures					S	S	S	S	S	T	T	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	P	P	S	S	S	S	S
5.0 Evaluate engine performance																																									
5.1 Evaluate steady-state performance					S	P	P	P	P	T	T	P	P	P	S	S	S	P	P	S	P	S	P	S	P	S	P	P	P	P	P	P	P	P	P	P	P	P	S	P	P
5.2 Determine engine start transients					P	S	S	S	S	T	T	S	S	S	P	P	S	S	S	P	S	P	S	P	S	P	P	S	S	P	P	P	P	S	S	S	S	S	S	S	S
5.3 Determine engine shutdown transients					P	S	S	S	S	T	T	S	S	S	P	P	S	S	S	P	S	P	S	P	S	P	P	S	S	P	P	P	S	S	S	S	P	P	S	P	P
5.4 Evaluate engine restart capability					S	S	S	S	S	T	T	S	S	P	S	S	S	S	S	S	P	S	P	S	P	S	S	S	S	S	S	S	P	P	S	S	S	S	S	S	S
5.5 Determine O/F ratio effect on system					S	S	S	S	S	T	T	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	S	S	S	S	S	P	P	S	S	S
5.6 Determine propellant temperature effect on system					S	S	S	S	P	T	T	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	P	P	S	S	S	S	S
5.7 Determine gimbal effect on system																P	P	P	P				P		P						P	P		P							

Symbols: P = Primary objective
S = Secondary objective
T = To be determined

[redacted]

[redacted]

Table 4-2. Test Conditions for Fixture F-2

Test Conditions	Cold Tests	HOT TESTS																		
Block No.	I	III	II						III											
Test No.		1	1	2	3	4	5	6	2	3	4	1	5	6	7	8	1	9	1
Master Run No.	1 2 3 4	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Number of firings		1	12	12	12	4	4	4	2	2	4/1/4	1	3	3	1/1	1	1	50	1
2. Propellant temperature (°F)		A	A	A	A	A	To be determined	To be determined	A	A	A	A	A	A	A	A	A	A	A
3. Duration of firings (sec)		10	10	10	10	10			30	30	5/90/5	10	30	20	90/30	200	10	5-60	10
4. O/F mixture ratios		2/1	2/1	2/1	2/1	2/1			2/1	2/1	2/1	2/1	2/1	2/1	2/1	2/1	2/1	2/1	2/1
5. Fuel load (percent full volume)		10	100% for initial firings	100% for initial firings	100% for initial firings	100% for initial firings			25	100	65	10	60	55	100	100	10	100	10
6. Oxidizer load (percent full volume)		10	100% for initial firings	100% for initial firings	100% for initial firings	100% for initial firings			25	100	65	10	60	55	100	100	10	100	10
7. Static regulator setting—fuel		185 psig ±4	185 psig ±4	185 psig ±4	185 psig ±4	185 psig ±4			185 psig ±4	185 psig ±4	185 psig ±4	185 psig ±4	185 psig ±4	As required	185 psig ±4	185 psig ±4	185 psig ±4	185 psig ±4	185 psig ±4
8. Static regulator setting—oxidizer		185 psig ±4				185 psig ±4			185 psig ±4	185 psig ±4	185 psig ±4	185 psig ±4	185 psig ±4	As required	185 psig ±4	185 psig ±4	185 psig ±4	185 psig ±4	185 psig ±4
9. Gimbal excursions			10-psig increments	10-psig increments	10-psig increments								4.5° in Y-axis 4.5° in Z-axis	6° in Y-axis 6° in Z-axis	4.5° in Y-axis 4.5° in Z-axis	1.5° in Y-axis 1.5° in Z-axis			
10. Gimbal rate													1 cps	3/4 cps	1 cps	3 cps			
11. Gimbal time duration													28 sec	18 sec	88/28 sec	190 sec			
12. Single engine valve bank operation																			
13. Low voltage, 18 to 20 volts dc																			
14. Accumulated time (sec)		10	130	250	370	410	450	490	550	610	740	10	100	160	280	480	10	740	10

Test Conditions (Cont)	HOT TESTS (Cont)																			
Block No.	IV	III	IV	III	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Test No.	1	1	2	1	1	2	3	4	7	8	12	13	14	15	5	6	11	9	10
Master Run No.	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1. Number of firings	1 1 1 1 19 1 1 1 1 1	1	1 1 1 1	1	2	2	2	2	4/1	4/1	1/3	2	3/3	3/3	1	1	To be determined	1	1
2. Propellant temperature (°F)	A	A	A	A	A	A	A	A	A	A	A	A	Oxidizer 135° Fuel 145°	Oxidizer 30° Fuel 40°	A	A	A	A	A
3. Duration of firings (sec)	17 7 7 400 5 5 120 5 2 2	10	18 635 2 5	10	20	20	20	20	5/30	5/30	30/5	30	30/5	30/5	2 to 40 sec	2 to 30 sec	To be determined	Unknown	Unknown
4. O/F mixture ratios	2/1	2/1	2/1	2/1	2/1	2/1	Varies with pressure	Varies with pressure	2/1	2/1	2/1	2/1	2/1	2/1	2/1	2/1	2/1	2/1	2/1
5. Fuel load (percent full volume)	100	10	100	10	75	75	75	75	40	40	100	100	50	50	75	50	To be determined	3200 lb	4500 lb
6. Oxidizer load (percent full volume)	100	10	100	10	75	75	75	75	40	40	100	100	50	50	75	50	To be determined	2700 lb	1350 lb
7. Static regulator setting—fuel	185 psig ±4	185 psig ±4	185 psig ±4	185 psig ±4	240 psig ±4	As required	As required	As required	185 psig ±4	185 psig ±4	185 psig ±4	185 psig ±4	185 psig ±4	185 psig ±4	As required	As required	185 psig ±4	185 psig ±4	185 psig ±4
8. Static regulator setting—oxidizer	185 psig ±4	185 psig ±4	185 psig ±4	185 psig ±4	240 psig ±4	As required	As required	As required	185 psig ±4	185 psig ±4	185 psig ±4	185 psig ±4	185 psig ±4	185 psig ±4	As required	As required	185 psig ±4	185 psig ±4	185 psig ±4
9. Gimbal excursions	As required per cps rate		As required per cps rate						4.5° in Z-axis 4.5° in Y-axis	4.5° in Z-axis 4.5° in Y-axis		9° in Z-axis 6° in Y-axis							
10. Gimbal rate	1/2 to 3 cps 1/2 to 3 cps		1/2 to 3 cps						1 cps	1 cps		3/4 cps							
11. Gimbal time duration	As required		As required						28 sec	28 sec		28 sec							
12. Single engine valve bank operation									Yes	Yes									
13. Low voltage, 18 to 20 volts dc											18 volts dc	18 volts dc							
14. Accumulated time (sec)	670	10	670	10	50	90	130	170	220	270	315	375	480	585					

Note: A = ambient temperature 50 to 100 F

[redacted]

[redacted]

4. The ground support equipment to be used in these tests is listed under paragraph 4.1.3.2.

4.1.11.1.1.3 Test Conditions. This test will be conducted per OTP-P-4100.

The gas and fluid systems will be leak-checked at operating pressure, using GN_2 for the liquid systems and He for the gas systems.

4.1.11.1.1.4 Data Required. In general, conclusive evidence of a leak-free and pressure-proof propellant storage and delivery system is required from these tests.

4.1.11.1.2 Test No. 2: Propulsion System and Controls Functional Checkout

4.1.11.1.2.1 Test Objectives

1. Primary

   1.2 Demonstrate systems function properly

   2.1 Establish servicing procedures

   2.2 Establish safety rules and procedures

   2.3 Establish operating techniques—GSE and systems.

   4.1 Obtain data on ullage pressures.

2. Secondary

   1.1 Determine systems are leak free

4.1.11.1.2.2 Test Configuration. The configuration of this test will be the same as for Test 1.

4.1.11.1.2.3 Test Conditions

1. The propellant tanks will be pressurized to 175 psig.

2. The helium gas storage vessels will be pressurized to 4000 psig.

3. This test will be performed per OTP-P-4101.

[redacted]

[redacted]

4.1.11.1.3 Test No. 3: Sight Gauge Calibration

4.1.11.1.3.1 Test Objectives

1. Primary

2.1 Establish servicing procedures

2.2 Establish safety rules and procedures

2.3 Establish operating techniques—GSE and systems

4.1.11.1.3.2 Test Configuration. The configuration of this test will be the same as for Test 1.

4.1.11.1.3.3 Test Conditions. (to be determined)

4.1.11.1.4 Test No. 4: Fueling and Defueling

4.1.11.1.4.1 Test Objectives

1. Primary

1.1 Determine systems are leak free

1.2 Demonstrate systems function properly

2.1 Establish servicing procedures

2.2 Establish safety rules and procedures

2.3 Establish operating techniques—GSE and systems

3.1 Obtain data on propellant temperature variation

4.1 Obtain data on ullage pressures

4.1.11.1.4.2 Test Configuration. The test configuration for this test will be the same as for Test No. 2, except that He will be used for all pressurization.

4.1.11.1.4.3 Test Conditions

1. A series of tanking and detanking operations will be conducted.

2. The propellant tanks will be pressurized to 176 psig.

[redacted]

[redacted]

3. The propellants will be tanked at ambient temperatures.

4. The propellant tanks will be filled to normal full condition (30,000 pounds N_2O_4 and 15,000 pounds UDMH/H, 50-50).

5. The helium gas storage vessel will be pressurized to 4000 psig.

4.1.11.2 Hot Tests

4.1.11.2.1 Master Run No. 1: Verification Firing

4.1.11.2.1.1 Test Objectives. The general test objectives are verification of system and components to insure satisfactory functioning at normal firing conditions. This test will be the initial firing test and will be repeated after all major component changes. The detailed test objectives are:

1. Primary

   1.1 Determine systems are leak free

   1.2 Demonstrate systems function properly

   1.3 Systems shakedown - hot firing conditions

   2.1 Establish servicing procedures

   2.2 Establish safety rules and procedures

   2.3 Establish operating techniques—GSE and systems

   4.2 Determine He system pressure surges

   5.2 Determine engine start transients

   5.3 Determine engine shutdown transients

2. Secondary

   3.1 Obtain data on propellant temperature variation

   3.2 Evaluate engine propellant inlet conditions

   3.3 Obtain data on system resonant frequency

   3.4 Evaluate mixture ratio control

[redacted]

[redacted]

3.5 Determine feed-line pressure surges

3.6 Evaluate PU system operation

3.7 Obtain data on propellant line vibration

3.8 Obtain data on propellant tank outlet pressures

4.1 Obtain data on ullage pressure

4.3 Obtain data on helium system temperature

5.1 Evaluate steady-state performance

5.4 Evaluate engine restart capability

5.5 Determine O/F ratio effect on system

5.6 Determine propellant temperature effect on system

4.1.11.2.1.2 Test Configuration. This test will be conducted with the F-2 test fixture in operational configuration as defined by S&ID drawing B17-400050, with the SPS engine, as defined by drawing V17-410101, installed per drawing B17-400250, with the following exceptions:

1. The ground support equipment to be used in these tests is listed under paragraph 4.1.3.2.

2. The engine will be locked in the neutral or null position.

4.1.11.2.1.3 Test Conditions

1. One firing of 10-second duration

2. Propellant temperatures will be ambient (50 to 100°F).

3. Mixture ratio will be 2 to 1.

4. Propellant loads will be 10 percent.

5. Regulator settings will be 185 psig ±4.

6. The engine will not be gimbaled.

[redacted]

[redacted]

4.1.11.2.1.4 Data Required

1. Instrumentation measurements will be recorded as indicated in Section 4.1.11.3.

2. Photographic data cameras will be installed as required to obtain data from the propellant tank sight gauges.

3. A high-speed (500-1000 frames per second) photographic data camera will be installed as required to cover the engine exhaust frame.

4. Documentation photographic cameras will be installed as determined during the prerun planning meeting.

5. Closed-circuit television monitoring cameras will be installed as directed by the test conductor.

6. Complete weather data will be recorded on the Engineering Data Sheet (format to be determined).

7. Test observers comments will be recorded on the Engineering Data Sheet (format to be determined).

8. Test conductors comments will be recorded on the Engineering Data Sheet (format to be determined).

4.1.11.2.2 Master Run No. 2: Propellant Orifice Flow Rate Calibration

4.1.11.2.2.1 Test Objectives. The general test objectives are to determine the exact sizes of the trim orifice in each fuel or oxidizer line. The detailed test objectives are:

1. Primary

   1.1 Determine systems are leak free

   1.2 Demonstrate systems function properly

   1.3 Systems shakedown - hot firing conditions

   2.1 Establish servicing procedures

   2.2 Establish safety rules and procedures

[redacted]

[redacted]

2.3 Establish operating techniques—GSE and systems

3.2 Evaluate engine propellant inlet conditions

3.5 Determine feed-line pressure surges

4.2 Determine helium system pressure surges

5.1 Evaluate steady-state performance

2. Secondary

3.1 Obtain data on propellant temperature variation

3.3 Obtain data on system resonant frequency

3.4 Evaluate mixture radio control

3.6 Evaluate PU system operation

3.7 Obtain data on propellant line vibration

3.8 Obtain data on propellant tank outlet pressures

4.1 Obtain data on ullage pressure

4.3 Obtain data on helium system temperature

5.2 Determine engine start transients

5.3 Determine engine shutdown transients

5.4 Evaluate engine restart capability

5.5 Determine O/F ratio effect on system

5.6 Determine propellant temperature effect on system

4.1.11.2.2.2 Test Configuration. This test will be conducted with test fixture F-2 operational configuration, as defined by S&ID drawing B-17-400050, with the SPS engine, as defined by drawing V17-410101, installed per drawing B17-400250, with the following exceptions:

1. The engine will be locked in the neutral or null position.

2. Trim orifice set number 1 will be installed.

[redacted]

[redacted]

4.1.11.2.2.3 Test Conditions

1. Twelve firings of 10-second duration each

2. Propellant temperatures will be ambient (50 to 100 F).

3. Mixture ratios will be 2 to 1.

4. Propellant loads will be 100 percent.

5. Regulator settings will be 185 psig ±4.

6. The engine will not be gimbaled.

4.1.11.2.2.4 Data Required. The data required for this test will be the same as required for Master Run No. 1, 4.1.11.2.1.4.

4.1.11.2.3 Master Run No 3: Propellant Orifice Flow-Rate Calibration

4.1.11.2.3.1 Test Objectives. The general test objectives for Master Run No. 3 are the same as for Master Run No. 2.

The detailed test objectives for Master Run No. 3 are the same as for Master Run No. 2.

4.1.11.2.3.2 Test Configuration. The test configuration is the same as for Master Run No. 2, with the following exceptions:

1. Trim orifice set number 2 will be installed.

4.1.11.2.3.3 Test Conditions. The test conditions are the same as for Master Run No. 2.

4.1.11.2.3.4 Data Required. The data required for this test will be the same as for Master Run No. 1, Section 4.1.11.2.1.4.

4.1.11.2.4 Master Run No. 4: Propellant Orifice Flow-Rate Calibration

4.1.11.2.4.1 Test Objectives. The general test objectives for Master Run No. 4 are the same as for Master Run No. 2.

[redacted]

[redacted]

The detailed test objectives for Master Run No. 4 are the same as for Master Run No. 1.

4.1.11.2.4.2 Test Configuration. The test configuration is the same as for Master Run No. 2, with the following exception:

1. Trim orifice set number 3 will be installed.

4.1.11.2.4.3 Test Conditions. The test conditions are the same as for Master Run No. 2.

4.1.11.2.4.4 Data Required. The data required for this test will be the same as for Master No. 1, para. 4.1.11.2.1.4.

4.1.11.2.5 Master Run No. 5: Flow-Meter Installation Calibration

4.1.11.2.5.1 Test Objectives. The general test objectives are (1) to verify the accuracy of the flow meters and (2) develop flow-rate curves in pounds per sec. The detailed test objectives are:

1. Primary

   2.1 Establish servicing procedures

   3.2 Evaluate engine propellant inlet conditions.

   3.5 Determine feed-line pressure surges

   4.2 Determine helium system pressure surges

   5.1 Evaluate steady-state performance

   5.6 Determine propellant temperature effect on system

2. Secondary

   1.1 Determine systems are leak free

   1.2 Demonstrate systems function properly

   1.3 Systems shakedown—hot firing conditions

   2.2 Establish safety rules and procedures

   2.3 Establish operating techniques—GSE and systems

are:

[redacted]

[redacted] [redacted]

3.1 Obtain data on propellant temperature variation

3.3 Obtain data on system resonant frequency

3.4 Evaluate mixture ratio control

3.6 Evaluate PU system operation

3.7 Obtain data on propellant line vibration

3.8 Obtain data on propellant tank outlet pressures

4.1 Obtain data on ullage pressures

4.3 Obtain data on helium system temperatures

5.2 Determine engine start transients

5.3 Determine engine shutdown transients

5.4 Evaluate engine restart capability

5.5 Determine O/F ratio effect on system

4.1.11.2.5.2 Test Configuration. The Test Configuration is the same as for Master Run No. 2.

4.1.11.2.5.3 Test Conditions

1. Four firings of 10-second duration each.
2. Propellant temperatures will be ambient (50 to 100 F).
3. Mixture ratios will be 2 to 1.
4. Propellant loads will be 100 percent for initial firings.
5. Regulator settings will be 185 psig ±4.
6. The engine will not be gimbaled.

[redacted]

4.1.11.2.5.4 Data Required. The data required for this test will be the same as for Master Run No. 1, paragraph 4.1.11.2.1.4.

4.1.11.2.6 Master Run No. 6: (To be determined)

4.1.11.2.6.1 Test Objectives. (To be determined)

4.1.11.2.6.2 Test Configuration. (To be determined)

4.1.11.2.6.3 Test Conditions.

4.1.11.2.6.4. Data Required. (To be determined)

4.1.11.2.7 Master Run No. 7: (To be determined)

4.1.11.2.7.1 Test Objectives. (To be determined)

4.1.11.2.7.2 Test Configuration. (To be determined)

4.1.11.2.7.3 Test Conditions. (To be determined)

4.1.11.2.7.4 Data Required. (To be determined)

4.1.11.2.8 Master Run No. 8: Steady-State Operation - Large Ullage

4.1.11.2.8.1 Test Objectives. The general test objectives are to establish basic system performance under steady-state operation with large ullage volume.

The detailed objectives are:

1. Primary

2.3 Establish operating techniques—GSE and systems.

[redacted]

[redacted] [redacted]

3.7 Obtain data on propellant line vibration

4.1 Obtain data on ullage pressures

4.2 Determine helium system pressure surges

5.1 Evaluate steady-state performance

2. Secondary

2.1 Establish servicing procedures

3.1 Obtain data on propellant temperature variation

3.2 Evaluate engine propellant inlet conditions

3.3 Obtain data on system resonant frequency

3.4 Evaluate mixture ratio control

3.5 Determine feed-line pressure surges

3.6 Evaluate PU system operation

3.8 Obtain data on propellant tank outlet pressures

4.3 Obtain data on helium system temperatures

5.2 Determine engine start transients

5.3 Determine engine shutdown transients

5.4 Evaluate engine restart capability

5.5 Determine O/F ratio effect on system

6.6 Determine propellant temperature effect on system

4.1.11.2.8.2 Test Configuration. The test configuration is the same as for Master Run No. 1.

4.1.11.2.8.3 Test Conditions

1. Two firings of 30 second-duration. Allow a 5-minute off-time.

2. Propellant temperatures will be ambient (50 F to 100 F).

 [redacted]

[redacted]

3. Mixture ratios will be 2 to 1.

4. Propellant loads will be 25 percent.

5. Regulator settings will be 185 psig ±4.

6. The engine will not be gimbaled.

4.1.11.2.8.4 Data Required. The data required for this test will be the same as required for Master Run No. 1, paragraph 4.1.11.2.1.4.

4.1.11.2.9 Master Run No. 9: Steady-State Operation—Small Ullage

4.1.11.2.9.1 Test Objectives. The general test objectives are to establish basic system performance under steady-state operation with small ullage volume.

The detailed test objectives are the same as for Master Run No. 8.

4.1.11.2.9.2 Test Configuration. The test configuration is the same as for Master Run No. 1.

4.1.11.2.9.3 Test Conditions. Test conditions are same as for Master Run No. 8, except that propellant load will be 100 percent.

4.1.11.2.9.4 Data Required. The data required for this test will be the same as required for Master Run No. 1, paragraph 4.1.11.2.1.4.

4.1.11.2.10 Master Run No. 10: Propellant Transfer and Restart

4.1.11.2.10.1 Test Objectives. The general test objectives are to evaluate system performance during engine restarts. Transient parameters of feed-line surges and transfer line emptying are to be evaluated.

The detailed test objectives are:

1. Primary

   3.5 Determine feed-line pressure surges

   3.8 Obtain data on propellant tank outlet pressures

   4.1 Obtain data on ullage pressures

   5.1 Evaluate steady-state performance

[redacted]

[redacted]

5.4 Evaluate engine restart capability

2. Secondary

2.1 Establish servicing procedures

2.3 Establish operating techniques—GSE and systems

3.1 Obtain data on propellant temperature variation

3.2 Evaluate engine propellant inlet conditions

3.3 Obtain data on system resonant frequency

3.4 Evaluate mixture ratio control

3.6 Evaluate PU system operation

3.7 Obtain data on propellant line vibration

4.2 Determine helium system pressure surges

4.3 Obtain data on helium system temperatures

5.2 Determine engine start transients

5.3 Determine engine shutdown transients

5.5 Determine O/F radio effect on system

5.6 Determine propellant temperature effect on system

4.1.11.2.10.2 Test Configuration. The test configuration is the same as for Master Run No. 1.

4.1.11.2.10.3 Test Conditions

1. Four firing of 5-second duration. Allow a 10-second off-time.
   One firing of 90-second duration. Allow a 5-minute off-time.
   Four firing of 5-second duration. Allow a 10-second off-time.

2. Propellant temperatures will be ambient (50 F to 100 F)

3. Mixture ratio will be 2 to 1.

4. Propellant loads will be 65 percent.

[redacted]

[redacted]

5. Regulator settings will be 185 psig ±4.

6. The engine will not be gimbaled.

4.1.11.2.10.4 Data Required. The data required for this test will be the same as required for Master Run No. 1, paragraph 4.1.11.2.1.4.

4.1.11.2.11 Master Run No. 11: Verification Firing. Master Run No. 11 is the same as Master Run No. 1 and is verification of a new engine.

4.1.11.2.12 Master Run No. 12: Engine Gimbal and Propellant Transfer

4.1.11.2.12.1 Test Objectives. The general test objectives are to determine the effect of gimbaling on the SPS system and the effect of gimbaling during propellant tank transfer. Transient parameters of feed-line surges and transfer lines to be evaluated. The detailed test objectives are:

1. Primary

   3.5 Determine feed-line pressure surges

   3.8 Obtain data on propellant tank outlet pressures

   4.1 Obtain data on ullage pressures

   4.2 Determine helium system pressure surges

   5.2 Determine engine start transients

   5.3 Determine engine shutdown transients

   5.7 Determine gimbal effect on system

2. Secondary

   1.1 Determine systems are leak free

   1.2 Demonstrate systems function properly

   1.3 Systems shakedown—hot firing conditions

   3.1 Obtain data on propellant temperature variation

   3.2 Evaluate engine propellant inlet conditions

[redacted]

3.3 Obtain data on system resonant frequency

3.4 Evaluate mixture ratio control

3.6 Evaluate PU system operation

3.7 Obtain data on propellant line vibration

4.3 Obtain data on helium system temperature

5.1 Evaluate steady-state performance

5.4 Evaluate engine restart capability

5.5 Determine O/F ratio effect on system

5.6 Determine propellant temperature effect on system

4.1.11.2.12.2 Test Configuration. The test configuration is the same as for Master Run No. 1, except that the engine is gimbaled for the second and third firings.

4.1.11.2.12.3 Test Conditions

1. Three firings of 30-second duration. Allow a 10-second off-time.

2. Propellant temperatures will be ambient (50 to 100 F)

3. Mixture ratios will be 2 to 1.

4. Propellant loads will be 60 percent.

5. Regulator settings will be 185 psig ± 4.

6. The engine will be gimbaled during the second and third firings. Gimbal excursions will be 4.5 degrees in Y-axis and 4.5 degrees in Z-axis, at a rate of 1 cps for a total duration of 28 seconds.

4.1.11.2.12.4 Data Required. The data required for this test will be the same as required for Master Run No. 1, paragraph 4.1.11.2.1.4.

4.1.11.2.13 Master Run No. 13: Engine Gimbal and Propellant Transfer

4.1.11.2.13.1 Test Objectives. The general test objectives are to determine the effect of gimbaling on the SPS system and the effect of

[redacted]

[redacted]

gimbaling during propellant tank transfer. Transient parameters of feed-line surges and transfer lines are to be evaluated. The detailed test objectives are:

1. Primary

   3.2 Evaluate engine propellant inlet conditions

   3.5 Determine feed-line pressure surges

   4.2 Determine helium system pressure surges

   5.7 Determine gimbal effect on system

2. Secondary

   3.1 Obtain data on propellant temperature variation

   3.3 Obtain data on system resonant frequency

   3.4 Evaluate mixture ratio control

   3.6 Evaluate PU system operation

   3.7 Obtain data on propellant line vibration

   3.8 Obtain data on propellant pressurant outlet pressures

   4.1 Obtain data on ullage pressures

   5.1 Evaluate steady-state performance

   5.2 Determine engine start transients

   5.3 Determine engine shutdown transients

   5.4 Evaluate engine restart capability

   5.5 Determine O/F ratio effect on system

   5.6 Determine propellant temperature effect on system

4.1.11.2.13.2 Test Configuration. The test configuration is the same as for Master Run No. 1, except that the engine is gimbaled for the second and third firings.

[redacted]

[redacted]

4.1.11.2.13.3 Test Conditions

1. Three firings of 20-second duration. Allow a sufficient off-time to investigate results and evaluate data between runs.

2. Engine inlet pressures will be adjusted to 160 psig (oxidizer) and 163 psig (fuel) at the engine inlet before each run.

3. Propellant temperatures will be ambient (50 F to 100 F).

4. Mixture ratios will be 2 to 1.

5. Propellant loads will be 55 percent.

6. The regulators will be adjusted as required to achieve 160 psig (oxidizer) and 163 psig (fuel).

7. The engine will be gimbaled during second and third firing. Gimbal excursions will be 6 degrees in Y-axis and 6 degrees in Z-axis, at a rate of 3/4 cps for a total duration of 18 seconds.

4.1.11.2.13.4 Data Required. The data required are the same as for Master Run No. 1, paragraph 4.1.11.2.1.4.

4.1.11.2.14 Master Run No. 14: Engine Gimbal—Full Propellant Tanks

4.1.11.2.14.1 Test Objectives. The general test objectives are to determine the effect of gimbaling on the system during steady-state firing with full propellant tanks. The detailed objectives are:

1. Primary

   3.5 Determine feed-line pressure surges

   3.8 Obtain data on propellant tank outlet pressures

   5.1 Evaluate steady-state performance

   5.7 Determine gimbal effect on system

2. Secondary

   3.1 Obtain data on propellant temperature variation

   3.2 Evaluate engine propellant inlet conditions

[redacted]

[redacted]

[redacted]

3.3 Obtain data on system resonant frequency

3.4 Evaluate mixture ratio control

3.6 Evaluate PU system operation

3.7 Obtain data on propellant line vibration

4.1 Obtain data on ullage pressures

4.2 Determine helium system pressure surges

4.3 Obtain data on helium system temperatures

5.2 Determine engine start transients

5.3 Determine engine shutdown transients

5.4 Evaluate engine restart capability

5.5 Determine O/F ratio effect on system

5.6 Determine propellant temperature effect on system

4.1.11.2.14.2 Test configuration. The test configuration is the same as for Master Run No. 1, except that the engine gimbals are not locked.

4.1.11.2.14.3 Test Conditions

1. One firing of 90-second duration. Allow a 10-minute off-time. One firing of 30-second duration.

2. Regulator settings will be 185 psig ±4.

3. Propellant temperatures will be ambient (50 F to 100 F).

4. Mixture ratios will be 2 to 1.

5. Propellant loads will be 100 percent.

6. The engine will be gimbaled 4.5 degrees in the Y-axis and 4.5 degrees in the Z-axis, at a rate of 1 cps for a duration of 88 seconds on the first firing and 28 seconds on the second firing.

4.1.11.2.14.4 Data Required. The data required for this test will be the same as required for Master Run No. 1, paragraph 4.1.11.2.1.4.

[redacted]

[redacted]

4.1.11.2.15 Master Run No. 15: Engine Gimbal—Fast Rate

4.1.11.2.15.1 Test Objectives. The general test objectives are:

1. Verify proper engine gimbal actuation signal
2. Determine transient responses on pressure system
3. Determine pressure surges in all systems during high-rate gimbal action

The detailed test objectives are:

1. Primary

   3.3 Obtain data on system resonant frequency

   3.5 Determine feed-line pressure surges

   3.8 Obtain data on propellant tank outlet pressures

   5.1 Evaluate steady-state performance

   5.7 Determine gimbal effect on system

2. Secondary

   3.1 Obtain data on propellant temperature variation

   3.2 Evaluate engine propellant inlet conditions

   3.4 Evaluate mixture ratio control

   3.6 Evaluate PU system operation

   3.7 Obtain data on propellant line vibration

   4.1 Obtain data on ullage pressures

   4.2 Determine helium system pressure surges

   4.3 Obtain data on helium system temperatures

   5.2 Determine engine start transients

   5.3 Determine engine shutdown transients

[redacted]

[redacted]

5.4 Evaluate engine restart capability

5.5 Determine O/F ratio effect on system

5.6 Determine propellant temperature effect on system

4.1.11.2.15.2 Test Configuration. The test configuration is the same as for Master Run No. 1, except that the engine gimbals are not locked.

4.1.11.2.15.3 Test Conditions

1. One firing of 200-second duration

2. Propellant temperatures will be ambient (50 F to 100 F)

3. Mixture ratios will be 2 to 1.

4. Propellant loads will be 100 percent.

5. Regulator settings will be 185 psig ± 4.

6. The engine will be gimbaled 1.5 degrees in Y-axis and 1.5 degrees in Z-axis, at a rate of 3 cps for a duration of 190 seconds.

4.1.11.2.15.4 Data Required. The data required for this test will be the same as required for Master Run No. 1, paragraph 4.1.11.2.1.4.

4.1.11.2.16 Master Run No. 16: Verification Firing. Master Run No. 16 is the same as Master Run No. 1 and is the verification of a new engine.

4.1.11.2.17 Master Run No. 17: Engine Restart Capability

4.1.11.2.17.1 Test Objectives. The general objectives are to evaluate the service propulsion system restart capability and demonstrate the engine capability to operate under high stress for full engine life. The detailed test objectives are:

1. Primary

3.3 Obtain data on system resonant frequency

3.5 Determine feed-line pressure surges

3.7 Obtain data on propellant line vibration

3.8 Obtain data on propellant tank outlet pressures

[redacted]

[redacted]

5.1 Evaluate steady-state performance

5.4 Evaluate engine restart capability

2. Secondary

3.1 Obtain data on propellant temperature variation

3.2 Evaluate engine propellant inlet conditions

3.4 Evaluate mixture ratio control

3.6 Evaluate PU system operations

4.1 Obtain data on ullage pressures

4.2 Determine helium system pressure surges

4.3 Obtain data on helium system temperature

5.2 Determine engine start transients

5.3 Determine engine shutdown transients

5.5 Determine O/F ratio effect on system

5.6 Determine propellant temperature effect on system

4.1.11.2.17.2 Test Configuration. The test configuration is the same as for Master Run No. 1.

4.1.11.2.17.3 Test Conditions

1. Fifty firings of random duration from five to sixty seconds, 730 seconds total firing time. Random off-time from one minute to 30 minutes duration.

2. Propellant temperatures will be ambient (50 to 100 F).

3. Mixture ratios will be 2 to 1.

4. Propellant loads will be 100 percent.

5. Regulator settings will be 185 psig ±4.

6. The engine will not be gimbaled.

[redacted]

[redacted]

4.1.11.2.17.4 Data Required. The data required for this test will be the same as required for Master Run No. 1, paragraph 4.1.11.2.1.4.

4.1.11.2.18 Master Run No. 18: Verification Firing. Master Run No. 18 is the same as Master Run No. 1 and is verification of a new engine.

4.1.11.2.19 Master Run No. 19: Simulated Lunar Orbit Mission

4.1.11.2.19.1 Test Objectives. The general objectives are to evaluate the ability of the pressurant, propellant, and engine systems to sustain long-duration operation. The detailed test objectives are:

1. Primary

   2.3 Establish operating techniques—GSE and systems

   3.3 Obtain data on system resonant frequency

   3.7 Obtain data on propellant line vibration

   4.1 Obtain data on ullage pressures

   4.2 Determine helium system pressure surges

   5.1 Evaluate steady-state performance.

   5.4 Evaluate engine restart capability

   5.7 Determine gimbal effect on system

2. Secondary

   1.1 Determine systems are leak free

   1.2 Demonstrate systems function properly

   1.3 Systems shakedown—hot firing conditions

   3.1 Obtain data on propellant temperature variation

   3.2 Evaluate engine propellant inlet conditions

   3.4 Evaluate mixture ratio control

   3.5 Determine feed-line pressure surges

[redacted]

[redacted]

3.6 Evaluate PU system operations

3.8 Obtain data on propellant tank outlet pressures

4.3 Obtain data on helium system temperatures

5.2 Determine engine start transients

5.3 Determine engine shutdown transients

5.5 Determine O/F ratio effect on system

5.6 Determine propellant temperature effect on system

4.1.11.2.19.2 Test Configuration. The test configuration is the same as for Master Run No. 1, except that the engine gimbals are not locked.

4.1.11.2.19.3 Test Conditions

1. One firing of 17-second duration. Allow a 30-minute off-time. One firing of 7-second duration. Allow a 30-minute off-time. One firing of 7-second duration. Allow a 30-minute off-time. One firing of 400-second duration. Allow a 12-hour off-time. Gimbal rate 0.5 to 3 cps.

   Nineteen firings of 5-second duration each. Allow a one-minute off-time.

   One firing of 5-second duration. Allow a 1-hour off-time.

   One firing of 120-second duration. Allow an 8-hour off-time. Gimbal rate 0.5 to 1 cps.

   One firing of 5-second duration. Allow a 30-minute off-time. One firing of 2-second duration. Allow a 30-minute off-time. One firing of 2-second duration.

2. Propellant temperatures will be ambient (50 to 100 F)

3. Mixture ratios will be 2 to 1.

4. Propellant loads will be 100 percent.

5. Regulator settings will be 185 psig ±4.

[redacted]

[redacted]

6. The engine will be gimbaled at the cps rates shown in test condition 1 for the times required.

4.1.11.2.19.4 Data Required. The data required for this test will be the same as required for Master Run No. 1, paragraph 4.1.11.2.1.4.

4.1.11.2.20 Master Run No. 20: Verification Firing. Master Run No. 20 is the same as Master Run No. 1 and is verification of a new engine.

4.1.11.2.21 Master Run No. 21: Simulated Abort Mission.

4.1.11.2.21.1 Test Objectives. The general objectives are to evaluate the ability of the pressurant, propellant, and engine systems to sustain long-duration operation. The detailed objectives are:

1. Primary

   2.3 Establish operating techniques—GSE and systems

   3.3 Obtain data on system resonant frequency

   3.7 Propellant line vibration

   4.1 Obtain data on ullage pressures

   4.2 Determine helium system pressure surges

   5.1 Evaluate steady-state performance

   5.4 Evaluate engine restart capability

   5.7 Determine gimbal effect on system

2. Secondary

   1.1 Determine systems are leak free

   1.2 Demonstrate systems function properly

   1.3 Systems shakedown—hot firing conditions

   3.1 Obtain data on propellant temperature variation

   3.2 Evaluate engine propellant inlet conditions

   3.4 Evaluate mixture ratio control

[redacted]

[redacted]

3.5 Determine feed-line pressure surges

3.6 Evaluate PU system operation

3.8 Obtain data on propellant tank outlet pressures

4.3 Obtain data on helium system temperatures

5.2 Determine engine start transients

5.3 Determine engine shutdown transients

5.5 Determine O/F ratio effect on system

5.6 Determine propellant temperature effect on system

4.1.11.2.21.2 Test Configuration. The test configuration is the same as for Master Run No. 1, except that the engine gimbals are not locked.

4.1.11.2.21.3 Test Conditions

1. One firing of 18-second duration. Allow a 30-minute off-time. One firing of 635-second duration. Allow an 8-hour off-time. Gimbal rate 1/2 to 3 cps.

   One firing of 2-second duration. Allow a 30-minute off-time. One firing of 5-second duration.

2. Propellant temperatures will be ambient (50 to 100 F).

3. Mixture ratios will be 2 to 1.

4. Propellant loads will be 100 percent.

5. Regulator settings will be 185 psig ±4.

6. The engine will be gimbaled as required at the cps rate shown in test condition 1 for the times required.

4.1.11.2.21.4 Data Required. The data required for this test will be the same as required for Master Run No. 1, paragraph 4.1.11.2.1.4.

4.1.11.2.22 Master Run No. 22: Verification Firing. Master Run No. 22 is the same as Master Run No. 1 and is verification of a new engine.

[redacted]

[redacted]

[redacted]

4.1.11.2.23 Master Run No. 23: Varying Propellant Pressure Test - Very High

4.1.11.2.23.1 Test Objectives. The general objectives are to evaluate the performance of the propulsion systems while operating at near relief pressure of the pressurant systems. The detailed objectives are:

1. Primary

   2.3 Establish operating techniques—GSE and systems

   3.2 Evaluate engine propellant inlet conditions

   4.1 Obtain data on ullage pressures

   4.2 Determine helium system pressure surges

   5.1 Evaluate steady-state performance

   5.2 Determine engine start transients

   5.3 Determine engine shutdown transients

2. Secondary

   1.1 Determine systems are leak free

   1.2 Demonstrate systems function properly

   1.3 Systems shakedown—hot firing conditions

   3.1 Obtain data on propellant temperature variation

   3.3 Obtain data on system resonant frequency

   3.4 Evaluate mixture ratio control

   3.5 Determine feed-line pressure surges

   3.6 Evaluate PU system operation

   3.7 Obtain data on propellant line vibration

   3.8 Obtain data on propellant tank outlet pressures

   4.3 Obtain data on helium system temperature

[redacted]

[redacted]

5.4 Evaluate engine restart capability

5.5 Determine O/F ratio effect on system

5.6 Determine propellant temperature effect on system

4.1.11.2.23.2 Test Configuration. The test configuration is the same as for Master Run No. 1.

4.1.11.2.23.3 Test Conditions

1. Two firings of 20-second duration each. Allow off-time to check for propellant leaks between firings

2. Propellant temperatures will be ambient (50 to 100 F)

3. Mixture ratios will be 2 to 1

4. Propellant loads will be 75 percent

5. Regulator settings will be 240 psig ±4

6. The engine will not be gimbaled

4.1.11.2.23.4 Data Required. The data required for this test will be the same as required for Master Run No. 1, paragraph 4.1.11.2.1.4.

4.1.11.2.24 Master Run No. 24: Varying Propellant Pressure Test - High

4.1.11.2.24.1 Test Objectives. The general objectives are to evaluate the performance of the propulsion systems, while operating at high ullage pressure. The detailed objectives are:

1. Primary

2.3 Establish operating techniques—GSE and systems

3.2 Evaluate engine propellant inlet conditions

3.7 Obtain data on propellant line vibration

4.1 Obtain data on ullage pressures

4.2 Determine helium system pressure surges

[redacted]

[redacted]

5.1 Evaluate steady-state performance

5.5 Determine O/F ratio effect on system

2. Secondary

3.1 Obtain data on propellant temperature variation

3.3 Obtain data on system resonant frequency

3.4 Evaluate mixture ratio control

3.5 Determine feed-line pressure surges

3.6 Evaluate PU system operation

3.8 Obtain data on helium system temperature

4.3 Obtain data on helium system temperature

5.2 Determine engine start transients

5.3 Determine engine shutdown transients

5.4 Evaluate engine restart capability

5.6 Determine propellant temperature effect on system

4.1.11.2.24.2 Test Configuration. The test configuration is the same as for Master Run No. 1.

4.1.11.2.24.3 Test Conditions

1. Two firings of 20-second duration each. Allow a 30-minute off-time.

2. Engine inlet pressures will be 170 psig oxidizer and 173 psig fuel.

3. Propellant temperatures will be ambient (50 to 100 F)

4. Mixture ratios will be 2 to 1.

5. Propellant loads will be 75 percent.

[redacted]

[redacted]

6. Regulator settings will be as required to maintain 170 psig oxidizer and 173 psig fuel.

7. The engines will not be gimbaled.

4.1.11.2.24.4 Data Required. The data required for this test will be the same as required for Master Run No. 1, paragraph 4.1.11.2.1.4.

4.1.11.2.25 Master Run No. 25: Varying Propellant Pressure Test - Low

4.1.11.2.25.1 Test Objectives. The general objectives are to evaluate the performance of the propulsion system while operating at low ullage pressure. The detailed objectives are:

1. Primary

   3.2 Evaluate engine propellant inlet conditions

   3.8 Obtain data on propellant tank outlet pressures

   4.2 Determine helium system pressure surges

   5.1 Evaluate steady-state operation

   5.5 Determine O/F ratio effect on system

2. Secondary

   2.3 Establish operating techniques—GSE and systems

   3.1 Obtain data on propellant temperature variation

   3.3 Obtain data on system resonant frequency

   3.4 Evaluate mixture ratio control

   3.5 Determine feed-line pressure surges

   3.6 Evaluate PU system operation

   3.7 Obtain data on propellant line vibration

   4.1 Obtain data on ullage pressures

   4.3 Obtain data on helium system temperature

[redacted]

[redacted]

5.2 Determine engine start transients

5.3 Determine engine shutdown transients

5.4 Evaluate engine restart capability

5.6 Determine propellant temperature effect on system

4.1.11.2.25.2 Test Configuration. The test configuration is the same as for Master Run No. 1.

4.1.11.2.25.3 Test Conditions

1. Two firings of 20-second duration each. Allow a 30-minute off-time.

2. Engine inlet pressures will be 151 psig oxidizer and 166 psig fuel.

3. Propellant temperatures will be ambient (50 to 100 F)

4. Mixture ratios will be 2 to 1.

5. Propellant loads will be 75 percent.

6. Regulator settings will be as required to maintain 151 psig oxidizer and 166 psig fuel.

7. The engine will not be gimbaled.

4.1.11.2.25.4 Data Required. The data required for this test will be the same as required for Master Run No. 1, paragraph 4.1.11.2.1.4.

4.1.11.2.26 Master Run No. 26: Varying Propellant Pressure Test - Very Low

4.1.11.2.26.1 Test Objectives. The general objectives are to evaluate the performance of the propulsion system while it is operating at very low ullage pressure. The detailed objectives are:

1. Primary

3.2 Evaluate engine propellant inlet conditions

3.5 Determine feed-line pressure surges

3.8 Obtain data on propellant tank outlet pressures

[redacted]

[redacted]

4.1 Obtain data on ullage pressure

5.1 Evaluate steady-state performance

5.2 Determine engine start on transients

5.3 Determine engine shutdown transients

5.5 Determine O/F ratio effect on system

2. Secondary

2.3 Establish operating techniques—GSE and systems

3.1 Obtain data on propellant temperature variation

3.3 Obtain data on system resonant frequency

3.4 Evaluate mixture ratio control

3.6 Evaluate PU system operation

4.2 Determine helium system pressure surges

4.3 Obtain data on helium system temperatures

5.4 Evaluate engine restart capability

5.6 Determine propellant temperature effect on system

4.1.11.2.26.2 Test Configuration. The test configuration is the same as for Master Run No. 1.

4.1.11.2.26.3 Test Conditions

1. Two firings of 20-second duration each. Allow a 30-minute off-time.

2. Engine inlet pressures will be 120 psig (oxidizer) and 122 psig (fuel).

3. Propellant temperatures will be ambient (50 to 100 F).

4. Mixture ratio varies with pressure.

5. Propellant loads will be 75 percent.

[redacted]

[redacted]

6. Regulator settings will be as required to maintain 120 psig oxidizer and 122 psig fuel.

7. The engine will not be gimbaled.

4.1.11.2.26.4 Data Required. The data required for this test will be the same as required for Master Run No. 1, paragraph 4.1.11.2.1.4.

4.1.11.2.27 Master Run No. 27: Engine Propellant Valve Failure - Closed

4.1.11.2.27.1 Test Objectives. The general test objectives are to evaluate the performance of the system under the condition of one bank of engine propellant valves failed closed. The detailed test objectives are:

1. Primary

   3.5 Determine feed-line pressure surges

   3.8 Obtain data on propellant tank outlet pressures

   5.1 Evaluate steady-state performance

   5.2 Determine engine start transients

   5.3 Determine engine shutdown transients

   5.5 Determine O/F ratio effect on system

   5.7 Determine gimbal effect on system

2. Secondary

   3.1 Obtain data on propellant temperature variation

   3.2 Evaluate engine propellant inlet conditions

   3.3 Obtain data on system resonant frequency

   3.4 Evaluate mixture ratio control

   3.6 Evaluate PU system operation

   3.7 Obtain data on propellant line vibration

   4.1 Obtain data on ullage pressures

[redacted]

[redacted]

4.2 Determine helium system pressure surges

4.3 Obtain data on helium system temperatures

5.4 Evaluate engine restart capability

5.6 Determine propellant temperature effect on system

4.1.11.2.27.2 Test Configuration. The test configuration is the same as for Master Run No. 1, except that the engine gimbals are not locked for 30-second firing.

4.1.11.2.27.3 Test Conditions

1. Four firings of 5-second duration each. Allow a 10-second off-time. One firing of 30-second duration.

2. Propellant temperatures will be ambient (50 to 100 F).

3. Mixture ratios will be 2 to 1.

4. Propellant loads will be 40 percent.

5. Regulator settings will be 185 psig ±4.

6. The engine valve bank "A" shall remain closed during this test. Engine valve bank "B" shall function.

7. The engine will be gimbaled 4.5 degrees in the Z-axis and 4.5 degrees in the Y-axis, at a rate of 1 cps for 28 seconds during the 30-second firing.

4.1.11.2.27.4 Data Required. The data required for this test will be the same as required for Master Run No. 1, paragraph 4.1.11.2.1.4.

4.1.11.2.28 Master Run No. 28: Engine Propellant Valve Failure - Closed

4.1.11.2.28.1 Test Objectives. The general objectives are to evaluate the performance of the system under the condition of one bank of engine propellant valves failed closed.

4.1.11.2.28.2 Test Configuration. The test configuration is the same as for Master Run No. 27.

[redacted]

[redacted]

4.1.11.2.28.3 Test Conditions. The test conditions are the same as for Master Run No. 27, except that engine valve bank "B" shall remain closed during this test and engine valve bank "A" shall function.

4.1.11.2.28.4 Data Required. The data required for this test will be the same as required for Master Run No. 1, paragraph 4.1.11.2.1.4.

4.1.11.2.29 Master Run No. 29: Low Voltage

4.1.11.2.29.1 Test Objectives. The general test objectives are to determine if the system will start and operate with a minimum electrical power supply. Evaluate valve and engine response times. The detailed objectives are:

1. Primary

   2.2 Establish safety rules and procedures

   3.2 Evaluate engine propellant inlet conditions

   3.5 Determine feed-line pressure surges

   3.8 Obtain data on propellant tank outlet pressures

   4.1 Obtain data on ullage pressures

   5.1 Evaluate a steady-state performance

   5.2 Determine engine start transients

   5.4 Evaluate engine restart capability

2. Secondary

   3.1 Obtain data on propellant temperature variation

   3.3 Obtain data on system resonant frequency

   3.4 Evaluate mixture ratio control

   3.6 Evaluate PU system operation

   3.7 Obtain data on propellant line vibration

   4.2 Determine helium system pressure surges

[redacted]

[redacted]

[redacted]

4.3 Obtain data on helium system temperatures

5.3 Determine engine shutdown transients

5.5 Determine O/F ratio effect on system

5.6 Determine propellant temperature effect on system

4.1.11.2.29.2 Test Configuration. The test configuration is the same as for Master Run No. 1.

4.1.11.2.29.3 Test Conditions

1. One firing of 30-second duration. Allow a 10-minute off-time. Three firings of 5-second duration each. Allow a 30-second off-time.

2. Propellant temperatures will be ambient (50 to 100 F)

3. Mixture ratios will be 2 to 1.

4. Propellant loads will be 100 percent.

5. Regulator settings will be 185 psig ±4.

6. Voltage will be 18 v dc.

7. The engines will not be gimbaled.

4.1.11.2.29.4 Data Required. The data required for this test will be the same as required for Master Run No. 1, paragraph 4.1.11.2.1.4.

4.1.11.2.30 Master Run No. 30: Low Voltage

4.1.11.2.30.1 Test Objectives. The general objectives are to determine the effect on the gimbal actuators of minimum electrical power and evaluate actuator response time. The detailed test objectives are:

1. Primary

2.2 Establish safety rules and procedures

3.2 Evaluate engine propellant inlet conditions

3.5 Determine feed-line pressure surges.

[redacted]

[redacted]

[redacted]

3.8 Obtain data on propellant tank outlet pressures

4.1 Obtain data on ullage pressures

5.1 Evaluate steady-state operation

5.4 Evaluate engine restart capability

5.7 Determine gimbal effect on system

2. Secondary

3.1 Obtain data on propellant temperature variation

3.3 Obtain data on system resonant frequency

3.4 Evaluate mixture ratio control

3.6 Evaluate PU system operation

3.7 Obtain data on propellant line vibration

4.2 Determine helium system pressure surges

4.3 Obtain data on helium system temperatures

5.2 Determine engine start transients

5.3 Determine engine shutdown transients

5.5 Determine O/F ratio effect on system

5.6 Determine propellant temperature effect on system

4.1.11.2.30.2 Test Configuration. The test configuration is the same as for Master Run No. 1, except that the engine gimbals are not locked.

4.1.11.2.30.3 Test Conditions

1. Two firings of 30-second duration. Allow a 10-minute off-time.

2. Propellant temperatures will be ambient (50 to 100 F).

3. Mixture ratios will be 2 to 1.

4. Propellant loads will be 100 percent.

[redacted]

[redacted]

5. Regulator settings will be 185 psig ±4.

6. Voltage will be 18 v dc.

7. Engine will be gimbaled 9 degrees in the Z-axis and 6 degrees in the Y-axis, at a rate of 3/4 cps for 28 seconds during each firing.

4.1.11.2.30.4 Data Required. The data required for this test will be the same as required for Master Run No. 1, paragraph 4.1.11.2.1.4.

4.1.11.2.31 Master Run No. 31: High Temperature. The detailed objectives are:

1. Primary

   3.1 Obtain data on propellant temperature variation

   3.5 Determine feed-line pressure surges

   4.2 Determine helium system pressure surges

   4.3 Obtain data on helium system temperatures

   5.1 Evaluate steady-state operation

   5.6 Determine propellant temperature effect on system

2. Secondary

   2.2 Establish safety rules and procedures

   3.2 Evaluate engine propellant inlet conditions

   3.3 Obtain data on system resonant frequency

   3.4 Evaluate mixture ratio control

   3.6 Evaluate PU system operation

   3.7 Obtain data on propellant line vibration

   3.8 Obtain data on propellant tank outlet pressures

   4.1 Obtain data on ullage pressure

   5.2 Determine engine start transients

[redacted]

[redacted]

5.3 Determine engine shutdown transients

5.4 Evaluate engine restart capability

5.5 Determine O/F ratio effect on system

4.1.11.2.31.2 Test Configuration. The test configuration is the same as for Master Run No. 1.

4.1.11.2.31.3 Test Conditions

1. Three firings of 30-second duration. Allow a 30-minute off-time. Three firings of 5-second duration. Allow a 5-second off-time.

2. Propellant temperatures are 135 F (oxidizer) and 145 F (fuel).

3. Mixture ratios will be 2 to 1.

4. Propellant loads will be 50 percent.

5. Regulator settings will be 185 psig ±4.

6. The engine will not be gimbaled.

4.1.11.2.31.4 Data Required. The data required for this test will be the same as required for Master Run No. 1, paragraph 4.1.11.2.1.4.

4.1.11.2.32 Master Run No. 32: Low Temperature

4.1.11.2.32.1 Test Objectives. The general test objectives are to evaluate SPS performance with low propellant temperatures.

The detailed test objectives are the same as for Master Run No. 31.

4.1.11.2.32.2 Test Configuration. The test configuration is the same as for Master Run No. 1.

4.1.11.2.32.3 Test Conditions. The conditions for this test are the same as for Master Run No. 31, except that the propellant temperature is 30 F (oxidizer) and 40 F (fuel).

4.1.11.2.32.4 Data Required. The data required for this test will be the same as for Master Run No. 1, paragraph 4.1.11.2.1.4.

4.1.11.2.33 Master Run No. 33: Decreasing Propellant Pressure - Long Duration

[redacted]

[redacted]

4.1.11.2.33.1 Test Objectives. The general objectives are the evaluation of the propulsion system while operating with constant declining pressures in the main engine valves. The detailed objectives are:

1. Primary

   3.2 Evaluate engine propellant inlet conditions

   3.5 Determine feed-line pressure surges

   4.1 Obtain data on ullage pressures

   4.2 Determine helium system pressure surges

   5.1 Evaluate steady-state performance

   5.3 Determine engine shutdown transients

   5.5 Determine O/F ratio effect on system

2. Secondary

   3.1 Obtain data on propellant temperature variation

   3.3 Obtain data on system resonant frequency

   3.4 Evaluate mixture ratio control

   3.6 Evaluate PU system operation

   3.7 Obtain data on propellant line vibration

   3.8 Obtain data on propellant tank outlet pressures

   4.3 Obtain data on helium system temperatures

   5.2 Determine engine start transients

   5.4 Evaluate engine restart capability

   5.6 Determine propellant temperature effect on system

4.1.11.2.33.2 Test Configuration. The test configuration is the same as for Master Run No. 1.

[redacted]

[redacted]

4.1.11.2.33.3 Test Conditions

1. One firing of unknown duration.

2. Main oxidizer valve pressure to be 210 psig, main fuel valve pressure to be 205 psig at start of test. He regulator valves to be closed and propulsion system to operate on pressure in propellant tanks until 140 psig is obtained at main engine valves.

3. Propellant temperatures to be ambient (50 to 100 F).

4. Mixture ratios will be 2 to 1.

5. Propellant loads will be 75 percent.

6. Regulator settings will be as required to make oxidizer pressure 210 psig, and fuel pressure 205 psig at the start of the test.

7. The engine will not be gimbaled.

4.1.11.2.33.4 Data Required. The data required for this test will be the same as required for Master Run No. 1, paragraph 4.1.11.2.1.4.

4.1.11.2.34 Master Run No. 34: Decreasing Propellant Pressure - Short Duration

4.1.11.2.34.1 Test Objectives. The general objectives are the evaluation of the propulsion system while it is operating with constant declining pressures in the main engine valves. The detailed test objectives are the same as for Master Run No. 33.

4.1.11.2.34.2 Test Configuration. The test configuration is the same as for Master Run No. 1.

4.1.11.2.34.3 Test Conditions

1. One firing of unknown duration

2. Main engine fuel valve pressure to be 156 psig. The He regulator valves are to be closed and the propulsion system is to operate on pressure contained within the propellant tanks until 145 psig is obtained at the main engine valves.

3. Propellant temperatures will be ambient (50 to 100 F).

4. Mixture ratios will be 2 to 1.

[redacted]

[redacted] [redacted]

5. Propellant loads will be 50 percent.

6. Regulator settings will be as required to make the main fuel valve pressure 156 psig at the start of the test.

7. The engine will not be gimbaled.

4.1.11.2.34.4 Data Required. The data required for this test will be the same as required for Master Run No. 1, paragraph 4.1.11.2.1.4.

4.1.11.2.35 Master Run No. 35: Helium Ingestion

4.1.11.2.35.1 Test Objectives. The general test objectives are to be determined. All detailed test objectives are listed as secondary pending further determination.

4.1.11.2.35.2 Test Configuration. The test configuration is to be determined.

4.1.11.2.35.3 Test Conditions

1. Number and duration of firings to be determined

2. Propellant temperatures to be ambient (50 to 100 F).

3. Mixture ratios will be 2 to 1.

4. Propellant loads will be determined.

5. Regulator settings will be 185 psig ±4.

6. The engine will not be gimbaled.

4.1.11.2.35.4 Data Required. Data requirements are to be determined.

4.1.11.2.36 Master Run No. 36: Oxidizer Depletion

4.1.11.2.36.1 Test Objectives. The general objectives are to evaluate system performance under conditions of oxidizer depletion. The detailed objectives are:

1. Primary

3.5 Determine feed-line pressure surges

3.8 Obtain data on propellant tank outlet pressures

[redacted]

[redacted]

[redacted]

4.2 Determine helium system pressure surges

5.1 Evaluate steady-state performance

5.3 Determine engine shutdown transients

2. Secondary

3.1 Obtain data on propellant temperature variation

3.2 Evaluate engine propellant inlet conditions

3.3 Obtain data on system resonant frequency

3.4 Evaluate mixture ratio control

3.6 Evaluate PU system operation

3.7 Obtain data on propellant line vibration

4.1 Obtain data on ullage pressures

4.3 Obtain data on helium system temperatures

5.2 Determine engine start transients

5.4 Evaluate engine restart capability

5.5 Determine O/F ratio effect on system

5.6 Determine propellant temperature effect on system

4.1.11.2.36.2 Test Configuration. The test configuration is the same as for Master Run No. 1.

4.1.11.2.36.3 Test Conditions

1. One firing of unknown duration

2. Propellant temperatures will be ambient (50 to 100 F).

3. Mixture ratios will be 2 to 1.

4. Propellant loads will be oxidizer, 2,700 pound; fuel, 3,200 pounds.

[redacted]

[redacted]

5. Regulator settings will be 185 psig ±4.

6. The engine will not be gimbaled.

7. Shutdown of engine required immediately after oxidizer depletion.

4.1.11.2.36.4 Data Required. The data required for this test will be the same as required for Master Run No. 1, paragraph 4.1.11.2.1.4.

4.1.11.2.37 Master Run No. 37: Fuel Depletion

4.1.11.2.37.1 Test Objectives. The general objectives are to evaluate system performance under conditions of fuel depletion. The detailed test objectives are the same as for Master Run No. 36.

4.1.11.2.37.2 Test Configuration. The test configuration is the same as for Master Run No. 1.

4.1.11.2.37.3 Test Conditions

1. One firing of unknown duration

2. Propellant temperatures will be ambient (50 to 100 F).

3. Mixture ratios will be 2 to 1.

4. Propellant loads will be oxidizer, 4,500 pounds; fuel, 1,350 pounds.

5. Regulator settings will be 185 psig ±4.

6. The engine will not be gimbaled.

7. Shutdown of engine required immediately after fuel depletion.

4.1.11.2.37.4 Data Required. The data required for this test will be the same as required for Master Run No. 1, paragraph 4.1.11.2.1.4.

4.1.11.3 F-2 Test Measurement List

This list is given in Table 4-3. It is not to be construed as final. Changes to this list will occur more frequently than revisions of the test plan.

[redacted]

[redacted]

Table 4-4. Airframe 001 Test Objectives (Test Series I)

Item	Test No. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Service module reaction control			X		X	X					X	X			X	X	X	X										
Service module main propulsion		X		X			X	X	X	X			X	X					X	X	X	X	X	X			X	X
Cryogenic storage	X																											
Electric power system																									X	X		
Test Objective																												
1. Determine system integrity																												
1.1 System leak check	P	P	P																									
1.2 Evaluate service equipment and GSE	P	P	P	P	P	P	P																		P			
1.3 System shakedown	P	P	P			P	P																		P			
2. Demonstrate servicing and safety																												
2.1 Servicing rates and procedures	P			P	P	S	S				S	S																
2.2 Develop safety rules and procedures	P	P	P	P	P	P	P				P	P													P			
2.3 Develop operating techniques	P	P	P	P	P	P	P				P	P													P			
3. Evaluate propellant system performance																												
3.1 Propellant temperature variation							S	S	S	P			P	P	P	P	P	P	P	P	P	P	P	S				P
3.2 Engine inlet condition							S	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P				P
3.3 System resonant frequency							S	P	P	S	P	P	S	S	P	P	P	P	S	S	S	S	S	P				S
3.4 Mixture ratio control							S	P	S	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P				P
3.5 Feed-line pressure surges							S	P	P	S	S	S	S	S	P	P	P	P	S	S	S	S	S	P				S
3.6 Propellant utilization system operation							S												P	P	P	P	P					P
3.7 Propellant line vibration							S	P	P	S	S	S	S	S	P	P	P	P	S	S	S	S	S	S				S
4. Evaluate pressurization system																												
4.1 Helium system pressure drop							S	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P				P
4.2 Ullage pressure							S	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P				P
5. Evaluate engine performance																												
5.1 Steady-state operation						S	S	P	P	S	P	P	P	P	P	P	P	P	P	S	S	S	S	P				P
5.2 Engine start transients						S	S	P	P	P	P	P	S	S	P	P	P	P	S	P	P	P	P	P				P
5.3 Engine shutdown transients						S	S	P	P	P	P	S	S	S	P	P	P	P	S	P	P	P	P	P				P
5.4 Engine restart capability						S	S	P	S	S	P	P	S	S	P	P	P	P	S	P	P	P	P	P				P
5.5 O/F ratio effects on system						S	S			P									S	P	P	P	P	P				S
5.6 Propellant temperature effects on system										S											S	S	S					
5.7 Gimbal effects on system									P				P												S			P
6. Acoustic and vibration characteristics																												
6.1 Effects on S/M and systems						P	P	P	P	P	P	S	S	P	S	S	P	P	S	S	S	S				P		P
7. Evaluate electrical power system																												
7.1 Evaluate fuel cell start and shutdown	P																								P	P		
7.2 Fuel cell normal power operation	P																								P	P		
7.3 Fuel cell transient power operation	P																								P	P		
7.4 Operation under vibration and acoustical noise																									P	P		
7.5 Operation requiring supplementary power	P																								P	P		
7.6 Fuel cell emergency power operation	P																								P	P		
7.7 Storage battery performance																									P	P		
7.8 Power distribution system	P																								P	P		
7.9 H_2O-PH factor and particle concentration	P																								P	P		
8. Controls and display evaluation (partial)																												

Symbols:
P Primary objectives
S Secondary objectives

[redacted]

[redacted]

4.2 SPACECRAFT 001 PROPULSION DETAILED TEST PLAN

4.2.1 Introduction

4.2.1.1 Purpose

Volume V of the Apollo Program General Test Plan provides the S&ID plan that governs implementation and conduct of individual major test programs.

4.2.1.2 Scope

This section includes the requirements for the spacecraft 001 propulsion test program to be conducted at White Sands Missile Range.

4.2.1.3 Precedence of Reports

This document takes precedence over other S&ID reports which discuss the implementation and conduct of this test plan.

4.2.1.4 Amendments

This document will be revised, as mutually agreed, to reflect program changes and to provide additional information which is unavailable at this time.

4.2.1.5 Definition of Priorities

4.2.1.5.1 Test Objective Priorities. The objectives for the subject tests are either primary or secondary.

4.2.1.5.1.1 Primary Test Objectives. Because primary test objectives must be obtained, tests will not be initiated or continued until the primary measurements are obtainable. A test will be repeated if the primary objectives are not achieved.

4.2.1.5.1.2 Secondary Test Objectives. Objectives will be accomplished, whenever possible, without cancellations or excessive delays in testing. The decision to proceed without having first obtained the necessary objective will be at the discretion of the test conductor. Engineering will determine whether a test requires a rerun, if an excessive number of secondary measurements are lost.

4.2.1.5.2 System Priorities. The spacecraft systems are assigned either primary or secondary priorities.

[redacted]

[redacted]

4.2.1.5.2.1 Primary Systems. Primary systems provide the functions vital to the start and completion of the planned test. A hold or scrub is mandatory if any one of the primary systems is not functioning. These systems include GSE needed to complete the test mission profile.

4.2.1.5.2.2 Secondary Systems. Secondary systems are those systems not functionally required to maintain the test vehicle in the configuration for the planned test.

4.2.1.6 Definition of Objective Terminology

The definitions of the following terms used in conjuntion with objectives for this report given in Definition of Terms, page 7-1.

Demonstrate
Determine
Evaluate
Obtain data
Establish

4.2.2 Test Programs

4.2.2.1 General Test Description

The spacecraft propulsion test program will be conducted on airframe 001, which is an actual service module equipped with the necessary flight-configured systems. Propulsion tests will be performed to verify the conformance of the combined propellant-rocket engine propulsion systems with the design specifications and to evaluate the interactions of the related spacecraft systems during propulsion operations. Related spacecraft systems will include partial stabilization and control and electrical power supply.

Static firing tests will be performed on the service propulsion and service module reaction control systems in their flight configurations. Static firings on the SPS will be conducted to investigate start-stop transients, systems response, and repeatability for normal- and malfunction-mode operations. Tests will be performed with high- and low-propellant delivery pressures and oxidizer-fuel ratios, both above and below nominal. Static firings on the RCS will be conducted to investigate normal mission duty cycles, but will not include off-limit testing. Mission profile tests will be conducted simulating actual mission profiles. Data will be obtained to provide a comprehensive evaluation of the propulsion and related on-board systems performance. In addition, the compatibility of the spacecraft systems associated with control and monitoring of the propulsion systems, GSE, and launch-site service systems will be evaluated.

Static firing tests of the service module will include control of the following systems from the blockhouse: Service Propulsion System (SPS), Reaction Control System (RCS), Electrical Power System (EPS) and various combinations of these systems. Program flexibility for the static firing program noted above, will be achieved by reverting to any previously employed configurations that will satisfy the specific test objectives.

4.2.2.2 Program Objectives and Test Sequence

4.2.2.2.1 General Objectives. The general test objectives to be accomplished with Airframe 001 are as follows:

1. Evaluate the performance of the S/M SPS and RCS during normal and mission profile conditions.

2. Determine the performance of the EPS and cryogenic storage subsystem during operation of the SPS and RCS.

3. Evaluate interface compatibility between all on-board systems during integrated systems tests; i.e., fuel cells/SPS, RCS/partial SCS, etc.

4. Determine the spacecraft structural vibration and acoustics characteristics and integrity during SPS fully gimbaled operations.

5. Demonstrate performance compatibility pertaining to GSE, safety rules, operating techniques, and checkout of all systems.

6. Evaluate the checkout, servicing, operating and maintenance procedures of all systems.

4.2.2.2.2 Test Series I. This test series covers those propulsion ground test evaluations required to certify the spacecraft systems for the flight requirements of spacecraft 009.

4.2.2.2.2.1 Block I – S/M and GSE System Operations (non-firing). This block of tests will include significant engineering tests for evaluation of the service module and GSE systems to be performed during the initial pre-firing checkout period. The specific tests to be performed are as follows:

Test No.

1. Leak-check all fluid and helium systems at the required pressure levels. Functional checkout of system components and control

[redacted]

systems to verify proper operation and correct hook-up of control circuitry.

2. Evaluate the propellant servicing equipment and the GSE compatibility with the service module by SPS fueling and defueling tests.

3. Evaluate propellant servicing and system compatibility by RCS fueling and defueling tests.

4.2.2.2.2.2 Block II Service Propulsion System's Normal Performance. Data will be obtained during this block of tests to evaluate the service propulsion system's performance under normal operating conditions. Engine start, shut-down, restart, steady-state, and gimbal characteristics will be investigated by the following tests:

1. A 10-second run with a 40-percent initial propellant loading. This test will provide information to establish baseline steady-state system operational characteristics.

2. Two 10-second runs will be made. Initial propellant loadings will be 25 and 10 percent. This test will provide assurance that the system is capable of performing at various propellant levels. The tests will furnish repeatability information and a partial family of testing for various propellant levels in the sump tanks.

3. Two runs will be made in this test: a 30-second run with a 40-percent initial propellant loading followed by a 180-second run with the remaining propellant load. Gimbaling will be performed during the second run from 50 to 150 seconds. The test will provide information for extended duration testing at a repeated propellant level.

4. Three 10-second runs will be made with 90, 75, and 60 percent initial propellant loading. The tests will furnish repeatability information and a partial family of testing for the four tanks serviced.

5. This test will consist of a 30-second run with a 90-percent initial propellant load. The test will provide information for extended duration testing for the four tanks serviced.

6. One 200-second run with a 90-percent initial propellant loading. During this test all four tanks will be serviced. The test will demonstrate the systems capability of extended duration operation for a repeated propellant level condition.

[redacted]

[redacted]

7. A 120-second firing with a 60-percent propellant load. The test will provide information of system operation during the propellant tank transfer transient.

8. A series of 5 multiple restarts with 5 seconds on, 5 seconds off timing. Initial propellant load will be 40 percent. The test will demonstrate restart capability for various on-off timing combinations.

9. A series of 5 multiple restarts with 2 seconds on, 2 seconds off timing. Initial propellant load will be 40 percent. The test will demonstrate restart capability for a repeated propellant level and reduced on-off timing.

10. A series of 5 multiple restarts with 5 seconds on, 5 seconds off timing. Initial propellant load will be 90 percent. The test will demonstrate restart capability for a repeated on-off timing and an increased propellant level.

11. A series of 5 multiple restarts with 2 seconds on, 2 seconds off timing. Initial propellant load will be 90 percent. The test will demonstrate restart capability for a repeated on-off timing and an increased propellant level.

12. This test will consist of a 10-second firing with a 50-percent initial propellant loading. This test will provide information to establish baseline steady-state system operational characteristics.

13. A total of 28 firings with a 100-percent initial propellant load. Maximum and minimum firing duration will be 400 and 2 seconds consecutively. Maximum and minimum off-time will be 3 hours and 1 minute consecutively. The test will demonstrate the ability of the system to perform a typical lunar mission profile.

4.2.2.2.2.3 Block III—S/M Reaction Control System's Normal Performance. Block III tests will be performed to evaluate the service module reaction control system's normal performance characteristics. Five tests will be performed to verify the RCS compatibility in the two different control modes (manual and automatic).

Test No.

1. Perform firing checkout runs to verify satisfactory operations of all RCS modules

[redacted]

[redacted]

2. Evaluate the performance of the A, B, C, and D reaction control systems by performing individual engine firings of all engines in each module, using the manual control mode:

Run	System	Operating Mode	Duration (sec) On	Duration (sec) Off	Cycles
1	A	Steady-state	5	2	1
2	C	Steady-state	5	2	1
3	A	Steady-state	2	2	2
4	C	Steady-state	2	2	2
5	B	Steady-state	5	2	1
6	D	Steady-state	5	2	1
7	B	Steady-state	2	2	2
8	D	Steady-state	2	2	2

Test No.

3. Evaluate the operating characteristics of the RCS by performing individual engine firings (of varying pulse widths) of all engines in each module, using the automatic control mode:

Run	System	Operating Mode	Duration (ms) On	Duration (ms) Off	Cycles
1	A	Pulse	200	200	5
2	C	Pulse	200	200	5
3	B	Pulse	200	200	5
4	D	Pulse	200	200	5
5	A	Pulse	50	50	10

[redacted]

Run	System	Operating Mode	Duration (ms) On	Duration (ms) Off	Cycles
6	C	Pulse	50	50	10
7	B	Pulse	50	50	10
8	D	Pulse	50	50	10
9	A	Pulse	10	50	10
10	C	Pulse	10	50	10
11	B	Pulse	10	50	10
12	D	Pulse	10	50	10

Test No.

4. Evaluate the propellant system dynamics of two engines operating simultaneously during four test runs:

Run	System	Engines	Control Mode	Operating Mode	Duration (ms) On	Duration (ms) Off	Cycles
1	A C	+P -P	Automatic	Pulse	500	200	3
2	B D	-P +P	Automatic	Pulse	500	200	3
3	C A	-R -R	Automatic	Pulse	500	200	3
4	D B	+R +R	Automatic	Pulse	500	200	3

[redacted]

Test No.

5. Perform two test runs on four engines operating simultaneously in two different combinations. RCS operation with engines firing simultaneously will be demonstrated to insure that adverse hydraulic hammering of the propellant system will not occur.

Run	System	Engines	Control Mode	Operating Mode	Duration (ms) On	Duration (ms) Off	Cycles
1	A	+R	Automatic	Pulse	200	200	2
	C	-R					
	B	+P					
	D	-P					
2	B	-R	Automatic	Pulse	200	200	2
	D	-R					
	A	+P					
	C	+P					

4. 2. 2. 2. 2. 4 Block IV - Service Propulsion System Design Limit and Malfunction Mode Performance Evaluation. The service propulsion system's operation and performance will be evaluated for limit design operating conditions and malfunction modes. The off-limit test requirements are being developed and will be provided in March 1964.

4. 2. 2. 2. 2. 5 Block V - S/M RCS Design Limit Condition Performance. This block of tests will be conducted to evaluate the S/M RCS performance with operating levels other than normal.

Test No.

1. This will consist of a series of four runs with the propellant pressurization system at the cracking pressure of the system relief valves.

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Run	System	Engines	Control Mode	Operating Mode	Duration On	Duration Off	Cycles
1	A C	+P, -R, +P, -P	Manual	Steady-state	2 sec	2 sec	2
2	B D	+P, -R, +P, -P	Manual	Steady-state	2 sec	2 sec	2
3	A C	-P, +R, -P, +R	Automatic	Pulse	200 ms	200 ms	5
4	B D	-P, +R, -P, +R	Automatic	Pulse	200 ms	200 ms	5

Test No.

2. A series of eight runs will be performed with the propellant pressurization system adjusted to simulate low-pressure conditions.

Run	System	Engines	Control Mode	Operating Mode	Duration On	Duration Off	Cycles
1	A C	+P +P	Manual	Steady-state	2 sec	2 sec	2
2	A C	+R +R	Manual	Steady-state	2 sec	2 sec	2
3	A C	-P -P	Automatic	Pulse	200 ms	200 ms	5
4	A C	-R -R	Automatic	Pulse	200 ms	200 ms	5
5	A C	+P +P	Automatic	Pulse	50 ms	50 ms	10

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Run	System	Engine	Control Mode	Operating Mode	Duration On	Duration Off	Cycles
6	A C	+R +R	Automatic	Pulse	50 ms	50 ms	10
7	A C	-P -P	Automatic	Pulse	10 ms	50 ms	10
8	A C	-R -R	Automatic	Pulse	10 ms	50 ms	10

4.2.2.2.2.6 Block VI - Electrical Power System Tests. These tests will be performed utilizing the fuel cells, cryogenic storage vessels, and spacecraft electrical system. They will be performed to develop methods and determine the length of time required to service the cryogenic vessels and to confirm start-up procedures of the fuel cells with the units installed in the service module. Operational control tests will be performed to determine power transients caused by removing one or two fuel cells as a power source. Operation of the cells at temperatures above normal will be evaluated. Peak loads will be imposed by gimbaling the service propulsion engine. The effect of purging on a low power producing cell will be evaluated. A series of tests will be performed to determine degradation of the fuel cells, radiators, and H_2O supply due to the vibration, acoustical noise, and exhaust gases produced by firing the service module service propulsion engine and the reaction control engines.

Test No.

1. The fuel cell power plants and their associated plumbing and electrical circuits will be checked for leaks and continuity to determine installation integrity. Instrumentation will be calibrated and the GSE operational functions verified. Servicing tests will be performed to evaluate and establish servicing methods and to determine GSE compatibility and operational control. After completion of servicing, the three fuel cell power plants will be activated and a baseline performance test made with a steady-stage load of 1700 watts. After completion of the test, procedures for fuel cell shutdown will be evaluated. In addition, a pH factor and particle concentration analysis will be made of the H_2O supply.

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2. Three fuel cells will be activated and a series of service propulsion engine firings will be made to determine fuel cell operation under vibration and acoustical noise conditions. The following conditions will be monitored.

   a. The service propulsion engine will be fired for 60 seconds with no transient load. A steady-state load of 1700 watts will be applied to the system.

   b. The SPS will be fired for 120 seconds with no transient load. A steady-state load of 2200 watts will be applied to the system. A back pressure of 92 psia will be applied to the H_2O system to simulate boost conditions at spacecraft lift-off.

   c. The SPS will be fired for 90 seconds with a transient load, imposed by gimbaling the SPS engine, applied to the steady-state load of 1700 watts.

   d. The SPS will be fired for 120 seconds with a transient load applied to the steady-state load of 2200 watts. Two of the fuel cells will be operated at 460 F and the third at 470 F.

   e. A steady-state load of 2200 watts will be applied to the system with two of the fuel cells operating at 460 F and the remainder at 470 F.

3. Two fuel cells will be activated and later reduced to one fuel cell to determine fuel-cell operation under vibration and acoustical noise conditions, battery support, and emergency operation with one fuel cell. The following operational conditions will be monitored.

   a. The service propulsion engine will be fired for 60 seconds with a steady-state load of 1700 watts on the system.

   b. A steady-state load of 1700 watts will be applied to the system.

   c. The steady-state load will be increased to 2200 watts.

   d. The service propulsion engine will be fired for 60 seconds with a steady-state load of 1700 watts applied to the system.

   e. The SPS will be fired for 120 seconds with a steady-state load of 2200 watts applied to the system and a transient load imposed by gimbaling the SPS engine.

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f. A steady-state load of 1700 watts will be applied to the system with two batteries in the circuit.

g. The SPS will be fired for 60 seconds with a steady-state load of 1700 watts applied to the system and a transient load imposed by gimbaling the SPS engine. Two batteries will be in the circuit.

h. The SPS will be fired for 60 seconds with a steady-state load of 2200 watts and a transient load imposed by gimbaling the SPS engine. Two batteries will be in the circuit.

i. One fuel cell will operate with a steady-state load of 1100 watts applied to the system with two batteries in the circuit.

j. The steady-state load will be increased to 1400 watts with no batteries in the circuit.

k. The SPS will be fired for 60 seconds with a steady-state load of 1100 watts and a transient load imposed by gimbaling the SPS engine. One fuel cell will be in operation and two batteries will be in the circuit.

l. The SPS will be fired for 60 seconds with a steady-state load of 1400 watts and a transient load imposed by gimbaling the SPS engine. One fuel cell will be in operation and two batteries will be in the circuit.

4.2.2.2.3 Test Series II. This series will include the tests required to certify the spacecraft systems in support of a manned earth orbital flight. The following sequence and number of tests are subject to change as definitive test requirements are evolved.

4.2.2.2.3.1 Block I - S/M Firings With Off-Limit Propellant Temperature and Mixture Ratios. Service propulsion system operation will be evaluated during a series of firings with off-limit propellant feed conditions.

4.2.2.2.3.2 Block II - Spacecraft Mission Duty Cycles. A number of mission profiles will be performed to support the qualification of the service module for a manned earth orbital mission. The Special Test Unit (STU) automatic programmer and the partial stabilization and control system will be utilized to program the simulated missions. The fuel cells will be operated to supply electrical power, and the water generated will be monitored for life systems evaluation.

[redacted]

4.2.2.2.4 Test Series III and Subsequent. These will include tests required to certify the spacecraft systems for extended earth orbital and lunar flights. In addition, multiple systems tests and problem and design improvement programs will be undertaken as required to support various phases of the Apollo Program.

4.2.2.2.5 Test Sequence. The ground test schedule for airframe 001 is presented in Section 4.2.10. The sequence and blocks of tests in support of the suborbital mission have been derived from current information and are subject to change as definitive test requirements are evolved.

4.2.2.3 Test Limitations

The static firing tests of spacecraft 001 are to be conducted at a test site (approximately 4900 feet above sea level) at the White Sands Missile Range.

Testing conducted under the above conditions will be subject to the following deviations from the mission configuration:

1. Variable climatic conditions of temperature, humidity, and wind

2. Spacecraft and equipment exposure to dust and sand

3. Rigid mounting of the command and service modules, thus affecting vibration response of the propulsion systems

4. Prevailing earth gravity

5. Firing of the service propulsion engine without the expansion nozzle in place.

6. The S/M RCS A&C systems of sea-level nozzles for elimination of nozzle flow instability (to obtain a more realistic system performance data); however, formulation of checkout procedures for AMR necessitates flight area ratio nozzles on the C&D systems.

4.2.2.4 Test Implementation

The tests set forth in this test plan will be implemented in the field through the medium of Section 4.2.11, Detailed Test Descriptions, which will be considered Test Directives. Deviations from these directives, necessary to configuration or test requirement changes, will be implemented through a verification notice from NAA to NASA. This notice will verify

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specific schedule dates for individual tests and will contain information as to whether the Detail Test Description (latest revision) will be followed or whether deviations are necessary. If deviations are necessary, they will be described in detail for approval.

4.2.3 Configuration

4.2.3.1 Test Vehicle

The test vehicle, spacecraft 001, will consist of a service module and a special test adapter. The module will contain various systems and subsystems that are described herein. These systems' descriptions reflect the present configuration planned for propulsion tests.

4.2.3.1.1 Service Module Systems. The service module systems are:

1. Service Propulsion System. The service propulsion system is a liquid propellant-type, which uses earth storable hypergolic propellants. The fuel (MIL-P-27402) is a 50-50 blend of unsymmetrical-dimethylhydrazine (UDMH) and hydrazine (N_2H_4); the oxidizer (MIL-P-26539) is nitrogen tetroxide (N_2O_4). A pressure-fed system supplies the propellants to the thrust chamber. The fuel supply is contained within two hemispherically domed, cylindrical tanks that are structurally mounted and connected in series. The capacity of the fuel system is 15,300 pounds. The oxidizer supply is also contained in two hemispherically domed, cylindrical tanks connected in series. The capacity of the oxidizer tanks is 30,600 pounds. A helium system is used to pressurize the propellant tanks. The helium supply is contained within two spherical tanks having a capacity of 35.0 cubic feet and holding a nominal 93 pounds of helium at 4000 psia. Initial testing will be conducted utilizing prequalified engines prior to receipt and installation of the qualified components. The propellant tanks are pressurized to 185 ± 4 psig (primary).

   The engine develops a nominal 21,900 pounds of thrust at altitude and has a specific impulse of 315 seconds. The thrust chamber has an expansion ratio of 60 to 1. The engine has a gimbal mechanism capable of providing an 8.5 ± 1 degree gimbal angle in yaw from null and a 6.0 ± 1 degree gimbal angle in pitch from null. For a more detailed breakdown of this system, refer to SID 62-700-2.

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2. S/M Reaction Control System. The S/M RCS is composed of four similar liquid propellant pressure-fed, reaction control subsystems. The subsystems have four reaction control engines each. The complete system utilizes eight of the sixteen thrust chambers for roll, four for pitch, and four for yaw. Earth-storable hypergolic propellants are utilized. The fuel is a 50-50 blend of UDMH and N_2H_4; the oxidizer is nitrogen tetroxide (N_2O_4). Each of the four subsystems has a helium storage and distribution system, and a fuel storage and distribution system. Each helium supply is contained in a spherical tank with a nominal capacity 0.81 pounds at a pressure of 4150 psia. Each oxidizer supply is contained in a spherical tank with a capacity of 138 pounds. Each fuel supply is contained in a spherical tank with a capacity of 70 pounds. The propellant tanks are pressurized to 181 ± 4 psia (primary).

   Each of the sixteen engines develops a nominal 100 pounds of thrust in space (vacuum) and has a specific impulse of 315 seconds during steady-state operation. Initial testing will be conducted utilizing prequalified engines prior to receipt and installation of the qualified components. For a more detailed breakdown of RCS, refer to SID 62-700-2.

3. Electrical Power System. The primary electrical power source of the Apollo spacecraft will be a fuel cell system with backup storage batteries.

   a. Fuel Cells. The Apollo fuel cell system will consist of three independent modules operating in parallel and capable of producing power at 27 to 31 volts dc for normal operation or, in the event of an emergency, one module will furnish 2200 watts at 21.5 volts dc. The modules will operate at a temperature level between 460 to 500 F, utilizing hydrogen and oxygen as the reactants and potassium hydroxide as the electrolyte. The reactants will be stored in the supercritical condition in stainless steel tanks, 58.4 pounds of LH_2 and 653 pounds of LO_2. Hydrogen storage tank pressures will be 250 psia, and oxygen storage tank pressures will be 900 psia.

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The fuel cell module will be pressurized to approximately 53 psia to restrict electrolyte vaporization and dissipation. The manifold pressures of both reactants inside the module will be maintained at approximately 7 psia above the 53 psia electrolyte pressure, or at 60 psia.

Nitrogen will be stored at 1500 psia in a tank, which will be furnished within each fuel cell module. During the propulsion systems ground test, the space radiators are inoperative. Heat sinks are provided by a water-glycol cooling system, supplemented by a radiator substitution unit. The water (H_2O) that is formed by operating the fuel cells during this test will be collected in a sterilized container, and a laboratory examination will be made to determine the pH factor and particle concentration.

The EPS will consist primarily of prototype hardware.

4.2.3.2 Support Equipment

Four groups of GSE will be used in the checkout and test area for spacecraft 001. They are:

Auxiliary equipment

Checkout and control equipment

Handling equipment

Servicing equipment

For detailed descriptions and up-to-date configuration as they become available, refer to SID 62-417.

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1. Auxiliary Equipment

Model No.	Nomenclature
A14-011	Ground cooling cart
A14-014	Cleaning Positioner
A14-019	Disconnect set, umbilical S/C fluid electrical
A14-020	S/M cover
A14-026	Cap and plug set
A14-031	C/M fluid systems substitution unit
A14-035	Vacuum cleaner
A14-044	Nozzle closure
A14-045	Nozzle plug (140 psi)
A14-046	Control crane, auxiliary
A14-051	C/M substitution unit, AFRM
A14-052	Heater power supply
A14-053	Fuel cell protective cover
A14-054	Cover, LO_2 cryogenic storage tank
A14-055	Cover, LH_2 cryogenic storage tank
A14-056	Link, gimbal lock fixture
A14-059	Fuel cell radiator substitution unit
A14-063	Cover set, protective
A14-074	Load Bank, d-c fuel cell
A14-084	Fuel cell substitution unit
A14-085	EPS substitution unit
A14-087	Inverter substitution unit
A14-127	Nozzle extension inertia simulator
A14-131	Nozzle plug (10 psi)
A14-134	Hydro-set (10)
C14-017	SPS engine alignment set
C14-040	C/M and S/M electrical power, BME

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1. Auxiliary Equipment (Contd)

Model No.	Nomenclature
C14-075	Propulsion system fluid checkout unit
C14-079	SPS engine electrical B/M console
C14-084	Fuel cell powerplant test stand
C14-089	Mobile data recorder
C14-163	S/M SPS propellant quantity gaging system, BME
C14-167	S/M RCS propellant quantity gaging system equipment
C14-179	Cable Set, electrical -11, -31, -51, and -61
C14-183	H_2 cryogenics storage system, BME
C14-193	Cable set, electrical
C14-406	Electrical termination distribution
C14-408	Thrust chamber assembly alignment, BME
C14-413	LO_2 cryogenic subsystem BME
C14-418	S/C ground power supply
C14-426	Calibration unit, pressure 6000 psig
C14-427	Calibration unit, fluid flow rate
C14-428	Calibration unit, temperature
C14-435	Electrical termination distribution terminal room J box
C14-437	Electrical terminal distribution control center J box
C14-438	Electrical terminal distribution test stand J box
C14-439	Electrical terminal distribution shelter J box
C14-444	FDSC unit, SPS oxidizer
C14-445	FDSC unit, SPS fuel
C14-447	FDSC unit, S/M RCS fuel

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1. Auxiliary Equipment (Contd)

Model No.	Nomenclature
C14-448	FDSC unit, RCS oxidizer
C14-449	FDSC unit, helium
C14-454	Propellant quantity gaging system checkout equipment
C14-455	SPS C/O and monitoring removable control rack
C14-456	Isolation amplifier
C14-467	C/M S/M umbilical test set
C14-468	Freon pressurization unit
C14-471	RCS flow nozzle sensor set
C14-476	FDSC unit, LH_2
C14-477	FDSC unit, LO_2
C14-478	FDSC unit, water/glycol
C14-483	RCS valve driver and monitor unit
C14-484	S/M external signal conditioner
C14-600	Electrical power system
C14-601	Fuel cell heater support
C14-602	SPS checkout and firing console
C14-606	S/M RCS checkout and fire control
C14-608	Fuel cell and cryogenic systems
C14-613	Test director panel
C14-615	Cryogenic oxygen servicing
H14-011	Launch escape alignment stand
H14-021	GSE handling cart
H14-024	S/M propulsion motor sling
H14-030	S/M support
H14-031	Base support stand
H14-037	Propulsion development test ground adapter

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1. Auxiliary Equipment (Contd)

Model No.	Nomenclature
H14-052	Position trailer narrow base
H14-060	Fuel and oxidizer tank sling
H14-064	Helium tank sling
H14-072	Mission propulsion engine support
H14-080	Fuel cell shipping container
H14-093	Boatswain chair
H14-098	Handling and installation set, RCS
H14-100	B-2 access stand
H14-101	B-1 access stand
H14-105	Service module dolly
H14-106	Test fixture and ground adapter sling
H14-113	S/M panel sling
H14-114	S/M panel storage rack
H14-115	S/M equipment installation fixture
H14-118	Container, LO_2 cryogenics storage tank
H14-119	Container, LH_2 cryogenics storage tank
H14-120	SPS engine support checkout and maintenance
H14-121	S/M equipment dolly
H14-132	Dolly, SPS engine
H14-134	Support base, integrated system
H14-136	Support ring set, S/C support structure
H14-137	Cover, environmental, S/C support structure
H14-138	Transfer erector, S/C support structure
H14-144	Mobile maintenance platform

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1. Auxiliary Equipment (Contd)

Model No.	Nomenclature
S14-002	Oxidizer transfer unit
S14-003	Mass spectrometer leak tester, helium
S14-008	Fuel transfer unit
S14-009	Helium transfer unit
S14-022	Helium booster unit
S14-023	Pressure maintenance unit
S14-026	LH_2 transfer unit
S14-032	LO_2 transfer unit
S14-054	Fuel cell powerplant servicing unit
S14-056	Mass spectrometer leak tester, hydrogen
S14-057	RCS oxidizer service unit
S14-058	Fuel ready storage unit
S14-059	Oxidizer, ready storage unit
S14-060	Fuel toxic vapor disposal unit
S14-061	Oxidizer toxic vapor disposal unit
S14-062	Helium ready storage unit
S14-063	S/M RCS fuel servicing unit
S14-065	LO_2 mobile storage unit
S14-066	LH_2 mobile storage unit
S14-069	Moisture monitor unit
S14-070	Engine decontamination unit
S14-071	Brazing unit, portable
S14-076	Mobile GN_2 bottle rack
S14-082	Fluid distribution system (Downey)
S14-084	Halogen leak detector unit
S14-086	Fluid distribution system (PSDF)
S14-089	Fluid distribution system (test preparation)

4.2.3.3 Facilities

The propulsion test facility description appears in Section 4.1.

4.2.4 Instrumentation and Data Acquisition Requirements

4.2.4.1 Instrumentation System

The propulsion test program will require an instrumentation system to accomplish the test requirements. The system will comprise the following types of equipment.

1. Transducers located on the test vehicles, test stands, and service equipment

2. Signal conditioning equipment located on the test vehicles, test stands, and bunkers

3. Excitation sources for the transducers

4. Junction boxes and associated wiring from the test vehicles and test stands to the bunker data input patch panels

5. Closed-circuit TV cameras and associated equipment

6. Fastex photo cameras for engineering data

7. Monitor cameras for documentation of hazardous operations

8. Six dual-channel potentiometer-type pen recorders for critical real time monitoring

4.2.4.1.1 Transducer Requirements. The transducer requirements are set forth in the measurement list, SID 63-501, dated November 1963.

4.2.4.2 Data Acquisition System

4.2.4.2.1 System Description. The data acquisition system will provide on-line instrumentation displays, quick-look playback capabilities, and magnetic tape storage of all data from the instrumentation system.

The output of the instrumentation system will terminate at the data acquisition system input patch panels in the bunkers. The high-frequency

measurements will use frequency modulation and FM multiplexing to prepare the data for magnetic tape storage. The high-accuracy measurements will employ PCM techniques. The subcarrier oscillators and multiplex equipment for the analog system and the multiplexing and digitizing equipment for the digital system will be located in the bunkers. Transmission from the bunker to the blockhouse will be by coaxial cables. Magnetic recorders will be located in the blockhouse. To provide playback and display, FM demodulation and PCM decommutation equipment will be required. The system will incorporate a timing system for time-code generation and system synchronization. The data output will be quick-look in nature: oscillographs, graphic recorders, event recorders, and meters. Detailed data analysis will be performed at Downey.

4.2.4.2.2 System Capacity. There will be 100-percent magnetic tape recording of all data. The 340 channels of PCM data will be recorded on one 16-channel tape transport. The 117 channels of analog data will be recorded on three 14-channel tape transports. Quick-look and playback capacity will be as follows:

Two 8-channel oscillographs
Two 8-channel brush recorders
One 50-channel event recorder
One 100-channel CRT bargraph

4.2.5 Support Requirements

4.2.5.1 General

Two types of support will be required—photographic processing and meteorological forecasting.

4.2.5.2 Photographic Processing

For post-run photographic accessibility, on-site processing of black and white movie film will be required. Primary instrumentation photography will be in color on 16-mm and 70-mm film. Color processing will be contracted to some local agency, with a requirement of 24-hour turn-around.

4.2.5.3 Meteorological Data

Local information is needed to permit hourly forecasts as follows: wind direction, turbulence, and speed; and temperature and humidity. Additional data from synoptic weather charts and nearby weather stations will permit long-range forecasting and test schedule correlation, so that test operations will be conducted under the most suitable material

dispersion characteristics. Complete twenty-four hour data will be needed prior to actual test firings.

4.2.6 Pretest Operations

The airframe 001 preparation program consists of planning, scheduling, implementing, performing, reporting, and evaluating engineering tests. The test program is designed to verify satisfactory operation of the individual and integrated systems at the Downey facility prior to delivery of the test article to WSMR.

4.2.6.1 Test Preparation-Downey

Airframe 001 will be delivered to the test preparation area from Manufacturing final assembly. The service module will be received and processed through the necessary checkouts and tests prior to shipment to the field site.

4.2.6.1.1 Service Module. Apollo Test and Operations will conduct a receiving inspection in Manufacturing final assembly as part of the normal closeout and transfer operations at Downey. The accomplishment of the record inspection will enable a realistic scheduling of the test operations in the test preparation area. A visual inspection of the test vehicle will be made, and any discrepancies and deviations will be resolved to determine if rework is required prior to acceptance or if items are assigned to carryover. The transfer documents will be evaluated, and the status of documentation deviations or discrepancies, parts shortages, fabrication and installation rework items, open engineering orders, nonconformance reports, and S/M adapter configurations will be recorded.

The service module and service module adapter will be fit-checked in Manufacturing final assembly. The S/M adapter will be shipped directly to the field site after completion of a satisfactory fit check.

The configuration of the service module and its associated GSE will be updated in the test preparation area to the latest design changes, specification changes, and NASA-requested changes. It will be reinspected to ensure the readiness of the hardware for systems checkout. Installation of miscellaneous equipment and R&D instrumentation not installed in the manufacturing final assembly area will be accomplished. Facility compatibility checks will be performed. Based on availability, the GSE and consoles will be functionally validated. Subsequently, a facility, GSE, and test-vehicle simulator integrated test will be performed.

The second phase of test preparation will be systems tests to verify operational capability. Continuity tests of the electrical power distribution system will be performed prior to power-on tests.

The instrumentation system will be calibrated, and functional verification of the various end instruments will be substantiated as operational within prescribed limits. Any special instruments supplied by NASA for the S/M will be functionally tested, either on the bench or in the S/M, utilizing the available checkout GSE. The S/M electrical power system will be functionally checked using ground power.

The propulsion system, the cryogenic storage system, and the reaction control system will be leak-checked in Manufacturing final assembly as a routine operation. If modification, up-dating, or a malfunction in a system warrants verification of the integrity of the systems, the systems will be leak-checked at the Downey high-pressure pit facility. The service propulsion system engine alignment will be normally accomplished in the Manufacturing area. A functional verification of the SPS, RCS, and cryogenic system will be performed in the test preparation area. Timing and synchronization of engine valves, and validation of the RCS propellant-indicating system validation will be accomplished. During these system tests, all necessary data will be recorded via hardline. Following the completion of the individual system tests, a final modification of the service module and GSE will be performed to update configuration, and an inspection will be accomplished to verify pre-integrated system configuration.

The third phase of operations will consist of an integrated system test and an EMI test. The integrated system test will be conducted utilizing the various simulators to demonstrate and verify proper operation and compatibility of S/M systems during a sequence of operations. Initially, the integrated test will be conducted using ground electrical power. Subsequently, the integrated test will be conducted using the fuel cell as the prime electrical power with umbilicals connected.

The operational characteristics of the fuel cell during normal and emergency operations will be evaluated and verified. All times and events will be monitored and taped to verify the performance of all systems. A detailed data reduction of the tests will be accomplished. During the integrated test, the control and monitoring of the service module will be via the STU and hardline to closely approximate actual field operations. In addition to the integrated system test, and electromagnetic interference test will be performed. The outputs of the end instrument amplifiers and any critical circuitry of the fuel cell, the SPS, RCS, and cryogenic storage systems will be monitored at all times. Energy signals generated during

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steady-state and emergency conditions will be determined. Any interference pickup levels from the cabling and between the S/M and the GSE will be monitored.

The final phase will include preparation of the service module for shipment and the shipping operations. The service module will be weighed for transportation. Packaging and transportation requirements will be resolved, and historical data and end item data packages of the S/M and associated GSE will be prepared for shipment. Status of the transfer documents will be recorded and evaluated prior to transfer to shipping operations. The service module and GSE will be secured and necessary systems will be prepared for shipment. The service module and associated GSE will be normally shipped by air. Shipment of the S/M and critical items of GSE by air to meet tests schedule requirements is dependent on NASA authorization. All the operations to be performed on the spacecraft 001 S/M in the Downey test preparation area can be listed in four phases, as follows:

Phase 1

Modification and miscellaneous equipment installation
GSE and facility configuration inspection
GSE console validations
GSE integrated checkout
Interconnecting cables installed
GSE and service module compatibility

Phase 2

Wiring Tests
Functional verification of electrical system (ground power)
Functional verification of instrumentation
Functional verification of thermal and vapor detection system
Functional and/or leak test of SPS
Functional and/or leak test of RCS
Functional and/or leak test of cryogenic storage system
Functional test of fuel cell
Preintegrated system inspection
Final modification

Phase 3

Integrated test preparation
Integrated system tests
EMI tests

[redacted]

[redacted]

Phase 4

Post inspection of S/M
S/M weighing
S/M closeout
S/M paint
S/M data package
Preparation of S/M for shipment
Preparation of GSE for shipment

4.2.6.2 Arrival and Receiving Inspection – WSMR

At the test site the modules will be installed in the preparation building. Here the command and service modules will be mounted to an adapter, preparatory to mounting on the test pad. Any outstanding modification will be performed and followed by checkout tests for verification. Instrumentation end items will be installed, calibrated, and functionally verified.

4.2.6.3 Combined Systems Check—Test Stand

At the test pad the modules will be mounted to their respective stands. Instrumentation continuity will be established with the data system and blockhouse. Instrumentation in the test vehicle will be calibrated with the data recording equipment.

All gas and fluid systems will be leak tested. System components will be verified for functional operation. Checkout and handling ground support equipment compatibility will be demonstrated.

Preliminary operations will be conducted to determine optimum propellant transfer and control techniques. Tanking, detanking, flushing, and purging methods will be developed. Procedures for systems operation, malfunction detection, manual override safety procedures, and emergency shutdown disciplines will be accomplished during these preliminary tests.

4.2.6.4 Test Procedures

This section will contain, when available, a listing of detail checkout procedures required for the conduct of all activity at the test areas. A procedures sequence chart depicting the time-phasing of all procedures in each test area will be established.

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4.2.7 Test Management and Organization

4.2.7.1 Program Management Relationships

The Apollo Program Manager, through his Apollo Engineering organization, is responsible for determining the requirements for tests, for properly utilizing the data from the tests, and for controlling the configuration of test vehicles and associated GSE.

The Division Director of Quality Assurance, through the Director of Apollo Test and Operations, has direct responsibility for the conduct of all Apollo testing at the WSMR.

The ATO-WSMR Manager, reporting directly to the Director of Apollo Test and Operations, is responsible for all test and support functions at the WSMR in keeping with established NAA/S&ID policies and procedures.

The ATO-WSMR Manager is responsible for interface with the NASA Resident Manager and the WSMR, in consonance with policy guidance from S&ID and MSC.

4.2.7.2 Test Preparation

The section will contain the organization and working relationships for test preparation of S/C 001 at Downey when final details are resolved.

4.2.7.3 ATO-WSMR

4.2.7.3.1 Basic Consideration. The S&ID Apollo Test and Operations concept for the conduct of the propulsion test program at WSMR is presented below. Included are the organizational charts, statements of functional responsibility, and relationships between the ATO-WSMR Manager and the NASA Resident Manager and the WSMR.

The propulsion tests will be conducted at the Apollo Development Facility on the west side of the WSMR. The NASA and the Corps of Engineers are responsible for site selection, preparation, and construction. NAA-S&ID will be responsible for the spacecraft, test equipment, and ground support equipment installation checkout.

The administrative functions shown in the attached organization charts were designed to support both the propulsion and mission abort test groups with minimum overhead and maximum utilization of personnel and resources. Both test groups are also mutually self-supporting, and the movement of both technical and support personnel to WSMR, on either a trip or change of assignment, is time-phased to match peak test periods.

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4.2.7.3.2 ATO-WSMR Organization. The lines of communications for the WSMR test organization are shown in Figure 4-11. The F-2 and spacecraft 001 test program and ATO technical responsibility are combined under one group, with formal conduct of the test operations being the responsibility of the respective test conductors.

4.2.7.3.3 ATO-WSMR Manager. The Manager of ATO-WSMR is responsible to the Director of Apollo Test and Operations, S&ID, Downey, and NASA for implementing and interpreting the directions and policies of the Apollo test program at WSMR. The manager, who directs all S&ID activities at WSMR, is responsible for establishing effective working relation with the local NASA, WSMR, and associate contractors.

4.2.7.3.4 Service Propulsion Test. The service propulsion test chief is responsible to the ATO-WSMR Manager for the planning, preparing, coordinating, conducting, and reporting of the service propulsion tests. This includes defining personnel requirements, facilities requirements, and criteria, instrumentation, and data requirements; the acceptance and preparation of propulsion test vehicles and the direct supervision of all tests conducted in the Apollo propulsion test area; the maintenance, modification, and operation of all GSE associated with his program; and the preparation and submittal of test plans procedures and reports. The functional breakdown of this organization is presented in Figure 4-12.

4.2.7.3.5 Engineering Project Engineer. The S&ID Apollo engineering project engineer represents the chief engineer in coordinating the effort on the propulsion test vehicles. This includes the following responsibilities:

Checks the configuration of the test vehicle, GSE, and instrumentation

Approves engineering orders, procurement specifications, schedules, and test plans

Coordinates all aspects of each test vehicle activity to assure proper balance in concept, design, construction, and test

4.2.7.3.6 Test Conduct. The assigned S/C 001 test conductor will be directly responsible to the service propulsion test chief for the conduct of test operations and will approve all working documents pertinent to the test accomplishment. The ATO test operations conduct is depicted by Figure 4-13.

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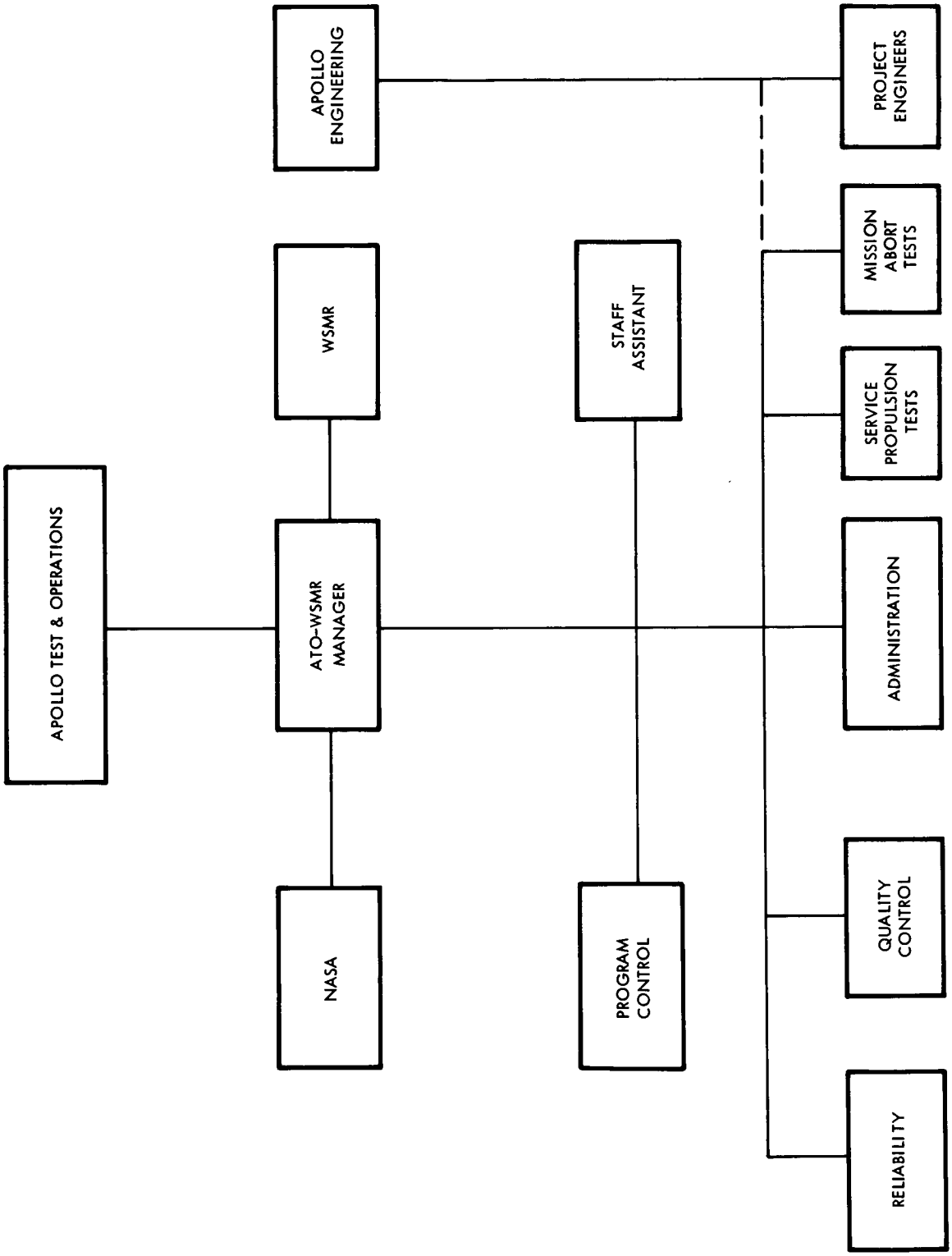

Figure 4-11. ATO-WSMR Organization

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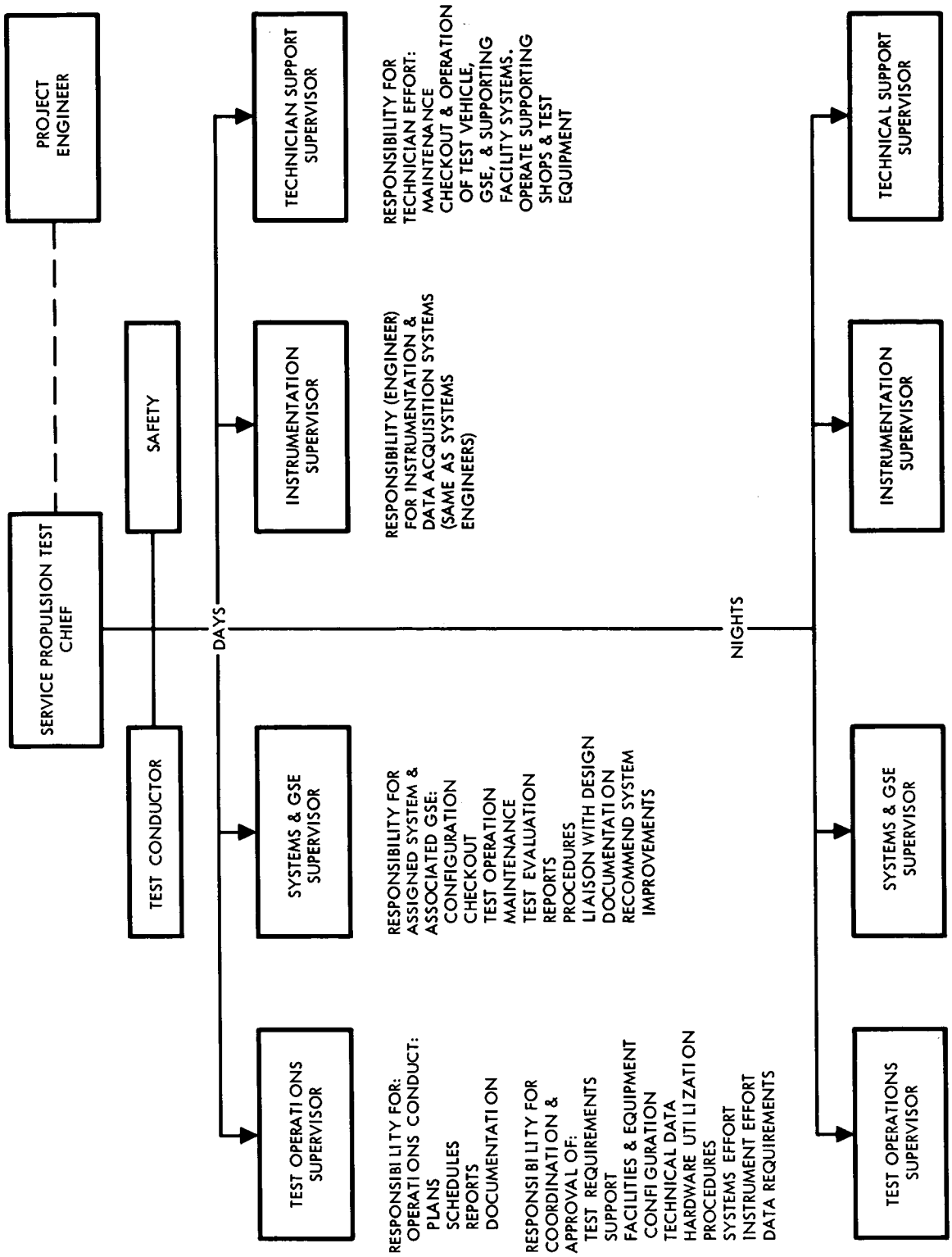

Figure 4-12. ATO-Propulsion Test Functional Organization (WSMR)

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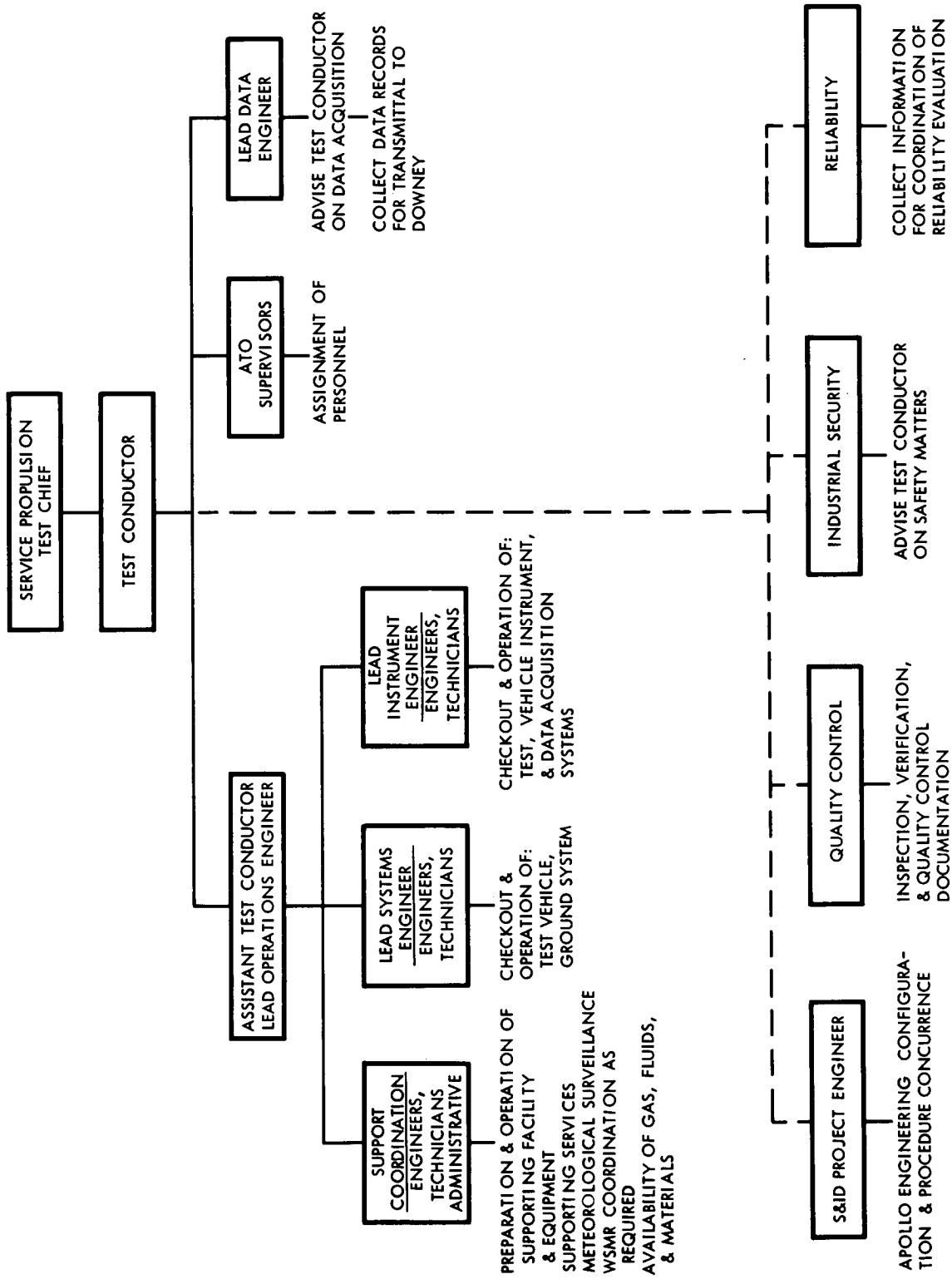

Figure 4-13. ATO-Test Operations Conduct Organization

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4.2.7.3.7 Administration. The administration chief is responsible to the ATO-WSMR Manager for all administrative and housekeeping functions associated with ATO testing at WSMR. He coordinates all administrative support furnished by WSMR for the mission abort tests and represents the ATO-WSMR Manager on such boards, panels, and committees as may be required. He is responsible for the operation, maintenance improvement, support, and modification of the propulsion administrative and test areas assigned to the NASA and S&ID. These responsibilities include:

Personnel—the supervisory and operating responsibility for employment, wages and salaries, employee relations, industrial hygiene and safety, medical and food services, and the preparation of all local operating procedures pertaining to these subjects

Finance—the supervisory and operating responsibility for timekeeping, disbursement, petty cash and payroll, and the preparation of all local operating procedures pertaining to these subjects

Material—the supervisory and operating responsibility for warehousing and supply, purchasing, property records and control, tool cribs, transportation (including pool cars and leased vehicles), and the maintenance of mobile equipment, and the preparation of all local operating procedures pertaining to these subjects

Logistics—the supervisory and operating responsibility for maintaining the currency of operating, launch, maintenance, checkout, and test procedures manuals; determination of spares and spares levels; the necessary personnel and equipment for reproduction, photographic support (including processing laboratory); and the preparation of all local operating procedures pertaining to these subjects

Security—the supervisory and operating responsibility for coordinating all security activity with WSMR: investigations, police and fire protection, lock and key, identification badges, communications, vehicle and visitor control, mail, classified document control, and the preparation of all local operating procedures pertaining to these subjects

Facilities—the responsibility for operation, maintenance, and modification of NASA and S&ID facilities in the propulsion area, industrial property records, and the preparation of all local operating procedures pertaining to these subjects

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4.2.7.3.8 Quality Control. The quality control supervisor is responsible to the ATO-WSMR Manager for the supervisory and operating functions which enable S&ID products at WSMR to meet the high standards required by NASA and NAA. This includes physical inspection and functional verification of test vehicles, GSE, and test facilities; the preparation of required historical records, inspection forms, and malfunction reports; the operation of laboratories and calibration standards, and the preparation of all local operating procedures pertaining to these subjects.

4.2.7.3.9 Reliability. Reliability includes the supervisory and operating responsibility for obtaining system performance data, system operating time, times-to-failure (for preparing failure analyses and non-conformance reports); reviewing all documents for compliance with established reliability requirements and monitoring all tests; and the preparation of all local operating procedures pertaining to these subjects.

4.2.7.4 Configuration Control

The S/C 001, GSE, and instrumentation configuration will be controlled by engineering drawings and engineering orders. Incorporation of EO's will be authorized through workbook entries by ATO engineers. Change verification records will be maintained on all major hardware assemblies so that a completed EO change configuration is available at all times. A test vehicle configuration control summary will be kept current, and the S&ID project engineer will be advised immediately of incorporated changes. This will facilitate updating of the configuration summary and dissemination to S&ID Downey and NASA.

The general outline of configuration control procedures will be amplified in more detail when methods and procedures for the maintenance of the above documentation and communication channels are resolved.

4.2.7.4.1 TAIR Book. The Test and Inspection Record (TAIR) book is a control and record document for all activities concerning the TEST VEHICLE and GSE. It remains with the hardware. Entries generating work will be entered in the TAIR Book by ATO service propulsion test and Quality Control Personnel.

4.2.7.5 Engineering Orders

The Apollo Test and Operations/Apollo Engineering working relationship as pertains to engineering orders is depicted by Figures 4-14 and 4-15.

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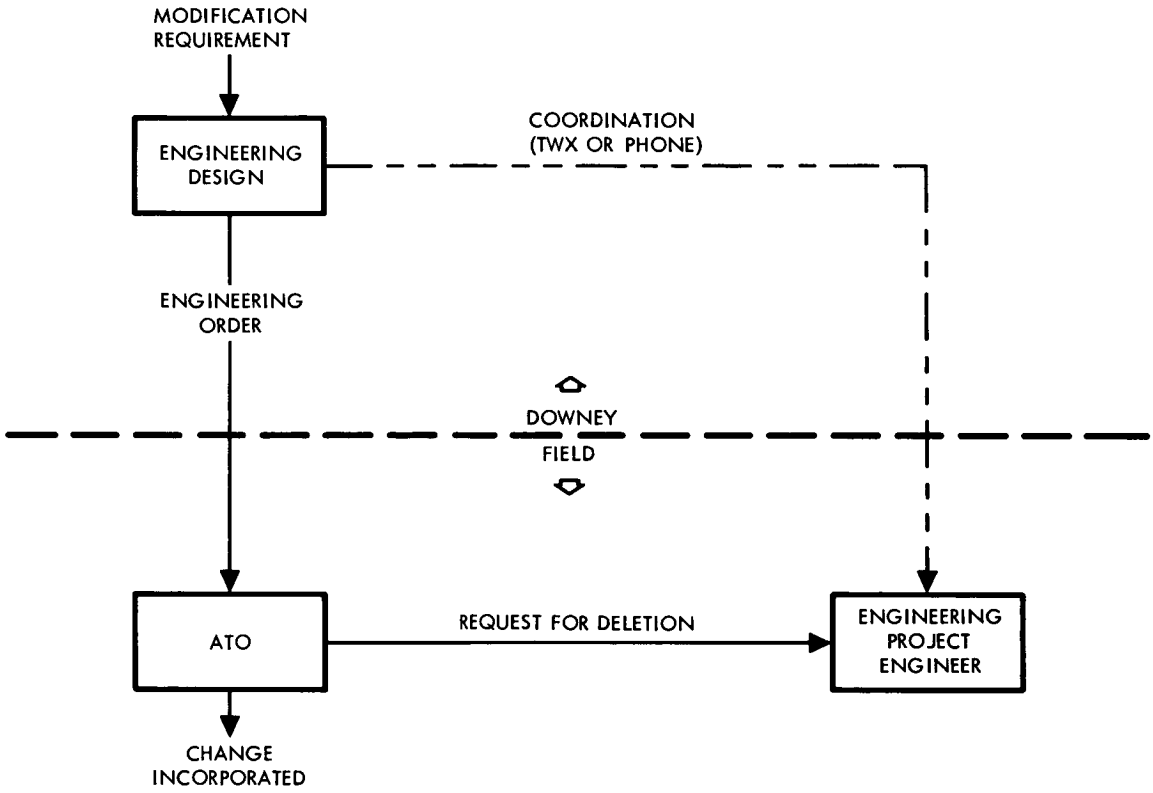

Figure 4-14. Downey-Originated Engineering Orders

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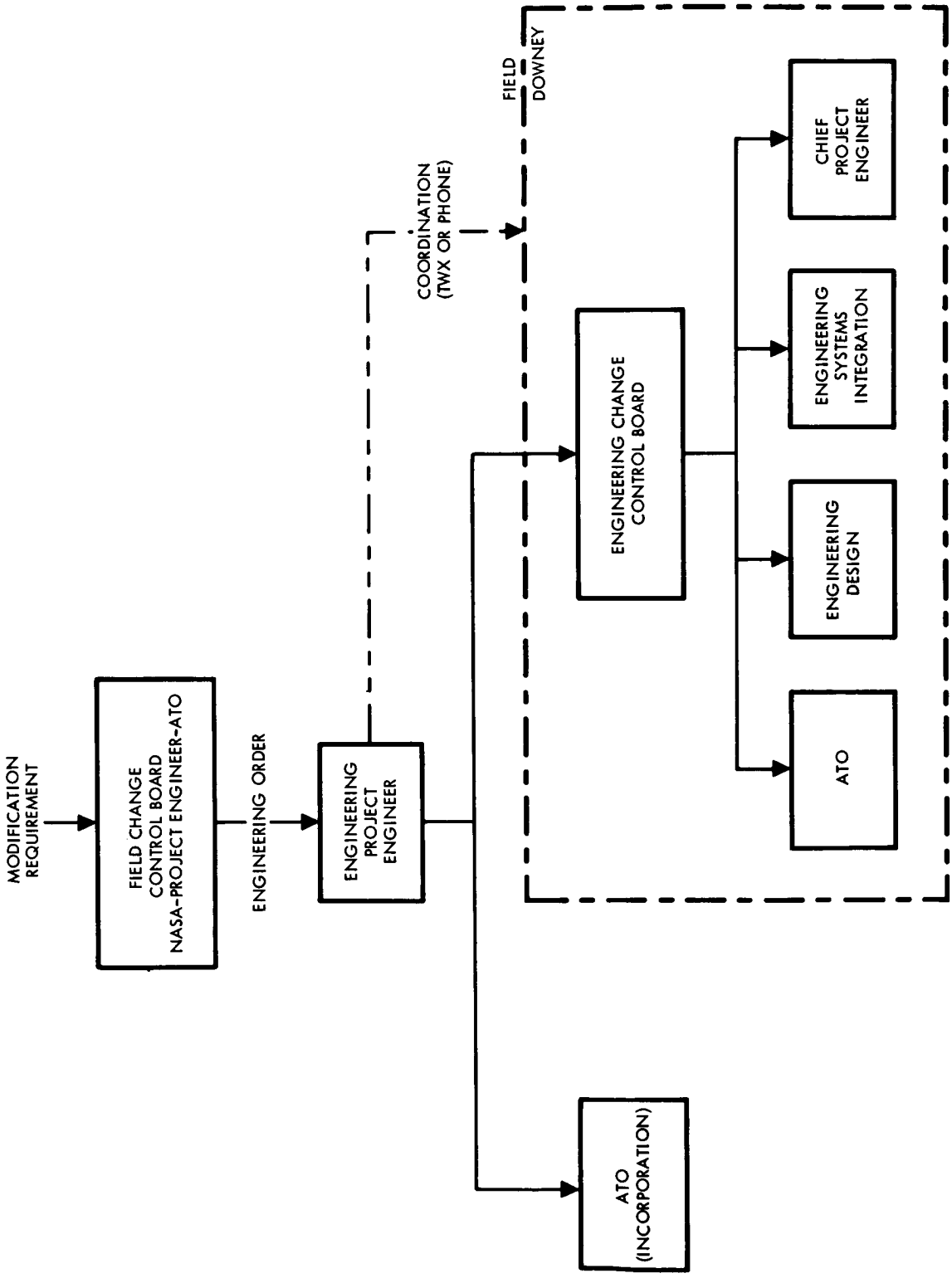

Figure 4-15. Field-Originated Engineering Orders

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4.2.7.6 Procedure Preparation and Control

Checkout procedures will be prepared by Apollo Test and Operations in accordance with engineering process specifications. These procedures will be approved by Engineering System Integration prior to use by ATO field organization. The assigned engineering project engineer will acquire this approval and/or approve the procedure in lieu of assigning Engineering Systems Integration personnel to the field. The basic procedure flow diagram is depicted in Figure 4-16.

4.2.7.7 Test Plan Preparation and Control

The S/C 001 propulsion test plan is prepared by Apollo Test and Operations to satisfy test requirements generated by Apollo Engineering. The general test plan flow diagram is depicted in Figure 4-17.

4.2.7.8 Instrumentation Measurement Lists Preparation and Control

The S/C 001 instrumentation measurement lists are prepared by Engineering Systems Integration in coordinated effort with ATO and Engineering Instrumentation Design. This list is primarily generated from individual data measurement required by the propulsion design units concerned with the test. The measurement list flow diagram is shown in Figure 4-18.

4.2.8 Safety Requirements

In general, WSMR test site safety regulations will reflect one or more of the following manuals and regulations:

1. All applicable NAA regulations

2. Air Force Manual 32-2, Accident Prevention Handbook

3. Corps of Engineers Manual EM385-1-1, General Safety Requirements

4. Ordnance Corps ORD M7724 (T.O. 11A-1-40), Ordnance Safety Manual

5. Air Force T. O. 11C-1-6, General Safety Precautions for Missile Liquid Propellants

6. Safety orders of the State of New Mexico

[redacted]

[redacted]

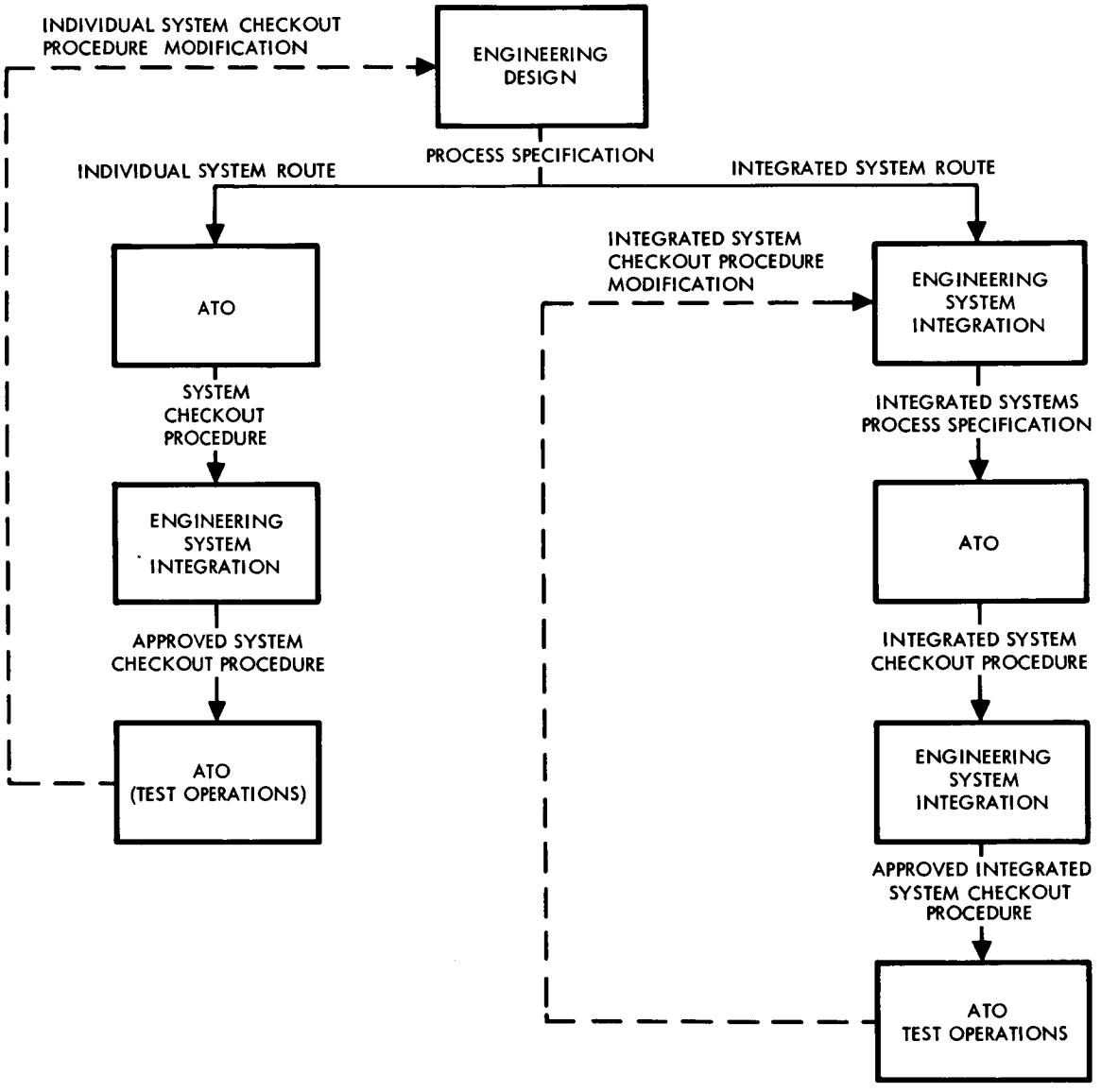

Figure 4-16. Checkout Procedures

[redacted]

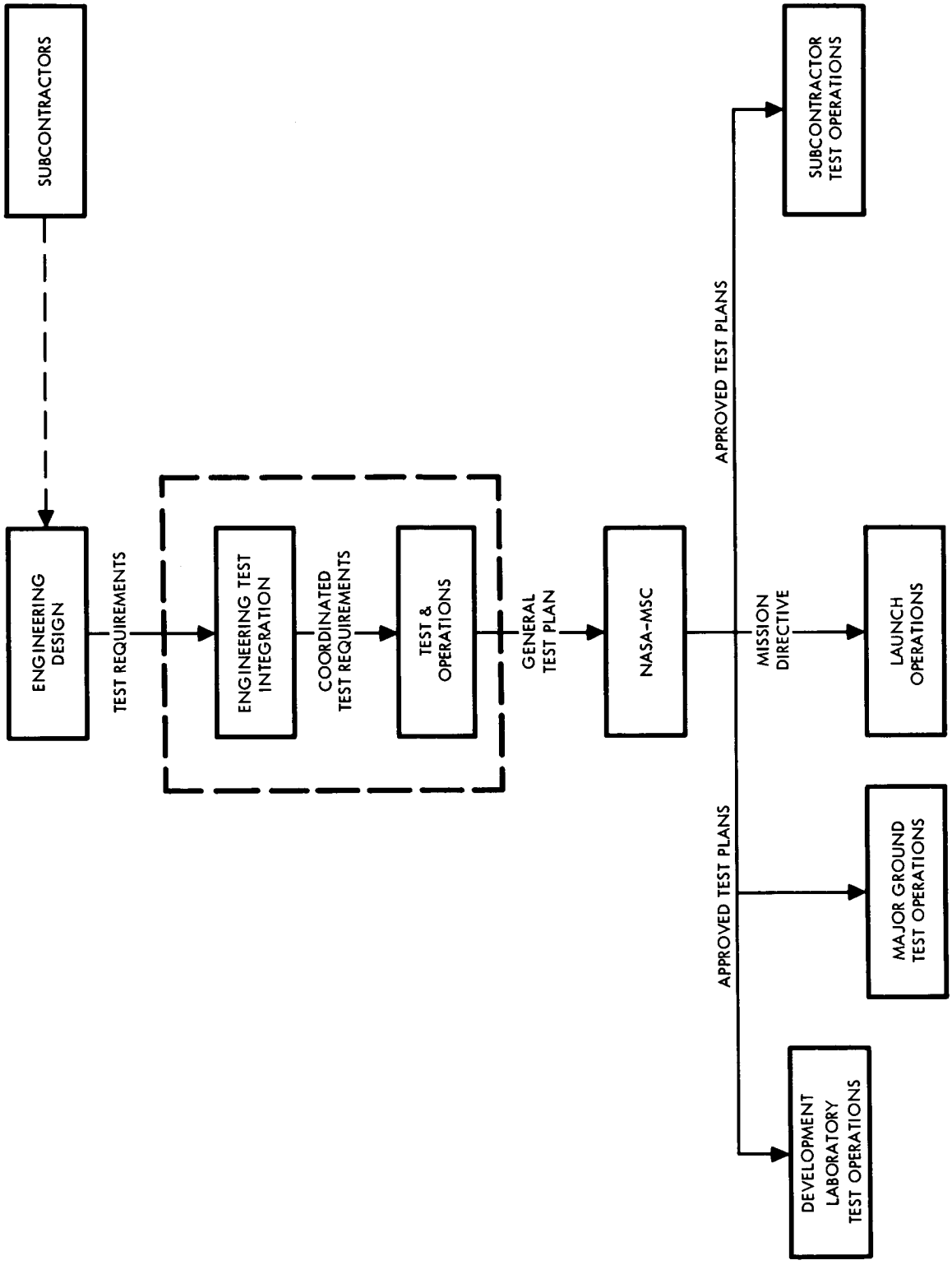

Figure 4-17. General Test Plan

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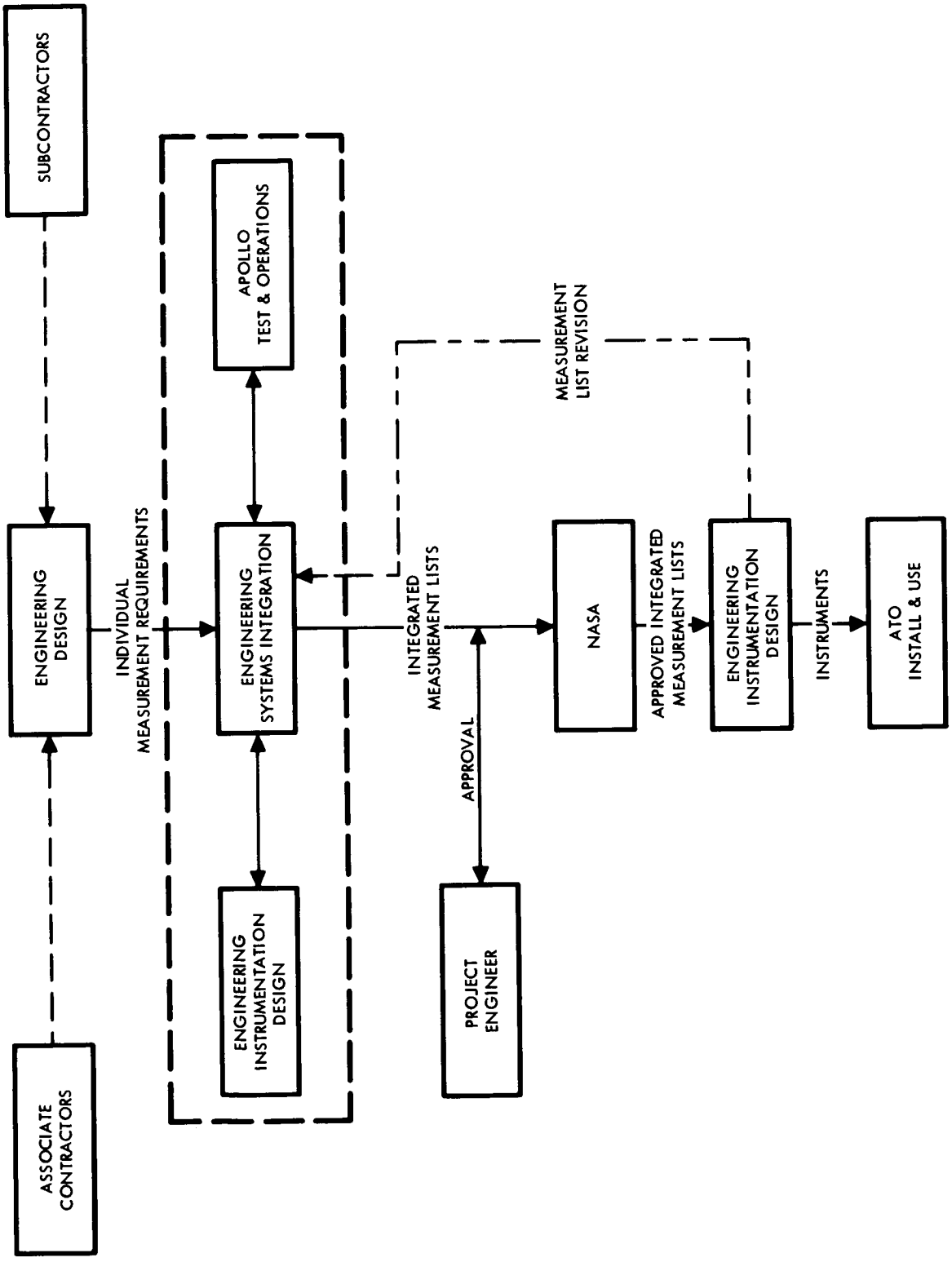

Figure 4-18. Instrumentation Measurement List Flow Diagram

[redacted]

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7. National Safety Council, Accident Prevention Manual for Industrial Operations.

4.2.8.1 Pad Safety

4.2.8.1.1 Safety Signals. Both visual and audible warning signal devices will be installed on the test site to inform personnel of hazard status. The system will consist of green, amber, and red lights; klaxon horns; and a public address system.

4.2.8.1.2 Damage Control. A fire control system will provide sufficient water to combat a major fire or "spill."

A vapor detection system will provide the capability of measuring concentrations of either N_2O_4 or UDMH to between 0 and 50 PPM in air. Vapor detectors will be located at all points in the test sites where the possibility of vapor concentration exists. The detection system will activate visible and audible alarm systems. The fire and vapor detection system controllers will be located in the blockhouse.

Self-contained breathing apparatus and escape suits will be provided for all personnel exposed to hazardous environments, and secondary protection will be provided in the form of splash suits and air packs for use in atmospheres not exceeding 4-percent contamination. Emergency protection for up to 10 minutes of exposure in atmospheres of less than 2-percent contamination will be provided by full-face masks with canisters. Eye-wash fountains and shower stalls will be provided at strategic locations throughout the test sites. Safety belts and nets will be provided on and below all work platforms on the test sites.

During all hazardous operations to be performed by personnel, the "buddy system" will be used, i.e., for each man working, a stand-by employee in full protector clothing will be assigned to monitor the operation and, if necessary, assist in evacuation.

4.2.8.1.3 Medical Program. First Aid stations, staffed with competent personnel, will be maintained at both the test and administration areas. These stations will be equipped to provide full emergency medical service.

Ambulance service will be available and hospital arrangements made for more serious treatment.

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4.2.9 Data Handling, Analysis, and Reporting

4.2.9.1 Reports

Test reporting will consist of 4-hour, 24-hour, and final reports. The 4-hour report will be submitted immediately following the test. The report will contain pertinent information, objectives, configuration, and procedures available at the time, and a qualitative description of the test. The 4-hour report will be followed by a comprehensive 24-hour report which will detail test conditions, observations, and on-site evaluations by the test team, plus other pertinent data bearing on the test results. Final test reports will be prepared upon completion of a significant number of tests and will contain a detailed engineering evaluation of the results of each test. Specific report flow and scheduling information will be included in this section when available.

4.2.9.2 Evaluation

Test evaluations will be accomplished in two areas. On-site evaluations at the Propulsion Systems Development Facility, WSMR, will be accomplished immediately following a test to evaluate test objective accomplishments and to determine the quality of the data. This evaluation will be performed by the ATO systems engineers for the purpose of controlling test operations progress and provide adequate field reports for engineering evaluation at Downey. Also, quantitative evaluations of the tests will be performed by Apollo Engineering utilizing the processed test data. Additional test evaluation methods and flow details will be included in this section when available.

4.2.9.3 Data Handling, Analysis, and Flow

NAA will acquire and process all data obtained from the propulsion test program. The planned data systems and data processing effort will (1) furnish the necessary data at the test site for operational requirements and (2) provide Apollo Engineering qualified data in tabular and plotted formats for evaluation and reporting of the tests. The handling and flow of data will be coordinated by the ATO data engineering section.

4.2.9.3.1 On-Site Data Handling. This involves the control and physical movement of all site-generated test data. These materials consist of calibration data, instrumentation configuration, various playbacks (mentioned in paragraph 4.2.4.2), and magnetic tape. The transmittal of

[redacted]

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these data will be within the test site, and between the site and S&ID Downey. Calibration and instrumentation information available prior to testing will be transmitted to Downey by the best means available, (e.g., FAX, hand-carry, or mail). All required quick-look playbacks will be produced by the site data acquisition system. After requests and processing, site-generated quick-look and real-time test data will be transported from the recording area to a data review area. The data will be annotated, logged, and stored for on-site data review. Those data that are essential to continued testing and require detailed processing by the Downey ground station will be stipulated. The required information will be sent back to the test site via TWX or FAX. After the site playback needs have expired, the physical data tape will be hand-carried or shipped to the Downey ground station for data verification, final data processing requirements, and permanent storage.

4.2.9.3.2 Downey Data Processing. Test data required for preliminary and final data review and analyses will be processed by the S&ID Downey ground station. Coordination with the design and test areas will be maintained to determine the support requirements. Those data essential to continued operations of the test group will be processed to appropriate formats and forwarded to the test site. Those test data designated for detailed analyses by Apollo Engineering design groups will be processed to final formats. Methods of display will include oscillograms, strip charts, plots, and tabulations, and will have been edited, scaled, and grouped. Alternate processing methods include preparation of computer input tapes for complete data reduction and calculation. Final data inputs will be prepared for inclusion into test reports.

4.2.9.3.3 Downey Data Handling. Data handling encompasses the distribution and maintenance of data generated through the S&ID Downey ground station. These data include calibration outputs, various processed displays (mentioned in paragraph 4.2.9.3.2), and magnetic tape. In addition, there will be a variety of bulk data (motion picture film, test information, etc.) received from the test site to be maintained. The distribution will be between the test site and Downey, as well as in-plant at S&ID Downey.

4.2.10 Detailed Test Objectives and Schedules

The detailed test schedule in support of the first suborbital flight is shown in Figure 4-19. Detailed test objectives and test conditions are presented in Tables 4-4 and 4-5.

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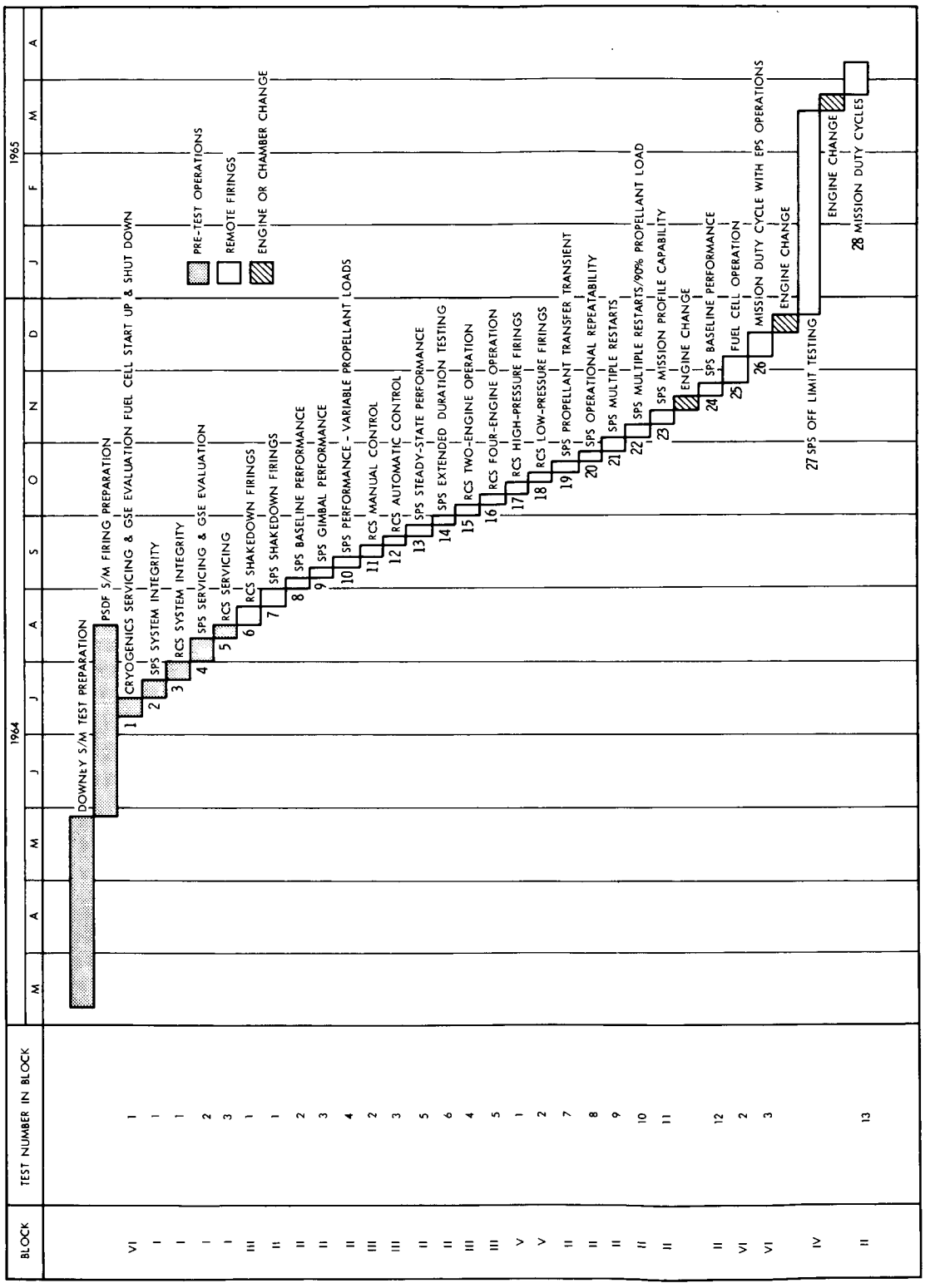

Figure 4-19. Airframe 001 Detailed Test Schedule I

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Table 4-4. Airframe 001 Test Objectives (Test Series I)

Item	Test No. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Service module reaction control			X		X	X					X	X			X	X	X	X										
Service module main propulsion		X		X			X	X	X	X			X	X					X	X	X	X	X	X			X	X
Cryogenic storage	X																											
Electric power system																									X	X		
Test Objective																												
1. Determine system integrity																												
1.1 System leak check	P	P	P																									
1.2 Evaluate service equipment and GSE	P	P	P	P	P	P	P																		P			
1.3 System shakedown	P	P	P			P	P																		P			
2. Demonstrate servicing and safety																												
2.1 Servicing rates and procedures	P			P	P	S	S				S	S																
2.2 Develop safety rules and procedures	P	P	P	P	P	P	P				P	P													P			
2.3 Develop operating techniques	P	P	P	P	P	P	P				P	P													P			
3. Evaluate propellant system performance																												
3.1 Propellant temperature variation							S	S	S	P			P	P	P	P	P	P	P	P	P	P	P	S				P
3.2 Engine inlet condition							S	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P				P
3.3 System resonant frequency							S	P	P	S	P	P	S	S	P	P	P	P	S	S	S	S	S	P				S
3.4 Mixture ratio control							S	P	S	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P				P
3.5 Feed-line pressure surges							S	P	P	S	S	S	S	S	P	P	P	P	S	S	S	S	S	P				S
3.6 Propellant utilization system operation							S												P	P	P	P	P					P
3.7 Propellant line vibration							S	P	P	S	S	S	S	S	P	P	P	P	S	S	S	S	S	S				S
4. Evaluate pressurization system																												
4.1 Helium system pressure drop							S	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P				P
4.2 Ullage pressure							S	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P				P
5. Evaluate engine performance																												
5.1 Steady-state operation						S	S	P	P	S	P	P	P	P	P	P	P	P	P	S	S	S	S	P				P
5.2 Engine start transients						S	S	P	P	P	P	P	S	S	P	P	P	P	S	P	P	P	P	P				P
5.3 Engine shutdown transients						S	S	P	P	P	P	S	S	S	P	P	P	P	S	P	P	P	P	P				P
5.4 Engine restart capability						S	S	P	S	S	P	P	S	S	P	P	P	P	S	P	P	P	P	P				P
5.5 O/F ratio effects on system						S	S			P										P	P	P	P					P
5.6 Propellant temperature effects on system										S									S		S	S	S					S
5.7 Gimbal effects on system									P				P												S			P
6. Acoustic and vibration characteristics																												
6.1 Effects on S/M and systems						P	P	P	P	P	P	S	S	P	S	S	P	P	S	S	S	S				P		P
7. Evaluate electrical power system																												
7.1 Evaluate fuel cell start and shutdown	P																								P	P		
7.2 Fuel cell normal power operation	P																								P	P		
7.3 Fuel cell transient power operation	P																								P	P		
7.4 Operation under vibration and acoustical noise																									P	P		
7.5 Operation requiring supplementary power	P																								P	P		
7.6 Fuel cell emergency power operation	P																								P	P		
7.7 Storage battery performance																									P	P		
7.8 Power distribution system	P																								P	P		
7.9 H_2O-PH factor and particle concentration	P																								P	P		
8. Controls and display evaluation (partial)																												

Symbols:
P Primary objectives
S Secondary objectives

[redacted]

[redacted]

Table 4.5 Airframe 001 Test Conditions

Test Conditions	Test Number																											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1. Blockhouse control of S/M				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2. Number of engine firings																												
2.1 Service propulsion							R	2	2	3			1	1					1	5	5	5	5	1				28
2.2 RCS system A						R					8/4	100			6	4	14	54										
2.3 RCS system B						R					8/4	100			6	4	14											
2.4 RCS system C						R					8/4	100			6	4	14	54										
2.5 RCS system D						R					8/4	100			6	4	14											
3. Duration of firings (sec)						R	10	10	30/180	10	2/5	0.01/0.05	30	200	0.5	0.02	0.02/2	0.01/2	120	5	2	5	2	10				400 200
4. Lapse time between firings (sec)						R	R	R	R	R	2				0.2	0.02	0.02/2	0.05/2		5	2	5	2					3 hr 1 min
5. Propellant temperature (°F)		A		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
6. Fuel quantity (initial volume percent)						100	40	25/10	40	90/75/60	100	100	90	90	10	100	100	100	60	40	40	90	90	50				100
7. Oxidizer quantity (initial volume percent)						100	40	25/10	40	90/75/60	100	100	90	90	10	100	100	100	60	40	40	90	90	50				100
8. O/F mixture ratio						2/1	2/1	2/1	2/1	2/1	2/1	2/1	2/1	2/1	2/1	2/1	2/1	2/1	2/1	2/1	2/1	2/1	2/1	2/1				2/1
9. Fuel regulator setting (psia)						180	175	175	175	175	180	180	175	175	180	180	240	140	175	175	175	175	175	175				175
10. Oxidizer regulator setting (psia)						180	175	175	175	175	180	180	175	175	180	180	240	140	175	175	175	175	175	175				175
11. Single SPS engine valve operation																												
12. Gimbal excursion (deg ±)									4.5																			4.5
13. Gimbal rate (cps)									1																			1
14. Gimbal duration (sec)									100																			28
15. Single engine valve operation																												
16. Low voltage (18 to 20 volts)																												
17. Number of fuel cells operating																												
18. Steady-state power load (watts)																									3	3/2		
19. Transient power load (watts)																									1700	2000 1700		
20. Fuel cell operating temperature (°F)																									N	N		
21. H_2O maximum back pressure (psi)																									N	460 470		
22. Heater power (watts)																									N	92		
23. Engine firing mode:																									N	R		
Manual						X	X	X		X	X		X	X				X	X					X				
Automatic						X			X			X			X	X	X			X	X	X	X					X
Direct																												
24. LO_2 quantity (initial volume percent)																									100	N		
25. LH_2 quantity (initial volume percent)																									100	N		

Symbols:

A Ambient temperature 50 to 100 F
R As required to accomplish the test objective
N Nominal value
X Applicable to this test
V O/F will vary with ullage pressure

[redacted]

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4.2.11 Detailed Test Descriptions

4.2.11.1 Test No. 1. Cryogenic Servicing and GSE Evaluation

4.2.11.1.1 Objectives. Primary objectives are as follows:

1. System leak check

2. Ground support equipment evaluation

3. System shakedown

4. Safety rules and procedures development

5. Operating techniques development

4.2.11.1.2 Configuration.

1. The EPS cryogenic system configuration will be prototype hardware similar to the flight configuration. The following drawings define the systems configuration.

   Electrical Power System, V14-945101

   Fuel Cell System, V17-94502

   Cryogenic System, V17-961002

2. The ground support equipment outlined in Paragraph 4.2.3.2 will be utilized during these tests.

4.2.11.1.3 Test Conditions. Standard test preparation, tanking, detanking, countdown, and inspection procedures are to be developed. The following conditions apply to this test.

1. The cryogenic fluids and gas systems will be leak-tested.

2. The system components and test control hookup will be verified with the applicable GSE.

4.2.11.1.4 Data Required. Parameters are required to substantiate a leak-free oxygen and hydrogen system. Specifically, the test measurements in Table 4-6 are required. Data requirements for each subsequent test will be outlined in Paragraph 4.2.12.1.

[redacted]

Table 4-6. Airframe 001 Test Measurement List

SYSTEM STRUCTURES — AIRFRAME 1 PHASE I — OCTOBER 25, 1963 PAGE NO. 1 — L- 1 F- 2

MEAS. ID	MEASUREMENT DESCRIPTION	CPG YRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S A0633 D	VIBRA THRUST MOUNT X AXIS	T	5000CPS	+0	+50	G	XS212,YS0,ZS15
S A0634 D	VIBRA THRUST MOUNT Y AXIS	T	5000CPS	+0	+50	G	XS212,YS0,ZS15
S A0635 D	VIBRA THRUST MOUNT Z AXIS	T	5000CPS	+0	+50	G	XS212,YS0,ZS15
* S A0674 D	SM VIBRA INTFAC POS 1 X AXIS	T	5000CPS	+0	+50	G	XS278.5,YS23,ZS-29.5
* S A0675 D	SM VIBRA INTFAC POS 1 Y AXIS	T	5000CPS	+0	+50	G	XS278.5,YS23,ZS-29.5
* S A0676 D	SM VIBRA INTFAC POS 1 Z AXIS	T	5000CPS	+0	+50	G	XS278.5,YS23,ZS-29.5
* S A0677 D	SM VIBRA INTFAC POS 2 X AXIS	T	5000CPS	+0	+50	G	XS257,YS32,ZS-42
* S A0678 D	SM VIBRA INTFAC POS 2 Y AXIS	T	5000CPS	+0	+50	G	XS257,YS32,ZS-42
* S A0679 D	SM VIBRA INTFAC POS 2 Z AXIS	T	5000CPS	+0	+50	G	XS257,YS32,ZS-42
* S A0680 D	SM VIBRA INTFAC POS 3 X AXIS	T	5000CPS	+0	+50	G	XS298,YS75,ZS-18
* S A0681 D	SM VIBRA INTFAC POS 3 Y AXIS	T	5000CPS	+0	+50	G	XS298,YS75,ZS-18
* S A0682 D	SM VIBRA INTFAC POS 3 Z AXIS	T	5000CPS	+0	+50	G	XS298,YS75,ZS-18
* S A0683 D	SM VIBRA INTFAC POS 4 X AXIS	T	5000CPS	+0	+50	G	XS290,YS67,ZS-24
* S A0684 D	SM VIBRA INTFAC POS 4 Y AXIS	T	5000CPS	+0	+50	G	XS290,YS67,ZS-24
* S A0685 D	SM VIBRA INTFAC POS 4 Z AXIS	T	5000CPS	+0	+50	G	XS290,YS67,ZS-24
* S A0686 Y	ACOUST OUT SM POS 1	T	10K CPS	+110	+180	DB	XS313,80 DEG
* S A0687 Y	ACOUST OUT SM POS 2	T	10K CPS	+110	+180	DB	XS313,200 DEG

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Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM STRUCTURES — AIRFRAME 1 — PHASE I — OCTOBER 25, 1963 — PAGE NO. 2 — L- 1 F- 2

MEAS. ID	MEASUREMENT DESCRIPTION	CPG YRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
* S A0688 Y	ACOUST OUT SM POS 3	T	10K CPS	+110	+180	DB	XS313,320 DEG
* S A0689 Y	ACOUST OUT SM POS 4	T	10K CPS	+110	+180	DB	XS213,80 DEG
* S A0690 Y	ACOUST OUT SM POS 5	T	10K CPS	+110	+180	DB	XS213,200 DEG
* S A0691 Y	ACOUST OUT SM POS 6	T	10K CPS	+110	+180	DB	XS213,320 DEG
S A0700 D	GIMBAL BEARING VIBRA Y-Y X AXIS	T	5000CPS	+0	+50	G	XS205,YS15,ZS0
S A0701 D	GIMBAL BEARING VIBRA Y-Y Y AXIS	T	5000CPS	+0	+50	G	XS205,YS15,ZS0
S A0702 D	GIMBAL BEARING VIBRA Y-Y Z AXIS	T	5000CPS	+0	+50	G	XS205,YS15,ZS0

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Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM ELECTRICAL | AIRFRAME 1 PHASE I | OCTOBER 25, 1963 PAGE NO. 3 | L- 1 F- 2

MEAS. ID	MEASUREMENT DESCRIPTION	CPG YRS	RESPONSE LOW	DATA RANGE HIGH	UNITS	LOCATION
S C2060 P	N2 PRESSURE F/C 1 REGULATED	B 0 2	CPS	+0	+75 PSIA	
S C2061 P	N2 PRESSURE F/C 2 REGULATED	B 0 2	CPS	+0	+75 PSIA	
S C2062 P	N2 PRESSURE F/C 3 REGULATED	B 0 2	CPS	+0	+75 PSIA	
S C2066 P	02 PRESSURE F/C 1 REGULATED	B 0 2	CPS	+0	+75 PSIA	
S C2067 P	02 PRESSURE F/C 2 REGULATED	B 0 2	CPS	+0	+75 PSIA	
S C2068 P	02 PRESSURE F/C 3 REGULATED	B 0 2	CPS	+0	+75 PSIA	
S C2069 P	H2 PRESSURE F/C 1 REGULATED	B 0 2	CPS	+0	+75 PSIA	
S C2070 P	H2 PRESSURE F/C 2 REGULATED	B 0 2	CPS	+0	+75 PSIA	
S C2071 P	H2 PRESSURE F/C 3 REGULATED	B 0 2	CPS	+0	+75 PSIA	
S C2081 T	TEMP F/C 1 COND EXHAUST	B 0 1	CPS	+175	+225 DEG F	
S C2082 T	TEMP F/C 2 COND EXHAUST	B 0 1	CPS	+175	+225 DEG F	
S C2083 T	TEMP F/C 3 COND EXHAUST	B 0 1	CPS	+175	+225 DEG F	
S C2084 T	TEMP F/C 1 SKIN	B 0 1	CPS	+80	+550 DEG F	
S C2085 T	TEMP F/C 2 SKIN	B 0 1	CPS	+80	+550 DEG F	
S C2086 T	TEMP F/C 3 SKIN	B 0 1	CPS	+80	+550 DEG F	
S C2087 T	TEMP FC 1 RADIATOR OUTLET	B 0 1	CPS	-50	+300 DEG F	
S C2088 T	TEMP FC 2 RADIATOR OUTLET	B 0 1	CPS	-50	+300 DEG F	

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Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM ELECTRICAL — AIRFRAME 1 PHASE I — OCTOBER 25, 1963 PAGE NO. 4 — L- 1 F- 2

MEAS. ID	MEASUREMENT DESCRIPTION	CPG YRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S C2089 T	TEMP FC 3 RADIATOR OUTLET	B 0 1	CPS	-50	+300	DEG F	
S C2110 V	DC VOLTAGE MAIN BUS A (SM)	B 2	CPS	+0	+40	VDC	
S C2111 V	DC VOLTAGE MAIN BUS B (SM)	B 2	CPS	+0	+40	VDC	
S C2113 C	DC CURRENT F/C 1 OUTPUT	B 0 1	CPS	+0	+100	AMP	
S C2114 C	DC CURRENT F/C 2 OUTPUT	B 0 1	CPS	+0	+100	AMP	
S C2115 C	DC CURRENT F/C 3 OUTPUT	B 0 1	CPS	+0	+100	AMP	
+ S C2120 X	FUEL CELL 1 BUS A DISCONNECT	B 0 10	S/S	OFF	ON	EVENT	
+ S C2121 X	FUEL CELL 2 BUS A DISCONNECT	B 0 10	S/S	OFF	ON	EVENT	
+ S C2122 X	FUEL CELL 3 BUS A DISCONNECT	B 0 10	S/S	OFF	ON	EVENT	
+ S C2125 X	FUEL CELL 1 BUS B DISCONNECT	B 0 10	S/S	OFF	ON	EVENT	
+ S C2126 X	FUEL CELL 2 BUS B DISCONNECT	B 0 10	S/S	OFF	ON	EVENT	
+ S C2127 X	FUEL CELL 3 BUS B DISCONNECT	B 0 10	S/S	OFF	ON	EVENT	
S C2130 X	PURGE VALVE H2 F/C 1 OPERATE	B P 10	S/S	CLOSE	OPEN	EVENT	
S C2131 X	PURGE VALVE H2 F/C 2 OPERATE	B P 10	S/S	CLOSE	OPEN	EVENT	
S C2132 X	PURGE VALVE H2 F/C 3 OPERATE	B P 10	S/S	CLOSE	OPEN	EVENT	
S C2133 X	PURGE VALVE O2 F/C 1 OPERATE	B P 10	S/S	CLOSE	OPEN	EVENT	
S C2134 X	PURGE VALVE O2 F/C 2 OPERATE	B P 10	S/S	CLOSE	OPEN	EVENT	

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Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM ELECTRICAL | AIRFRAME 1 | PHASE I | OCTOBER 25, 1963 PAGE NO. 5 | L- 1 F- 2

MEAS. ID	MEASUREMENT DESCRIPTION	CPG YRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S C2135 X	PURGE VALVE O2 F/C 3 OPERATE	B P 10	S/S	CLOSE	OPEN	EVENT	
S C2139 R	FLOW RATE H2 F/C 1	B O 1	CPS	+0	+0.2	LB/HR	
S C2140 R	FLOW RATE H2 F/C 2	B O 1	CPS	+0	+0.2	LB/HR	
S C2141 R	FLOW RATE H2 F/C 3	B O 1	CPS	+0	+0.2	LB/HR	
S C2142 R	FLOW RATE O2 F/C 1	B O 1	CPS	+0	+1.6	LB/HR	
S C2143 R	FLOW RATE O2 F/C 2	B O 1	CPS	+0	+1.6	LB/HR	
S C2144 R	FLOW RATE O2 F/C 3	B O 1	CPS	+0	+1.6	LB/HR	
S C2160 Z	PH FACTOR WATER CONDITION F/C 1	B O 1	CPS	+6	+12	PH	
S C2161 Z	PH FACTOR WATER CONDITION F/C 2	B O 1	CPS	+6	+12	PH	
S C2162 Z	PH FACTOR WATER CONDITION F/C 3	B O 1	CPS	+6	+12	PH	
S C2323 X	FUEL CELL 1 SHUT OFF MON	B O 10	S/S	CLOSE	OPEN	EVENT	
S C2324 X	FUEL CELL 2 SHUT OFF MON	B O 10	S/S	CLOSE	OPEN	EVENT	
S C2325 X	FUEL CELL 3 SHUT OFF MON	B O 10	S/S	CLOSE	OPEN	EVENT	

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Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM AIRFRAME 1 PHASE I OCTOBER 25, 1963 L- 1
PROPULSION SYSTEM PAGE NO. 6 F- 2

MEAS. ID	MEASUREMENT DESCRIPTION	CPG YRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S P0001 P	HE PRESS TANK	B 0 1	CPS	+0	+5K	PSIA	
S P0002 T	HE TEMP TANK	B 0 1	CPS	-100	+200	DEG F	
S P0003 P	PRESS OXIDIZER TANKS	B 0 20	CPS	+0	+300	PSIA	
S P0004 T	TEMP OXIDIZER TRANSFER LINE	T 1	CPS	+0	+200	DEG F	
S P0005 T	TEMP OXIDIZER ENG FEED LINE	T 1	CPS	+0	+200	DEG F	
S P0006 P	PRESS FUEL TANKS	B 0 20	CPS	+0	+300	PSIA	
S P0007 T	TEMP FUEL TRANSFER LINE	T 1	CPS	+0	+200	DEG F	
S P0008 T	TEMP FUEL ENG FEED LINE	T 1	CPS	+0	+200	DEG F	
S P0009 P	PRESS MAIN VLV ENG OXIDIZER IN	B 0 500	CPS	+0	+300	PSIA	
S P0010 P	PRESS MAIN VLV ENG FUEL IN	B 0 500	CPS	+0	+300	PSIA	
S P0011 Q	TOTAL QUANTITY OXIDIZER	T 1	CPS	+0	+31K	LB	
S P0012 Q	TOTAL QUANTITY FUEL	T 1	CPS	+0	+16K	LB	
S P0013 R	LEAK RATE OXIDIZER 1	C 2	CPS	+0	+100	CC/M	
S P0015 R	LEAK RATE FUEL 1	C 2	CPS	+0	+100	CC/M	
S P0020 T	TEMP CHAMBER OUTER SKIN 1	B 0 1	CPS	+0	+500	DEG F	
S P0022 H	POSITION FUEL/OXIDIZER VLV 1	B 0 100	CPS	+0	+90	DEG	
S P0023 H	POSITION FUEL/OXIDIZER VLV 2	B 0 100	CPS	+0	+90	DEG	

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Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM
PROPULSION SYSTEM

AIRFRAME 1 PHASE I

OCTOBER 25, 1963
PAGE NO. 7

L- 1
F- 2

MEAS. ID	MEASUREMENT DESCRIPTION	CPG YRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S P0024 H	POSITION FUEL/OXIDIZER VLV 3	B O	100 CPS	+0	+90	DEG	
S P0025 H	POSITION FUEL/OXIDIZER VLV 4	B O	100 CPS	+0	+90	DEG	
S P0030 X	HE ISOLATION VLV 1	B O	10 S/S	CLOSE	OPEN	EVENT	
S P0031 X	HE ISOLATION VLV 2	B O	10 S/S	CLOSE	OPEN	EVENT	
S P0040 T	TEMP MAIN VLV ENGINE FUEL IN	T	1 CPS	+0	+200	DEG F	
S P0041 T	TEMP MAIN VLV ENGINE OXIDIZER IN	T	1 CPS	+0	+200	DEG F	
S P0060 T	TEMP INJECTOR MANIFOLD	T	1 CPS	+0	+200	DEG F	
S P0602 P	PRESS OXIDIZER ENG FEED LINE	T	100 CPS	+0	+300	PSIA	
S P0604 P	PRESS FUEL ENG FEED LINE	T	100 CPS	+0	+300	PSIA	
S P0610 P	PRESS INLET TO PU SYSTEM	T	100 CPS	+0	+300	PSIA	
S P0611 P	PRESS OUTLET OF PU SYSTEM	T	100 CPS	+0	+300	PSIA	
S P0650 P	HE REG 1 INTERMEDIATE PRESS	T	100 CPS	+0	+5K	PSIA	
S P0652 P	HE REG 2 INTERMEDIATE PRESS	T	100 CPS	+0	+5K	PSIA	
S P0654 P	HE MANIFOLD PRESS	T	20 CPS	+0	+350	PSIA	
S P0655 Q	QUANTITY SPS OXIDIZER TANK 1	B O	1 CPS	+0	+16K	LB	
S P0656 Q	QUANTITY SPS OXIDIZER TANK 2	B O	1 CPS	+0	+16K	LB	
S P0657 Q	QUANTITY SPS FUEL TANK 1	B O	1 CPS	+0	+8K	LB	

Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM
PRØPULSIØN SYSTEM

AIRFRAME 1 PHASE I

ØCTØBER 25, 1963
PAGE NØ. 8

L- 1
F- 2

MEAS. ID	MEASUREMENT DESCRIPTIØN	CPG YRS	RESPØNSE	DATA RANGE LØW	HIGH	UNITS	LØCATIØN
S P0658 Q	QUANTITY SPS FUEL TANK 2	B Ø	1 CPS	+0	+8K	LB	
S P0661 P	PRESS ENGINE CHAMBER	B Ø	2000CPS	+0	+150	PSIA	
S P0670 C	SERVICE ENG SØL VLV 1 CURRENT	B H	200 CPS	+0	+2	AMP	
S P0671 C	SERVICE ENG SØL VLV 2 CURRENT	B H	200 CPS	+0	+2	AMP	
S P0672 C	SERVICE ENG SØL VLV 3 CURRENT	B H	200 CPS	+0	+2	AMP	
S P0673 C	SERVICE ENG SØL VLV 4 CURRENT	B H	200 CPS	+0	+2	AMP	
S P0690 V	PITCH ACTUATØR MØTØR 1 VØLT	B H	100 CPS	+0	+32	VDC	
S P0691 C	PITCH ACTUATØR MØTØR 1 CURRENT	B H	100 CPS	+0	+150	AMP	
S P0696 V	YAW ACTUATØR MØTØR 2 VØLT	B H	100 CPS	+0	+32	VDC	
S P0697 C	YAW ACTUATØR MØTØR 2 CURRENT	B H	100 CPS	+0	+150	AMP	
* S P0889 P	ØXIDIZER TRANSFER LINE PRESS	T	100 CPS	+0	+300	PSIA	
S P0900 P	ØXIDIZER FLØWMETER IN PRESS	T	100 CPS	+0	+300	PSIA	
* S P0905 P	FUEL TRANSFER LINE PRESS	T	100 CPS	+0	+300	PSIA	
S P0916 R	FUEL FLØW RATE	T	5 CPS	+0	+30	LB/S	
S P0917 R	ØXIDIZER FLØW RATE	T	5 CPS	+0	+60	LB/S	
S P0918 P	FUEL FLØWMETER IN PRESS	T	100 CPS	+0	+300	PSIA	
S P0919 T	FUEL FLØWMETER IN TEMP	T	1 CPS	+0	+200	DEG F	

Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM AIRFRAME 1 PHASE I OCTOBER 25, 1963 L- 1
PROPULSION SYSTEM PAGE NO. 9 F- 2

MEAS. ID	MEASUREMENT DESCRIPTION	CPG YRS	RESPONSE		DATA RANGE LOW	HIGH	UNITS	LOCATION
S P0920 P	FUEL FLOWMETER OUT PRESS	T	100	CPS	+0	+300	PSIA	
S P2075 T	TEMP OX HT EXCHANGER HELIUM IN	T	1	CPS	-100	+200	DEG F	
S P2076 T	TEMP OX HT EXCHANGER HELIUM OUT	T	1	CPS	-100	+200	DEG F	
S P2077 T	TEMP FUEL HT EXCHANGER HELIUM IN	T	1	CPS	-100	+200	DEG F	
S P2078 T	TEMP FUEL HT EXCHGR HELIUM OUT	T	1	CPS	-100	+200	DEG F	

Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM AIRFRAME 1 PHASE I OCTOBER 25, 1963 L- 1
REACTION CONTROL PAGE NO. 10 F- 2

MEAS. ID	MEASUREMENT DESCRIPTION	CPG YRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S R5001 P	HE PRESS TANK A	B 0 1	CPS	+0	+5K	PSIA	XA963,YA-11,ZA-81
S R5002 P	HE PRESS TANK B	B 0 1	CPS	+0	+5K	PSIA	XA963,YA81,ZA-11
S R5003 P	HE PRESS TANK C	B 0 1	CPS	+0	+5K	PSIA	XA963,YA11,ZA81
S R5004 P	HE PRESS TANK D	B 0 1	CPS	+0	+5K	PSIA	XA963,YA-81,ZA11
S R5005 T	HE TEMP TANK A	C P 1	CPS	-100	+200	DEG F	XA963,YA-11,ZA-81
S R5006 T	HE TEMP TANK B	C P 1	CPS	-100	+200	DEG F	XA963,YA81,ZA-11
S R5007 T	HE TEMP TANK C	C P 1	CPS	-100	+200	DEG F	XA963,YA11,ZA81
S R5008 T	HE TEMP TANK D	C P 1	CPS	-100	+200	DEG F	XA963,YA-81,ZA11
S R5009 P	PRESS FUEL TANK IN A	T 1	CPS	+0	+300	PSIA	
S R5010 P	PRESS FUEL TANK IN B	T 1	CPS	+0	+300	PSIA	
S R5011 P	PRESS FUEL TANK IN C	T 1	CPS	+0	+300	PSIA	
S R5012 P	PRESS FUEL TANK IN D	T 1	CPS	+0	+300	PSIA	
S R5017 T	TEMP FUEL LINE A	B 0 1	CPS	+0	+200	DEG F	
S R5018 T	TEMP FUEL LINE B	B 0 1	CPS	+0	+200	DEG F	
S R5019 T	TEMP FUEL LINE C	B 0 1	CPS	+0	+200	DEG F	
S R5020 T	TEMP FUEL LINE D	B 0 1	CPS	+0	+200	DEG F	
S R5021 P	PRESS OXIDIZER TANK IN A	T 1	CPS	+0	+300	PSIA	

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Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM
REACTION CONTROL

AIRFRAME 1 PHASE I

OCTOBER 25, 1963
PAGE NO. 11

L- 1
F- 2

MEAS. ID	MEASUREMENT DESCRIPTION	CPG YRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S R5022 P	PRESS OXIDIZER TANK IN B	T 1	CPS	+0	+300	PSIA	
S R5023 P	PRESS OXIDIZER TANK IN C	T 1	CPS	+0	+300	PSIA	
S R5024 P	PRESS OXIDIZER TANK IN D	T 1	CPS	+0	+300	PSIA	
S R5029 T	TEMP OXIDIZER LINE A	T 1	CPS	+0	+200	DEG F	
S R5030 T	TEMP OXIDIZER LINE B	T 1	CPS	+0	+200	DEG F	3 IN FRM OX TANK
S R5031 T	TEMP OXIDIZER LINE C	T 1	CPS	+0	+200	DEG F	
S R5032 T	TEMP OXIDIZER LINE D	T 1	CPS	+0	+200	DEG F	
S R5055 Q	QUANTITY FUEL TANKS A,B,C,D	B 0 2	CPS	+0	+70	LB	
S R5056 Q	QUANTITY OX TANKS A,B,C,D	B 0 2	CPS	+0	+140	LB	
S R5065 T	TEMP ENGINE PACKAGE A1	B 0 1	CPS	+0	+300	DEG F	XA963,YA-11,ZA-81
S R5066 T	TEMP ENGINE PACKAGE B1	B 0 1	CPS	+0	+300	DEG F	XA963,YA-81,ZA11
S R5067 T	TEMP ENGINE PACKAGE C1	B 0 1	CPS	+0	+300	DEG F	XA963,YA11,ZA81
S R5068 T	TEMP ENGINE PACKAGE D1	B 0 1	CPS	+0	+300	DEG F	XA963,YA81,ZA-11
S R5725 P	A HE REG 1 IN PRESS	T 1	CPS	+0	+5K	PSIA	
S R5726 P	A HE REG 2 IN PRESS	T 1	CPS	+0	+5K	PSIA	
S R5727 P	A HE REG 1 INTMED PRESS	T 2	CPS	+0	+5K	PSIA	
S R5728 P	A HE REG 2 INTMED PRESS	T 2	CPS	+0	+5K	PSIA	

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Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM AIRFRAME 1 PHASE I OCTOBER 25, 1963 L- 1
REACTION CONTROL PAGE NO. 12 F- 2

MEAS. ID	MEASUREMENT DESCRIPTION	CPG YRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S R5729 P A	HE MANIFOLD PRESS	B G	20 CPS	+0	+300	PSIA	XA963,YA-11,ZA-81
S R5730 P A	OXIDIZER TANK OUT PRESS	T	1 CPS	+0	+300	PSIA	
S R5731 R A	OXIDIZER FLOW RATE	T	2 CPS	+0	+0.47	LB/S	
S R5733 P A	OXIDIZER MANFLD PRESS RD	T	2000CPS	+0	+1K	PSIA	
S R5734 P A	FUEL TANK OUT PRESS	T	1 CPS	+0	+300	PSIA	
S R5735 R A	FUEL FLOW RATE	T	2 CPS	+0	+0.26	LB/S	
S R5737 P A	FUEL MANFLD PRESS RD	T	2000CPS	+0	+1K	PSIA	
S R5738 T A	FUEL TEMP ENG +P	T	1 CPS	+0	+250	DEG F	
S R5739 T A	FUEL TEMP ENG -P	T	1 CPS	+0	+250	DEG F	
S R5740 T A	FUEL TEMP ENG CW	T	1 CPS	+0	+250	DEG F	
S R5741 T A	FUEL TEMP ENG CCW	T	1 CPS	+0	+250	DEG F	
S R5742 T A	OXIDIZER TEMP ENG +P	T	1 CPS	+0	+250	DEG F	
S R5743 T A	OXIDIZER TEMP ENG -P	T	1 CPS	+0	+250	DEG F	
S R5744 T A	OXIDIZER TEMP ENG CW	T	1 CPS	+0	+250	DEG F	
S R5745 T A	OXIDIZER TEMP ENG CCW	T	1 CPS	+0	+250	DEG F	
S R5747 P A	CHAMBER PRESS ENG -P	T	2000CPS	+0	+150	PSIA	XA963,YA-11,ZA-81
S R5748 P A	CHAMBER PRESS ENG CW	T	2000CPS	+0	+150	PSIA	

Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM AIRFRAME 1 PHASE I OCTOBER 25, 1963 L- 1
REACTION CONTROL PAGE NO. 13 F- 2

MEAS. ID	MEASUREMENT DESCRIPTION	CPG YRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S R5749 P A	CHAMBER PRESS ENG CCW	T	2000CPS	+0	+150	PSIA	XA963,YA-11,ZA-81
S R5754 P A	CHAMBER PRESS ENG +P	T	2000CPS	+0	+150	PSIA	
S R5764 P A	FUEL PRESS ENG +P	T	2000CPS	+0	+1K	PSIA	
S R5765 P A	FUEL PRESS ENG -P	T	2000CPS	+0	+1K	PSIA	
S R5766 P A	FUEL PRESS ENG CW	T	2000CPS	+0	+1K	PSIA	
S R5767 P A	FUEL PRESS ENG CCW	T	2000CPS	+0	+1K	PSIA	
S R5768 P A	OXIDIZER PRESS ENG +P	T	2000CPS	+0	+1K	PSIA	
S R5769 P A	OXIDIZER PRESS ENG -P	T	2000CPS	+0	+1K	PSIA	
S R5770 P A	OXIDIZER PRESS ENG CW	T	2000CPS	+0	+1K	PSIA	
S R5771 P A	OXIDIZER PRESS ENG CCW	T	2000CPS	+0	+1K	PSIA	
S R5772 P B	HE REG 1 IN PRESS	T	1 CPS	+0	+5K	PSIA	
S R5773 P B	HE REG 2 IN PRESS	T	1 CPS	+0	+5K	PSIA	
S R5774 P B	HE REG 1 INTMED PRESS	T	2 CPS	+0	+5K	PSIA	
S R5775 P B	HE REG 2 INTMED PRESS	T	2 CPS	+0	+5K	PSIA	
S R5776 P B	HE MANIFOLD PRESS	B	0 20 CPS	+0	+300	PSIA	XA963,YA81,ZA-11
S R5777 P B	OXIDIZER TANK OUT PRESS	T	1 CPS	+0	+300	PSIA	
S R5778 R B	OXIDIZER FLOW RATE	T	2 CPS	+0	+0.47	LB/S	

Table 4-6. Airframe 001 Test Measurement List (Cont)

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MEAS. ID	MEASUREMENT DESCRIPTION	CPG YRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S R5780 P B	OXIDIZER MANFLD PRESS RD	T	2000CPS	+0	+1K	PSIA	
S R5781 P B	FUEL TANK OUT PRESS	T	1 CPS	+0	+300	PSIA	
S R5782 R B	FUEL FLOW RATE	T	2 CPS	+0	+0.26	LB/S	
S R5784 P B	FUEL MANFLD PRESS RD	T	2000CPS	+0	+1K	PSIA	
S R5785 T B	FUEL TEMP ENG +Y	T	1 CPS	+0	+250	DEG F	
S R5786 T B	FUEL TEMP ENG -Y	T	1 CPS	+0	+250	DEG F	
S R5787 T B	FUEL TEMP ENG CW	T	1 CPS	+0	+250	DEG F	
S R5788 T B	FUEL TEMP ENG CCW	T	1 CPS	+0	+250	DEG F	
S R5789 T B	OXIDIZER TEMP ENG +Y	T	1 CPS	+0	+250	DEG F	
S R5790 T B	OXIDIZER TEMP ENG -Y	T	1 CPS	+0	+250	DEG F	
S R5791 T B	OXIDIZER TEMP ENG CW	T	1 CPS	+0	+250	DEG F	
S R5792 T B	OXIDIZER TEMP ENG CCW	T	1 CPS	+0	+250	DEG F	
S R5794 P B	CHAMBER PRESS ENG -Y	T	2000CPS	+0	+150	PSIA	XA963,YA81,ZA-11
S R5795 P B	CHAMBER PRESS ENG CW	T	2000CPS	+0	+150	PSIA	
S R5796 P B	CHAMBER PRESS ENG CCW	T	2000CPS	+0	+150	PSIA	
S R5801 P B	CHAMBER PRESS ENG +Y	T	2000CPS	+0	+150	PSIA	
S R5809 P B	FUEL PRESS ENG +Y	T	2000CPS	+0	+1K	PSIA	

Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM AIRFRAME 1 PHASE I OCTOBER 25, 1963 L- 1
REACTION CONTROL PAGE NO. 15 F- 2

MEAS. ID	MEASUREMENT DESCRIPTION	CPG YRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S R5810 P B	FUEL PRESS ENG -Y	T	2000CPS	+0	+1K	PSIA	
S R5811 P B	FUEL PRESS ENG CW	T	2000CPS	+0	+1K	PSIA	
S R5812 P B	FUEL PRESS ENG CCW	T	2000CPS	+0	+1K	PSIA	
S R5813 P B	OXIDIZER PRESS ENG +Y	T	2000CPS	+0	+1K	PSIA	
S R5814 P B	OXIDIZER PRESS ENG -Y	T	2000CPS	+0	+1K	PSIA	
S R5815 P B	OXIDIZER PRESS ENG CW	T	2000CPS	+0	+1K	PSIA	
S R5816 P B	OXIDIZER PRESS ENG CCW	T	2000CPS	+0	+1K	PSIA	
S R5817 P C	HE MANIFOLD PRESS	B	0 20 CPS	+0	+300	PSIA	XA963,YA11,ZA81
S R5830 P D	HE MANIFOLD PRESS	B	0 20 CPS	+0	+300	PSIA	XA963,YA-81,ZA11
S R6010 P	PRESS SYS A TEST POINT 2	C		+0	+5K	PSIG	
S R6011 P	PRESS SYS A TEST POINT 3	C		+0	+5K	PSIG	
S R6012 P	PRESS SYS B TEST POINT 2	C		+0	+5K	PSIG	
S R6013 P	PRESS SYS B TEST POINT 3	C		+0	+5K	PSIG	
S R6014 P	PRESS SYS C TEST POINT 2	C		+0	+5K	PSIG	
S R6015 P	PRESS SYS C TEST POINT 3	C		+0	+5K	PSIG	
S R6016 P	PRESS SYS D TEST POINT 2	C		+0	+5K	PSIG	
S R6017 P	PRESS SYS D TEST POINT 3	C		+0	+5K	PSIG	

Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM AIRFRAME 1 PHASE I OCTOBER 25, 1963 L- 1
REACTION CONTROL PAGE NO. 16 F- 2

MEAS. ID	MEASUREMENT DESCRIPTION	CPG RESPONSE YRS	DATA RANGE LOW	HIGH	UNITS	LOCATION
S R6020	P PRESS SYS A TEST POINT 4	C	+0	+300	PSIG	
S R6021	P PRESS SYS A TEST POINT 5	C	+0	+300	PSIG	
S R6022	P PRESS SYS B TEST POINT 4	C	+0	+300	PSIG	
S R6023	P PRESS SYS B TEST POINT 5	C	+0	+300	PSIG	
S R6024	P PRESS SYS C TEST POINT 4	C	+0	+300	PSIG	
S R6025	P PRESS SYS C TEST POINT 5	C	+0	+300	PSIG	
S R6026	P PRESS SYS D TEST POINT 4	C	+0	+300	PSIG	
S R6027	P PRESS SYS D TEST POINT 5	C	+0	+300	PSIG	
S R6030	P PRESS SYS A TEST POINT 11	C	+0	+300	PSIG	
S R6031	P PRESS SYS A TEST POINT 12	C	+0	+300	PSIG	
S R6032	P PRESS SYS B TEST POINT 11	C	+0	+300	PSIG	
S R6033	P PRESS SYS B TEST POINT 12	C	+0	+300	PSIG	
S R6034	P PRESS SYS C TEST POINT 11	C	+0	+300	PSIG	
S R6035	P PRESS SYS C TEST POINT 12	C	+0	+300	PSIG	
S R6036	P PRESS SYS D TEST POINT 11	C	+0	+300	PSIG	
S R6037	P PRESS SYS D TEST POINT 12	C	+0	+300	PSIG	
S R6050	P PRESS SYS A TEST POINT 6	C	+0	+300	PSIG	

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Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM
REACTION CONTROL

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MEAS. ID	MEASUREMENT DESCRIPTION	CPG RESPONSE YRS	DATA RANGE LOW	HIGH	UNITS	LOCATION
S R6051	P PRESS SYS B TEST POINT 6	C	+0	+300	PSIG	
S R6052	P PRESS SYS C TEST POINT 6	C	+0	+300	PSIG	
S R6053	P PRESS SYS D TEST POINT 6	C	+0	+300	PSIG	
S R6054	P PRESS SYS A TEST POINT 7	C	+0	+300	PSIG	
S R6055	P PRESS SYS A TEST POINT 8	C	+0	+300	PSIG	
S R6056	P PRESS SYS B TEST POINT 7	C	+0	+300	PSIG	
S R6057	P PRESS SYS B TEST POINT 8	C	+0	+300	PSIG	
S R6058	P PRESS SYS C TEST POINT 7	C	+0	+300	PSIG	
S R6059	P PRESS SYS C TEST POINT 8	C	+0	+300	PSIG	
S R6060	P PRESS SYS D TEST POINT 7	C	+0	+300	PSIG	
S R6061	P PRESS SYS D TEST POINT 8	C	+0	+300	PSIG	
S R6062	P PRESS SYS A TEST POINT 9	C	+0	+300	PSIG	
S R6063	P PRESS SYS A TEST POINT 10	C	+0	+300	PSIG	
S R6064	P PRESS SYS B TEST POINT 9	C	+0	+300	PSIG	
S R6065	P PRESS SYS B TEST POINT 10	C	+0	+300	PSIG	
S R6066	P PRESS SYS C TEST POINT 9	C	+0	+300	PSIG	
S R6067	P PRESS SYS C TEST POINT 10	C	+0	+300	PSIG	

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Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM
REACTION CONTROL

AIRFRAME 1 PHASE I

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MEAS. ID	MEASUREMENT DESCRIPTION	CPG RESPONSE YRS	DATA RANGE LOW	HIGH	UNITS	LOCATION
S R6068	P PRESS SYS D TEST POINT 9	C	+0	+300	PSIG	
S R6069	P PRESS SYS D TEST POINT 10	C	+0	+300	PSIG	
S R6070	P PRESS SYS A TEST POINT 13	C	+0	+300	PSIG	
S R6071	P PRESS SYS B TEST POINT 13	C	+0	+300	PSIG	
S R6072	P PRESS SYS C TEST POINT 13	C	+0	+300	PSIG	
S R6073	P PRESS SYS D TEST POINT 13	C	+0	+300	PSIG	
S R6074	P PRESS SYS A TEST POINT 14	C	+0	+300	PSIG	
S R6075	P PRESS SYS B TEST POINT 14	C	+0	+300	PSIG	
S R6076	P PRESS SYS C TEST POINT 14	C	+0	+300	PSIG	
S R6077	P PRESS SYS D TEST POINT 14	C	+0	+300	PSIG	
S R6080	P PRESS SYS A TEST POINT 1	C	+0	+5K	PSIG	
S R6081	P PRESS SYS B TEST POINT 1	C	+0	+5K	PSIG	
S R6082	P PRESS SYS C TEST POINT 1	C	+0	+5K	PSIG	
S R6083	P PRESS SYS D TEST POINT 1	C	+0	+5K	PSIG	
S R6084	P PRESS SYS A TEST POINT 15	C	+0	+300	PSIG	
S R6085	P PRESS SYS B TEST POINT 15	C	+0	+300	PSIG	
S R6086	P PRESS SYS C TEST POINT 15	C	+0	+300	PSIG	

Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM
REACTION CONTROL

AIRFRAME 1 PHASE I

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MEAS. ID	MEASUREMENT DESCRIPTION	CPG RESPONSE YRS	LOW	DATA RANGE HIGH	UNITS	LOCATION
S R6087	P PRESS SYS D TEST POINT 15	C		+0	+300 PSIG	
S R6088	P PRESS SYS A TEST POINT 16	C		+0	+300 PSIG	
S R6089	P PRESS SYS B TEST POINT 16	C		+0	+300 PSIG	
S R6090	P PRESS SYS C TEST POINT 16	C		+0	+300 PSIG	
S R6091	P PRESS SYS D TEST POINT 16	C		+0	+300 PSIG	
S R6092	P PRESS SYS A TEST POINT 17	C		+0	+300 PSIG	
S R6093	P PRESS SYS B TEST POINT 17	C		+0	+300 PSIG	
S R6094	P PRESS SYS C TEST POINT 17	C		+0	+300 PSIG	
S R6095	P PRESS SYS D TEST POINT 17	C		+0	+300 PSIG	
S R6096	P PRESS SYS A TEST POINT 18	C		+0	+300 PSIG	
S R6097	P PRESS SYS B TEST POINT 18	C		+0	+300 PSIG	
S R6098	P PRESS SYS C TEST POINT 18	C		+0	+300 PSIG	
S R6099	P PRESS SYS D TEST POINT 18	C		+0	+300 PSIG	
S R7125	T TEMP INJ HEAD +P ENG SYS A	T	1 CPS	+0	+500 DEG F	
S R7126	T TEMP INJ HEAD -P ENG SYS A	T	1 CPS	+0	+500 DEG F	
S R7127	T TEMP INJ HEAD -Y ENG SYS B	T	1 CPS	+0	+500 DEG F	
S R7128	T TEMP INJ HEAD +Y ENG SYS B	T	1 CPS	+0	+500 DEG F	

Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM
REACTION CONTROL

AIRFRAME 1 PHASE I

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MEAS. ID	MEASUREMENT DESCRIPTION	CPG YRS	RESPONSE		DATA RANGE LOW	HIGH	UNITS	LOCATION
S R7133 T	TEMP INJ HEAD CW ENG SYS A	T	1	CPS	+0	+500	DEG F	
S R7134 T	TEMP INJ HEAD CCW ENG SYS A	T	1	CPS	+0	+500	DEG F	
S R7135 T	TEMP INJ HEAD CW ENG SYS B	T	1	CPS	+0	+500	DEG F	
S R7136 T	TEMP INJ HEAD CCW ENG SYS B	T	1	CPS	+0	+500	DEG F	

Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM STRUCTURES — AIRFRAME 1 PHASE II — OCTOBER 26, 1963 — PAGE NO. 1 — L- 6 F-12

MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG SYRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S A0633 D	VIBRA THRUST MOUNT X AXIS					T	5000CPS	+0	+50	G	XS212,YS0,ZS15
S A0634 D	VIBRA THRUST MOUNT Y AXIS					T	5000CPS	+0	+50	G	XS212,YS0,ZS15
S A0635 D	VIBRA THRUST MOUNT Z AXIS					T	5000CPS	+0	+50	G	XS212,YS0,ZS15
S A0674 D	SM VIBRA INTFAC POS 1 X AXIS					T	5000CPS	+0	+50	G	XS278.5,YS23,ZS-29.5
S A0675 D	SM VIBRA INTFAC POS 1 Y AXIS					T	5000CPS	+0	+50	G	XS278.5,YS23,ZS-29.5
S A0676 D	SM VIBRA INTFAC POS 1 Z AXIS					T	5000CPS	+0	+50	G	XS278.5,YS23,ZS-29.5
S A0677 D	SM VIBRA INTFAC POS 2 X AXIS					T	5000CPS	+0	+50	G	XS257,YS32,ZS-42
S A0678 D	SM VIBRA INTFAC POS 2 Y AXIS					T	5000CPS	+0	+50	G	XS257,YS32,ZS-42
S A0679 D	SM VIBRA INTFAC POS 2 Z AXIS					T	5000CPS	+0	+50	G	XS257,YS32,ZS-42
S A0680 D	SM VIBRA INTFAC POS 3 X AXIS					T	5000CPS	+0	+50	G	XS298,YS75,ZS-18
S A0681 D	SM VIBRA INTFAC POS 3 Y AXIS					T	5000CPS	+0	+50	G	XS298,YS75,ZS-18
S A0682 D	SM VIBRA INTFAC POS 3 Z AXIS					T	5000CPS	+0	+50	G	XS298,YS75,ZS-18
S A0683 D	SM VIBRA INTFAC POS 4 X AXIS					T	5000CPS	+0	+50	G	XS290,YS67,ZS-24
S A0684 D	SM VIBRA INTFAC POS 4 Y AXIS					T	5000CPS	+0	+50	G	XS290,YS67,ZS-24
S A0685 D	SM VIBRA INTFAC POS 4 Z AXIS					T	5000CPS	+0	+50	G	XS290,YS67,ZS-24
S A0686 Y	ACOUST OUT SM POS 1					T	10K CPS	+110	+180	DB	XS313,80 DEG
S A0687 Y	ACOUST OUT SM POS 2					T	10K CPS	+110	+180	DB	XS313,200 DEG

Table 4-6. Airframe 001 Test Measurement List (Cont)

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MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG SYRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S A0688	Y ACOUST OUT SM POS 3					T	10K CPS	+110	+180	DB	XS313,320 DEG
S A0689	Y ACOUST OUT SM POS 4					T	10K CPS	+110	+180	DB	XS213,80 DEG
S A0690	Y ACOUST OUT SM POS 5					T	10K CPS	+110	+180	DB	XS213,200 DEG
S A0691	Y ACOUST OUT SM POS 6					T	10K CPS	+110	+180	DB	XS213,320 DEG
S A0700	D GIMBAL BEARING VIBRA Y-Y X AXIS					T	5000CPS	+0	+50	G	XS205,YS15,ZS0
S A0701	D GIMBAL BEARING VIBRA Y-Y Y AXIS					T	5000CPS	+0	+50	G	XS205,YS15,ZS0
S A0702	D GIMBAL BEARING VIBRA Y-Y Z AXIS					T	5000CPS	+0	+50	G	XS205,YS15,ZS0
S A0799	D SM VIB INTERFACE POS 5 X AXIS					T	5000CPS	+0	+50	G	XS278,YS-13,ZS51.5
S A0800	D SM VIB INTERFACE POS 5 Y AXIS					T	5000CPS	+0	+50	G	XS278,YS-13,ZS51.5
S A0801	D SM VIB INTERFACE POS 5 Z AXIS					T	5000CPS	+0	+50	G	XS278,YS-13,ZS51.5
S A0802	D SM VIB INTERFACE POS 6 X AXIS					T	5000CPS	+0	+50	G	XS278,YS-46,ZS59
S A0803	D SM VIB INTERFACE POS 6 Y AXIS					T	5000CPS	+0	+50	G	XS278,YS-46,ZS59
S A0804	D SM VIB INTERFACE POS 6 Z AXIS					T	5000CPS	+0	+50	G	XS278,YS-46,ZS59
S A0805	D SM VIB INTERFACE POS 7 X AXIS					T	5000CPS	+0	+50	G	XS224,YS-54,ZS50
S A0806	D SM VIB INTERFACE POS 7 Y AXIS					T	5000CPS	+0	+50	G	XS224,YS-54,ZS50
S A0807	D SM VIB INTERFACE POS 7 Z AXIS					T	5000CPS	+0	+50	G	XS224,YS-54,ZS50
S A0808	D SM VIB INTERFACE POS 8 X AXIS					T	5000CPS	+0	+50	G	XS356,YS57,ZS-32

Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM STRUCTURES — AIRFRAME 1 PHASE II — OCTOBER 26, 1963 — PAGE NO. 3 — L- 6 F-12

MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG SYRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S A0809	D SM VIB INTERFACE POS 8 Y AXIS					T	5000CPS	+0	+50	G	XS356,YS57,ZS-32
S A0810	D SM VIB INTERFACE POS 8 Z AXIS					T	5000CPS	+0	+50	G	XS356,YS57,ZS-32
S A0811	D SM VIB INTERFACE POS 9 X AXIS					T	5000CPS	+0	+50	G	XS203,YS-7,ZS-22
S A0812	D SM VIB INTERFACE POS 9 Y AXIS					T	5000CPS	+0	+50	G	XS203,YS-7,ZS-22
S A0813	D SM VIB INTERFACE POS 9 Z AXIS					T	5000CPS	+0	+50	G	XS203,YS-7,ZS-22

Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM ELECTRICAL — AIRFRAME 1 PHASE II — OCTOBER 26, 1963 — PAGE NO. 4 — L- 6 F-12

MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG SYRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S C2060 P	N2 PRESSURE F/C 1 REGULATED					B 0 2	CPS	+0	+75	PSIA	
S C2061 P	N2 PRESSURE F/C 2 REGULATED					B 0 2	CPS	+0	+75	PSIA	
S C2062 P	N2 PRESSURE F/C 3 REGULATED					B 0 2	CPS	+0	+75	PSIA	
S C2066 P	O2 PRESSURE F/C 1 REGULATED					B 0 2	CPS	+0	+75	PSIA	
S C2067 P	O2 PRESSURE F/C 2 REGULATED					B 0 2	CPS	+0	+75	PSIA	
S C2068 P	O2 PRESSURE F/C 3 REGULATED					B 0 2	CPS	+0	+75	PSIA	
S C2069 P	H2 PRESSURE F/C 1 REGULATED					B 0 2	CPS	+0	+75	PSIA	
S C2070 P	H2 PRESSURE F/C 2 REGULATED					B 0 2	CPS	+0	+75	PSIA	
S C2071 P	H2 PRESSURE F/C 3 REGULATED					B 0 2	CPS	+0	+75	PSIA	
S C2081 T	TEMP F/C 1 COND EXHAUST					B 0 1	CPS	+175	+225	DEG F	
S C2082 T	TEMP F/C 2 COND EXHAUST					B 0 1	CPS	+175	+225	DEG F	
S C2083 T	TEMP F/C 3 COND EXHAUST					B 0 1	CPS	+175	+225	DEG F	
S C2084 T	TEMP F/C 1 SKIN					B 0 1	CPS	+80	+550	DEG F	
S C2085 T	TEMP F/C 2 SKIN					B 0 1	CPS	+80	+550	DEG F	
S C2086 T	TEMP F/C 3 SKIN					B 0 1	CPS	+80	+550	DEG F	
S C2087 T	TEMP FC 1 RADIATOR OUTLET					B 0 1	CPS	-50	+300	DEG F	
S C2088 T	TEMP FC 2 RADIATOR OUTLET					B 0 1	CPS	-50	+300	DEG F	

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Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM ELECTRICAL — AIRFRAME 1 PHASE II — OCTOBER 26, 1963 PAGE NO. 5 — L- 6 F-12

MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG SYRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S C2089 T	TEMP FC 3 RADIATOR OUTLET					B 0 1	CPS	-50	+300	DEG F	
S C2110 V	DC VOLTAGE MAIN BUS A (SM)					B 2	CPS	+0	+40	VDC	
S C2111 V	DC VOLTAGE MAIN BUS B (SM)					B 2	CPS	+0	+40	VDC	
S C2113 C	DC CURRENT F/C 1 OUTPUT					B 0 1	CPS	+0	+100	AMP	
S C2114 C	DC CURRENT F/C 2 OUTPUT					B 0 1	CPS	+0	+100	AMP	
S C2115 C	DC CURRENT F/C 3 OUTPUT					B 0 1	CPS	+0	+100	AMP	
S C2120 X	FUEL CELL 1 BUS A DISCONNECT					B 0 10	S/S	OFF	ON	EVENT	
S C2121 X	FUEL CELL 2 BUS A DISCONNECT					B 0 10	S/S	OFF	ON	EVENT	
S C2122 X	FUEL CELL 3 BUS A DISCONNECT					B 0 10	S/S	OFF	ON	EVENT	
S C2125 X	FUEL CELL 1 BUS B DISCONNECT					B 0 10	S/S	OFF	ON	EVENT	
S C2126 X	FUEL CELL 2 BUS B DISCONNECT					B 0 10	S/S	OFF	ON	EVENT	
S C2127 X	FUEL CELL 3 BUS B DISCONNECT					B 0 10	S/S	OFF	ON	EVENT	
S C2130 X	PURGE VALVE H2 F/C 1 OPERATE					B P 10	S/S	CLOSE	OPEN	EVENT	
S C2131 X	PURGE VALVE H2 F/C 2 OPERATE					B P 10	S/S	CLOSE	OPEN	EVENT	
S C2132 X	PURGE VALVE H2 F/C 3 OPERATE					B P 10	S/S	CLOSE	OPEN	EVENT	
S C2133 X	PURGE VALVE O2 F/C 1 OPERATE					B P 10	S/S	CLOSE	OPEN	EVENT	
S C2134 X	PURGE VALVE O2 F/C 2 OPERATE					B P 10	S/S	CLOSE	OPEN	EVENT	

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Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM ELECTRICAL — AIRFRAME 1 PHASE II — OCTOBER 26, 1963 — PAGE NO. 6 — L- 6 F-12

MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG SYRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S C2135 X	PURGE VALVE O2 F/C 3 OPERATE					B P 10	S/S	CLOSE	OPEN	EVENT	
S C2139 R	FLOW RATE H2 F/C 1					B O 1	CPS	+0	+0.2	LB/HR	
S C2140 R	FLOW RATE H2 F/C 2					B O 1	CPS	+0	+0.2	LB/HR	
S C2141 R	FLOW RATE H2 F/C 3					B O 1	CPS	+0	+0.2	LB/HR	
S C2142 R	FLOW RATE O2 F/C 1					B O 1	CPS	+0	+1.6	LB/HR	
S C2143 R	FLOW RATE O2 F/C 2					B O 1	CPS	+0	+1.6	LB/HR	
S C2144 R	FLOW RATE O2 F/C 3					B O 1	CPS	+0	+1.6	LB/HR	
S C2160 Z	PH FACTOR WATER CONDITION F/C 1					B O 1	CPS	+6	+12	PH	
S C2161 Z	PH FACTOR WATER CONDITION F/C 2					B O 1	CPS	+6	+12	PH	
S C2162 Z	PH FACTOR WATER CONDITION F/C 3					B O 1	CPS	+6	+12	PH	
S C2323 X	FUEL CELL 1 SHUT OFF MON					B O 10	S/S	CLOSE	OPEN	EVENT	
S C2324 X	FUEL CELL 2 SHUT OFF MON					B O 10	S/S	CLOSE	OPEN	EVENT	
S C2325 X	FUEL CELL 3 SHUT OFF MON					B O 10	S/S	CLOSE	OPEN	EVENT	

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Table 4-6. Airframe 001 Test Measurement List (Cont)

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MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG SYRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S F0030 Q	QUANTITY H2 TANK 1					B 0 1	CPS	+0	+28	LB	
S F0031 Q	QUANTITY H2 TANK 2					B 0 1	CPS	+0	+28	LB	
S F0032 Q	QUANTITY O2 TANK 1					B 0 1	CPS	+0	+320	LB	
S F0033 Q	QUANTITY O2 TANK 2					B 0 1	CPS	+0	+320	LB	
S F0037 P	PRESS O2 TANK 1					B 0 1	CPS	+50	+1050	PSIA	
S F0038 P	PRESS O2 TANK 2					B 0 1	CPS	+50	+1050	PSIA	
S F0039 P	PRESS H2 TANK 1					B 0 1	CPS	+0	+350	PSIA	
S F0040 P	PRESS H2 TANK 2					B 0 1	CPS	+0	+350	PSIA	
S F0041 T	TEMP O2 TANK 1					B 0 1	CPS	-325	+80	DEG F	
S F0042 T	TEMP O2 TANK 2					B 0 1	CPS	-325	+80	DEG F	
S F0043 T	TEMP H2 TANK 1					B 0 1	CPS	-425	-200	DEG F	
S F0044 T	TEMP H2 TANK 2					B 0 1	CPS	-425	-200	DEG F	
S F0050 C	O2 TANK 1 HEATER CURRENT					B U 2	CPS	+0	+10	AMP	
S F0051 C	O2 TANK 2 HEATER CURRENT					B U 2	CPS	+0	+10	AMP	
S F0052 C	H2 TANK 1 HEATER CURRENT					B U 2	CPS	+0	+2	AMP	
S F0053 C	H2 TANK 2 HEATER CURRENT					B U 2	CPS	+0	+2	AMP	
S F0056 X	O2 TANK SHUTOFF VLV 1 MON					B 0 10	S/S	CLOSE	OPEN	EVENT	

Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM
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AIRFRAME 1 PHASE II

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MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG SYRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S F0057	X O2 TANK SHUTOFF VLV 2 MON					B O 10	S/S	CLOSE	OPEN	EVENT	
S F0062	X H2 TANK SHUTOFF VLV 1 MON					B O 10	S/S	CLOSE	OPEN	EVENT	
S F0063	X H2 TANK SHUTOFF VLV 2 MON					B O 10	S/S	CLOSE	OPEN	EVENT	
S F0088	X LIQUID LEVEL IND O2 TANK 1					C P 10	S/S				
S F0089	X LIQUID LEVEL IND O2 TANK 2					C P 10	S/S				
S F0090	X LIQUID LEVEL IND H2 TANK 1					C P 10	S/S				
S F0091	X LIQUID LEVEL IND H2 TANK 2					C P 10	S/S				
S F0092	X PRESS SWITCH 1 OPEN O2 TANK 1					C P 10	S/S	OPEN	CLOSE	EVENT	
S F0093	X PRESS SWITCH 1 OPEN O2 TANK 2					C P 10	S/S	OPEN	CLOSE	EVENT	
S F0094	X PRESS SWITCH 1 OPEN H2 TANK 1					C P 10	S/S	OPEN	CLOSE	EVENT	
S F0095	X PRESS SWITCH 1 OPEN H2 TANK 2					C P 10	S/S	OPEN	CLOSE	EVENT	
S F0096	X PRESS SWITCH 2 OPEN O2 TANK 1					C P 10	S/S	OPEN	CLOSE	EVENT	
S F0097	X PRESS SWITCH 2 OPEN O2 TANK 2					C P 10	S/S	OPEN	CLOSE	EVENT	
S F0098	X PRESS SWITCH 2 OPEN H2 TANK 1					C P 10	S/S	OPEN	CLOSE	EVENT	
S F0099	X PRESS SWITCH 2 OPEN H2 TANK 2					C P 10	S/S	OPEN	CLOSE	EVENT	

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Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM AIRFRAME 1 PHASE II OCTOBER 26, 1963 L- 6
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MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG SYRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S P0001 P	HE PRESS TANK					B 0 1	CPS	+0	+5K	PSIA	
S P0002 T	HE TEMP TANK					B 0 1	CPS	-200	+200	DEG F	
S P0003 P	PRESS OXIDIZER TANKS					B 0 20	CPS	+0	+300	PSIA	
S P0004 T	TEMP OXIDIZER TRANSFER LINE					T 1	CPS	+0	+200	DEG F	
S P0005 T	TEMP OXIDIZER ENG FEED LINE					T 1	CPS	+0	+200	DEG F	
S P0006 P	PRESS FUEL TANKS					B 0 20	CPS	+0	+300	PSIA	
S P0007 T	TEMP FUEL TRANSFER LINE					T 1	CPS	+0	+200	DEG F	
S P0008 T	TEMP FUEL ENG FEED LINE					T 1	CPS	+0	+200	DEG F	
S P0009 P	PRESS MAIN VLV ENG OXIDIZER IN					B 0 500	CPS	+0	+300	PSIA	
S P0010 P	PRESS MAIN VLV ENG FUEL IN					B 0 500	CPS	+0	+300	PSIA	
S P0011 Q	TOTAL QUANTITY OXIDIZER					T 1	CPS	+0	+31K	LB	
S P0012 Q	TOTAL QUANTITY FUEL					T 1	CPS	+0	+16K	LB	
S P0013 R	LEAK RATE OXIDIZER 1					C 2	CPS	+0	+100	CC/M	
S P0015 R	LEAK RATE FUEL 1					C 2	CPS	+0	+100	CC/M	
S P0018 H	GIMBAL POSITION PITCH 1B					T 100	CPS	-8	+8	DEG	
S P0019 H	GIMBAL POSITION YAW 1B					T 100	CPS	-10	+10	DEG	
S P0020 T	TEMP CHAMBER OUTER SKIN 1					B 0 1	CPS	+0	+500	DEG F	

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Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM AIRFRAME 1 PHASE II OCTOBER 26, 1963 L- 6
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MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG SYRS	RESPONSE	LOW	HIGH	UNITS	LOCATION
S P0022 H	POSITION FUEL/OXIDIZER VLV 1					B	0 100 CPS	+0	+90	DEG	
S P0023 H	POSITION FUEL/OXIDIZER VLV 2					B	0 100 CPS	+0	+90	DEG	
S P0024 H	POSITION FUEL/OXIDIZER VLV 3					B	0 100 CPS	+0	+90	DEG	
S P0025 H	POSITION FUEL/OXIDIZER VLV 4					B	0 100 CPS	+0	+90	DEG	
S P0030 X	HE ISOLATION VLV 1					B	0 10 S/S	CLOSE	OPEN	EVENT	
S P0031 X	HE ISOLATION VLV 2					B	0 10 S/S	CLOSE	OPEN	EVENT	
S P0040 T	TEMP MAIN VLV ENGINE FUEL IN					T	1 CPS	+0	+200	DEG F	
S P0041 T	TEMP MAIN VLV ENGINE OXIDIZER IN					T	1 CPS	+0	+200	DEG F	
S P0060 T	TEMP INJECTOR MANIFOLD					T	1 CPS	+0	+200	DEG F	
S P0602 P	PRESS OXIDIZER ENG FEED LINE					T	100 CPS	+0	+300	PSIA	
S P0604 P	PRESS FUEL ENG FEED LINE					T	100 CPS	+0	+300	PSIA	
S P0610 P	PRESS INLET TO PU SYSTEM					T	100 CPS	+0	+300	PSIA	
S P0611 P	PRESS OUTLET OF PU SYSTEM					T	100 CPS	+0	+300	PSIA	
S P0650 P	HE REG 1 INTERMEDIATE PRESS					T	100 CPS	+0	+5K	PSIA	
S P0652 P	HE REG 2 INTERMEDIATE PRESS					T	100 CPS	+0	+5K	PSIA	
S P0654 P	HE MANIFOLD PRESS					T	20 CPS	+0	+350	PSIA	
S P0655 Q	QUANTITY SPS OXIDIZER TANK 1					B	0 1 CPS	+0	+16K	LB	

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Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM AIRFRAME 1 PHASE II OCTOBER 26, 1963 L- 6
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MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG SYRS	RESPONSE		DATA RANGE LOW	HIGH	UNITS	LOCATION
S P0656 Q	QUANTITY SPS OXIDIZER TANK 2					B	0	1 CPS	+0	+16K	LB	
S P0657 Q	QUANTITY SPS FUEL TANK 1					B	0	1 CPS	+0	+8K	LB	
S P0658 Q	QUANTITY SPS FUEL TANK 2					B	0	1 CPS	+0	+8K	LB	
S P0661 P	PRESS ENGINE CHAMBER					B	0	2000CPS	+0	+150	PSIA	
S P0670 C	SERVICE ENG SOL VLV 1 CURRENT					B	H	200 CPS	+0	+2	AMP	
S P0671 C	SERVICE ENG SOL VLV 2 CURRENT					B	H	200 CPS	+0	+2	AMP	
S P0672 C	SERVICE ENG SOL VLV 3 CURRENT					B	H	200 CPS	+0	+2	AMP	
S P0673 C	SERVICE ENG SOL VLV 4 CURRENT					B	H	200 CPS	+0	+2	AMP	
S P0674 C	SERVICE ENG SOL VLV 5 CURRENT					B	H	200 CPS	+0	+2	AMP	
S P0675 C	SERVICE ENG SOL VLV 6 CURRENT					B	H	200 CPS	+0	+2	AMP	
S P0690 V	PITCH ACTUATOR MOTOR 1 VOLT					B	H	100 CPS	+0	+32	VDC	
S P0691 C	PITCH ACTUATOR MOTOR 1 CURRENT					B	H	100 CPS	+0	+200	AMP	
S P0692 V	YAW ACTUATOR MOTOR 1 VOLT					B	H	100 CPS	+0	+32	VDC	
S P0693 C	YAW ACTUATOR MOTOR 1 CURRENT					B	H	100 CPS	+0	+200	AMP	
S P0694 V	PITCH ACTUATOR MOTOR 2 VOLT					B	H	100 CPS	+0	+32	VDC	
S P0695 C	PITCH ACTUATOR MOTOR 2 CURRENT					B	H	100 CPS	+0	+200	AMP	
S P0696 V	YAW ACTUATOR MOTOR 2 VOLT					B	H	100 CPS	+0	+32	VDC	

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Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM AIRFRAME 1 PHASE II OCTOBER 26, 1963 L- 6
PROPULSION SYSTEM PAGE NO. 12 F-12

MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG SYRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S P0697 C	YAW ACTUATOR MOTOR 2 CURRENT					B H	100 CPS	+0	+200	AMP	
S P0889 P	OXIDIZER TRANSFER LINE PRESS					T	100 CPS	+0	+300	PSIA	
S P0900 P	OXIDIZER FLOWMETER IN PRESS					T	100 CPS	+0	+300	PSIA	
S P0905 P	FUEL TRANSFER LINE PRESS					T	100 CPS	+0	+300	PSIA	
S P0916 R	FUEL FLOW RATE					T	5 CPS	+0	+30	LB/S	
S P0917 R	OXIDIZER FLOW RATE					T	5 CPS	+0	+60	LB/S	
S P0918 P	FUEL FLOWMETER IN PRESS					T	100 CPS	+0	+300	PSIA	
S P0919 T	FUEL FLOWMETER IN TEMP					T	1 CPS	+0	+200	DEG F	
S P0920 P	FUEL FLOWMETER OUT PRESS					T	100 CPS	+0	+300	PSIA	
S P1000 X	PITCH MOTOR FAIL					T	500 S/S			EVENT	
S P1001 X	YAW MOTOR FAIL					T	500 S/S			EVENT	
S P1022 X	ROUGH COMBUSTION CUTOFF					T	500 S/S			EVENT	
S P1023 A	ROUGH COMBUSTION MONITOR					T	1000CPS	-100	+100	G	
S P2075 T	TEMP OX HT EXCHANGER HELIUM IN					T	1 CPS	-100	+200	DEG F	
S P2076 T	TEMP OX HT EXCHANGER HELIUM OUT					T	1 CPS	-100	+200	DEG F	
S P2077 T	TEMP FUEL HT EXCHANGER HELIUM IN					T	1 CPS	-100	+200	DEG F	
S P2078 T	TEMP FUEL HT EXCHGR HELIUM OUT					T	1 CPS	-100	+200	DEG F	

Table 4-6. Airframe 001 Test Measurement List (Cont)

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MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG SYRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S R5001 P	HE PRESS TANK A					B 0 1	CPS	+0	+5K	PSIA	XA963,YA-11,ZA-81
S R5002 P	HE PRESS TANK B					B 0 1	CPS	+0	+5K	PSIA	XA963,YA81,ZA-11
S R5003 P	HE PRESS TANK C					B 0 1	CPS	+0	+5K	PSIA	XA963,YA11,ZA81
S R5004 P	HE PRESS TANK D					B 0 1	CPS	+0	+5K	PSIA	XA963,YA-81,ZA11
S R5005 T	HE TEMP TANK A					C P 1	CPS	-100	+200	DEG F	XA963,YA-11,ZA-81
S R5006 T	HE TEMP TANK B					C P 1	CPS	-100	+200	DEG F	XA963,YA81,ZA-11
S R5007 T	HE TEMP TANK C					C P 1	CPS	-100	+200	DEG F	XA963,YA11,ZA81
S R5008 T	HE TEMP TANK D					C P 1	CPS	-100	+200	DEG F	XA963,YA-81,ZA11
S R5009 P	PRESS FUEL TANK IN A					T 1	CPS	+0	+300	PSIA	
S R5010 P	PRESS FUEL TANK IN B					T 1	CPS	+0	+300	PSIA	
S R5011 P	PRESS FUEL TANK IN C					T 1	CPS	+0	+300	PSIA	
S R5012 P	PRESS FUEL TANK IN D					T 1	CPS	+0	+300	PSIA	
S R5017 T	TEMP FUEL LINE A					B 0 1	CPS	+0	+200	DEG F	
S R5018 T	TEMP FUEL LINE B					B 0 1	CPS	+0	+200	DEG F	
S R5019 T	TEMP FUEL LINE C					B 0 1	CPS	+0	+200	DEG F	
S R5020 T	TEMP FUEL LINE D					B 0 1	CPS	+0	+200	DEG F	
S R5021 P	PRESS OXIDIZER TANK IN A					T 1	CPS	+0	+300	PSIA	

Table 4-6. Airframe 001 Test Measurement List (Cont)

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MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG SYRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S R5022 P	PRESS OXIDIZER TANK IN B					T 1	CPS	+0	+300	PSIA	
S R5023 P	PRESS OXIDIZER TANK IN C					T 1	CPS	+0	+300	PSIA	
S R5024 P	PRESS OXIDIZER TANK IN D					T 1	CPS	+0	+300	PSIA	
S R5029 T	TEMP OXIDIZER LINE A					T 1	CPS	+0	+200	DEG F	
S R5030 T	TEMP OXIDIZER LINE B					T 1	CPS	+0	+200	DEG F	3 IN FRM OX TANK
S R5031 T	TEMP OXIDIZER LINE C					T 1	CPS	+0	+200	DEG F	
S R5032 T	TEMP OXIDIZER LINE D					T 1	CPS	+0	+200	DEG F	
S R5050 X	COMBINED PROP ISO VLV MON SYS A					B 0 10	S/S			EVENT	
S R5051 X	COMBINED PROP ISO VLV MON SYS B					B 0 10	S/S			EVENT	
S R5052 X	COMBINED PROP ISO VLV MON SYS C					B 0 10	S/S			EVENT	
S R5053 X	COMBINED PROP ISO VLV MON SYS D					B 0 10	S/S			EVENT	
S R5055 Q	QUANTITY FUEL TANKS A,B,C,D					B 0 2	CPS	+0	+70	LB	
S R5056 Q	QUANTITY OX TANKS A,B,C,D					B 0 2	CPS	+0	+140	LB	
S R5065 T	TEMP ENGINE PACKAGE A1					B 0 1	CPS	+0	+300	DEG F	XA963,YA-11,ZA-81
S R5066 T	TEMP ENGINE PACKAGE B1					B 0 1	CPS	+0	+300	DEG F	XA963,YA-81,ZA11
S R5067 T	TEMP ENGINE PACKAGE C1					B 0 1	CPS	+0	+300	DEG F	XA963,YA11,ZA81
S R5068 T	TEMP ENGINE PACKAGE D1					B 0 1	CPS	+0	+300	DEG F	XA963,YA81,ZA-11

Table 4-6. Airframe 001 Test Measurement List (Cont)

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MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG SYRS	RESPONSE		DATA RANGE LOW	HIGH	UNITS	LOCATION
S R5101 X	HE ISOLATION VLV A1 POSITION					B 0	10	S/S	OPEN	CLOSE	EVENT	
S R5102 X	HE ISOLATION VLV B1 POSITION					B 0	10	S/S	OPEN	CLOSE	EVENT	
S R5103 X	HE ISOLATION VLV C1 POSITION					B 0	10	S/S	OPEN	CLOSE	EVENT	
S R5104 X	HE ISOLATION VLV D1 POSITION					B 0	10	S/S	OPEN	CLOSE	EVENT	
S R5105 X	HE ISOLATION VLV A2 POSITION					B 0	10	S/S	OPEN	CLOSE	EVENT	
S R5106 X	HE ISOLATION VLV B2 POSITION					B 0	10	S/S	OPEN	CLOSE	EVENT	
S R5107 X	HE ISOLATION VLV C2 POSITION					B 0	10	S/S	OPEN	CLOSE	EVENT	
S R5108 X	HE ISOLATION VLV D2 POSITION					B 0	10	S/S	OPEN	CLOSE	EVENT	
S R5109 X	FUEL ISOLATION VLV A1 POSITION					C P	10	S/S	OPEN	CLOSE	EVENT	
S R5110 X	FUEL ISOLATION VLV B1 POSITION					C P	10	S/S	OPEN	CLOSE	EVENT	
S R5111 X	FUEL ISOLATION VLV C1 POSITION					C P	10	S/S	OPEN	CLOSE	EVENT	
S R5112 X	FUEL ISOLATION VLV D1 POSITION					C P	10	S/S	OPEN	CLOSE	EVENT	
S R5113 X	OX ISOLATION VLV A2 POSITION					C P	10	S/S	OPEN	CLOSE	EVENT	
S R5114 X	OX ISOLATION VLV B2 POSITION					C P	10	S/S	OPEN	CLOSE	EVENT	
S R5115 X	OX ISOLATION VLV C2 POSITION					C P	10	S/S	OPEN	CLOSE	EVENT	
S R5116 X	OX ISOLATION VLV D2 POSITION					C P	10	S/S	OPEN	CLOSE	EVENT	
S R5725 P	A HE REG 1 IN PRESS					T	1	CPS	+0	+5K	PSIA	

Table 4-6. Airframe 001 Test Measurement List (Cont)

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MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG SYRS	RESPONSE		DATA RANGE LOW	HIGH	UNITS	LOCATION
S R5726 P A	HE REG 2 IN PRESS					T	1	CPS	+0	+5K	PSIA	
S R5727 P A	HE REG 1 INTMED PRESS					T	2	CPS	+0	+5K	PSIA	
S R5728 P A	HE REG 2 INTMED PRESS					T	2	CPS	+0	+5K	PSIA	
S R5729 P A	HE MANIFOLD PRESS					B	0 20	CPS	+0	+300	PSIA	XA963,YA-11,ZA-81
S R5730 P A	OXIDIZER TANK OUT PRESS					T	1	CPS	+0	+300	PSIA	
S R5731 R A	OXIDIZER FLOW RATE					T	2	CPS	+0	+0.47	LB/S	
S R5733 P A	OXIDIZER MANFLD PRESS RD					T	2000	CPS	+0	+1K	PSIA	
S R5734 P A	FUEL TANK OUT PRESS					T	1	CPS	+0	+300	PSIA	
S R5735 R A	FUEL FLOW RATE					T	2	CPS	+0	+0.26	LB/S	
S R5737 P A	FUEL MANFLD PRESS RD					T	2000	CPS	+0	+1K	PSIA	
S R5738 T A	FUEL TEMP ENG +P					T	1	CPS	+0	+250	DEG F	
S R5739 T A	FUEL TEMP ENG -P					T	1	CPS	+0	+250	DEG F	
S R5740 T A	FUEL TEMP ENG CW					T	1	CPS	+0	+250	DEG F	
S R5741 T A	FUEL TEMP ENG CCW					T	1	CPS	+0	+250	DEG F	
S R5742 T A	OXIDIZER TEMP ENG +P					T	1	CPS	+0	+250	DEG F	
S R5743 T A	OXIDIZER TEMP ENG -P					T	1	CPS	+0	+250	DEG F	
S R5744 T A	OXIDIZER TEMP ENG CW					T	1	CPS	+0	+250	DEG F	

Table 4-6. Airframe 001 Test Measurement List (Cont)

SYSTEM
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MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG SYRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S R5745 T A	OXIDIZER TEMP ENG CCW					T	1 CPS	+0	+250	DEG F	
S R5747 P A	CHAMBER PRESS ENG -P					T	2000CPS	+0	+150	PSIA	XA963,YA-11,ZA-81
S R5748 P A	CHAMBER PRESS ENG CW					T	2000CPS	+0	+150	PSIA	
S R5749 P A	CHAMBER PRESS ENG CCW					T	2000CPS	+0	+150	PSIA	
S R5754 P A	CHAMBER PRESS ENG +P					T	2000CPS	+0	+150	PSIA	XA963,YA-11,ZA-81
S R5758 P D	CHAMBER PRESS ENG CCW					T	2000CPS	+0	+150	PSIA	
S R5759 P D	CHAMBER PRESS ENG CW					T	2000CPS	+0	+150	PSIA	
S R5760 P D	CHAMBER PRESS ENG +Y					T	2000CPS	+0	+150	PSIA	XA963,YA-81,ZA11
S R5761 P D	CHAMBER PRESS ENG -Y					T	2000CPS	+0	+150	PSIA	
S R5764 P A	FUEL PRESS ENG +P					T	2000CPS	+0	+1K	PSIA	
S R5765 P A	FUEL PRESS ENG -P					T	2000CPS	+0	+1K	PSIA	
S R5766 P A	FUEL PRESS ENG CW					T	2000CPS	+0	+1K	PSIA	
S R5767 P A	FUEL PRESS ENG CCW					T	2000CPS	+0	+1K	PSIA	
S R5768 P A	OXIDIZER PRESS ENG +P					T	2000CPS	+0	+1K	PSIA	
S R5769 P A	OXIDIZER PRESS ENG -P					T	2000CPS	+0	+1K	PSIA	
S R5770 P A	OXIDIZER PRESS ENG CW					T	2000CPS	+0	+1K	PSIA	
S R5771 P A	OXIDIZER PRESS ENG CCW					T	2000CPS	+0	+1K	PSIA	

Table 4-6. Airframe 001 Test Measurement List (Cont)

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MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG SYRS	RESPONSE		DATA RANGE LOW	HIGH	UNITS	LOCATION
S R5772 P B	HE REG 1 IN PRESS					T	1	CPS	+0	+5K	PSIA	
S R5773 P B	HE REG 2 IN PRESS					T	1	CPS	+0	+5K	PSIA	
S R5774 P B	HE REG 1 INTMED PRESS					T	2	CPS	+0	+5K	PSIA	
S R5775 P B	HE REG 2 INTMED PRESS					T	2	CPS	+0	+5K	PSIA	
S R5776 P B	HE MANIFOLD PRESS					B	0 20	CPS	+0	+300	PSIA	XA963,YA81,ZA-11
S R5777 P B	OXIDIZER TANK OUT PRESS					T	1	CPS	+0	+300	PSIA	
S R5778 R B	OXIDIZER FLOW RATE					T	2	CPS	+0	+0.47	LB/S	
S R5780 P B	OXIDIZER MANFLD PRESS RD					T	2000	CPS	+0	+1K	PSIA	
S R5781 P B	FUEL TANK OUT PRESS					T	1	CPS	+0	+300	PSIA	
S R5782 R B	FUEL FLOW RATE					T	2	CPS	+0	+0.26	LB/S	
S R5784 P B	FUEL MANFLD PRESS RD					T	2000	CPS	+0	+1K	PSIA	
S R5785 T B	FUEL TEMP ENG +Y					T	1	CPS	+0	+250	DEG F	
S R5786 T B	FUEL TEMP ENG -Y					T	1	CPS	+0	+250	DEG F	
S R5787 T B	FUEL TEMP ENG CW					T	1	CPS	+0	+250	DEG F	
S R5788 T B	FUEL TEMP ENG CCW					T	1	CPS	+0	+250	DEG F	
S R5789 T B	OXIDIZER TEMP ENG +Y					T	1	CPS	+0	+250	DEG F	
S R5790 T B	OXIDIZER TEMP ENG -Y					T	1	CPS	+0	+250	DEG F	

Table 4-6. Airframe 001 Test Measurement List (Cont)

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MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG SYRS	RESPONSE		DATA RANGE LOW	HIGH	UNITS	LOCATION
S R5791 T B	OXIDIZER TEMP ENG CW					T	1	CPS	+0	+250	DEG F	
S R5792 T B	OXIDIZER TEMP ENG CCW					T	1	CPS	+0	+250	DEG F	
S R5794 P B	CHAMBER PRESS ENG -Y					T	2000	CPS	+0	+150	PSIA	XA963,YA81,ZA-11
S R5795 P B	CHAMBER PRESS ENG CW					T	2000	CPS	+0	+150	PSIA	
S R5796 P B	CHAMBER PRESS ENG CCW					T	2000	CPS	+0	+150	PSIA	
S R5801 P B	CHAMBER PRESS ENG +Y					T	2000	CPS	+0	+150	PSIA	
S R5803 P C	CHAMBER PRESS ENG +P					T	2000	CPS	+0	+150	PSIA	
S R5804 P C	CHAMBER PRESS ENG -P					T	2000	CPS	+0	+150	PSIA	XA963,YA11,ZA81
S R5805 P C	CHAMBER PRESS ENG CCW					T	2000	CPS	+0	+150	PSIA	
S R5806 P C	CHAMBER PRESS ENG CW					T	2000	CPS	+0	+150	PSIA	
S R5809 P B	FUEL PRESS ENG +Y					T	2000	CPS	+0	+1K	PSIA	
S R5810 P B	FUEL PRESS ENG -Y					T	2000	CPS	+0	+1K	PSIA	
S R5811 P B	FUEL PRESS ENG CW					T	2000	CPS	+0	+1K	PSIA	
S R5812 P B	FUEL PRESS ENG CCW					T	2000	CPS	+0	+1K	PSIA	
S R5813 P B	OXIDIZER PRESS ENG +Y					T	2000	CPS	+0	+1K	PSIA	
S R5814 P B	OXIDIZER PRESS ENG -Y					T	2000	CPS	+0	+1K	PSIA	
S R5815 P B	OXIDIZER PRESS ENG CW					T	2000	CPS	+0	+1K	PSIA	

Table 4-6. Airframe 001 Test Measurement List (Cont)

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MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG SYRS	RESPONSE	DATA RANGE LOW	HIGH	UNITS	LOCATION
S R5816 P B	OXIDIZER PRESS ENG CCW					T	2000CPS	+0	+1K	PSIA	
S R5817 P C	HE MANIFOLD PRESS					B	0 20 CPS	+0	+300	PSIA	XA963,YA11,ZA81
S R5820 P C	OXIDIZER MANIFOLD PRESS RD					T	2000CPS	+0	+1K	PSIA	
S R5821 P D	OXIDIZER MANIFOLD PRESS RD					T	2000CPS	+0	+1K	PSIA	
S R5822 P C	FUEL MANIFOLD PRESS RD					T	2000CPS	+0	+1K	PSIA	
S R5823 P D	FUEL MANIFOLD PRESS RD					T	2000CPS	+0	+1K	PSIA	
S R5830 P D	HE MANIFOLD PRESS					B	0 20 CPS	+0	+300	PSIA	XA963,YA-81,ZA11
S R5858 P	BARO PRESS TEST STAND					T	1 CPS	+0	+15	PSIA	
S R5859 T	AMB TEMP TEST STAND					T	1 CPS	+0	+150	DEG F	
S R6000 R	FUEL LEAK RATE HIGH A					B	1 CPS	+0	+0.1	CC/M	
S R6001 R	FUEL LEAK RATE HIGH B					B	1 CPS	+0	+0.1	CC/M	
S R6002 R	FUEL LEAK RATE HIGH C					B	1 CPS	+0	+0.1	CC/M	
S R6003 R	FUEL LEAK RATE HIGH D					B	1 CPS	+0	+0.1	CC/M	
S R6004 R	OXIDIZER LEAK RATE HIGH A					B	1 CPS	+0	+0.1	CC/M	
S R6005 R	OXIDIZER LEAK RATE HIGH B					B	1 CPS	+0	+0.1	CC/M	
S R6006 R	OXIDIZER LEAK RATE HIGH C					B	1 CPS	+0	+0.1	CC/M	
S R6007 R	OXIDIZER LEAK RATE HIGH D					B	1 CPS	+0	+0.1	CC/M	

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Table 4-6. Airframe 001 Test Measurement List (Cont)

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MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG RESPONSE SYRS	DATA RANGE LOW	HIGH	UNITS	LOCATION
S R6010	P PRESS SYS A TEST POINT 2					C	+0	+5K	PSIG	
S R6011	P PRESS SYS A TEST POINT 3					C	+0	+5K	PSIG	
S R6012	P PRESS SYS B TEST POINT 2					C	+0	+5K	PSIG	
S R6013	P PRESS SYS B TEST POINT 3					C	+0	+5K	PSIG	
S R6014	P PRESS SYS C TEST POINT 2					C	+0	+5K	PSIG	
S R6015	P PRESS SYS C TEST POINT 3					C	+0	+5K	PSIG	
S R6016	P PRESS SYS D TEST POINT 2					C	+0	+5K	PSIG	
S R6017	P PRESS SYS D TEST POINT 3					C	+0	+5K	PSIG	
S R6020	P PRESS SYS A TEST POINT 4					C	+0	+300	PSIG	
S R6021	P PRESS SYS A TEST POINT 5					C	+0	+300	PSIG	
S R6022	P PRESS SYS B TEST POINT 4					C	+0	+300	PSIG	
S R6023	P PRESS SYS B TEST POINT 5					C	+0	+300	PSIG	
S R6024	P PRESS SYS C TEST POINT 4					C	+0	+300	PSIG	
S R6025	P PRESS SYS C TEST POINT 5					C	+0	+300	PSIG	
S R6026	P PRESS SYS D TEST POINT 4					C	+0	+300	PSIG	
S R6027	P PRESS SYS D TEST POINT 5					C	+0	+300	PSIG	
S R6030	P PRESS SYS A TEST POINT 11					C	+0	+300	PSIG	

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Table 4-6. Airframe 001 Test Measurement List (Cont)

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MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG RESPONSE SYRS	DATA RANGE LOW	HIGH	UNITS	LOCATION
S R6031	P PRESS SYS A TEST POINT 12					C	+0	+300	PSIG	
S R6032	P PRESS SYS B TEST POINT 11					C	+0	+300	PSIG	
S R6033	P PRESS SYS B TEST POINT 12					C	+0	+300	PSIG	
S R6034	P PRESS SYS C TEST POINT 11					C	+0	+300	PSIG	
S R6035	P PRESS SYS C TEST POINT 12					C	+0	+300	PSIG	
S R6036	P PRESS SYS D TEST POINT 11					C	+0	+300	PSIG	
S R6037	P PRESS SYS D TEST POINT 12					C	+0	+300	PSIG	
S R6050	P PRESS SYS A TEST POINT 6					C	+0	+300	PSIG	
S R6051	P PRESS SYS B TEST POINT 6					C	+0	+300	PSIG	
S R6052	P PRESS SYS C TEST POINT 6					C	+0	+300	PSIG	
S R6053	P PRESS SYS D TEST POINT 6					C	+0	+300	PSIG	
S R6054	P PRESS SYS A TEST POINT 7					C	+0	+300	PSIG	
S R6055	P PRESS SYS A TEST POINT 8					C	+0	+300	PSIG	
S R6056	P PRESS SYS B TEST POINT 7					C	+0	+300	PSIG	
S R6057	P PRESS SYS B TEST POINT 8					C	+0	+300	PSIG	
S R6058	P PRESS SYS C TEST POINT 7					C	+0	+300	PSIG	
S R6059	P PRESS SYS C TEST POINT 8					C	+0	+300	PSIG	

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Table 4-6. Airframe 001 Test Measurement List (Cont)

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MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG RESPONSE SYRS	DATA RANGE LOW	HIGH	UNITS	LOCATION
S R6060	P PRESS SYS D TEST POINT 7					C	+0	+300	PSIG	
S R6061	P PRESS SYS D TEST POINT 8					C	+0	+300	PSIG	
S R6062	P PRESS SYS A TEST POINT 9					C	+0	+300	PSIG	
S R6063	P PRESS SYS A TEST POINT 10					C	+0	+300	PSIG	
S R6064	P PRESS SYS B TEST POINT 9					C	+0	+300	PSIG	
S R6065	P PRESS SYS B TEST POINT 10					C	+0	+300	PSIG	
S R6066	P PRESS SYS C TEST POINT 9					C	+0	+300	PSIG	
S R6067	P PRESS SYS C TEST POINT 10					C	+0	+300	PSIG	
S R6068	P PRESS SYS D TEST POINT 9					C	+0	+300	PSIG	
S R6069	P PRESS SYS D TEST POINT 10					C	+0	+300	PSIG	
S R6070	P PRESS SYS A TEST POINT 13					C	+0	+300	PSIG	
S R6071	P PRESS SYS B TEST POINT 13					C	+0	+300	PSIG	
S R6072	P PRESS SYS C TEST POINT 13					C	+0	+300	PSIG	
S R6073	P PRESS SYS D TEST POINT 13					C	+0	+300	PSIG	
S R6074	P PRESS SYS A TEST POINT 14					C	+0	+300	PSIG	
S R6075	P PRESS SYS B TEST POINT 14					C	+0	+300	PSIG	
S R6076	P PRESS SYS C TEST POINT 14					C	+0	+300	PSIG	

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Table 4-6. Airframe 001 Test Measurement List (Cont)

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MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG RESPONSE SYRS	DATA RANGE LOW	HIGH	UNITS	LOCATION
S R6077	P PRESS SYS D TEST POINT 14					C	+0	+300	PSIG	
S R6080	P PRESS SYS A TEST POINT 1					C	+0	+5K	PSIG	
S R6081	P PRESS SYS B TEST POINT 1					C	+0	+5K	PSIG	
S R6082	P PRESS SYS C TEST POINT 1					C	+0	+5K	PSIG	
S R6083	P PRESS SYS D TEST POINT 1					C	+0	+5K	PSIG	
S R6084	P PRESS SYS A TEST POINT 15					C	+0	+300	PSIG	
S R6085	P PRESS SYS B TEST POINT 15					C	+0	+300	PSIG	
S R6086	P PRESS SYS C TEST POINT 15					C	+0	+300	PSIG	
S R6087	P PRESS SYS D TEST POINT 15					C	+0	+300	PSIG	
S R6088	P PRESS SYS A TEST POINT 16					C	+0	+300	PSIG	
S R6089	P PRESS SYS B TEST POINT 16					C	+0	+300	PSIG	
S R6090	P PRESS SYS C TEST POINT 16					C	+0	+300	PSIG	
S R6091	P PRESS SYS D TEST POINT 16					C	+0	+300	PSIG	
S R6092	P PRESS SYS A TEST POINT 17					C	+0	+300	PSIG	
S R6093	P PRESS SYS B TEST POINT 17					C	+0	+300	PSIG	
S R6094	P PRESS SYS C TEST POINT 17					C	+0	+300	PSIG	
S R6095	P PRESS SYS D TEST POINT 17					C	+0	+300	PSIG	

Table 4-6. Airframe 001 Test Measurement List (Cont)

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MEAS. ID	MEASUREMENT DESCRIPTION	ACCESSIBILITY TM	IFTS	DISP	GSE	MCPG SYRS	RESPONSE		LOW	DATA RANGE HIGH	UNITS	LOCATION
S R6096	P PRESS SYS A TEST POINT 18					C			+0	+300	PSIG	
S R6097	P PRESS SYS B TEST POINT 18					C			+0	+300	PSIG	
S R6098	P PRESS SYS C TEST POINT 18					C			+0	+300	PSIG	
S R6099	P PRESS SYS D TEST POINT 18					C			+0	+300	PSIG	
S R7125	T TEMP INJ HEAD +P ENG SYS A					T	1	CPS	+0	+500	DEG F	
S R7126	T TEMP INJ HEAD -P ENG SYS A					T	1	CPS	+0	+500	DEG F	
S R7127	T TEMP INJ HEAD -Y ENG SYS B					T	1	CPS	+0	+500	DEG F	
S R7128	T TEMP INJ HEAD +Y ENG SYS B					T	1	CPS	+0	+500	DEG F	
S R7133	T TEMP INJ HEAD CW ENG SYS A					T	1	CPS	+0	+500	DEG F	
S R7134	T TEMP INJ HEAD CCW ENG SYS A					T	1	CPS	+0	+500	DEG F	
S R7135	T TEMP INJ HEAD CW ENG SYS B					T	1	CPS	+0	+500	DEG F	
S R7136	T TEMP INJ HEAD CCW ENG SYS B					T	1	CPS	+0	+500	DEG F	
S R7145	T +P ENG FUEL VLV SOLENOID SYS A					T	1	CPS	+0	+300	DEG F	
S R7148	T CCW ENG FUEL VLV SOLENOID SYS A					T	1	CPS	+0	+300	DEG F	
S R7149	T +Y ENG FUEL VLV SOLENOID SYS B					T	1	CPS	+0	+300	DEG F	
S R7155	T CW ENG FUEL VLV SOLENOID SYS C					T	1	CPS	+0	+300	DEG F	

[redacted]

[redacted]

4.2.11.2 Test 2-SPS Systems Integrity and GSE Evaluation

4.2.11.2.1 Objectives. Primary objectives are as follows:

1. System leak-check

2. Ground support equipment evaluation

3. System shakedown

4. Safety rules and procedures development

5. Operating techniques development

4.2.11.2.2 Configuration

1. The SPS propellant system configuration will be similar to the flight vehicle. The following NAA drawings define the subsystems:

Pressurization	-	V17-460201
Oxidizer system	-	V17-470201
Fuel system	-	V17-480201

2. The ground support equipment outlined in paragraph 4.2.3.2 will be utilized during these tests.

4.2.11.2.3 Test Conditions. Standard test preparation, tanking, detanking, countdown, and inspection procedures are to be developed. These procedures will be in an operational procedure form and will be referenced under test conditions. The following conditions apply to this test:

1. The gas and fluid systems will be leak-tested.

2. The system components and test control hookup will be unified with the applicable GSE.

4.2.11.2.4 Data Required. Parameters are required to substantiate a leak-free helium and propellant system. Specifically, the data outlined in the measurement list in Table 4-6 is required. Data requirements for each subsequent test will be outlined in paragraph 4.2.12.1.

[redacted]

4.2.11.3 Test 3 - Service Module RCS (Integrity and GSE evaluation)

4.2.11.3.1 Objectives. Primary objectives are as follows:

1. System leak-check
2. GSE evaluation
3. System shakedown
4. Safety rules and procedures development
5. Operating techniques development

4.2.11.3.2 Configuration

1. The service module RCS system will be of the configuration specified by the following NAA drawings:

Pressurization system	-	V17-460101
Oxidizer system	-	V17-470101
Fuel systems	-	V17-480101

2. The ground support equipment outlined in paragraph 4.2.3.2 will be utilized during these tests.

4.2.11.3.3 Test Conditions

1. The gas and fluid systems will be leak-tested
2. The RCS components and test control hookup will be verified with the applicable GSE.

4.2.11.3.4 Data Required. Data required will be the same as Test 1.

4.2.11.4 Test 4 - SPS Servicing and GSE Evaluation

4.2.11.4.1 Objectives. Primary objectives are as follows:

1. Servicing rates demonstration and procedures
2. Ground support equipment evaluation
3. Operating techniques and procedures development
4. Safety rules and procedures development

[redacted]

4.2.11.4.2 Configuration. The propellant system will be to the configuration specified in Test 1. The ground support equipment units that will be evaluated are as follows:

Oxidizer transfer and ready-storage units	- S14-002 and S14-059
Fuel transfer and ready-storage units	- S14-008 and S14-058
Helium transfer and ready-storage units	- S14-009 and S14-062
Propellant tank purge unit	- S14-070

4.2.11.4.3 Test Conditions. The following conditions apply to this test:

1. A series of propellant tanking and detanking tests will be performed at design servicing rates

2. Propellants will be conditioned to approximately 70 F

3. Test operations will be remotely controlled from the blockhouse transfer control panel

4. Detanking rates will be performed

5. Helium spheres will be pressurized to 4000 psig (SPS) and 4150 psig (RCS).

4.2.11.4.4 Data.

1. TV monitoring and photo coverage of the test stand and servicing will be accomplished

2. Meteorological data throughout all tanking and detanking operations

3. Propellant transfer unit flow rates, pressures, and temperatures (to be displayed in the blockhouse)

4. Propellant tank pressures, temperatures, and quantities (to be permanently recorded)

4.2.11.5 Test 5 - Service Module RCS and GSE Evaluation

4.2.11.5.1 Objectives. Primary objectives are as follows:

1. Servicing rates demonstration

2. Ground support equipment evaluation

[redacted]

3. Operational techniques and procedures development

4. Safety rules and procedures development

4.2.11.5.2 Configuration. The S/M RCS propellant system will be to the configuration specified in Test 3. The ground support equipment units which will be evaluated are as follows:

Oxidizer transfer unit	- S14-057
Fuel transfer unit	- S14-056
Propellant tank purge unit	- S14-070
Helium transfer unit	- S14-009

4.2.11.5.3 Test Conditions

1. A series of propellant tanking and detanking tests will be performed.

2. Propellants will be conditioned to approximately 70F.

3. Helium spheres will be pressurized to 4150 psi.

4. Propellant tanks will be serviced to their capacity at specified rates.

5. Test operations will be controlled from the blockhouse.

4.2.11.5.4 Data

1. TV monitoring and photo coverage of the RCS module being serviced will be accomplished.

2. Meteorological data will be obtained and monitored throughout tanking and detanking.

3. Transfer unit flow rates, pressures, and temperatures will be monitored in the blockhouse.

4. Propellant tank temperatures, pressures, and quantities will be permanently recorded.

4.2.11.6 Test 6 - Service Module RCS Shakedown

4.2.11.5.1 Objectives. Primary objectives are as follows:

1. System integrity determination

[redacted]

[redacted]

2. Ground support equipment evaluation

3. Operation techniques and procedures development

4. S/M vibration and acoustics evaluation

Secondary objectives are as follows:

1. Propellant servicing evaluation

2. Propellant system performance evaluation

3. Evaluate pressurization system

4. Evaluate engine performance

4.2.11.6.2 Configuration

1. The S/M RCS propellant systems will be of the configuration specified in Test 3.

2. Prototype reaction engines will be installed in each module in accordance with S&ID drawing V17-417001.

4.2.11.6.3 Test Conditions

1. Pulse and steady-state firings will be performed in the manual mode, using the blockhouse control console.

2. Helium and propellant tanks will be serviced to capacity.

3. Propellants will be at ambient temperature.

4. Fuel and oxidizer pressure will be nominal at 180 psia.

4.2.11.5.4 Data

1. TV monitoring and photo coverage of the RCS modules will be obtained throughout the test program as required.

2. Meteorological data will be obtained as during servicing operation.

[redacted]

[redacted]

3. Propellant and engine system parameters will be recorded throughout the firings.

4. Vibration and acoustic measurements will be recorded.

4.2.11.7 Test 7 - SPS Shakedown Firing

4.2.11.7.1 Objectives. The primary and secondary objectives are the same as in Test 6.

4.2.11.7.2 Configuration

1. The propellant system will be to the configuration specified in Test 2.

2. The service propulsion engine (AJ10-137) will be installed in accordance with S&ID drawing V17-400104.

3. The engine will be prequalified article employing a 6:1 area ratio nozzle

4.2.11.7.3 Test Conditions. A number of firings of approximately five seconds duration will be required to accomplish the following objectives. Each firing will be followed by an inspection period and data review to detect incipient failures.

1. Engine gimbal system locked in the null position

2. Propellants and helium tanks serviced to capacity

3. Propellants conditioned to approximately 70 F

4. Engine mixture ratio nominal at 2.0

4.2.11.7.4 Data

1. TV monitoring and photo coverage of the vehicles will be obtained throughout the program as required.

2. Meteorological data will be obtained as required servicing operations.

[redacted]

3. SPS propellant and engine system parameters will be recorded throughout the firings.

4. Vibration and acoustic measurements will be recorded throughout the vehicle.

4.2.11.8 Test 8 - SPS Baseline Performance

4.2.11.7.1 Objectives. The primary objectives are as follows:

1. Evaluate propellant system performance.

2. Evaluate pressurization system.

3. Evaluate engine performance.

4. Evaluate acoustic and vibration effects on system.

The secondary objective is:

1. Evaluate propellant system temperature variation.

4.2.11.8.2 Configuration. The system configuration for this test will be the configuration specified in Test 7.

4.2.11.8.3 Test Conditions. Five firings will be made. Duration of the firings will be from 10 to 20 seconds. The test will establish basic start, stop, and steady-state performance. All other test conditions will be the same as in Test 7.

4.2.11.8.4 Data. Data for this test will be the same as for Test 7.

4.2.11.9 Test 9 - Service Module Gimbal Performance

4.2.11.9.1 Objectives. Primary objectives are as follows:

1. Evaluate propellant system performance

2. Evaluate pressurization system

3. Evaluate engine performance

4. Evaluate gimbal effects on system

5. Acoustic and vibration effects on S /M and systems

[redacted]

[redacted]

Secondary objectives are as follows:

1. Evaluate propellant temperature variation

2. Evaluate propellant mixture ratio control

3. Evaluate engine restart capability

4.2.11.9.2 Configuration. The system configuration for this test will be the same as for Test 7.

4.2.11.9.3 Test Conditions. Two 30-second firings will be run. All test conditions will be the same as in Test 8, except for the following:

1. Engine gimbal excursion will be 4.5 degree.

2. Engine gimbal rate will be 1 cps.

3. Engine gimbal duration will be 28 seconds.

4.2.11.9.4 Data. Data recorded during this test will be the same as Test 8 except for the monitoring of gimbal parameters.

4.2.11.10 Text No. 10. SPS Performance Variable Propellant Loads.

4.2.11.10.1 Objectives. The primary objectives are as follows:

1. Evaluate system operational characteristics for various propellant level combinations.

2. Demonstrate system operational characteristics repeatability.

3. Evaluate Engine Performance.

4. Evaluate Pressurization System.

The secondary objectives are as follows:

1. Evaluate engine start transients.

2. Evaluate propellant temperature effects on system.

4.2.11.10.2 Configuration. System configuration for this test will be the same as Test 9.

[redacted]

4.2.11.10.3 Test Conditions. Three 10-second runs will be made. For each test there will be a different propellant level conditions. All other conditions will be the same as Test 9.

1. Engine gimbal system will be locked in null position.

2. Propellant tanks will be serviced to 90, 75, and 60 percent for the three consecutive firings.

3. Helium tanks will be serviced to capacity.

4. Propellants will be conditioned to approximately 70 F.

5. Engine mixture ratio will be nominal at 2.0.

4.2.11.10.4 Data. Data monitored for this test will be the same as Test No. 8.

4.2.11.11 Test 11 - RCS Manual Control

4.2.11.11.1 Objectives. Primary objectives are as follows:

1. Develop safety rules and procedures

2. Develop operating techniques

3. Evaluate propellant system performance

4. Evaluate pressurization system

5. Evaluate engine performance

Secondary objectives are as follows:

1. Servicing rates and procedures

2. Feed-line pressure surges

3. Propellant line vibration

4. Engine restart capability

4.2.11.11.2 Configuration. System configuration for this test will be the same as in Test 6.

[redacted]

[redacted]

4.2.11.11.3 Test Conditions. All RCS systems will be fired eight times for a duration of 2 seconds, followed by four firings of each system for a duration of 5 seconds. All other test conditions will be the same as Test 6.

4.2.11.11.4 Data. Data for this test will be the same as in Test 6.

4.2.11.12 Test 12 - RCS Automatic Control

4.2.11.12.1 Objectives. Primary and secondary objectives for this test will be the same as in Test 11.

4.2.11.12.2 Configuration. System configuration for this test will be the configuration of Test 11.

4.2.11.12.3 Test Conditions. Test conditions for this test will be the same as in Test 11.

4.2.11.12.4 Data. Data recorded will be the same as for Test 11.

4.2.11.13 Test 13 - SPS Steady-State Performance

4.2.11.13.1 Objectives. The primary objectives are as follows:

1. Evaluate propellant temperature variation
2. Evaluate engine inlet condition
3. Evaluate propellant mixture ratio control
4. Evaluate helium pressurization system
5. Evaluate engine steady-state performance

Secondary objectives are as follows:

1. Evaluate system resonant frequency
2. Evaluate feed-line pressure surges
3. Evaluate propellant vibration
4. Evaluate engine start transients

[redacted]

[redacted]

5. Evaluate engine shutdown transients

6. Evaluate engine restart capability.

4.2.11.13.2 Configuration. System configuration for this test will be the configuration of Test 8.

4.2.11.13.3 Test Conditions. Two engine firings will be made. Duration of the firings will be 90 seconds and 30 seconds, respectively. All test conditions will be the same as in Test 10, except for the following:

1. Fuel quantity will be 60 percent of capacity.

2. Oxidizer quantity will be 60 percent of capacity.

3. Gimbal excursion on the 30-second run will be 4.5 degrees.

4. Gimbal rate on the 30-second run will be 1 cps.

5. Gimbal duration on the 30-second run will be 30 seconds.

4.2.11.13.4 Data. Data for this test will be the same as in Test 10, plus the monitoring of gimbal effects on the system.

4.2.11.14 Test No. 14. SPS Extended Duration Testing.

All objectives, test conditions, data requirements, and the system configuration will be the same as Test 13.

4.2.11.15 Test 15 - RCS Two-Engine Operation

4.2.11.15.1 Objectives. Primary objectives are as follows:

1. Evaluate propellant system performance

2. Evaluate pressurization system

3. Evaluate engine performance

Secondary objective is as follows:

1. Evaluate acoustic and vibration effects on S/M and systems.

4.2.11.15.2 Configuration. System configuration for this test will be the configuration of Test 11.

[redacted]

[redacted]

4.2.11.15.3 Test Conditions. A total of six firings will be run on each RCS system. All other test conditions will be the same as in Test 11, except the following:

1. Duration of engine firings will be 0.5 seconds.

2. Lapse time between firings will be 0.2 seconds.

3. Fuel and oxidizer quantity will be 10 percent of capacity.

4.2.11.15.4 Data. Data for this test will be the same as in Test 10.

4.2.11.16 Test 16 - RCS Four-Engine Operation

4.2.11.16.1 Objectives. Primary and secondary objectives for this test will be the same as in Test 15.

4.2.11.16.2 Configuration. System configuration for this test will be the same as in Test 15.

4.2.11.16.3 Test Conditions. A total of 4 firings will be run on each RCS system. All conditions will be the same as in Test 15, except for the following:

1. Duration of each firing will be 0.20 seconds.

2. Lapse time between firings will be 0.20 seconds.

3. Fuel and oxidizer quantities will be 100 percent of capacity.

4.2.11.16.4 Data. All data for this test will be the same as in Test 15.

4.2.11.17 Test 17 - RCS High-Pressure Firings

4.2.11.17.1 Objectives. Primary objectives are as follows:

1. Evaluate propellant system performance

2. Evaluate pressurization system

3. Evaluate engine performance

4. Evaluate acoustic and vibration effects on system

[redacted]

[redacted]

4.2.11.17.2 Configuration. System configuration for this test will be the same as in Test 15.

4.2.11.17.3 Test Conditions. A total of fourteen runs will be made on the RCS systems. Four runs will be made on the RCS system. Four runs will be steady-state and 10 runs will be pulse. All test conditions will be the same as in Test 16, except for the following:

1. Duration of the steady-state firings will be 2.0 seconds.

2. Duration of the pulse firings will be 0.02 seconds.

3. Lapse time between steady-state firings will be 2 seconds.

4. Lapse time between pulse firings will be 0.02 seconds.

5. Fuel and oxidizer regulator setting will be 240 psi.

4.2.11.17.4 Data. Data recording for this test will be the same as for Test 16.

4.2.11.18 Test 18 - RCS Low-Pressure Firings

4.2.11.18.1 Objectives. Primary objectives are as follows:

1. Evaluate propellant systems performance

2. Evaluate pressurization system

3. Evaluate engine performance

4. Evaluate acoustics and vibration effects on S/M and systems.

4.2.11.18.2 Configuration. System configuration for this test will be the same as in Test 17.

4.2.11.18.3 Test Conditions. A series of eight runs will be performed with the propellant pressurization system adjusted to simulate low-pressure conditions. All other test conditions will be the same as in Test 16, except for the following:

1. Fuel and oxidizer regulator settings will be 140 psi.

2. Runs 1 and 2 will be 2-cycle runs, with both duration and lapse time being 2 seconds. Operating mode will be steady-state.

[redacted]

[redacted]

3. Runs 3 and 4 will be 5-cycle runs, with both duration and lapse time being 0.2 seconds. Operating mode will be pulse.

4. Runs 5 and 6 will be 10-cycle runs, with both duration and lapse times being 0.05 seconds. Operating mode will be pulse.

5. Runs 7 and 8 will be 10-cycle runs, with a duration of 0.01 seconds and a lapse time of 0.05 seconds. Operating mode will be pulse.

4.2.11.18.4 Data. Data recording on this test will be the same as for Test 17.

4.2.11.19 SPS Propellant Transfer Transient

4.2.11.19.1 Objectives. Primary objectives are as follows:

1. Evaluate system operational characteristics during propellant transfer transient.

2. Demonstrate capability of extended duration operation.

Secondary objectives are as follows:

1. Evaluate propellant temperature variation.

2. Evaluate mixture ratio control characteristics.

3. Evaluate start and shut-down transients.

4.2.11.19.2 Configuration. The configuration for this test will be the same as Test No. 13.

4.2.11.19.3 Test Conditions. A 120-second run with a 60-percent initial propellant load. All other test conditions will be the same as Test 13 except for initial fuel load of 60 percent and initial oxidizer load of 60 percent.

4.2.11.19.4 Data. Data for this test will be the same as Test 13, except for the monitoring of propellant transfer transients.

[redacted]

4.2.11.20 Test No. 20. SPS Operational Repeatability.

4.2.11.20.1 Objectives. Primary objectives are as follows:

1. Evaluate propellant system performance.

2. Evaluate pressurization systems.

3. Evaluate engine performance.

4. Evaluate acoustic and vibration effects on S/M and systems.

Secondary objectives are as follows:

1. Evaluate propellant temperature variation.

2. Evaluate steady-state engine operation.

4.2.11.20.2 Configuration. System configuration for this test will be the same as in Test 10.

4.2.11.20.3 Test Conditions. A total of five multiple restarts will occur with on-off timing of 5 seconds. All other test conditions will be the same as in Test 19.

4.2.11.20.4 Data. Data will be the same as in Test 19.

4.2.11.21 Test 21 - SPS Restart

4.2.11.21.1 Objectives. The primary objectives are as follows:

1. Evaluate propellant system performance

2. Evaluate pressurization system

3. Evaluate engine performance

Secondary objectives are as follows:

1. Evaluate propellant temperature variation

2. Evaluate engine steady-state performance

4.2.11.21.2 Configuration. System configuration for this test will be the same as in Test 20.

[redacted]

[redacted]

4.2.11.21.3 Test Conditions. Four firings will occur in quick succession for 5 seconds each, followed by one 90-second stead-state run. All other test conditions will be the same as in Test 20.

4.2.11.21.4 Data. Data for this test will be the same as in Test 20.

4.2.11.22 Test 22 - SPS Multiple Restarts (90-percent Propellant Load).

4.2.11.22.1 Objectives. Primary objectives are as follows:

1. Evaluate propellant system performance
2. Evaluate pressurization system
3. Evaluate engine performance
4. Evaluate acoustic and vibration effects on S/M and systems

Secondary objectives are as follows:

1. Evaluate propellant temperature variation
2. Evaluate stead-state engine operation

4.2.11.22.2 Configuration. System configuration for this test will be the same as in Test 21.

4.2.11.22.3 Test Conditions. A total of 20 starts will occur with random duration firings and off-times for a total of 300 seconds. All other test conditions will be the same as in Test 21.

4.2.11.22.4 Data. Data for this test will be the same as in Test 21.

The remainder of the detailed test descriptions for Test Series I will be included in the next revision of the General Test Plan.

4.2.12 Detailed Instrumentation

4.2.12.1 Instrumentation Schedule

This schedule will be added in the next revision.

[redacted]

4.2.12.2 Instrumentation Tabulation

The AFRM 001 measurement list appears in Table 4-6. This is not a final list and will be changed frequently during the program. For a current measurement list, refer to SID 63-501.

4.2.13 System Priorities

The system priorities are reflected in the detailed test objectives of Section 4.2.10.

[redacted]

[redacted]

5.0 SPACECRAFT ENVIRONMENTAL PROOF DETAILED TEST PLANS*

5.1 INTRODUCTION

5.1.1 Purpose

This report presents the detailed environmental proof tests required to support the initial manned Apollo missions. The test program will evaluate the flight spacecraft configuration, including component systems, under simulated mission environmental conditions. Proof level tests, within practical limits of test facilities, economy, and safety, will verify that the spacecraft can be expected to meet, reliably, the critical environments to which it will be exposed during an actual mission.

5.1.2 Scope

The spacecraft (Airframe 008) environmental proof test program encompasses all of the multiple system environmental chamber (thermal-vacuum) tests in support of the initial manned flights. Primary test emphasis during this initial test phase will be placed on the proper functioning of the spacecraft systems with respect to their effects on and effects caused by (1) other spacecraft systems, (2) the spacecraft structure, and (3) the local environment created as a result of exposing the spacecraft to simulated earth orbit gross-space conditions of vacuum, solar radiation, and cold temperature.

5.1.3 Precedence

This document will take precedence over all other S&ID documents governing implementation and conduct of this detailed test plan.

5.1.4 Amendments

This test plan will be revised to reflect approved changes and to provide additional information on a quarterly basis.

5.1.5 Definition of Priorities

5.1.5.1 Test Objective Priority

Test objectives are either first-order or second-order. These categories are defined as follows:

*Entire section reissued

[redacted]

5.1.5.1.1 First-Order Test Objectives. These test objectives must be achieved for the test to be a success and must define the main reason for conducting the test. Malfunction of spacecraft systems, ground equipment, or instrumentation which jeopardizes the attainment of first-order objectives will hold or scrub the test until a fix can be made.

5.1.5.1.2 Second-Order Test Objectives. Second-order test objectives will support future tests or will supply supplementary data for spacecraft evaluation. Malfunction of spacecraft systems, ground equipment, or instrumentation which jeopardizes the attainment of second-order objectives will not necessitate holding or scrubbing the test. Test continuation or malfunction correction will be made at the discretion of the test director.

5.1.5.2 System Priority

The spacecraft systems are assigned either primary or secondary priorities.

5.1.5.2.1 Primary Systems. Primary systems are those functionally required for the spacecraft to perform its planned test and achieve the first-order test objectives. A hold or scrub will be mandatory, if any of these systems indicate improper performance prior to test. Positive indication of satisfactory performance must be available.

5.1.5.2.2 Secondary Systems. Secondary systems are not functionally required for the spacecraft to perform its planned test or achieve first-order test objectives. Malfunction of any of these systems will not necessitate holding or scrubbing the test. Test continuation or malfunction correction will be made at the discretion of the test director.

5.1.6 Definition of Objective Terminology

The definition of terms used in connection with objectives for this report is given in Definition of Terms (page 7-1).

5.2 TEST PROGRAM

5.2.1 General Test Description

The spacecraft will be installed vertically in the MSC space environmental simulation chamber and subjected to flight simulations of vacuum, heat, and cold approximating earth orbit conditions wherein the top, bottom, and side of the spacecraft are subjected to solar heating and space cooling.

Since Airframe 008 is the first flight-configured spacecraft to be subjected to space conditions, verification of its ability to provide a safe

[redacted]

environment for manned testing must be accomplished prior to conducting manual operations under simulated space conditions (see Section 5. 2. 2. 2, Test Sequence).

The environmental tests with respect to systems operation are divided into three general categories: (1) normal mode mission tests, (2) alternate mode mission tests, and (3) special tests.

Normal mode mission tests will subject the spacecraft to conditions approximating actual launch, earth orbit, and reentry within the capabilities of the environmental chamber. All spacecraft systems will be operated on a normal duty cycle wherein the primary modes of operation will be utilized for time periods similar to actual flight times.

During alternate mode mission tests, actual flight conditions will also be approximated. However, spacecraft systems will be tested in emergency or redundant back-up modes of operation.

Special tests will be utilized to repeat test conditions for data validity verification, malfunction analyses, and off-limit conditions.

Simulation of an earth orbit flight mission will be accomplished in the following manner:

1. Launch. Commence pumpdown of chamber (requires approximately 24 hours to achieve orbit altitude) and operate systems accordingly.

2. Earth Orbit. With environmental chamber walls at deep space cooling conditions and spacecraft at orbit injection conditions, cycle the three solar simulators in the following duty cycle:

   a. Top simulator—ON for 14 minutes—OFF
   b. Side simulator—ON for 22 minutes—OFF
   c. Bottom simulator—ON for 14 minutes—OFF
   d. All three simulators—OFF for 40 minutes.
   e. Repeat steps a through d for each orbit.

   This cyclic operation of the solar simulators will approximate the conditions of the spacecraft emerging from the earth's shadow, traversing between sun and earth, and reentering the earth's shadow.

3. Atmospheric Reentry. Chamber pressure is to be increased in accordance with the flight profile.

[redacted]

[redacted]

4. Spacecraft Roll. The lunar plane (spacecraft mounting table) will be rotated to simulate spacecraft roll during orbit simulation.

The propellant systems will operate with a water-glycol fluid in lieu of hypergolic propellants. The off-loaded fluid will be ducted to the chamber exterior.

Operational prelaunch, post-test, and recovery duty cycle procedures will be utilized as applicable.

Tests will be conducted in a sequence providing progessive levels of qualification commensurate with the safety requirements for manned operation and the constraints on Airframe 008 for Airframe 011.

The following constraints for Airframe 011 assume a successful sub-orbital flight of Airframe 009.

1. Environmental Control System. Ability to control cabin atmosphere, suit atmosphere, and control equipment temperatures in normal and emergency modes; C/M atmosphere sampling for contaminants; and ability to meet C/M leakage rates

2. Fuel Cells (FC). Performance under normal and emergency demands and performance of shut-down and purging operation

3. Cryogenics Subsystem (CSS). Performance in all modes

4. Electrical Power System. Performance of EPS equipment and distribution system and effects of 180,000-foot altitude on distribution system insulation

5. Instrumentation System. Adequacy of instrumentation and effects of instrumentation on S/C system

6. Guidance and Navigation System. Performance of functional modes and mode switching

7. Stabilization and Control System. Performance of functional modes and mode switching

8. Propulsion Systems. Dynamic operation of all system functions, propellant leakage, interface with SCS and manual controls, and propellant freezing at engine injectors and nozzle throats.

9. Structure and Thermal Protection System. Effects on structure and heat shields, puncture simulation and repair

[redacted]

[redacted]

10. Mechanical Devices. Operation of mechanical devices, separation system; jettison of forward heat shield after orbit; and couch repositioning

11. Earth Landing System. Operation of equipment and timers and sequencers after orbit; and check for propellant leaks into parachute compartment

12. Crew and Crew Interfaces With S/C Systems. Adequacy of flight operating procedures; appraisal of displays and controls; and crew performance in suits and 100-percent O_2

13. Integrated Systems and General. Adequacy of ground checkout procedures; effects of 100 percent O_2 on integrated systems; effects of vacuum on integrated systems; effects of power source variations and losses on equipment performance; effects of temperature on equipment performance; functioning of devices with moving seals; and effectiveness of hermetic seals

5.2.2 Program Objectives and Test Sequence

5.2.2.1 General Objectives

1. Demonstrate the operational suitability of the flight spacecraft configuration under simulated flight environmental conditions of launch, earth orbit, and reentry

2. Demonstrate the design adequacy of the flight spacecraft configuration and the suitability of the vehicle for manned flight operations

3. Determine the heat balance and equilibrium temperature distributions during earth orbit conditions

4. Evaluate the effects of outgassing during systems operation

5. Evaluate the effects of cyclic heating and cooling on the structure and systems operations

6. Demonstrate the spacecraft capability to provide a life supporting environment during earth orbit mission simulations

7. Demonstrate satisfactory manned spacecraft operation, including alternate mode systems operation

[redacted]

8. Evaluate the individual and integrated systems operation under normal, extreme, and emergency operational conditions while the spacecraft is subjected to earth orbit environmental conditions

5. 2. 2. 2 Test Sequence

The test sequence itemized below and on the test run charts is based on the safety requirements for manned operation, the spacecraft systems rework and remote control stimuli required for unmanned operation, and the constraints for Airframe 011.

Initial consideration was given to complete operation of all spacecraft systems during unmanned operations. Due to the major rework of manually operated controls, the large number of remote control stimuli, and the special equipments required on-board the spacecraft, this method was deemed to be unworkable.

Therefore, the initial tests are oriented to qualifying the spacecraft for manned operation and to obtaining gross spacecraft operating information. Subsequent tests allow complete manned operation of the spacecraft systems in all operating modes in a non-hazardous reduced pressure condition. Manned tests in support of Airframe 011 with particular emphasis on removal of the flight constraints will then be conducted under conditions simulating earth orbit.

Pretest spacecraft preparation operations are discussed in Section 5. 6.

5. 2. 2. 2. 1 Test Series I. This test series covers those tests required subsequent to installation of the spacecraft in the environmental chamber to ensure readiness of the spacecraft, chamber, instrumentation, and control and monitoring GSE prior to commencement of earth orbit simulation tests. It is assumed that proper chamber operation has previously been demonstrated and man-rated.

5. 2. 2. 2. 1. 1 Test No. 1, Spacecraft/Chamber Integrated Systems Test, Ambient Conditions (Spacecraft installed in chamber)

1. Leak-check all fluid and gaseous systems

2. Establish proper interface of all systems with GSE and data acquisition station

3. Establish proper functional operation (including remote stimuli) of individual spacecraft systems

[redacted]

[redacted]

4. Demonstrate spacecraft, chamber, GSE, and instrumentation readiness during integrated systems test

5.2.2.2.1.2 Test No. 2, Chamber Run No. 1, Command Module Leak Check (Table 5-1).

Establish integrity of C/M within design leak limitations.

5.2.2.2.2 Test Series II. This test series covers those tests required to evaluate and determine the ability of the spacecraft, chamber, and operating procedures to provide a safe environment and operation for manned testing. Gross spacecraft operating data will be obtained from which major potential problem areas may be defined.

5.2.2.2.2.1 Test No. 1, Chamber Run No. 2, Unmanned—Simulated Launch, Earth Orbit, and Reentry (Table 5-2).

1. Demonstrate general safety and stability of spacecraft and chamber under simulated orbital conditions

2. Demonstrate satisfactory normal mode operation of all systems under simulated orbital conditions

3. Demonstrate satisfactory normal mode operation of all systems with command module depressurized under simulated orbital conditions

Earth orbit conditions simulated with hard vacuum, solar simulators, and cold walls. All systems will be operating in their normal mode or will be "turned on." Systems will have been started and normal mode preset prior to run. The command module cabin will be depressurized for one-orbit duration. Remote stimuli will be used for minimum system operation and safety requirements.

5.2.2.2.2.2 Test No. 2, Chamber Run No. 3, Initial Manned Test—Simulated Earth Orbital Mission in a Non-Hazardous Reduced Pressure Environment (Table 5-3).

1. Demonstrate safety and stability of spacecraft and chamber utilizing manned spacecraft operation at partial vacuum conditions

2. Evaluate manned spacecraft operations, associated life support systems, and crew systems

3. Demonstrate satisfactory normal mode operation of all systems

4. Evaluate propellant off-loading from RCS and SPS

[redacted]

Table 5-1. Run 1 (Unmanned)

General Objectives and Run Description	Chamber Operation	Test Length (hr)	System Operation	
			System	Operating Mode
Determine cabin leakage rate, using GSE leakage rate tester	Pumpdown to 10^{-2} torr or lower	20	All	All spacecraft systems are installed but not operated during this test.
	Vacuum only. Chamber at 10^{-2} torr or lower	4		

Table 5-2. Run 2 (Unmanned)

General Objectives and Run Description	Chamber Operation	Test Length (hr)	System Operation: System	System Operation: Operating Mode
1. Demonstrate general safety and stability of S/C and chamber prior to manning: a. Orbital mission simulated with hard vacuum, programmed solar and lunar plane heating, programmed lunar plane rotation, and complete cold walls. b. All systems will be operating in their normal mode or will be "turned on." Systems will have been started and normal modes preset prior to run; they will operate throughout the run. Minimum stimuli will be required - only those required by test techniques or by safety considerations. c. All fluid systems will be filled; all gas systems at operating pressures. 2. Demonstrate satisfactory normal mode operation of all systems under simulated orbital conditions. This will give an early indication of S/C design adequacy and any potential major problem areas.	1. Pumpdown to 10^{-5} torr 2. Control chamber to set up theoretical orbit injection temperatures at completion of pumpdown	24	All	Normal modes
			ECS	Preset at ambient (H_2O-glycol and H_2O systems serviced; power supplied by F/C; O_2 supplied by CSS; manual and electric valves preset; O_2 atmosphere established; compressor and blower selected and turned on; suit temperature, cabin temperature and other selectors and controls preset; etc.). System on ground cooling until chamber cold walls activated; then radiators handle cooling. Metabolic simulator simulating 3 men in suits. Thermal loads supplied by operation of other systems. Stimuli to start glycol pump when radiators activated to open and close cabin pressure relief valve for deressurization tests, etc.
	3. Maintain 10^{-5} torr for 36 hours Simulate 90-minute earth orbits by programming solar panels, lunar plane heating, and rotation	36		
			CSS	Charged with flight quantities of cryogenic H_2 and O_2. Supplying ECS and F/C. Stimuli to close tank isolation valves and to dump tanks in emergency.
	4. Remotely depressurize cabin and hold for one orbit	1-1/2		
			F/C	All three cells started at ambient. Supply S/C power throughout run. Stimuli to isolate F/C from busses and from O_2 and H_2 supply in emergency.
	5. Remotely repressurize cabin using ECS. Repressurize chamber simulating real time descent	1/2		
			EPS	Preset at ambient (supplied by F/C; d-c busses activated; one inverter selected and started; a-c busses activated; breakers and switches preset as required by system loads; etc.). Operating throughout run. Stimuli to deactivate a-c and d-c busses in emergency.

Table 5-2. Run 2 (Unmanned) (Cont)

General Objectives and Run Description	Chamber Operation	Test Length (hr)	System Operation	
			System	Operating Mode
3. Demonstrate satisfactory normal mode operation of all systems with cabin depressurized for one orbit duration			SPS RCS (C/M & S/M)	Filled with flight quantities of substitute propellant He systems charged at operating pressures. No off-loading. Stimuli to relieve pressure on tanks in emergency.
			SCS G&N Telecom ELS	Preset at ambient (mode selected and power supplied). System ON during run. Minimum stimuli (e.g., stimuli for arming ELS sequencer).

Table 5-3. Run 3 (Manned)

General Objectives and Run Description	Chamber Operation	Test Length	System Operation	
			System	Operating Mode
1. Initial manned testing 2. Further demonstrate S/C chamber safety with a manned system normal mode orbital mission simulation at a partial (nonhazardous) chamber vacuum level. This will permit general verification of manned operations (i. e., suit operation, life systems instrumentation checkout, crew control room communications, etc.) a. Orbital simulation will include programmed solar and lunar plane heating, lunar plane rotation and cold walls. b. All systems will have been preset but crew action will be used to replace the system operating stimuli of Run 2 and in the event of a failure. c. All fluid systems will be filled; all gas systems pressurized to operating level. 3. Further demonstrate system normal mode operation with manned testing at a partial chamber vacuum level. Testing will include substitute propellant off-loading.	1. Pumpdown to 40,000 feet	Min	All	Normal modes Same as Run 2. All systems ON in preset mode. Crew action required to replace remote stimuli or in the event of a failure. Substitute propellants will be off-loaded to simulate firing.
	2. Maintain 40,000 feet for mission duration (3 orbits) in conjunction with cold walls and programmed solar and lunar plane heating and lunar plane rotation simulating orbit conditions	4-1/2 hr		
	3. Repressurize chamber simulating real time descent	Min		

[redacted]

Systems operation will be conducted simulating an earth orbit. Environmental conditions will include solar simulation and cold walls at a non-hazardous pressure altitude of 40,000 feet. All systems will be operating, and normal mode will be preset prior to run. Crew control will be utilized to replace remote stimuli.

5.2.2.2.2.3 Test No. 3, Chamber Run No. 4, Manned Test—Simulation of Airframe 011 Flight Plan and All Systems, All Modes Operation in a Non-Hazardous Reduced Pressure Environment (Table 5-4).

1. Demonstrate safety and stability of spacecraft and chamber utilizing manned spacecraft operation at partial vacuum conditions

2. Evaluate manned spacecraft operations, associated life support systems, and crew systems

3. Demonstrate satisfactory system operation in accordance with Airframe 011 flight plan utilization

4. Evaluate operation of all spacecraft systems in all modes of operation with spacecraft externally subjected to partial vacuum conditions

5. Evaluate operation of all spacecraft systems in all modes of operation with command module depressurized to partial vacuum conditions

Systems operation initially will be conducted simulating the flight plan of Airframe 011. Environmental conditions will include solar simulation and cold walls at a non-hazardous pressure altitude of 40,000 feet. The latter portion of the test includes crew operation of all systems in alternate modes with the command module both pressurized and unpressurized.

5.2.2.2.3 Test Series III. This test series covers those tests required to determine and demonstrate the manned operational suitability of the spacecraft under simulated flight environmental conditions of launch, earth orbit, and reentry, including manual modes systems operation. Constraints for the flight of Airframe 011 will be satisfied during this test series.

5.2.2.2.3.1 Test No. 1, Chamber Run No. 5, Manned Test—Simulation of Airframe 011 Flight Plan Under Environmental Conditions Utilizing Solar Simulators, Cold Walls, and Hard Vacuum (Table 5-5).

[redacted]

Table 5-4. Run 4 (Manned)

General Objectives and Run Description	Chamber Operation	Test Length	System Operation	
			System	Operating Mode
1. Completion of S/C chamber safety demonstration by conducting manned, all systems, all modes tests at a partial (nonhazardous) chamber vacuum level: a. Orbital conditions will include programmed solar and lunar plane heating, lunar plane rotation, and cold walls. b. Initial testing will consist of real time operation by the crew of all systems according to the flight plan of AFRM 011. Testing will conclude with all system, all modes, crew conducted tests to check-out any system modes or redundancies not previously tested. c. All fluid systems will be filled; all gas systems, pressurized to operating levels. 2. Demonstrate system flight mode operation with manned testing at a partial chamber vacuum level	1. Pumpdown to 40,000 feet	Min	All	According to AFRM 011 flight plan for first three orbits. All other modes and redundancies checked out during last three orbits.
	2. Maintain 40,000 feet for six orbits in conjunction with cold walls and programmed solar and lunar plane heating and lunar plane rotation simulating orbit conditions 3. Depressurize cabin to 40,000 feet and maintain for the sixth orbit	9 hr	ECS	Initially preset. Crew operated according to flight plan for first three orbits. Crew checkout of all other modes and redundancies during last three simulated orbits (operation of redundant pump, compressor and blower; operation of all manual valves; varying of selected suit and cabin temperatures to verify response; dumping of radiators and glycol loop to evaluate evaporators, etc.) Crew will operate ECS to depressurize cabin.
			CSS	Charged with flight quantities of cryogenic H_2 and O_2. Supplying ECS and F/C. Isolation valve operation checked.
	4. Repressurize chamber simulating real-time descent	Min	F/C	All three started at ambient. Supply S/C power throughout run. System operation according to flight plan will provide load profile check. Crew will shut-down F/C to test emergency modes. Crew controlled reactant purging will be checked.
			EPS	Preset at ambient. Controlled according to flight plan for first three orbits. During last three orbits crew will operate all switches and breakers and activate all inverters.

Table 5-4. Run 4 (Manned) (Cont)

General Objectives and Run Description	Chamber Operation	Test Length	System Operation	
			System	Operating Mode
3. Demonstrate all system, all modes operation with manned testing at a partial chamber vacuum level. This includes testing with the cabin depressurized to a partial vacuum level.			SPS RCS (C/M & S/M)	Filled with substitute propellants; He pressurization systems at operating pressure. Crew-G&N-SCS link will control off-loading (simulate firing) according to flight plan during first three orbits. Crew will operate all firing modes, operate all valves, checkout SPS manual propellant utilization system, etc. during last three orbits.
			SCS G&N C&I ELS	Mode selection and crew operation according to flight plan for first three orbits. All modes and redundancies checked out by crew during last three orbits.

Table 5-5. Run 5 (Manned)

General Objectives and Run Description	Chamber Operations	Test Length (hr)	System Operation	
			System	Operating Mode
1. Conduct complete manned orbital mission simulation: a. Simulated orbital conditions will consist of 10^{-5} torr vacuum, complete cold walls, programmed solar and lunar plane heating and lunar plane rotation. Orbit and reentry simulation will be in real time.	1. Pumpdown to 10^{-5} torr Hold at 60,000 feet to verify general safety and stability of all systems Control S/C and chamber to set up theoretical orbit injection temperatures at completion of pumpdown.	24	All	Operating modes and crew action according to AFRM 011 flight plan
	2. Maintain 10^{-5} torr for three orbits Simulate 90-minute earth orbits with complete cold walls, programmed solar and lunar plane heating, and lunar plane rotation	4-1/2		
	3. Repressurize chamber, simulating real-time descent	1/2		

[redacted]

1. Demonstrate safety and stability of spacecraft utilizing manned spacecraft operation at earth orbit conditions

2. Evaluate manned spacecraft operations, associated life support systems, and crew systems

3. Demonstrate satisfactory system operation in accordance with Airframe 011 flight plan utilization

Systems operation will be conducted simulating the flight plan of Airframe 011. Test conditions will approximate earth orbit conditions as closely as possible, including the reentry pressure profile.

5. 2. 2. 2. 3. 2 Test No. 2, Chamber Run No. 6, Manned Test—Simulation of Airframe 011 Flight Plan and Testing of All Systems, All Modes Operation Under Earth Orbit Environmental Conditions (Table 5-6).

1. Demonstrate safety and stability of spacecraft utilizing manned spacecraft operation at earth orbit conditions

2. Demonstrate manned spacecraft operations, associated life support systems, and crew systems

3. Demonstrate satisfactory system operation in accordance with Airframe 011 flight plan utilization

4. Demonstrate operation of all spacecraft systems in all modes of operation with spacecraft externally subjected to earth orbit environmental conditions.

Initial systems operation will be in accordance with the flight plan of Airframe 011. Environmental conditions will approximate earth orbit. The latter portion of the test will demonstrate proper systems operation in all alternate modes.

5. 2. 2. 2. 4 Test Series IV. This test series covers those special tests required to complete a full evaluation of spacecraft operations for limited earth orbit flights. These tests are not mandatory for removal of the flight constraints on Airframe 011.

5. 2. 2. 2. 4. 1 Test No. 1, Chamber Run No. 7, Manned Test—Simulation of Special Earth Orbit Conditions or Spacecraft Operating Conditions (Table 5-7).

Table 5-6. Run 6 (Manned)

General Objectives and Run Description	Chamber Operation	Test Length (hr)	System Operation	
			System	Operating Mode
1. Conduct complete manned orbital mission simulation, including all systems, all modes checkout: a. Simulated orbital conditions will consist of 10^{-5} torr vacuum, complete cold walls, programmed solar and lunar plane rotation. Orbit and re-entry simulation will be in real time. b. All systems will be operated. Operating modes and crew action during first half (three orbits) of run will be in real time, according to the flight plan of AFRM 011. During last three orbits, crew will function to check out any system modes or redundancies not previously tested. c. All fluid systems will be filled; all gas systems, pressurized to operating levels. 2. Further demonstrate system flight mode operation 3. Demonstrate all system, all modes operation under external hard vacuum conditions	1. Pumpdown to 10^{-5} torr Hold at 60,000 feet to verify general safety and stability of all systems Control S/C and chamber to set up theoretical orbit injection temperatures at completion of pumpdown	24	All	First three orbits: operating modes and crew action according to AFRM 011 flight plan. Duplicate of Run 5 Last three orbits: all system modes and redundancies checked out, as in Run 4
	2. Maintain 10^{-5} torr for six orbits. Simulate 90-minute earth orbits with complete cold wall, programmed solar and lunar plane heating, and lunar plane rotation	9		
	3. Repressurize chamber, simulating real-time descent	1/2		

Table 5-7. Run 7 (Manned)

General Objectives and Run Description	Chamber Operation	Test Length (hr)	System Operation	
			System	Operating Mode
Conduct special tests to meet objectives not previously tested. These tests are not required to lift flight constraints on AFRM 011 but will provide valuable operating data. The special tests include: a. ECS maximum and minimum heating tests b. F/C maximum and minimum heating tests c. SPS maximum and minimum heating tests d. SCS and G & N maximum and minimum operating voltage checkout	1. Pumpdown to 10^{-5} torr	24	ECS	1. ECS maximum heating test: S/C positioned by lunar plane so that side solar panels supply maximum heat input to ECS radiators 2. ECS minimum heating test: S/C subjected to cold soak
	2. S/C positioning by lunar plane, cold wall operation, and solar and lunar plane heating as required to accomplish special tests	12	F/C	1. F/C minimum heating test: S/C positioned by lunar plane so that side solar panels supply maximum heat input to F/C radiators 2. F/C minimum heating test: S/C subjected to cold soak
	3. Repressurize chamber	1	SPS	1. Engine assembly maximum heating test: lunar plane heaters simulate maximum solar heat input to S/M end 2. SPS minimum heating test: S/C subjected to cold soak
			SCS G&N	Maximum and minimum voltage test: S/C on ground power (F/C off). Apply maximum and minimum voltages to systems

CO[redacted]

1. Evaluate ECS operation during maximum and minimum radiator heating conditions

2. Evaluate fuel cell operation during maximum and minimum radiator heating conditions

3. Evaluate SPS operation during maximum and minimum heat input conditions

4. Evaluate SCS and G&N operation at conditions of maximum and minimum voltage inputs.

Systems operation will be in accordance with the particular test being conducted. Earth orbit environmental conditions will be maintained with the spacecraft oriented to the solar simulator as required to provide heat inputs.

5.2.3 Test Limitations

1. Zero-g conditions of outer space cannot be duplicated.

2. Heat flow to or from the S/C through support structure and hardware lines cannot be entirely eliminated and will affect thermal balance.

3. Nuclear radiation cannot be simulated during environmental tests.

4. Propulsion system and reaction control engine firing will not be accomplished.

5. S/C acceleration loadings and vibration during launch, reentry, and propulsion firing phases cannot be duplicated.

6. Real time launch pressure profile cannot be simulated.

7. Aerodynamic heating during both launch and reentry cannot be simulated.

8. Pyrotechnic systems cannot be fired.

9. Simulation of exact mission thermal profiles is not possible due to limitations of the chamber and vehicle.

10. Thermal effects from SPS and RCS engine firings cannot be tested.

11. Communications radiation cannot be tested.

[redacted]

[redacted]

5.2.4 Test Implementation

General test implementation is discussed under the General Test Description, Section 5.2.1. Detailed implementation will be added at a later date as the information becomes available.

5.3 CONFIGURATION

5.3.1 Test Vehicle

5.3.1.1 General Description

The test vehicle (Spacecraft 008) includes the command and service modules and a GSE S/C support base with complete spacecraft systems as applicable to the test phase. The spacecraft structure and systems will be of flight spacecraft configuration.

All systems will be serviced in accordance with the particular mission being simulated, i.e., cryogenics, fuel loadings with substitute fluids (water-glycol), etc.

Additional instrumentation systems will handle R&D signals not present on a flight vehicle.

Crewman metabolic simulators will be used during the unmanned operations. Manually controlled equipment that will be operated during unmanned tests will be reworked to permit remote as well as on board operation.

5.3.1.2 Detailed Description

The spacecraft will have complete flight systems (with minor exceptions) as follows:

1. Environmental Control System (ECS). Complete. Overboard vent lines required from main dump point and glycol vent to sump outside chamber. Metabolic simulator required.

2. Cryogenic Storage System (CSS). Complete.

   The cryogenic storage system, which is located in the service module, consists of two H_2 tanks (connected in parallel) and two O_2 tanks (connected in parallel). The H_2 and O_2 tanks are serviced with liquified gases at 20 ± 5 psig. The tanks are topped off until the fill and vent lines are disconnected, just prior to the

[redacted]

[redacted]

start of the test. With the fill, vent, and isolation valves closed, heat is added to each tank until the pressure rises above the critical values (900 psig for O_2, 240 psig for H_2).

The ground support equipment required to supply the liquified gases consists of an 800-gallon LH_2 storage tank and a 1280-gallon LO_2 storage tank. The tanks are located 400 feet (if unbarricaded) from any inhabited area. The liquified gases are transferred to the S/M storage tanks through insulated vacuum jacketed lines. The LH_2 transfer lines must have extremely low heat inleak to provide rapid cooling and single-phase flow in a very short time.

The LH_2 transfer unit is a model S14-026 which will control the purging, cooling, filling and topping off of the S/C H_2 tank. The unit will be capable of local operation from a control panel or from a remote control point.

The LO_2 transfer unit is a model S14-032 which will control the purging, cooling, filling and topping off of the S/C O_2 tank. The unit will be capable of local operation from a control panel or from a remote control point.

3. Electrical Power System (EPS). Complete.

4. Service Propulsion System (SPS). Complete, except that the nozzle extension may be replaced with a mass-thermal simulator. Water will be used as a substitute propellant. Vent lines will be required from the engine nozzle to a dump point outside the chamber.

5. Reaction Control System (C/M and S/M RCS). Complete.

The S/M RCS is composed of sixteen (16) MA-109XAA rocket engines arranged in clusters of four each, 90° apart around the module. The four engines are mounted on a panel in a plane tangent to the outer surface. The axes of the engines parallel to the "X" axis are inclined 10° outward from the plane in which they are mounted. The engines can be pulsed or operated continuously for periods up to 60 seconds.

The fuel (unsymmetrical dimethylhydrazine) and the oxidizer (nitrogen tetroxide) tanks will be filled with distilled water. The fuel and oxidizer tanks will be pressurized with helium.

[redacted]

Substitute propellants will be off-loaded through vacuum-jacketed lines to the exterior of the chamber.

6. Guidance and Navigation (G&N). Complete.

7. Stabilization and Control System (SCS). Complete.

8. In-Flight Test System (IFTS). Complete.

9. Communications and Data System (C&DS). Complete. Additional instrumentation will handle R&D signals.

10. Controls and Displays. Complete.

11. Life Systems (LS). Complete, including back packs (PLSS), crew provisions, etc. Couches will have to be modified because of prolonged one "g" environment.

12. Earth Landing System (ELS). Complete, including parachutes, forward and aft heat shields, etc.

13. Launch Escape System (LES). On-board items such as sequencers, batteries, etc., will be used. LES rocket engines and tower will not be used.

14. Fuel Cell System (F/C). Complete, all three F/C.

    The F/C System consists of three F/C modules, each containing 31 single hydrogen-oxygen fuel cells. Any one or all of the modules may be operating and connected to the main buses.

    The S/M will be provided with insulated lines connected to the O_2 and H_2 overboard ports to get these vented gases out of the chamber. If an excess amount of H_2O is produced, it will be discharged out of the chamber through an insulated line so that it will not freeze on its way through the extremely cold environment of the space chamber.

Detailed system descriptions similar to those included above for CSS, RCS and F/C will be supplied for all systems in the next revision of the General Test Plan.

[redacted]

5.3.2 Support Equipment

A set of servicing, handling, and checkout GSE, C/M and S/M simulators, and bench maintenance equipment are required as listed in SID 62-417.

5.3.3 Facility (MSC Environmental Facility, Chamber A)

A thermal-vacuum chamber and an adjacent checkout and support area (see Section 5.5), having the capabilities listed, are required to support the test program. The required facility joint occupancy date is 1 October 1964, and beneficial occupancy date is 15 April 1965. The required chamber joint occupancy date is 1 October 1964, and the beneficial occupancy date is 1 July 1965.

5.3.3.1 Spacecraft Handling

Side Entry. Hook and rail height must be 25 feet; hook capacity must be 20,000 pounds minimum.

5.3.3.2 Spacecraft Installation and Support

The spacecraft is 13 feet in diameter and 25 feet in length. A mounting structure is required with ±180 degrees freedom in one axis with respect to the solar side simulator. Interference with solar simulation must be minimal.

5.3.3.3 Solar Simulation

The solar simulator must be capable of exposing the entire vehicle (13 feet by 25 feet) with an incident energy of 443 Btu per hour per square foot or 1400 watts per square meter. The incident energy spectral distribution is required as follows:

Ultraviolet	2,000 to 3,800 A, 8 ± 1 percent of incident energy
Visible	3,800 to 7,000 A, 41 ± 3 percent of incident energy
Infrared	7,000 to 10,000 A, 22 ± 3 percent of incident energy
	10,000 to 20,000 A, 23 ± 2 percent of incident energy

Collimation of radiation is required within plus or minus 2 degrees.

5.3.3.4 Pumpdown System

An ultimate pressure of 1×10^{-5} millimeters of mercury is required during spacecraft operation (including outgassing).

[redacted]

[redacted]

5.3.3.5 Heat Sink

A near infinite heat sink (100 K or lower) is required.

5.3.3.6 Manned Operation

During most tests, manned occupancy of the spacecraft will be required. The chamber must be man-rated prior to commencing spacecraft testing.

5.4 INSTRUMENTATION, DATA ACQUISITION, AND COMMAND SYSTEM REQUIREMENTS

5.4.1 Instrumentation System

5.4.1.1 Measurement Sources

Measurements for the environmental proof test program are conveyed by six system carriers: flight measurements, PACE-S/C measurements, R&D test measurements, MSC environmental facility measurements, ground service measurements, and biomedical measurements.

5.4.1.1.1 Description of Measurements.

1. Flight measurements are those measurements required to support the flight of AFRM 011.

2. PACE-S/C measurements are those measurements required in test preparation to check out the spacecraft. A number of these measurements will also be required during a test operation.

3. Facility measurements are those measurements required to monitor the status of the environmental facility and include chamber measurements, biomedical measurements, facility ECS measurements, and spacecraft cabin ECS measurements.

   The biomedical measurements are treated as a separate class of measurements because they require special handling. They will be described under biomedical measurements in a following paragraph.

   The chamber measurements include lunar heat sink temperature, lunar plane temperature, lunar plane position, chamber pressure, and solar simulation current.

[redacted]

[redacted]

The facility ECS measurements are those measurements used to monitor the status of the air locks. These measurements are transmitted by hard wire to the facility ECS consoles.

The spacecraft cabin ECS measurements are those measurements used to monitor the status of the ECS. These measurements are transmitted by hard wire from the PACE-S/C ground station to the ECS console, i.e., the outputs of the PCM ground station are routed through D/A converters to the ECS consoles.

4. Ground Service equipment measurements are those measurements required to monitor the operation of GSE servicing equipment in support of AFRM 008.

5. Biomedical measurements are those measurements required to monitor the physiological conditions of the men in the S/C or chamber. These measurements are routed from the chamber umbilical and S/C throughputs to the MSC biomedical consoles. Types of measurements are body temperature, respiration, suit pressure, suit inlet temperature, and CO_2 partial pressure.

6. R&D test measurements are those additional measurements needed to fully accomplish the test objectives of the environmental proof test program. These measurements are divided into two groups: (1) those measurements whose source is within the C/M pressure cell and (2) those measurements whose source is external to the C/M pressure cell, including the R&D test measurement in/on the S/M. The R&D test measurements are in addition to the measurements described above.

5.4.1.1.2 S/C Measurement List. A detailed listing of the measurements is available in a separate document, SID 63-508, Apollo Measurement Requirements, AFRM 008. This document contains information concerning the nomenclature used in the preparation of the list and diagrams of the individual systems showing approximate locations of the R&D test measurements.

5.4.1.1.3 Facility Measurement List (Table 5-8).

[redacted]

[redacted]

Table 5-8. Facility Measurement List

System	Quantity Chamber A	Description
Facility	100	Linear heat sink temperatures
	32	Lunar plane temperatures
	2	Lunar plane position
	60	Solar simulation
	14	Vacuum (ion gauges)
	100	Status (events signals)
Ecological (six men)	6	Blood pressure
	18	Body temperature
	6	Respiration
	6	ECG
Pressure suit (six men)	6	Baroswitch
	18	Suit pressure
	6	Inlet temperature
	6	CO_2 partial pressure
	6	Suit O_2 flow
S/C cabin ECS	1	Cabin pressure
	11	CO_2 partial pressure
	1	O_2 partial pressure
	1	O_2 reservoir pressure
	1	Cabin temperature
	1	Cabin humidity (percent RH)
	1	O_2 storage (quantity)
	1	O_2 storage temperature
	2	Water-glycol loop temperature and pressure
	1	Suit circuit temperature
	1	Suit circuit pressure
	16	Status (events signals)
Facility ECS	4	Ventilation O_2 flow
	4	Make-up O_2 flow
	4	CO_2 partial pressure
	4	O_2 partial pressure
	4	Pressure in air lock
	60	Status (event signals)

[redacted]

[redacted] [redacted]

5.4.1.2 Measurement Handling Systems

The measurements described in Paragraph 5.4.1.1.1 will be handled using the following systems:

Flight PCM Telemetry System
PACE-S/C Carry-On Equipment
PACE-S/C (C14-240)
PACE-S/C Equipment

5.4.1.2.1 Description of Systems.

The flight PCM telemetry system will handle the flight measurements.

The PACE-S/C carry-on equipment will accomodate the PACE-S/C checkout measurements and R&D test measurements internal to the C/M pressure vessel. This equipment will remain in the S/C during testing.

The PACE-S/C (C14-240) will accommodate the GSE ground service equipment measurements.

The PACE-S/C (C14-XXX), in conjunction with MSC facility equipment, will accomodate the R&D test measurements which are external to the pressure vessel, the biomedical measurements, and the MSC environmental facility measurements. Chamber penetrations are provided for by transmitting these measurements by hard wire to the PACE-S/C equipment.

The PACE-S/C interleaver (C14-230) will be used to interleave the above system outputs into one PCM wave train to be routed to the PACE-S/C station.

5.4.2 Data Acquisition System

The data acquisition system for the MSC environmental facility will be a PACE-S/C station. The PACE-S/C station will have provisions for analog recording, decommutation, discrimination, displays, computer complex, digital recording, and command system.

5.4.2.1 Description of System

Wide-band analog recorders will be used to record the serial output of the interleaver and/or the parallel output of the PCM decommutation system. All magnetic tape from the wide band recorders will contain central timing signals.

[redacted] [redacted]

[redacted]

The PCM decommutation system will convert the serial wave train of the interleaver to an eight-bit parallel format for input to the computer complex. The outputs of the decommutators are routed to a computer adapter for formulating an input to the computer complex.

The computer complex will have the capacity for scaling the raw data inputs to engineering units and displaying these data on CRT's. The computer will be used to generate commands for remote control operation. Depending on the program in use, the computer will automatically check out the S/C in test preparation and evaluate test objectives during an actual test operation.

Digital recording capabilities are available as an output from the computer complex. Test objectives that require computer evaluation can be recorded digitally and forwarded to a computer complex for off-line computation and/or played back for quick-look evaluation, using the existing MSC PACE computer complex.

5.4.3 Command and Stimuli System

A system for remote control of the S/C during unmanned testing is required for AFRM 008. The standard PACE-S/C command and stimuli system augmented with additional command receivers, decoders, and stimuli generators will satisfy the up-link command requirements during the unmanned testing.

The PACE-S/C command and stimuli system will be used in a normal manner during test preparation, i.e., a man will be in the loop. During tests, when the S/C is unmanned, only that portion of the command and stimuli system required to operate the S/C in a prescribed manner will be used. The PACE-S/C computer complex will be used to generate commands by a stored program and/or by a manual override system. The PACE-S/C command and stimuli system may be partially removed during the manned tests.

5.4.3.1 Stimuli Remote Control

Stimuli remote controls for unmanned testing and safety requirements are listed in Table 5-9.

[redacted] [redacted]

Table 5-9. Stimuli Remote Controls

System	Number	Description
Metabolic simulator	1	Regulation of CO_2
	1	Regulation of water vapor
	1	Regulation of heat input
	1	Regulation of O_2 removal
	1	Regulation of ΔP
ECS	1	Control on-off glycol pump
	1	Control two-way glycol valve
	1	Control open-close of cabin outflow pressure relief valve
	1	Control cabin pressure regulation valve
EPS	8	Control total S/C power on-off
Fuel cell	3	Control F/C O_2 shutoff valve for each fuel cell
	3	Control F/C H_2 shutoff valve for each fuel cell
	6	Control F/C H_2 and O_2 purge valves
	2	Control venting of H_2 and O_2 tank
	3	Control venting of N_2 tank
C/M RCS	2	Control venting of the He pressure vessels
	2	Control venting of fuel and oxidizer tanks
S/M RCS	8	Control venting of He pressure vessels
	8	Control venting of fuel and oxidizer tanks
SPS	2	Control venting of He tanks
	1	Control venting of fuel and oxidizer tanks
TOTAL	57	

5.5 SUPPORT REQUIREMENTS

The environmental proof test support requirements are listed in SID 62-975, which includes the following information:

- Facilities
- Services
- Vehicles
- Office furniture and equipment
- Shop equipment
- Test support equipment - electronic

[redacted]

[redacted]

[redacted]

Test support equipment - general	Mechanical stock
Ground support equipment	Electrical stock
Provisioned spares	Office supplies and forms
Protective clothing and equipment	Test data supplies
Tools and tool crib supplies	Raw stock
	Fluids

5.6 PRETEST OPERATIONS

5.6.1 Test Preparation Area, S&ID, Downey

A complete examination of the command and service module systems will be made in the test preparation area to insure conformance to the latest configurations, specifically those of AFRM 011. R&D instrumentation equipment installation will be completed and functionally checked for compatibility with data requirements. Compatibility will be checked on all systems, including the GSE at all interface points.

The second phase of test preparation will include gross weight and center-of-gravity verification for shipping purposes. All modules and subsystems will be fit checked in command and service modules. Attach points will be checked for alignment, clearance, and proper fit. Procedures will be verified for later use in the detailed systems tests.

The third phase will verify operational configuration and capability as required to support AFRM 011 at AMR. Individual systems tests, including instrument calibration, will assure compliance to individual test requirements. An integrated systems test will verify functional conformance of all systems to assure the completion of the assigned mission. Use of simulators and adapters will be held to a minimum, and they will be used only where safety or facility limitations demand it. Particular attention will be paid to systems and subsystems that interact or where sequential operations are necessary.

After completion of the integrated tests, the proposed mission profile (with necessary limitations) of AFRM 011 will run to verify that the projected mission test plan and the spacecraft are compatible.

Test preparation work items include the following procedures:

1. Installation of R&D instrumentation.

2. Modification and up-dating.

3. Instrumentation checkout.

[redacted]

[redacted]

[redacted]

4. Tumble and clean.

5. Electrical power checkout.

6. PACE interface checkout.

7. Individual system checkout.

ECS	SPS
PCM	RCS
ELS	C&D
SCS	G&N

8. Mating of C/M and S/M.

9. EMI checks.

10. Integrated systems tests.

11. Weight and CG determination for shipping.

12. Preparation for shipping.

5.6.2 Test Preparation, Test Site

Test preparation at the chamber site will be as near as possible to flight vehicle test preparation within the limitations imposed by the environmental proof program.

Operations to be performed to complete vehicle checkout and facility integration include:

1. Receiving inspection.

2. GSE interface.

3. Facility and servicing equipment compatibility.

4. Individual systems test.

5. Modification and updating.

6. Instrumentation calibration and checkout.

7. Integrated system and R&D instrumentation test.

8. Simulated test run.

[redacted]

[redacted]

[redacted]

9. Trial data run.

10. Installation of S/C in chamber.

11. GSE and instrumentation hookup.

12. Instrumentation system checkout.

13. Service and supply line hookup and checkout.

14. GSE servicing, chamber instrumentation, R&D instrumentation data station compatibility.

5.6.3 Test Procedures

This section will contain test procedures as they become available for the individual multisystems tests in support of AFRM 011. A multisystems chamber, control, and GSE countdown procedure will be given as the program progresses and details become available.

5.7 TEST MANAGEMENT AND ORGANIZATION

Figure 5-1 shows the environmental proof test organization.

5.8 SAFETY

This section will contain S&ID - NASA safety operating requirements. Details will be added when they become available.

5.9 DATA REPORTING AND HANDLING

5.9.1 Reporting

Reporting times and methods will be determined at a later date.

5.9.2 Evaluation

Details of quick-look data, on-the-spot evaluations, and S&ID engineering evaluations will be included at a later date.

5.10 DETAILED TEST OBJECTIVE SCHEDULE

Table 5-10 presents the detailed test objectives.

[redacted]

[redacted]

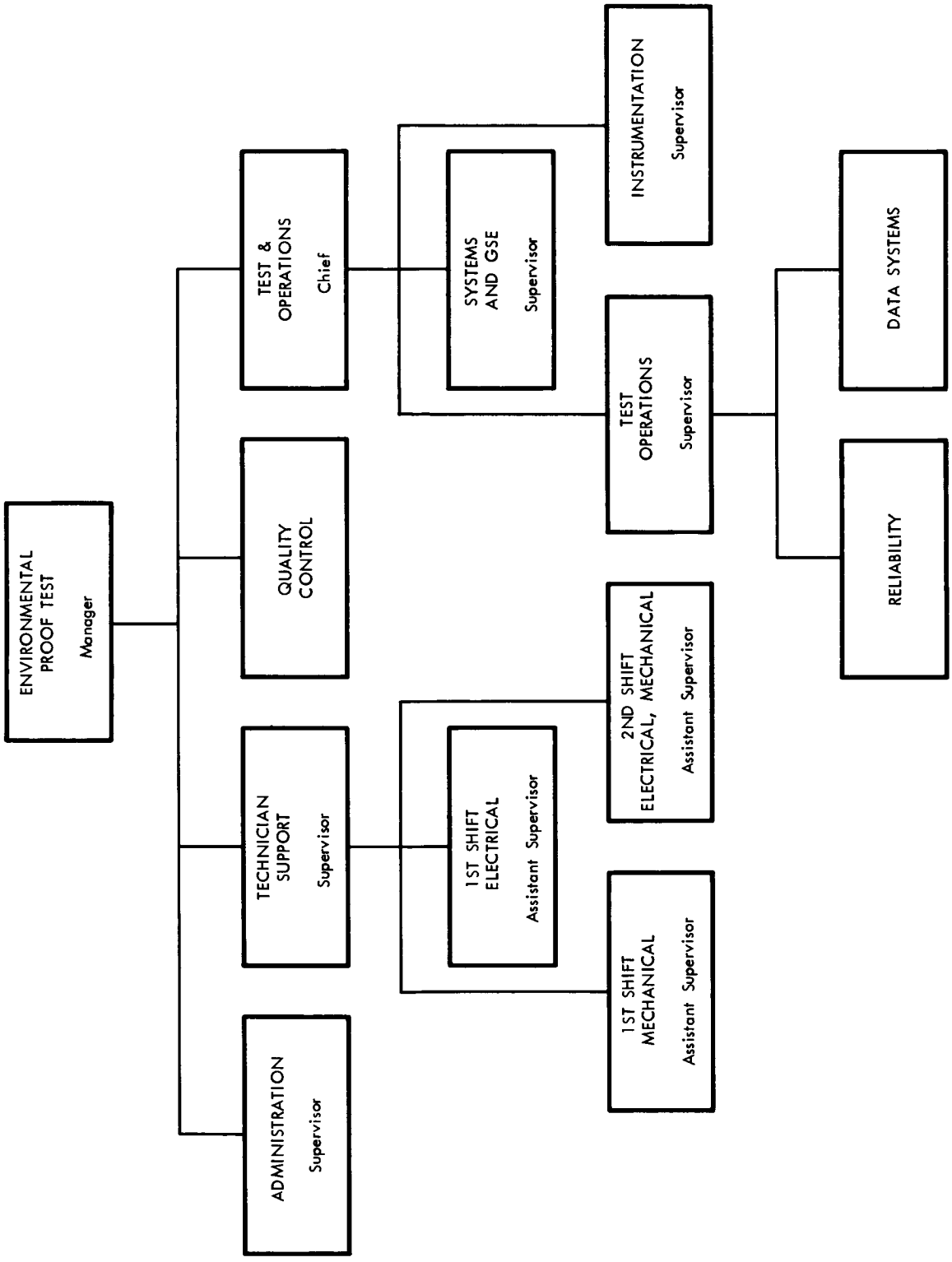

Figure 5-1. Environmental Proof Test Management and Organization

[redacted]

Table 5-10. Detailed Test Objective Schedule

Test Objectives	Objective Number	Chamber Run Number						
		1	2	3	4	5	6	7
General safety								
Determine cabin leak rate		P						
Demonstrate proper operation of cabin outflow valve		P						
Demonstrate structural integrity of C/M		S	P					
Demonstrate integrity of pressurized systems			P					
Environmental control system	5.11.1							
Determine adequacy of suit circuit atmosphere control	1,5		P	P	P	P	P	P
Determine adequacy of cabin atmospheric control	2		P	P	P	P	P	P
Evaluate equipment cooling (cold plates)	3		P	P	P	P	P	P
Evaluate Astronaut ECS manual control	4			S	P	S	P	S
Determine functional capability of redundant and backup components and subsystems	6				P		P	S
Evaluate ability to handle CO_2 and water vapor content limit conditions	8		P					
Evaluate ability of ECS to operate during and after a rapid cabin depressurization	9, 10		P					
Determine thermal stability with all S/C orientations	11		S	S	S	S	S	P
Determine O_2 and water consumption within design limits	1		P	P	P	P	P	P
Service propulsion system	5.11.2							
Determine adequacy of He pressurization system	1,2,3		P	P	P	P	P	P
Evaluate functional adequacy of propellant utilization system	4,11				P		P	

Notes: "P" indicates a first-order test objective (See Section 5.1.5.1).
"S" indicates a second-order test objective.
Objective number refers to detailed test objectives itemized in Section 5.11.

Table 5-10. Detailed Test Objective Schedule (Cont)

Test Objectives	Objective Number	Chamber Run Number						
		1	2	3	4	5	6	7
Service propulsion system (cont)								
Evaluate temperature and flow characteristics of propellant system	5, 6, 7			P	P	P	P	P
Determine functional operation of SPS redundancies and backups	8, 9, 14				P		P	
Evaluate SPS operation during and after max/min heating conditions	10, 12, 13, 15							P
Earth landing and mechanical systems	5. 11. 3							
Demonstrate design operation of ELS sequencer	1, 5		S	S	S	P	P	P
Evaluate condition of parachutes	2	P	P	S	S	P	P	P
Demonstrate proper operation of recovery aids	3		S	S	S	P	S	S
Demonstrate proper operation of mechanical systems	4		S	S	S	P	P	P
Communications and data subsystems	5. 11. 4							
Demonstrate adequacy of communications and data subsystems	1, 3, 6			P	P	P	P	P
Determine malfunction effects on associated systems	2		S	S	S	P	P	S
Determine effects of varying thermal loads on system	4		S	S	S	P	P	S
Determine communications quality under emergency conditions	5							P

Notes: "P" indicates a first-order test objective (See Section 5. 1. 5. 1).
"S" indicates a second-order test objective.
Objective number refers to detailed test objectives itemized in Section 5. 11.

Table 5-10. Detailed Test Objective Schedule (Cont)

Test Objectives	Objective Number	Chamber Run Number						
		1	2	3	4	5	6	7
Electrical power distribution	5.11.5							
Demonstrate adequacy of distribution system	3		P	P	P	P	P	P
Demonstrate compatibility with other systems	1, 2		P	P	P	P	P	P
Demonstrate adequacy of battery power output	5			S	P	P	P	
Demonstrate adequacy of emergency circuits	6			S	P	P	P	
Reaction control system (C/M and S/M)	5.11.6							
Demonstrate adequacy of helium pressurization system	1		P	P	P	S	P	S
Determine helium tank pressure range	2		P	P	P	S	P	S
Determine fuel and oxidizer storage temperature range	3		P	P	P	P	P	P
Determine ΔT between fuel and oxidizer during firing	4			P	P	S	P	S
Demonstrate SCS/RCS valve control compatibility	7			P	P	S	P	S
Stabilization control system	5.11.7							
Demonstrate automatic operation	1		S	P	P	P	P	S
Demonstrate manual operation	2			S	P	S	P	S
Demonstrate display accuracies	3			S	S	P	P	S
Determine power input limits for satisfactory operation	4, 5							P
Demonstrate emergency mode performance	7				P	S	P	
Determine time to reach maximum safe temperature without cooling	11							P
Demonstrate SCS/RCS valve control compatibility	12			P	P	S	P	S

Notes: "P" indicates a first-order test objective (See Section 5.1.5.1).
"S" indicates a second-order test objective.
Objective number refers to detailed test objectives itemized in Section 5.11.

Table 5-10. Detailed Test Objective Schedule (Cont)

Test Objectives	Objective Number	Chamber Run Number						
		1	2	3	4	5	6	7
Stabilization control system (cont)								
Demonstrate SCS/SPS gimbal and valve control compatibility	13			P	P	P	P	P
Determine run up time limits of SPS gimbal drive servos	14							P
Determine G&N interface tolerance limits	15							P
Thermo and fluid dynamics	5.11.8							
Obtain data to satisfy objectives							P	P
Fuel cells	5.11.9							
Demonstrate adequacy of F/C power output to support mission	1		P	P	P	P	P	P
Determine F/C reactant consumption and water production	2		P	P	P	P	P	P
Determine adequacy of single F/C power output	4				P		P	
Demonstrate adequacy of F/C purging procedure	5		P	S	P		P	
Cryogenic storage system	5.11.10							
Determine cryogenic storage thermal stability	1, 2		P	P	P	P	P	P
Demonstrate adequacy of manual control	3				P		P	
Demonstrate adequacy of H_2 and O_2 feed and pressure regulation	4, 5, 6		P	P	P	P	P	P

Notes: "P" indicates a first-order test objective (See Section 5.1.5.1).
"S" indicates a second-order test objective.
Objective number refers to detailed test objectives itemized in Section 5.11.

Table 5-10. Detailed Test Objective Schedule (Cont)

Test Objectives	Objective Number	Chamber Run Number						
		1	2	3	4	5	6	7
Life systems	5.11.11							
Demonstrate adequacy of crew systems	1			P	P	S	P	S
Demonstrate crew compatibility with manual controls	2				P	P	P	
Evaluate physiological effects of C/M environment	3				P	P	P	
Guidance and navigation	5.11.12							
Demonstrate adequate automatic and manual operation	1		S	P	P	P	P	P
Determine power and temperature limitations	2							P
Demonstrate G&N - SCS compatibility	3			S	P	S	P	P
Determine thermal environment	4			S	P	S	P	S
Demonstrate in-flight maintenance capability	5				S		P	
Displays and controls system	5.11.13							
Demonstrate performance	1			P	P	P	P	S
Establish inter-system compatibility	2			S	P	S	P	S
In-flight test system	5.11.14							
Demonstrate performance	1			S	P	S	P	S

Notes: "P" indicates a first-order test objective (See Section 5.1.5.1).
"S" indicates a second-order test objective.
Objective number refers to detailed test objectives itemized in Section 5.11.

[redacted]

5.11 DETAILED TEST OBJECTIVES

The test objectives listed are those considered most important at this time. They are subject to change as program changes occur.

5.11.1 Environmental Control System

1. Determine ability of the ECS to provide a controlled atmosphere in the suit circuit during normal orbital flight modes. (Controlled parameters include pressure, temperature, humidity, and CO_2 and toxic gas levels.)

2. Demonstrate capability of the ECS to provide a shirtsleeve environment in the cabin during normal orbital flight modes.

3. Evaluate equipment cooling (cold plates) provided by the ECS during normal flight modes.

4. Evaluate functional compatibility of astronaut ECS manual control during normal orbital flight modes.

5. Demonstrate ability of the ECS to provide proper cabin and suit pressure control during ascent and descent flight modes.

6. Demonstrate functional capability of redundant and backup components.

7. Determine effects of loss of the water-glycol loop. This will include data on two cooling loop failure areas: (1) loss of radiators (only) due to meteor puncture and (2) complete loss of the water-glycol loop and fluid due either to radiator puncture or other loop failure.)

8. Evaluate ability of the ECS to handle overconcentrations of CO_2 and water vapor in the suit loop.

9. Demonstrate ability of the ECS to operate satisfactorily during a rapid cabin depressurization (simulating C/M meteor rupture or crew initiated depressurization in the event of a cabin fire).

10. Demonstrate satisfactory ECS operation during an extended period (one orbit) of cabin depressurization (to 10^{-4} torr).

11. Determine that the ECS is not thermally unstable as regards S/C orientation by subjecting the ECS to its maximum and minimum heating modes.

[redacted]

[redacted]

5.11.2 Service Propulsion System

1. Determine that the environment of the helium tanks (and insulation) provides storage of He at satisfactory temperatures and pressures.

2. Demonstrate ability of the helium system to supply He to the propellant tanks at design pressures.

3. Demonstrate proper operation of the He system with respect to low temperatures accompanying firing and high pressures accompanying return to thermal equilibrium.

4. Evaluate ability of the propellant utilization system to supply propellant storage proportion control under a normal-mission environment.

5. Demonstrate ability of the propellant tanks (and insulation) to maintain design propellant temperatures.

6. Demonstrate ability of the propellant lines to maintain design propellant temperatures.

7. Demonstrate engine assembly firing control (water flows) under a normal-mission environment.

8. Evaluate operation of He secondary regulators.

9. Demonstrate proper operation of He pressure relief valves.

10. Evaluate operation of He system after a continued maximum/minimum SPS heating environment.

11. Evaluate ability of the propellant utilization system to supply propellant storage proportion control after an induced proportion off-set.

12. Evaluate ability of the propellant tanks (and accompanying insulation) to maintain satisfactory propellant temperatures during a continued maximum/minimum SPS heating environment.

13. Evaluate ability of the propellant lines to maintain satisfactory propellant temperatures during a continued maximum/minimum SPS heating environment.

[redacted]

[redacted] [redacted]

14. Demonstrate redundant backup capability of pilot valves, actuators, and propellant valves.

15. Demonstrate proper operation of engine assembly following extended maximum/minimum SPS heating environments.

5.11.3 Earth Landing and Mechanical Systems

1. Demonstrate proper operation of the normal mode ELS sequential events at the respective times and altitudes.

2. Evaluate the chute systems as to excessive water outgassing, contamination, and general condition after completion of earth-orbit simulation.

3. Demonstrate proper occurrence of the recovery aids after completion of earth-orbit simulation.

4. Obtain qualitative data on mechanical systems by manual operation during simulated space flight.

5. Demonstrate proper occurrence of the alternate mode ELS sequential events at the respective times and altitudes.

5.11.4 Communications and Data Subsystem

1. Demonstrate the capability of the communications and data subsystem (C&D) to perform satisfactorily during simulated earth orbit.

2. Evaluate the performance of the C&D subsystem individually, as well as the effect on associated subsystems (e.g., EPS, ECS, Fuel Cells, etc.) when simulated malfunctions are introduced into the C&D subsystem equipment. [redacted]

3. Determine C&D subsystems operating characteristics, under predetermined emergency conditions (e.g., simulated command module puncture with decompression to 10^{-4} torr for a period of one hour).

4. Evaluate system temperatures and voltages to insure proper system performance during various thermal load changes.

5. Determine communications quality under emergency operating conditions to insure the gathering of usable information in the event of such emergencies.

[redacted] [redacted]

6. Evaluate system audio and RF outputs of the following units to ascertain the degree of intelligible communication during or subsequent to exposure to simulated space environments.

   a. VHF-FM transmitter.
   b. VHF-AM transmitter.
   c. Unified S-band equipment.
   d. S-band power amplifier.
   e. C-band transponder.
   f. HF transceiver.
   g. Audio center equipment.
   h. Premodulation processor.
   i. Data storage equipment.
   j. VHF recovery beacon.

5.11.5 Electrical Power Distribution

1. Demonstrate proper performance of the electrical power system (EPS), when integrated with all other Apollo systems, under simulated mission environment and profiles.

2. Establish proper compatibility of the EPS with other spacecraft systems.

3. Establish that the EPS will supply and distribute through its designed bus structure the required a-c and d-c power.

4. Evaluate system temperatures and pressures to insure proper system operation under varied thermal load changes.

5. During entry and recovery phases, evaluate battery power to determine its ability to sustain command module operational requirements.

6. During simulated emergency operating conditions the following circuits in the EPS will be utilized to evaluate their capability to provide necessary power requirements.

   a. Undervoltage circuit
   b. Voltage failure circuit
   c. Overvoltage circuit
   d. Main d-c buses

 [redacted]

[redacted]

5.11.6 Reaction Control System (C/M and S/M)

1. Demonstrate that the helium pressurization system will maintain fuel and oxidizer pressure within their normal tolerance.

2. Determine that the temperature of the He tank and its contents are within the proper operating range.

3. Demonstrate that the fuel and oxidizer storage temperatures remain within their normal operating limits throughout a simulated mission.

4. Determine that ΔT between fuel and oxidizer during short duration simulated firings remains within the nominal operating range.

5. Evaluate component temperatures with respect to their particular design specifications.

6. Demonstrate that propellant line temperatures remain within the proper operating range after a short duration simulated firing.

7. Demonstrate the compatibility of the SCS electronics and the RCS valves.

5.11.7 Stabilization Control System

1. Demonstrate the proper operation of the SCS system to sense displacement and rate information; compute the required corrective action; and then take this corrective action in the form of engine selection or SPS nozzle thrust vector angle.

2. Evaluate the operation of the hand controllers and the manual controls to control the SPS nozzle thrust vector and RCS engine selections.

3. Determine that the display accuracy remains in tolerance in the simulated mission environment of the environmental proof tests.

4. Determine limits of proper operation of the SCS power supplies using ground power as a source to simulate power sources during flight modes.

5. Determine that voltage and current limits of operation are within (1) specific SCS performance limits, (2) +15 percent of normal performance. Determine the point where reentry could not be performed satisfactorily.

[redacted]

[redacted]

6. Determine that fuel cell interface, voltage, current, and impedance are within the envelope of nominal power requirements of the SCS.

7. Determine that the SCS in an emergency mode (rate backup, etc.) will perform satisfactorily while being powered by the batteries. This will include the starting transients, voltage decay with usage, and total usable watt-hours.

8. Determine the total and individual package heat load to the cold plates during all modes.

9. Determine the heat load under nominal inputs.

10. Determine heat loads under minimum and maximum tolerance of the ECS.

11. Determine the operating time, without ECS cold plate cooling, to reach the maximum safe operating temperature of SCS packages.

12. Evaluate the performance of the SCS when the RCS valves, nozzles, etc. (C/M and S/M) are subjected to the heat and cold of deep space.

13. Demonstrate proper operation of the gimbal and valve system of the SPS in deep-space environmental conditions.

14. Determine minimum and maximum run-up times of the RCS gimbal drive servos.

15. Determine interface limits of the G&N attitude, ΔV, and entry modes.

16. Determine suitability of the IFTS to detect problem areas in sufficient detail for in-flight corrective action.

5.11.8 Thermo and Fluid Dynamics

1. Evaluate the effects of cyclic heating and cooling on the spacecraft structure and systems operation.

2. Determine thermo and fluid dynamic characteristics of the spacecraft systems under normal, extreme, and emergency operational conditions.

[redacted]

3. Determine the spacecraft heat load absorption and rejection dissipation rates, transfer rates, and flow distribution.

4. Determine the heat flow paths and temperature distribution within the C/M systems.

5. Determine the thermo and fluid dynamic functional characteristics of the ECS and ECS radiators during manned operation while subjected to earth orbit transient heat loads and space cooling.

6. Determine the heat flow paths and temperature distribution within the S/M systems.

7. Determine the thermo and fluid dynamic characteristics of the EPS radiators.

8. Determine the temperature distribution within the C/M RCS under earth orbit conditions with normal-mission-programmed propellant usage.

9. Determine the temperature distribution within the S/M RCS under earth orbit conditions with normal-mission-programmed propellant usage.

10. Determine the temperature distribution within the SPS under earth orbit conditions with normal-mission-programmed propellant usage.

11. Demonstrate proper thermal and pressure recovery of the SPS helium pressurization tanks.

12. Evaluate the absorptivity and emissivity characteristics of spacecraft structural surfaces and major component heat transfer surfaces.

5.11.9 Fuel Cells

1. Demonstrate the ability of the fuel cells to supply the required S/C electrical power loads when subjected to a normal orbital flight environment.

2. Determine fuel cell reactant consumption and water production rates accompanying normal orbital mission flight modes.

3. Evaluate operation of the fuel cells with one fuel cell shut down.

[redacted]

[redacted]

4. Determine the ability of one fuel cell to supply required power.

5. Demonstrate proper fuel cell purging.

5.11.10 Cryogenic Storage System

1. Determine cryogenic-storage-system thermal stability in a normal orbital flight environment.

2. Demonstrate proper manual control.

3. Demonstrate proper operation of storage tank heaters.

4. Evaluate O_2 feed to both the ECS and fuel cells.

5. Evaluate H_2 feed to the fuel cells.

6. Demonstrate proper O_2 and H_2 pressure regulation.

5.11.11 Life Systems

1. Evaluate operation and interface of the crew systems (i.e., personal, food and water management, contaminate control, etc.).

2. Evaluate operation of the manual controls (i.e., PLSS, ECS valves, G&N, etc.).

3. Evaluate the physiological crew effects as result of the C/M interior environment (i.e., pressure, gases, temperature, contamination, solar radiation filters, etc.).

4. Demonstrate manual control of spacecraft systems.

5.11.12 Guidance and Navigation System

1. Demonstrate satisfactory automatic and manual G&N operation.

2. Determine satisfactory power limit and operating temperature limitations.

3. Demonstrate G&N - SCS interface compatibility.

4. Determine thermal environment imposed on G&N.

5. Demonstrate in-flight maintenance capabilities.

[redacted]

[redacted]

5.11.13 Displays and Controls System

1. Demonstrate the proper performance of the displays and controls system when subjected to simulated mission environments.

2. Establish proper compatibility of the displays and controls system with other S/C systems.

5.11.14 In-Flight Test System

1. Demonstrate that the performance of the IFTS is adequate when the S/C is subjected to simulated mission environments.

5.12 DETAILED INSTRUMENTATION LIST

A detailed listing of the instrumentation is published in SID 63-508, Apollo Measurement Requirements, Airframe 008.

5.13 SYSTEM PRIORITIES

System priorities are in accordance with Section 5.1.5.2 and 5.10.

[redacted]

6.0 HOUSE SPACECRAFT DETAILED TEST PLANS*

6.1 INTRODUCTION

6.1.1 Purpose

The purpose of the house spacecraft test program is to evaluate the engineering design of the complete spacecraft and associated ground support equipment during actual ground checkout.

6.1.2 Scope

The house spacecraft program involves two or more vehicles, Boilerplate 14, Airframe 006, and later airframe vehicles. The first vehicle is a boilerplate structure with removable skins. The second and subsequent vehicles will be typical of a manned spacecraft.

The B-14 vehicle will use original prototype systems which are continuously up-dated to operational configuration as time and availability of parts permit. The AFRM spacecrafts will be maintained in the latest flyable system configuration at all times.

House spacecraft testing will be a continuous effort with three principal categories of activity.

1. Systems and GSE evaluation

2. Operations development and support

3. Design support

Wherever possible, all systems will be tested and evaluated. However, actual firing of mission propulsion and reaction control system engines will not be accomplished.

Initial testing of Airframe 006 systems will be accomplished with the assistance of the Engineering Development Laboratory and the Los Angeles Division facilities. This initial testing will investigate the effects of vibration and acoustic environments on the spacecraft as an operating system. Later testing of Airframe 006 will be directed toward design support testing in conjunction with Boilerplate 14. The results of the

*Entire section reissued

[redacted] [redacted]

program will assist in final qualification of the Apollo spacecraft design for manned spaceflight.

6.1.3 Amendments

Amendments to this test plan will be made quarterly as a part of the General Test Plan.

6.1.4 Test Objectives and Priorities

6.1.4.1 Test Objectives

6.1.4.1.1 Systems and GSE Evaluation. The test objectives are:

1. To determine performance of components, subsystems, and systems in the integrated environment.

2. To determine individual major systems performance under ambient and certain vibration and acoustic environments

3. To determine system conformance to design specifications in the integrated environment

4. To assess GSE (including PACE-S/C and STU) compatibility with spacecraft systems

5. To evaluate prototype design modifications

6. To determine adequacy of individual, combined, and integrated systems checkout procedures

6.1.4.1.2 Second Phase - Operations Development and Support. The test objectives are:

1. To determine adequacy of GSE to detect and isolate system failure

2. To determine in-flight maintenance capability

3. To determine electromagnetic susceptibility levels

4. To demonstrate improved performance of development design modifications

5. To verify human performance criteria (handling, checkout, and maintenance operations)

[redacted]

6. To determine system performance as function of operating time, specific functional inputs, and environmental conditions

7. To develop operational procedures for vehicle and mission (ground and flight crews)

8. To verify that all equipment, procedures, and checkout environments are designed for optimum safety

9. To evaluate system malfunctions occurring during checkout operations

6.1.4.1.3 Design Support. The test objectives are:

1. To determine adequacy of design specifications

2. To determine malfunction modes, limits, and trends

3. To evaluate design changes to automatic checkout equipment or techniques

4. To evaluate crew systems control and information displays for optimum checkout and performance

5. To determine suitability of design specifications

6.1.4.2 Test Priorities

Test priorities will be originated by the Apollo Engineering Project Integration Group. These priorities will be reviewed by the Apollo Engineering Project Engineer and the house spacecraft test project engineer. A test sequence number will be assigned based upon their evaluation of the priority.

The suggested general classification of priorities is listed below, in order of importance:

1. Tests affecting crew safety or mission reliability

2. Test affecting field activities

3. Tests involving design evaluation data

4. Tests involving convenience-type improvements

[redacted]

[redacted]

6.2 TEST PROGRAM

6.2.1 General Test Description

House spacecraft tests will be in phases due to the time phasing of vehicle and systems delivery. These tests will consist of individual systems tests, combined systems tests, and integrated systems tests, supported by the STU (systems test unit) initially, and by PACE-S/C (preflight automatic checkout equipment - spacecraft) after its integration into the house spacecraft facility. After delivery and early stages of testing on both house spacecrafts, operations will be continuous. Initial test emphasis is directly related to the program objectives, as listed below. See Figures 6-1 and 6-2.

6.2.2 Program Objectives

Program objectives for the house spacecrafts are:

1. Test Series I - to verify compatibility of spacecraft, and GSE, and vehicle systems.

2. Test Series II - to evaluate interaction of vehicle systems, GSE, and PACE-S/C during integrated system checkout.

3. Test Series III - to verify and demonstrate qualifications of the spacecraft for manned spaceflight.

The second house spacecraft (Airframe 006), due to a later delivery and configuration, will not require as much emphasis on systems checkout as house spacecraft 1.

House spacecraft 2 will support the environmental proof test program initially. After completion of environmental program support, house spacecraft 2 operations will be centered on accomplishment of Test Series III.

In addition to the three main program objectives listed, there are several minor objectives to be accomplished. Logistics manuals that are developed for use as operational guides for spacecraft systems must be reviewed and verified for technical integrity by house spacecraft engineers. The house spacecraft engineers will have performed the first operational tests with a complete, integrated systems spacecraft and will have the knowledge to adequately criticize an operational manual.

The Reliability Engineering Group will accumulate specific data from the house spacecraft tests to assist in the qualitative and quantitative assessment of reliability for each spacecraft system.

[redacted]

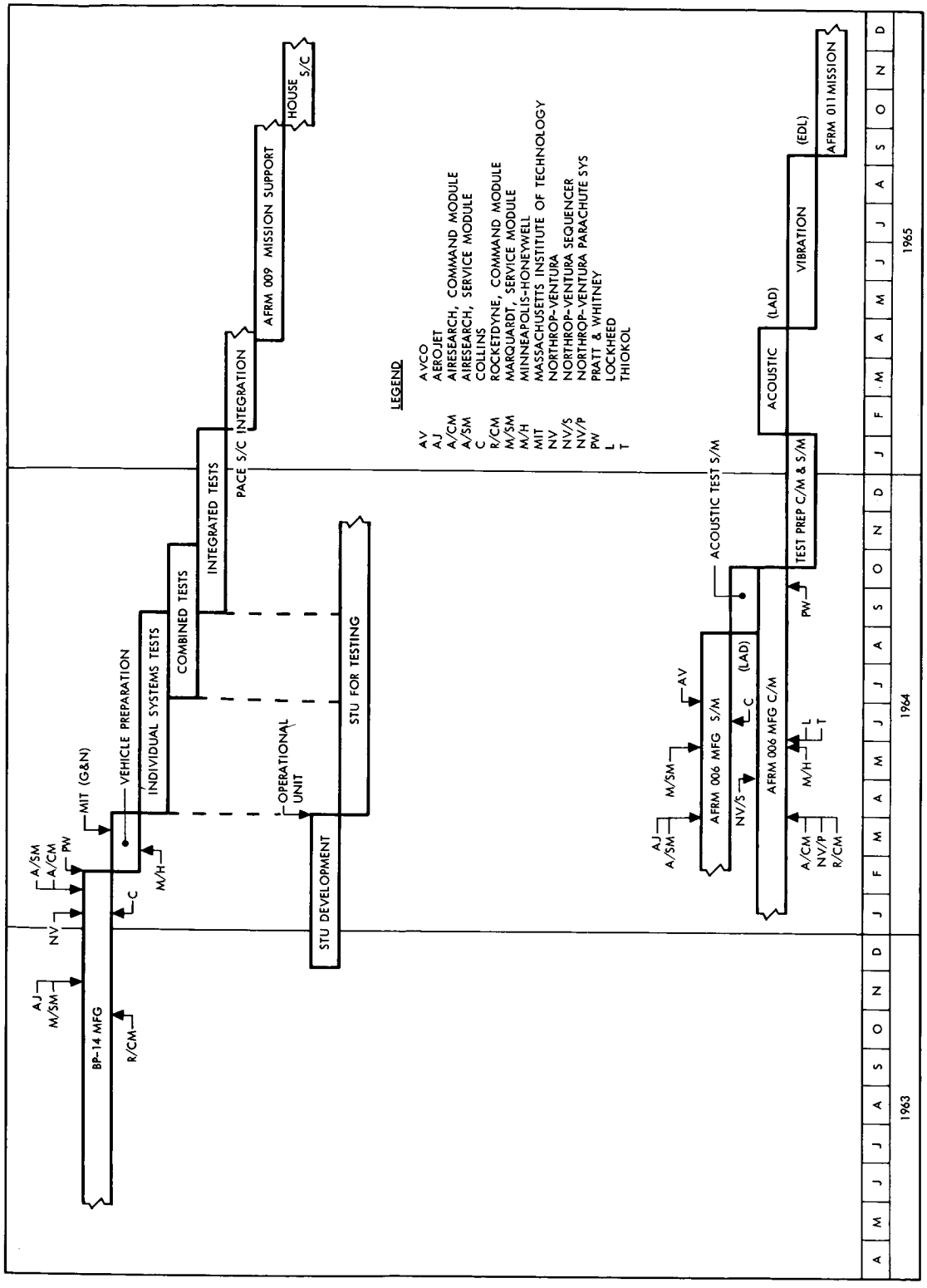

Figure 6-1. House Spacecraft Systems Delivery Schedule

[redacted]

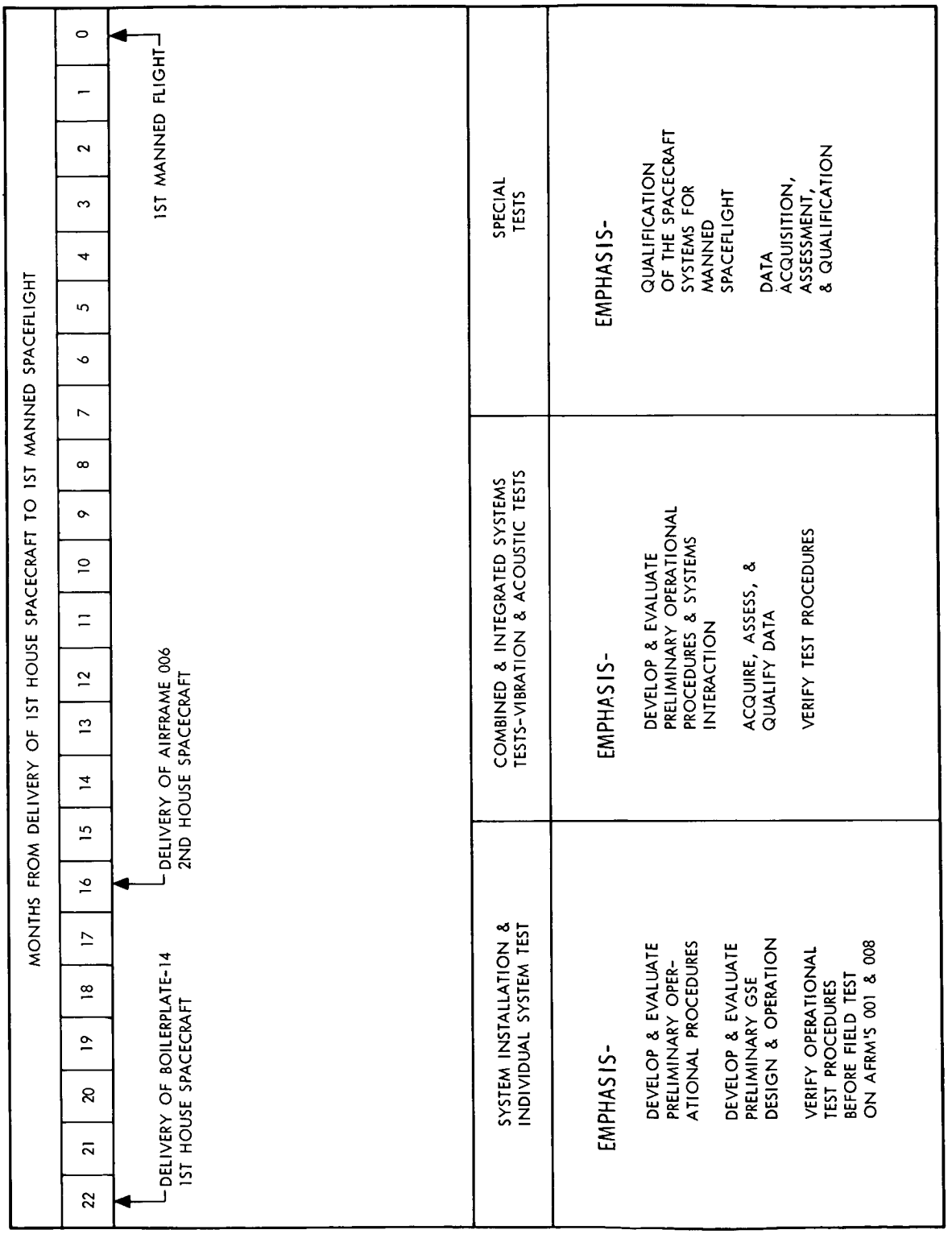

Figure 6-2. House Spacecraft Program Phasing

[redacted]

Malfunctions or problems that occur in other spacecraft test operations may be analyzed on the house spacecraft. These analyses will permit assessment of any fixes proposed to eliminate such malfunctions.

6.2.3 Test Limitations

In order to limit hazardous conditions in the house spacecraft test area, fuels, pyrotechnics, and cryogenic fluids will not be used in individual system tests and integrated system tests conducted on the house spacecrafts.

Fuel and oxidizer tanks for the reaction control systems and the service propulsion system will be filled with water, and the systems pressurized with a gas. Tests will consist of verifying the operation of the various system components and the sequence of operation.

Liquid hydrogen and liquid oxygen normally used in the fuel cell power system will be replaced with gaseous oxygen and gaseous hydrogen piped into the test facility from storage tanks located outside the building.

All pyrotechnic devices will be replaced with simulator devices. Tests will include verification of the operation of circuit components in proper sequences.

Simulated or expended rocket motors will be used on the launch escape system in place of the three solid-fuel rockets. Tests will include verification of the operation of circuit components in proper sequence.

6.2.4 Procedures

Test operations with the house spacecrafts will in most cases be initiated with a test request; the actual operations will be conducted, utilizing individual test procedures, operating manuals, or integrated system procedures. In support of actual operations, the following documents will also be used: workbooks, a CVR book (change verification record), and an operations log. Wherever possible all procedures and supporting documents will follow existing S&ID and ATO policies and procedures. These are described in the following paragraphs.

6.2.4.1 Test Requests

Test requests will be submitted by Apollo Design Engineering through the Apollo Project Integration Group to the ATO house spacecraft organization. The test request will describe systems or components for testing, test specifications, reason for testing, suggested priority, requested time

[redacted]

of completion, drawings, and other information required to successfully accomplish the test. The test request will initiate the house spacecraft testing.

Upon receipt within ATO, the test request will be screened for proper detail and essential content, scheduled, and recorded. The test request will then be assigned to a specific test conductor, who will coordinate the detail test planning and the actual implementation of the test. This test conductor will be responsible for the conduct of the test and the preparation of the preliminary report. A sample test request is given in Figure 6-3.

6.2.4.2 Individual System Procedures

Individual system test procedures will be prepared by ATO personnel using process specifications, drawings, placards and limitations, operational manuals, and other applicable information. After preparation, the document will be jointly approved by ATO and Apollo Engineering. The test procedures will be prepared utilizing the format shown in Figure 6-4. (Reference Apollo document 112-050-63-028, Apollo Specific Process Specification.)

6.2.4.3 Integrated Systems Procedures

Integrated systems procedures will be prepared by ATO personnel using process specifications, drawings, placards and limitations, operational manuals, and other applicable information. After preparation, the document will be jointly approved by ATO and Apollo Engineering. The test procedures will be prepared, utilizing the format shown in Figure 6-4. (Reference Apollo document 311-110-63-063, Integrated Systems Checkout Requirements for B-14.)

6.2.4.4 Workbook

The workbook will contain a description of action items affecting the status of all hardware, including spacecraft systems and GSE. Items of work to be performed will be entered in the workbook via the test preparation sheet by the test engineers or the technician supervision in detail. Work items will not be completed until the house spacecraft project engineer or his delegated representative approves the work item. Quality Control (inspection) will enter all discrepancies as a work item, and it will be the responsibility of the appropriate test engineer to determine proper corrective action. Approval of the corrective action will be the responsibility of the house spacecraft project engineer or his delegated representative. The workbook is used to control all direct hardware activity.

[redacted]

[redacted]

NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION

TEST REQUEST

TITLE:	NO.
	VEHICLE:
SCHEDULE REQUIREMENT: ESTIMATED TEST DURATION _____	PAGE OF
	CONTRACT NO.
SYSTEM OR PROCEDURE INVOLVED:	ACCOUNT NO.
WITNESSES REQUIRED	DEPARTMENT NO.
REPORT(s) REQUIRED Formal (NASA) ☐ NAA ☐	REPORT DISTRIBUTION:
COORDINATOR FOR REQUESTING UNIT:	

OBJECT OF TEST

REFERENCE DATA

TEST SPECIMEN

SUGGESTED INSTRUMENTATION

SUGGESTED TEST PROCEDURE (USE ADDITIONAL SHEET(S) IF NECESSARY)

OFFICE	UNIT	SIGNATURES	DATE
REQUESTING			
COORDINATING			
OTHER			
TEST INTEG.			
PROJECT ENGR.			
TEST & OPERATIONS			

FORM 959-E NEW 1-63

Figure 6-3. Example of Test Request Form for House Spacecraft System

[redacted]

[redacted]

I. INTRODUCTION

1.1 PURPOSE
SYSTEM OR COMBINATION SYSTEM TESTS

1.2 SCOPE
LIST EQUIPMENT OR VEHICLE THAT IS APPLICABLE; LIST WHETHER USED FOR PRE- OR POST-FLIGHT CHECKS, ETC.
WHEN AND WHERE PERFORMED.

II. REFERENCE

2.1 DOCUMENTS
S&ID SPECIFICATIONS AND DOCUMENTS, MILITARY, SUBCONTRACTOR, OR NASA DOCUMENTS, ETC.

2.2 DRAWING OR SCHEMATIC; NO. AND TITLE COLUMN

III. SPECIAL TOOLS AND EQUIPMENT

IV. SUPPORT EQUIPMENT

V. PERSONNEL

VI. SAFETY PRECAUTIONS AND SPECIAL INSTRUCTIONS

6.1 SAFETY

6.2 SPECIAL INSTRUCTIONS
(ABILITY TO PERFORM INDIVIDUAL SECTIONS IN ANY LOGICAL ORDER) (OPTIONAL)

VII. PREPARATIONS

7.1 GENERAL SETUP,
DIAGRAMS, SERIES OF STEPS, INITIAL CONDITIONS, ETC.

VIII. TEST PROCEDURE

8.1 PREPARATIONS FOR CHECKOUT

8.2 CHECKOUT

8.3 SHUTDOWN

8.4 POST-TEST VERIFICATION

Figure 6-4. Example of Operational Test Procedure Form (Individual or Integrated System)

[redacted]

6.2.4.5 Change Verification Record Book

CVR (Change Verification Record) books will be maintained on each spacecraft major element (i.e., command module, service module, escape tower, etc.), major system and subsystem, and on GSE. The CVR book will contain a listing of all outstanding engineering orders (EO's). The CVR book is the most basic configuration record for the house spacecraft and associated equipment.

6.2.4.6 Operations Log

The operations log will contain a daily account of work progress, and entries will be recorded in sufficient detail to permit a smooth transition of intershift operations. Information will be recorded for all operations within the house spacecraft area. This information will be readily adaptable to status and progress reports.

6.2.4.7 Status Boards

Status boards will be maintained to illustrate up-to-date testing schedules, systems and GSE status, and EO work scheduled and in process.

6.2.4.8 Nonconformance Reports

In the event of a component failure or malfunction during house spacecraft testing, existing S&ID and NASA nonconformance reporting policies will be complied with.

6.2.4.9 Scheduling

Scheduling of tests will be detailed by Apollo Test and Operations, in accordance with the objectives and priorities of the boilerplates. Resolution of schedule conflicts, changes, or reassignments due to unforeseen events and other schedule questions will be stipulated by Apollo Project Integration. This will be the case for such variables as introduction of responses to requests from field operations, evolutionary engineering development, and recheckout and requalification of systems revisions as they are final released.

Apollo Test and Operations will maintain and publish a current, detailed schedule, covering all planned operations on Boilerplate 14. The schedule will show testing on a day-to-day basis. This schedule will require a concurring signature from Apollo Project Integration.

[redacted]

6.2.5 Test Logic

The following paragraphs will explain briefly the sequence of events that result in integrated system testing. A more complete and detailed explanation of GSE testing is included in Section 6.8, the GSE Detailed Test Plan.

6.2.5.1 Ground Support Equipment (Figure 6-5)

The GSE requirements will be established, based on the equipment necessary to support the ATO Boilerplate 14 testing program. Each unit required will have a desired delivery date, based on support of system deliveries. The GSE test program will provide for a detailed test plan and test procedures for each unit required to be checked. GSE preparation prior to acceptance will involve print and specification analysis and sequence scheduling and phasing on all GSE items.

Facility support for GSE will include checking and verifying that the layout for GSE and utility requirements necessary for installation are compatible.

The handling equipment acceptance will involve visual inspection and engineering drawings conformity analysis. The handling equipment will be evaluated for operational compatibility with the spacecraft systems.

The servicing equipment acceptance will include a visual inspection, continuity check, and no-load power-on verification checkout. Installatio and facility compatibility will be required after the inspection.

Auxiliary equipment acceptance will provide for the visual inspection and continuity checkout. Installations compatibility will be checked where necessary.

STU acceptance will involve a visual inspection, continuity checkout, no-load power-on verification checkout, as well as facility compatibility checks. After acceptance, the STU will proceed with a self-checkout phase, verifying operation conditions of each unit. The STU will be interfaced with the associated auxiliary and servicing equipment, assuring compatibility mechanically and electrically. The STU will be interfaced first with spacecraft systems to assure compatibility, before the testing program is started. The STU will be utilized for individual system checkout, combined systems checkout, and integrated system checkout.

PACE-S/C preparation will involve evaluation and interface checkout with the facility and servicing equipment.

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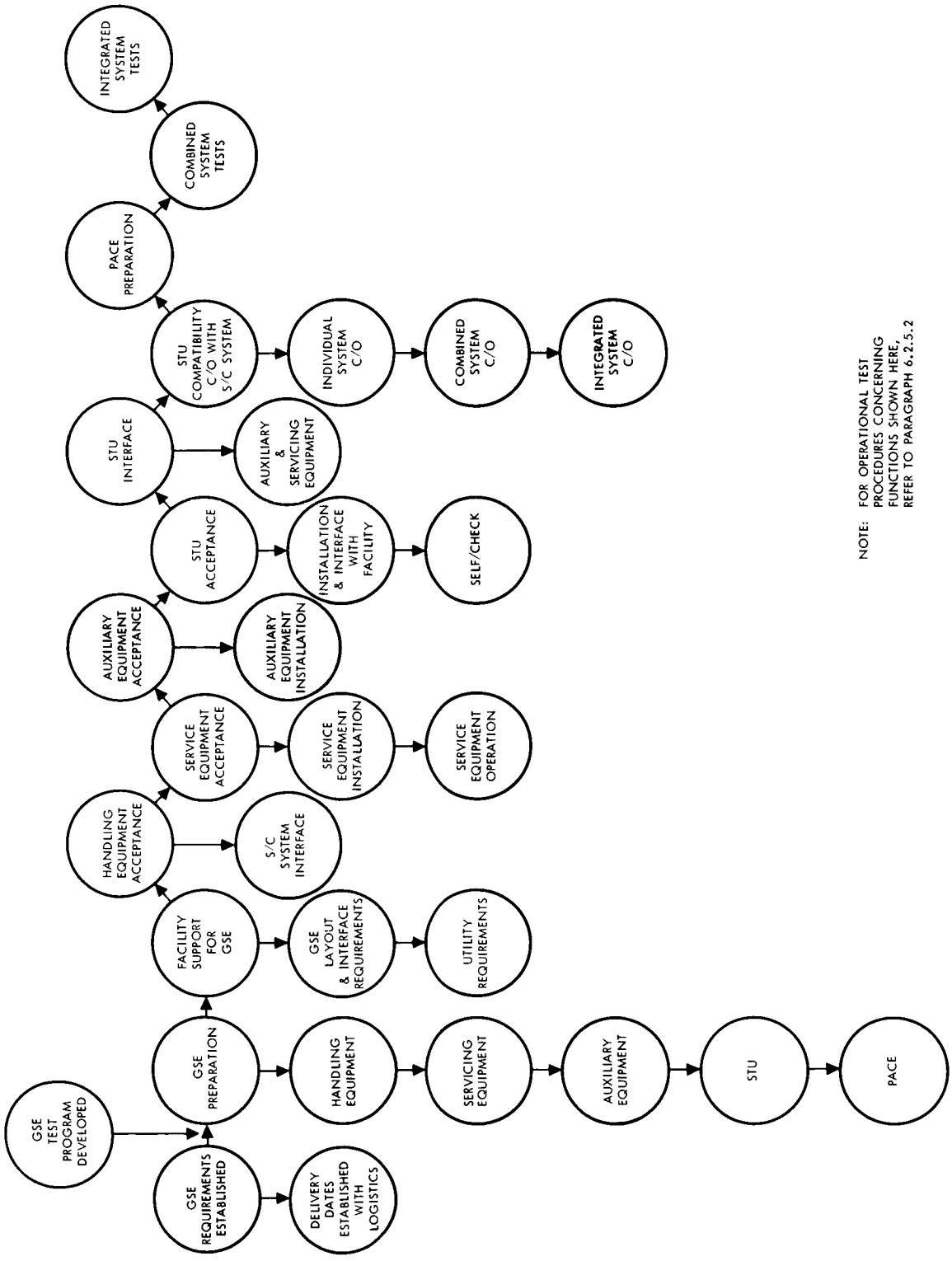

Figure 6-5. Test Logic for House Spacecraft GSE

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6.2.5.2 Operational Test Procedures - Ground Support Equipment

No specific operational test procedure numbers or titles have been assigned to GSE. GSE operational test procedures will be listed as they pertain to the individual systems.

6.2.5.3 Environmental Control System (Figures 6-6 and 6-7)

The environmental control system will be installed in the C/M and S/M, and interface evaluations will be made. The GSE handling equipment will be evaluated to design specifications.

The post-installation checkout will be made to verify the integrity of the installation. Electrical continuity, pressure, module cabling, and plumbing compatibility checks will be accomplished.

During the subsystem checkout each subsystem will be operated independently to determine the ability to perform its intended functions.

The individual system level checks will involve operation of the complete ECS to determine the compatibility between the subsystems and the ability of the complete system to perform its designed function.

The combined systems checkout will involve the operation of the ECS system simultaneously with the other S/C systems to determine that all systems perform to specification.

6.2.5.4 Operational Test Procedures - Environmental Control System Operational Test Procedure numbers appear below.

Test Procedure No.	Title
H-5500	ECS preinstallation checkout
H-5501	ECS installation (C/M)
H-5502	ECS installation (S/M)
H-5503	ECS post installation (C/M)
H-5504	ECS post installation (S/M)
H-5505	ECS purge and contamination check (test cases)
H-5506	ECS fluid servicing

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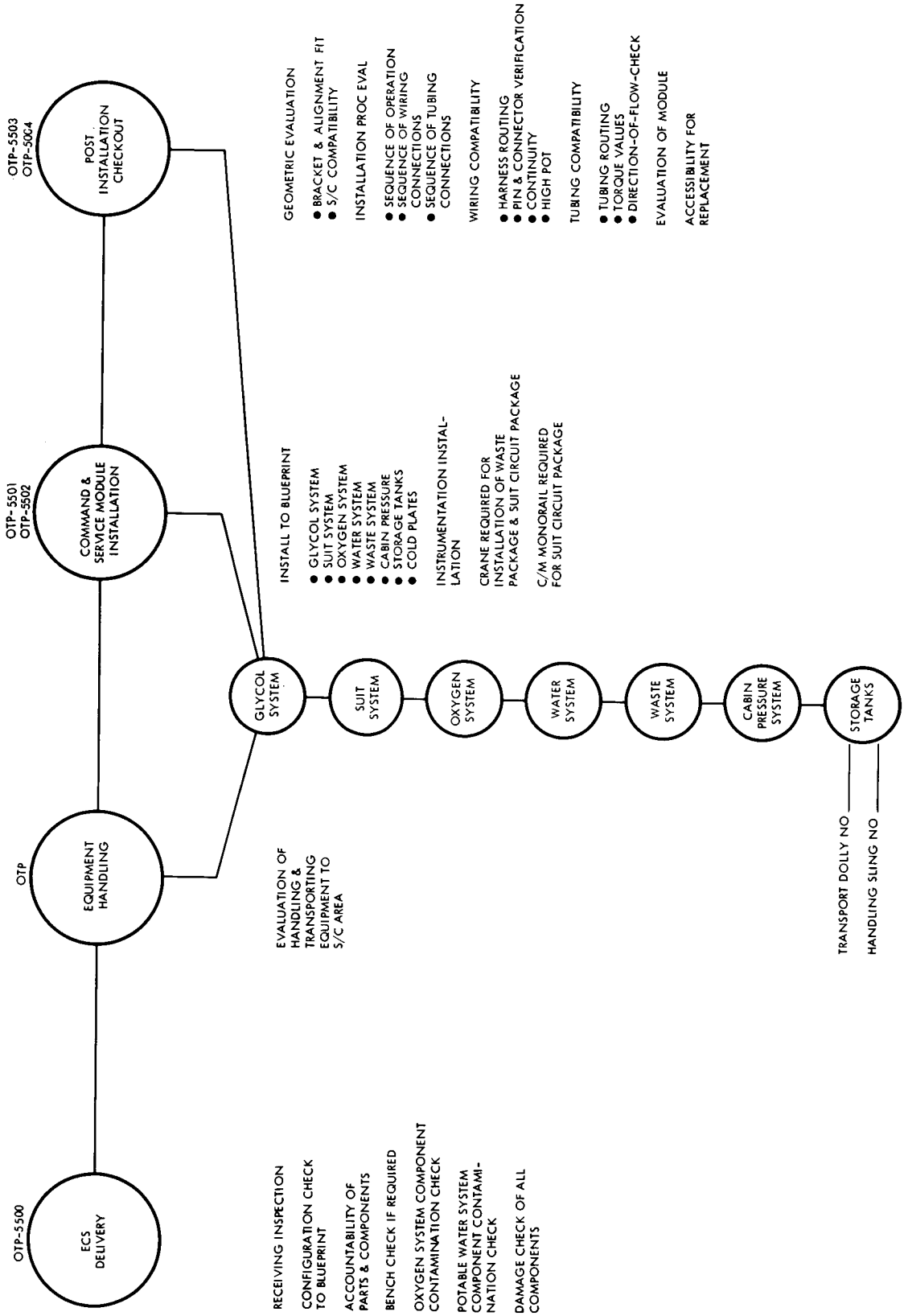

Figure 6-6. Test Logic for ECS Mechanical Compatibility

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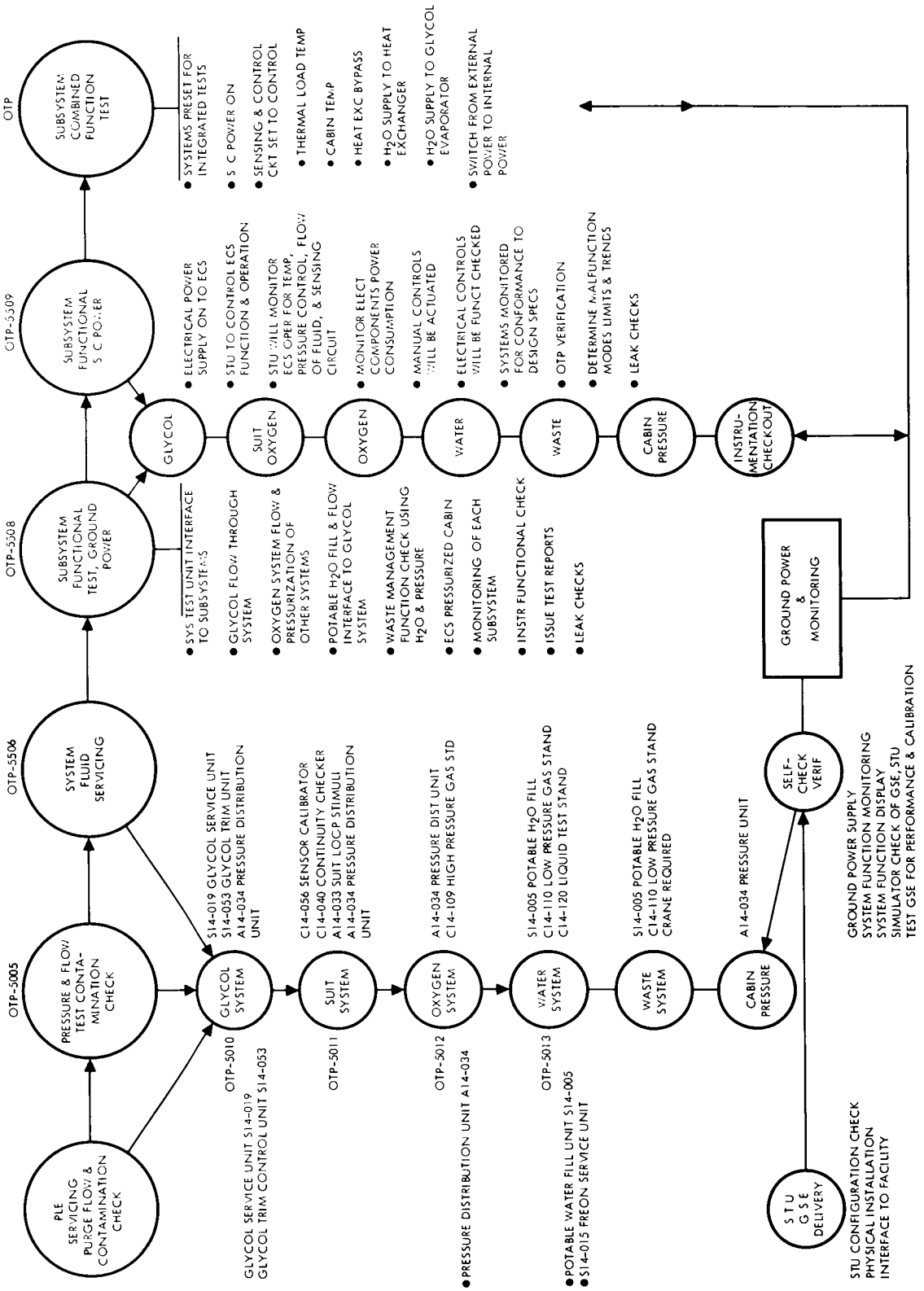

Figure 6-7. Test Logic for ECS Electrical Compatibility (Sheet 1 of 2)

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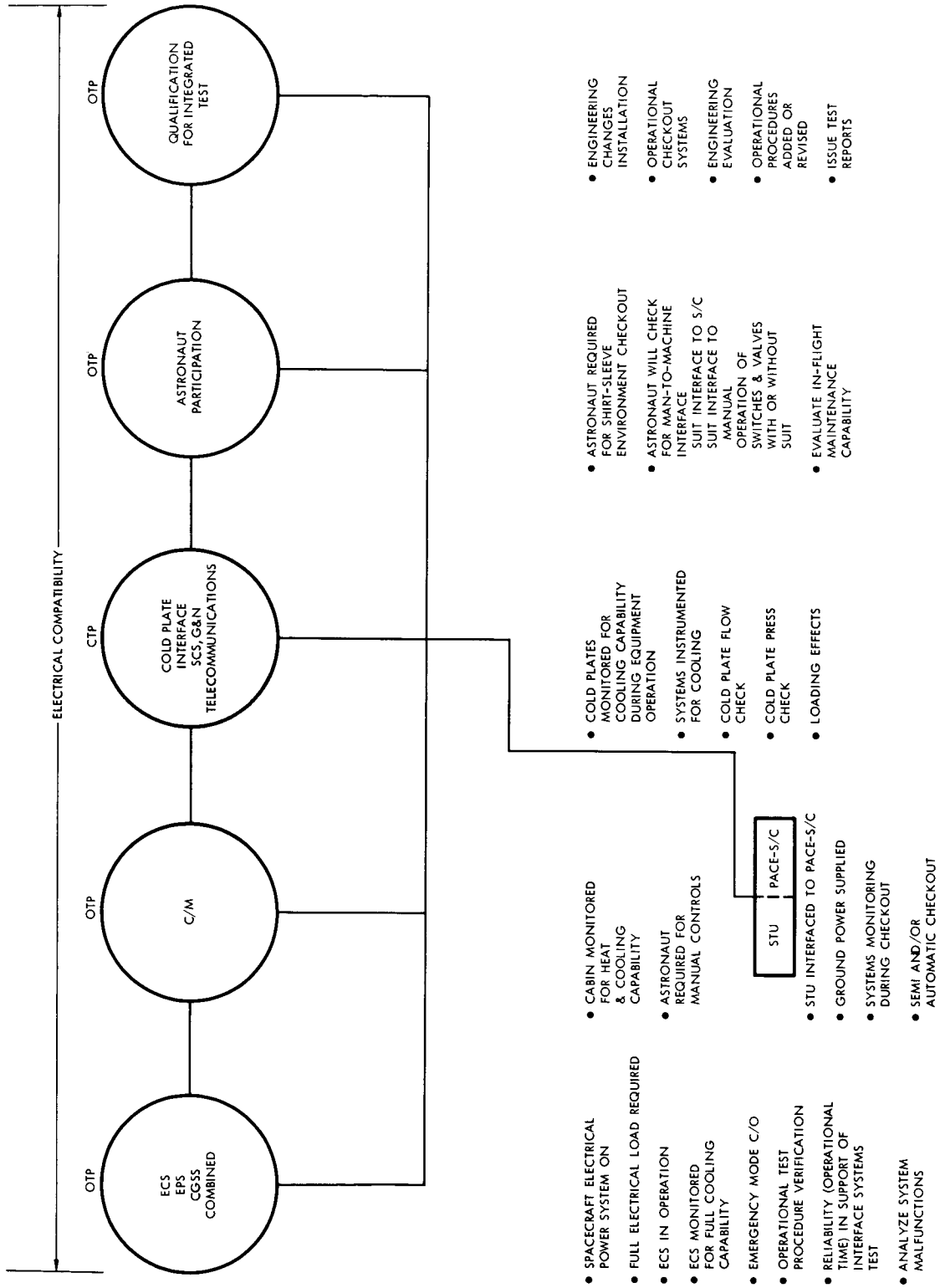

Figure 6-7. Test Logic for ECS Electrical Compatibility (Sheet 2 of 2)

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Test Procedure No.	Title
H-5507	ECS pressure flow and contamination checks (actual fluids)
H-5508	ECS subsystems functional checkout
H-5509	ECS subsystems combined functional test (ground power and S/C power)

6.2.5.5 Electrical Power System (Figures 6-8, 6-9, and 6-10)

Prior to test operations, the storage tank installation and its plumbing and associated bracketry will be checked for support bracketing, cable routing, and fittings and mating configuration. The electrical power system inspection of Boilerplate 14 will be visual to determine proper manufacturing installation. The inspection will include these items: wiring, tubing, circuit breaker panels, module inventories, and installation drawing analysis.

The electrical power system preparation will include a configuration check, engineering drawing analysis, parts inventory, installation sequence schedule, and if required, bench maintenance checkout. The GSE handling equipment will be evaluated for specification conformance, and results analyzed for design recommendations, if necessary.

A command module and service module installation verification will determine fits, support bracketing, hard and soft line routing, installation drawing analysis, and fitting and mating interfaces. A step-by-step installation procedure verification will be made for these items: fuel cells, batteries, inverters, power distribution boxes, and the command module control panel.

The post-installation checkout will include command module and service module soft- and hard-line compatibility. Fuel cell high- and low-pressure reactants flow checks will be made using gaseous hydrogen, oxygen, and nitrogen.

The initial ground power checkout will verify the command module electrical power distribution system using the control and display panels. An unloaded system level checkout will be made with the electrical power systems using GSE, as required. The checkout will be limited to operation compatibility. A loaded system level checkout will be made with the electrical power systems using GSE to verify specified ranges, limits and tolerances, operation under simulated conditions, and verification of each phase of power specified.

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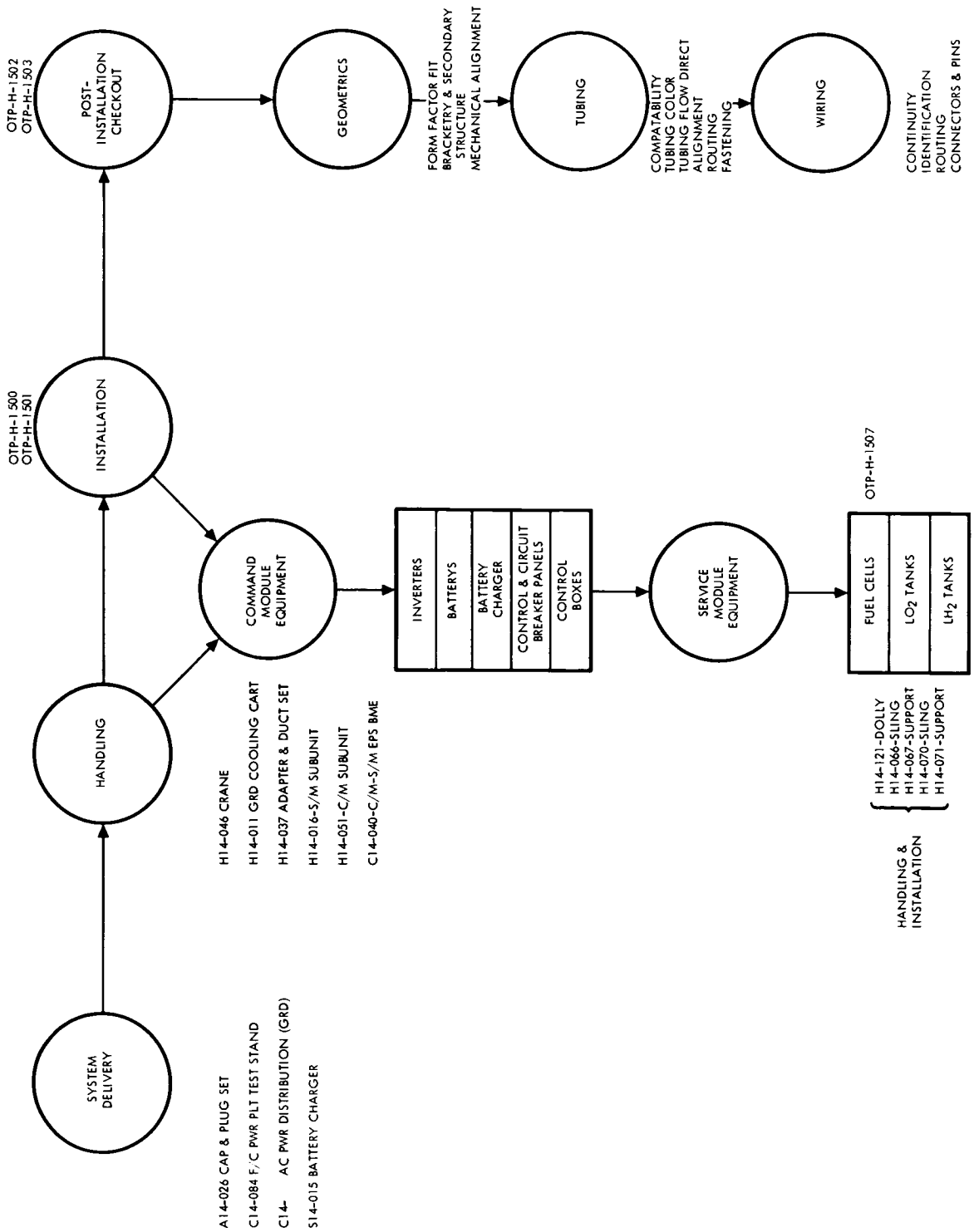

Figure 6-8. Test Logic for House Spacecraft EPS

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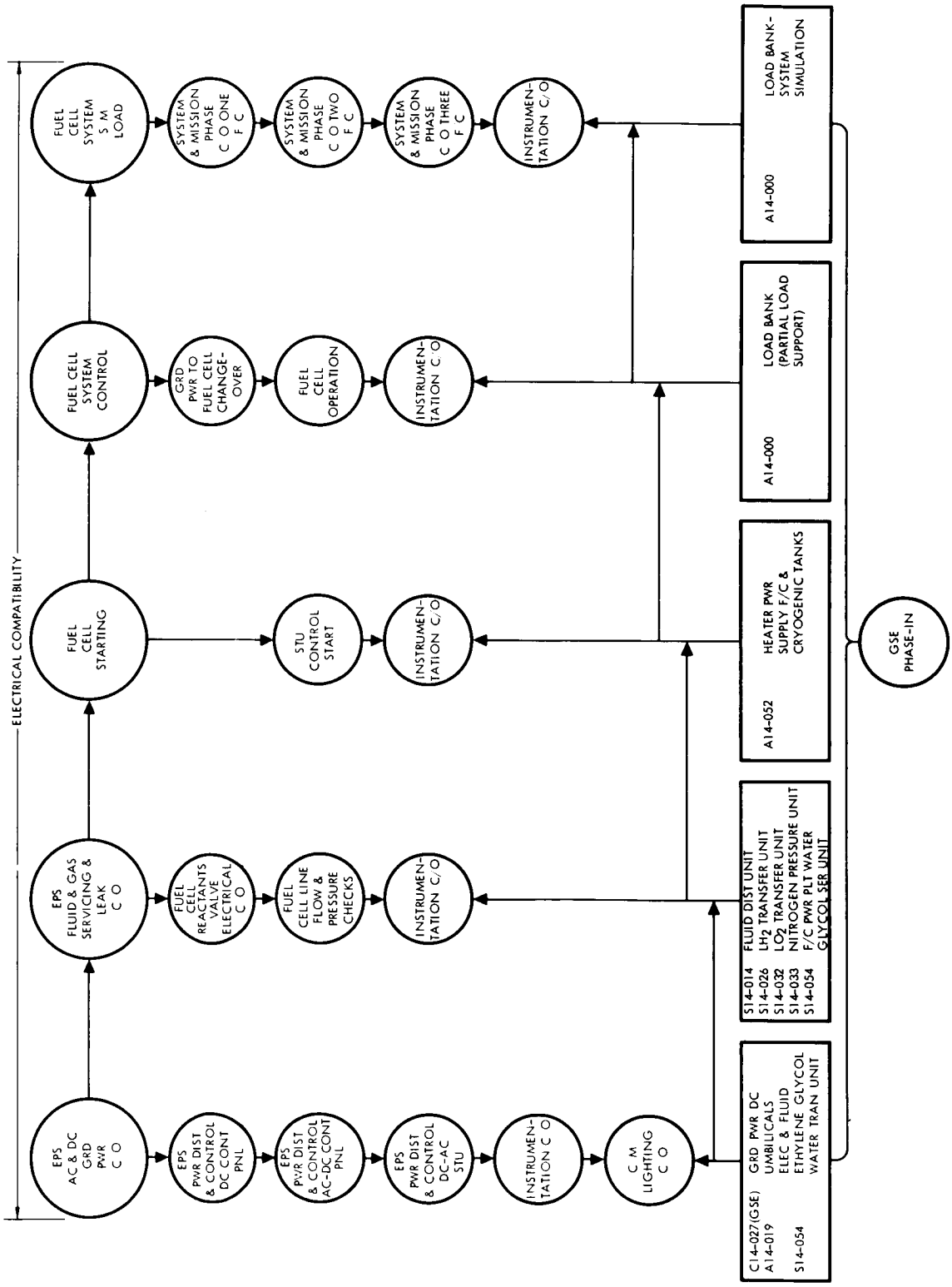

Figure 6-9. Test Logic for EPS Electrical Compatibility

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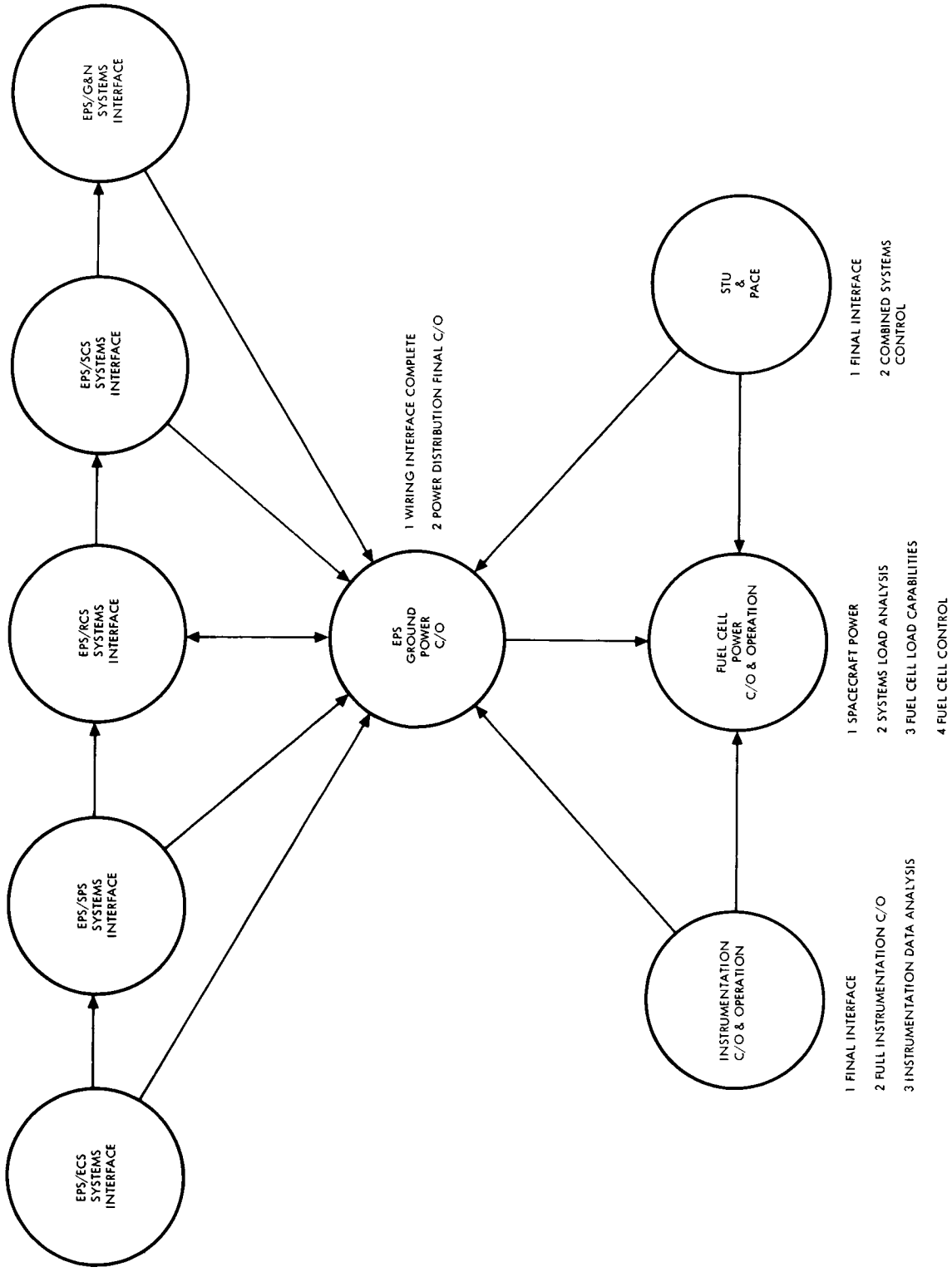

Figure 6-10. Test Logic for EPS Combined System Test Support

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As Boilerplate 14 is prepared for combined systems testing, other systems will become operational, resulting in an increase in power requirements. Real loads will be compared to simulated loads, and a final set of limits, ranges, and tolerances will be established as the combined systems test phase continues on Boilerplate 14.

Prior to the post-installation checkout, a STU evaluation will be accomplished by Apollo Engineering. An interface checkout with the facility and servicing equipment will then be made. The interface checkout will consist of connecting the ground carts and other servicing equipment, which will supply pneumatic pressures, necessary fluids, and electrical power to the STU and Boilerplate 14.

6.2.5.6 Operational Test Procedures - Electrical Power System Procedure Numbers appear below.

Test Procedure No.	Title
H-1500	EPS installation (C/M)
H-1501	EPS installation (S/M)
H-1502	EPS post-installation (C/M checkout)
H-1503	EPS post installation (S/M checkout)
H-1504	EPS fluid and gas servicing, leak and pressure checkout
H-1505	AC and DC ground power checkout
H-1506	LES/ELS checkout
H-1507	Fuel cell start
H-1508	Fuel cell component checkout (unloaded)
H-1509	Fuel cell system checkout (unloaded and loaded)

6.2.5.7 Propulsion System (Figures 6-11 and 6-12)

A visual inspection of Boilerplate 14 to verify the structure for propulsion system installation will be made together with an engineering drawing inventory. Upon delivery, a visual inspection of the propulsion system to prepare it for installation will be made. Subassemblies will be inventoried, and engineering drawings analyzed before the installation is made.

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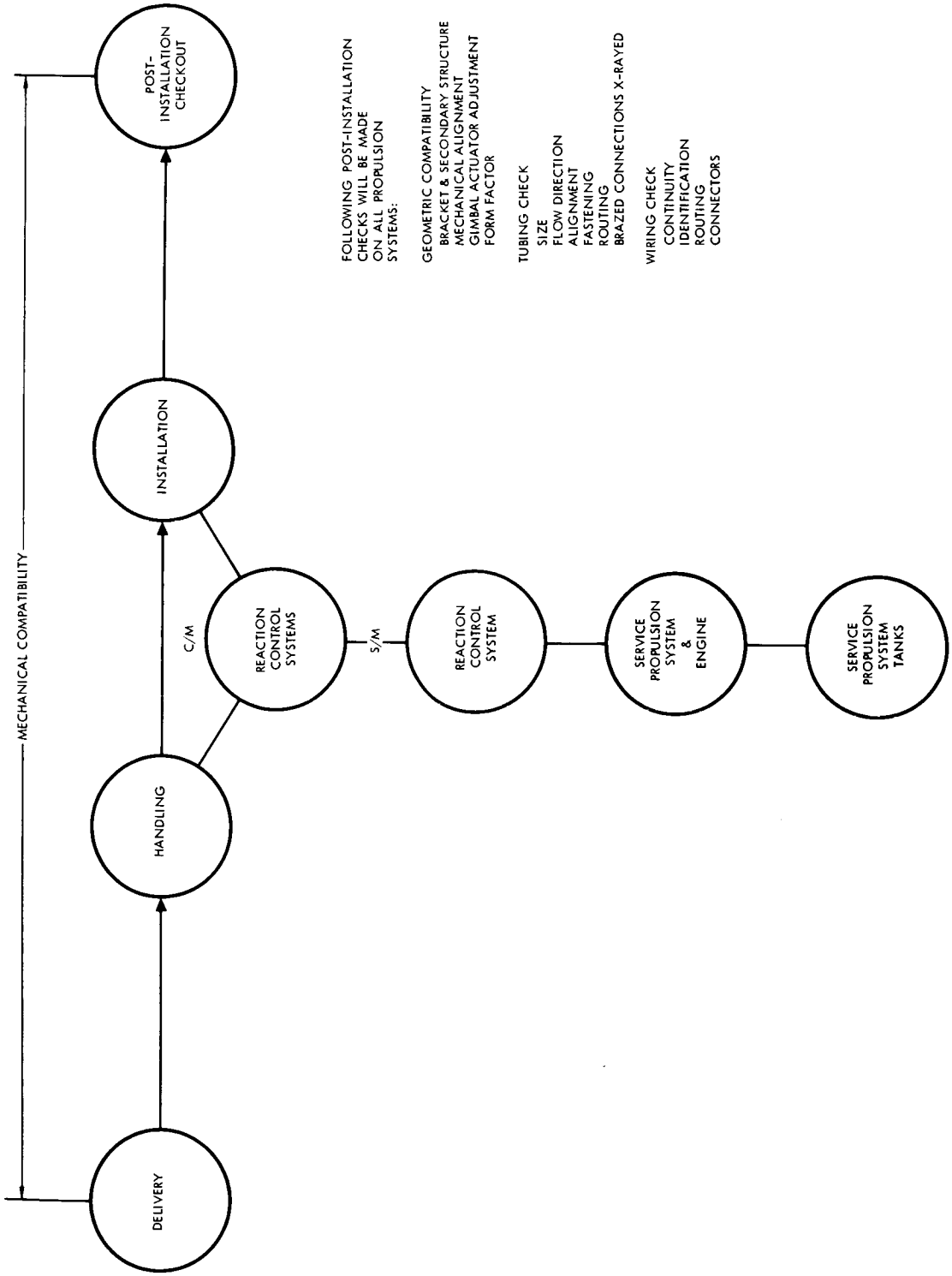

Figure 6-11. Test Logic for Propulsion System Mechanical Compatibility

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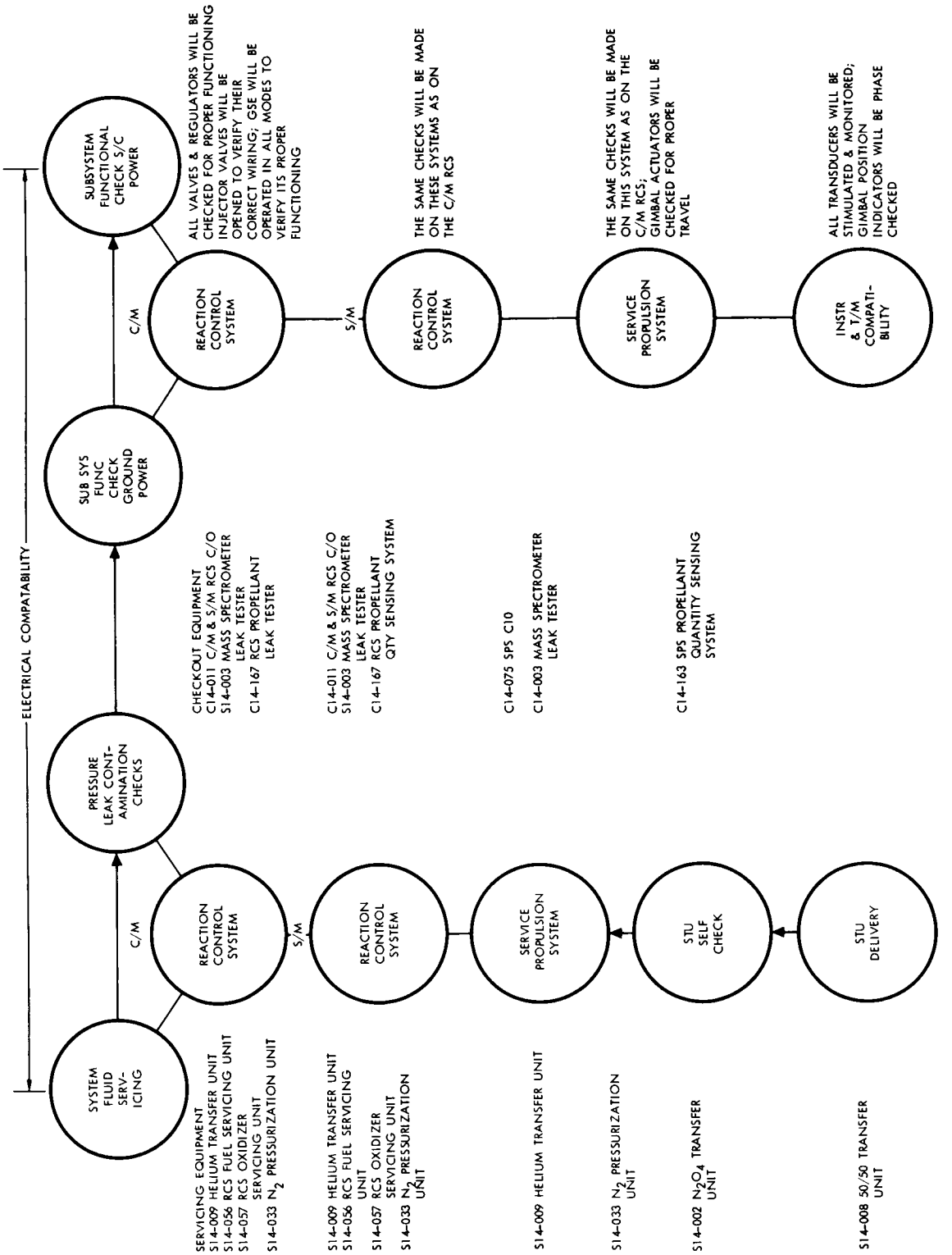

Figure 6-12. Test Logic for Propulsion System Electrical Compatibility

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The handling procedures for components and subassemblies will be checked out with the GSE handling equipment. Design recommendations will be made, if necessary. The plumbing and storage tank installation will be checked, and the S/M-RCS, C/M-RCS, and SPS installations will be made.

An STU evaluation will be made by Apollo Engineering prior to the facility and servicing equipment facility interface checkout. The interface checkout will consist of connecting the ground carts and other servicing equipment, which supply pressures, fluids, and power to the STU and Boilerplate 14.

A propulsion electrical checkout will be made with the SCS and control panel interfaces. The continuity and functional electrical checks will be made before the pressure and leak tests.

During the individual system checkout, instrumentation and controls and panels will be verified. The operable systems will be fueled and defueled using substitute fluids, flushed, and purged.

6.2.5.8 Operational Test Procedures - Propulsion System

The Procedure Numbers appear below.

Test Procedure No.	Title
H-4500	Pre-installation checkout
H-4501	RCS-C/M installation
H-4502	RCS-S/M installation
H-4503	SPS installation
H-4504	RCS-C/M post installation
H-4505	RCS-S/M post installation
H-4506	SCS post installation
H-4507	RCS-C/M servicing
H-4508	RCS-C/M pressure, leak and contamination checkout
H-4509	RCS-S/M servicing

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Test Procedure No.	Title
H-4510	RCS-S/M pressure, leak and contamination checkout
H-4511	SPS servicing
H-4512	SPS pressure, leak and contamination checkout
H-4513	RCS-C/M functional checkout
H-4514	RCS-S/M functional checkout
H-4515	SPS functional checkout
H-4516	RCS-C/M and S/M system checkout

6.2.5.9 Stabilization and Control System (Figure 6-13)

6.2.5.9.1 Preinstallation (H-7500).

6.2.5.9.1.1 Command Module. Cable installation will be verified for routing, shielding, clamping and protection. A continuity check of the SCS wire harness will be accomplished to verify the integrity of the wire list and the SCS configuration to be installed. A checklist for the mechanical structure will verify that mounting brackets, gyro alignment brackets, and mounting surfaces will be compatible with the SCS system.

6.2.5.9.1.2 Stabilization and Control System. Each package of the SCS will be given a complete functional checkout on the bench maintenance equipment prior to installation in Boilerplate 14.

6.2.5.9.2 SCS Installation and Alignment (H-7501). Steps will be provided for inspection of mounted hardware for stress and ease of installation and removal. The SCS packages will be installed in varying sequence in order to establish the preferred installation procedure. The use of in-flight maintenance tools will be evaluated at this time.

A grounding check will be accomplished to eliminate ground loops. Ground power will be applied during this phase to evaluate proper operation of the gyro heaters and the control and displays from the SCS electronics.

6.2.5.9.3 SCS Subsystem Checkout (H-7504). SCS power supply tolerances will be verified to engineering specifications. Operation of the various SCS modes will be evaluated for loading characteristics and proper phasing of the controls and displays.

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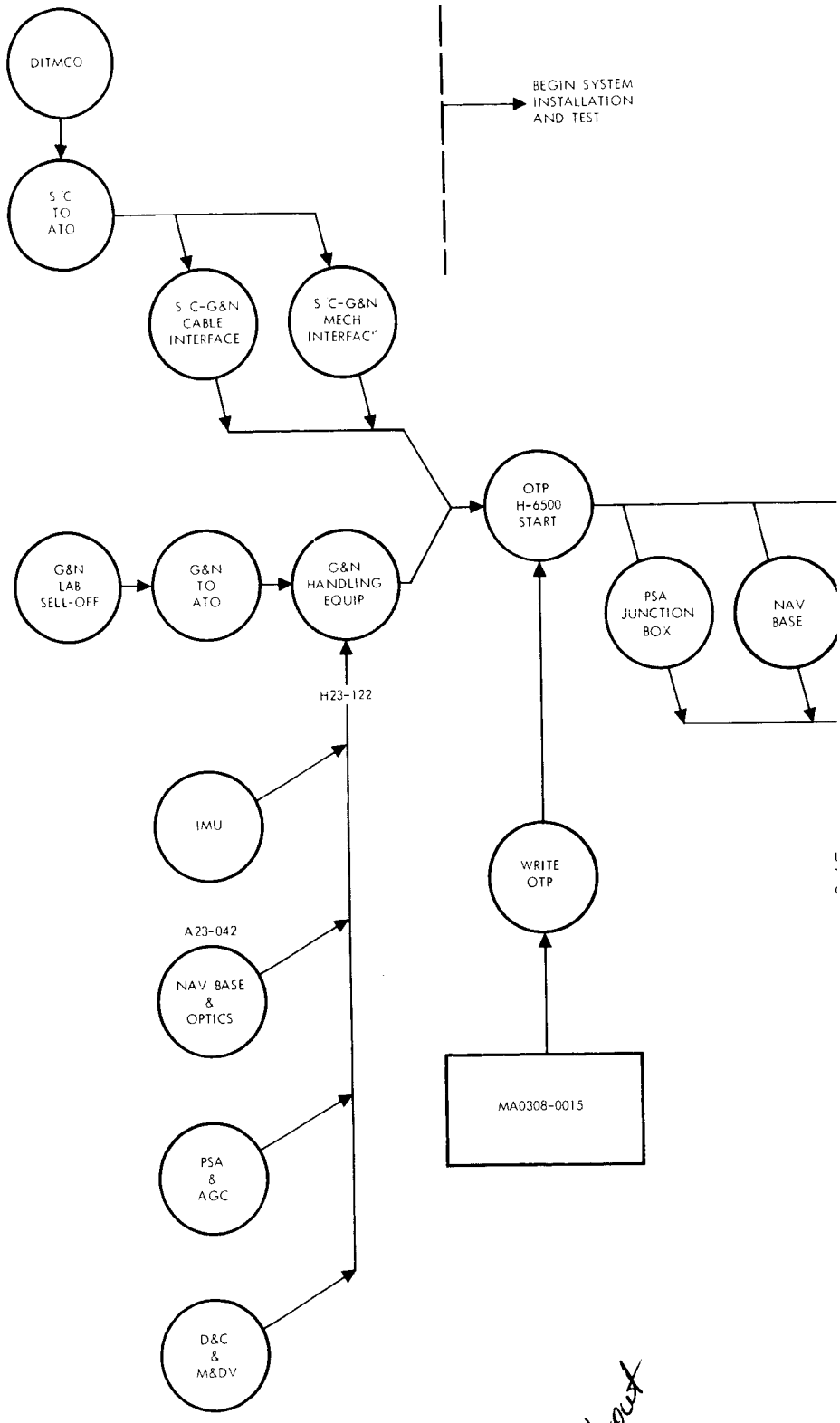

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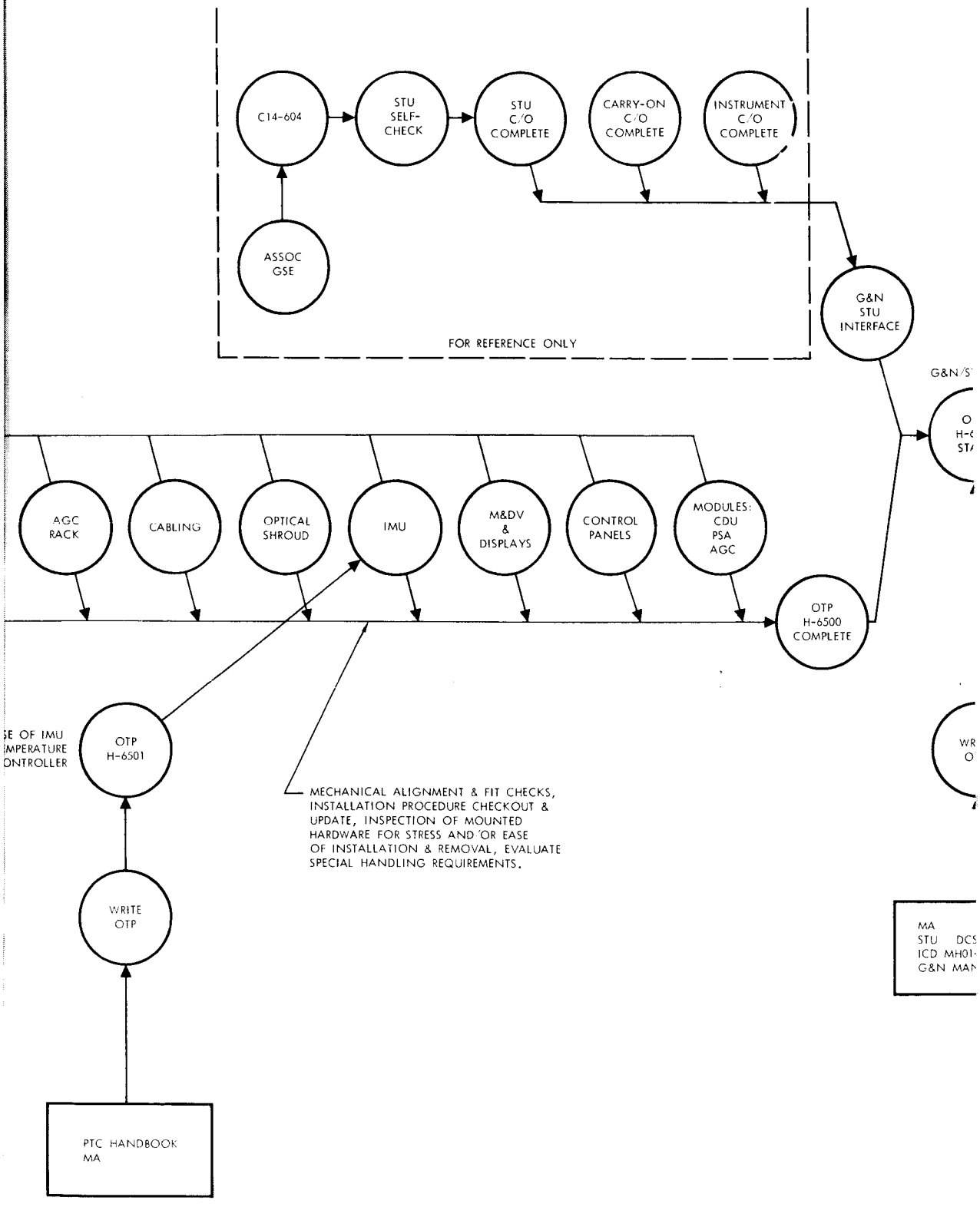
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STU SELF-CHECK
STU C/O COMPLETE
CARRY-ON C/O COMPLETE
INSTRUMENT C/O COMPLETE
ASSOC GSE
FOR REFERENCE ONLY
G&N STU INTERFACE
G&N/S
AGC RACK
CABLING
OPTICAL SHROUD
IMU
M&DV & DISPLAYS
CONTROL PANELS
MODULES: CDU PSA AGC
OTP H-6500 COMPLETE
SE OF IMU
MPERATURE
ONTROLLER
OTP H-6501
MECHANICAL ALIGNMENT & FIT CHECKS, INSTALLATION PROCEDURE CHECKOUT & UPDATE, INSPECTION OF MOUNTED HARDWARE FOR STRESS AND/OR EASE OF INSTALLATION & REMOVAL, EVALUATE SPECIAL HANDLING REQUIREMENTS.
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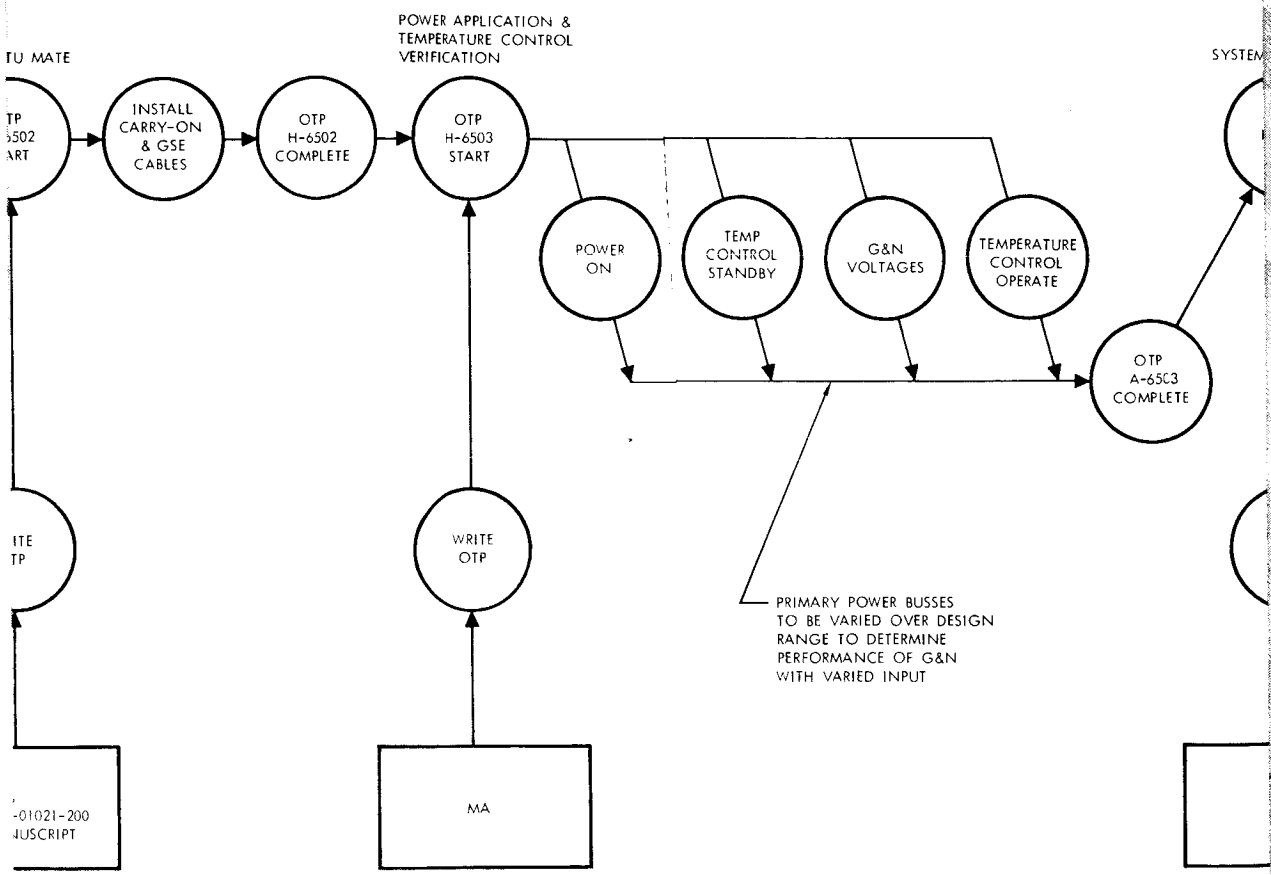
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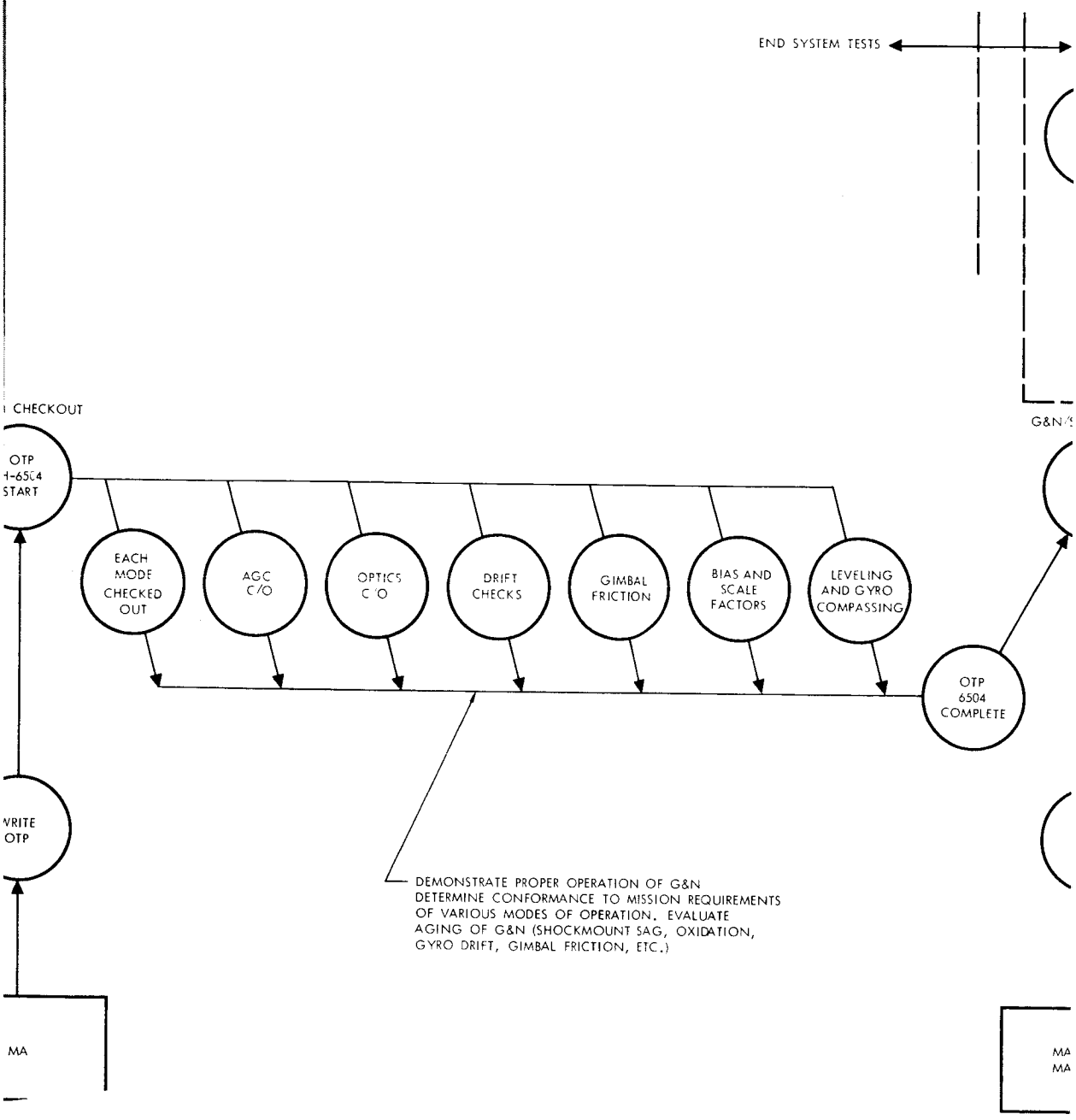
NORTH
END SYSTEM TESTS
CHECKOUT
OTP
START
EACH MODE CHECKED OUT
AGC C/O
OPTICS C/O
DRIFT CHECKS
GIMBAL FRICTION
BIAS AND SCALE FACTORS
LEVELING AND GYRO COMPASSING
OTP 6504 COMPLETE
WRITE OTP
DEMONSTRATE PROPER OPERATION OF G&N
DETERMINE CONFORMANCE TO MISSION REQUIREMENTS
OF VARIOUS MODES OF OPERATION. EVALUATE
AGING OF G&N (SHOCKMOUNT SAG, OXIDATION,
GYRO DRIFT, GIMBAL FRICTION, ETC.)
MA

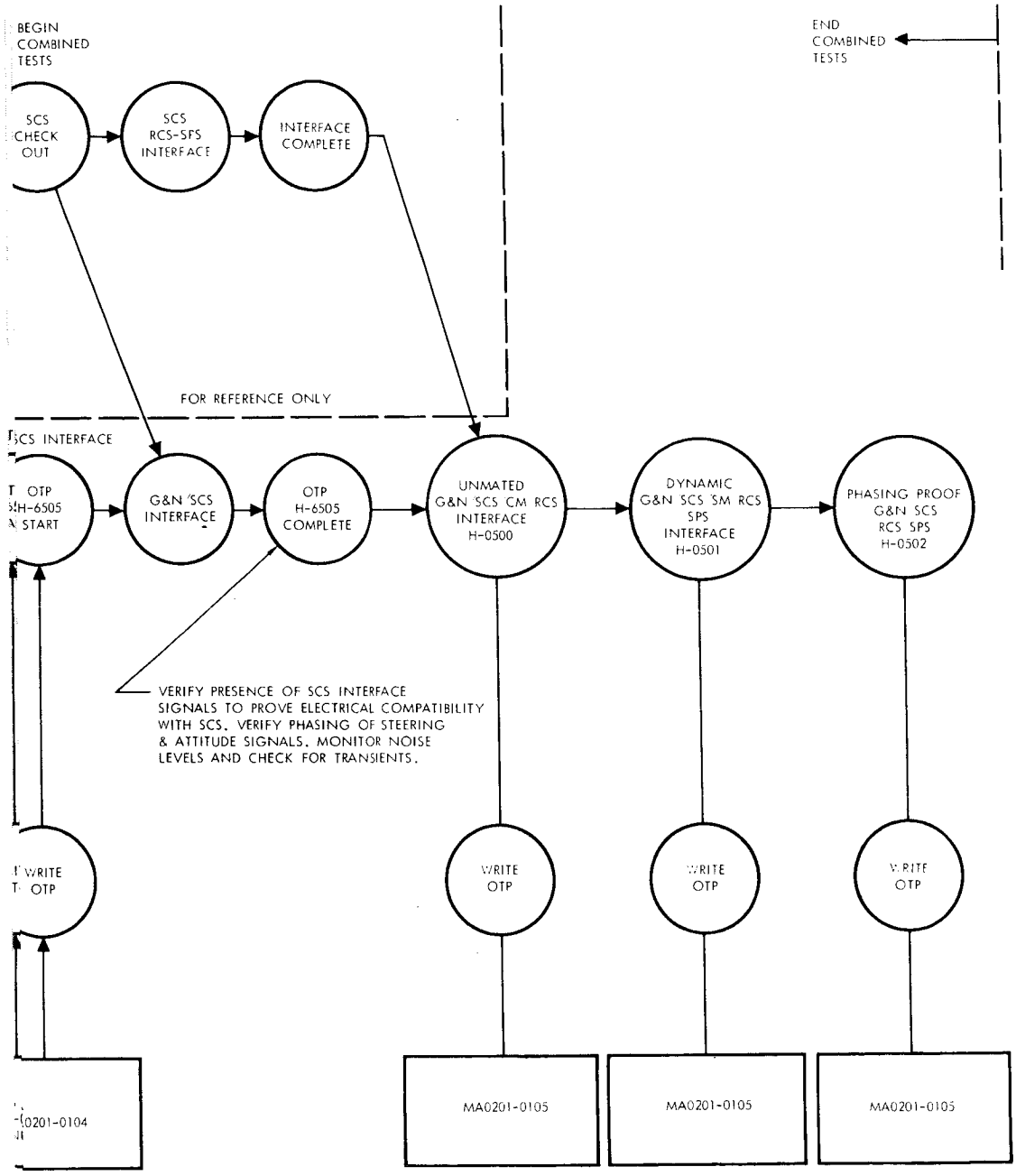

Figure 6-13. SCS Installation and Checkout (Boilerplate 14) (5)

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6.2.5.11 House Spacecraft Telecommunication System (Figures 6-14 through 6-25)

Because of the many charts concerning the telecommunications system, no attempt will be made to describe each chart as was done with the other house spacecraft systems. Each telecommunications chart is constructed using the same job functions but in a different sequence. A description of these functions is made below, unless the function is evident from its title.

6.2.5.11.1 ATO Test Coordination. The engineer responsible for the specific equipment will be present during vendor's test and inspection.

6.2.5.11.2 S&ID Receiving and Inspection. The system equipment will be inspected for damage, and the purchase order will be inventoried. The mechanical portions of the system will be examined to verify proper operation.

6.2.5.11.3 Storage - Group 054. The equipment will be put into storage after inspection decals are attached. Form 918K will be issued to order the installation of the equipment in the test vehicle.

6.2.5.11.4 Engineering - Group 697. Engineering will issue installation drawings in addition to test requirements for bench checks for individual systems tests and test requirements for integrated systems tests. Engineering will coordinate with the vendor to establish an end item test plan.

6.2.5.11.5 House Spacecraft Bench Test - Operational Test Procedures. Engineering will issue the test requirements, so that house spacecraft test operations can establish the bench test procedures.

6.2.5.11.6 Preinstallation Check. Prior to installation of equipment, bench maintenance equipment will be used to verify operating parameters.

6.2.5.11.7 Harness and Wiring Check. Prior to equipment installation the associated connectors, harness, and wiring will be continuity checked followed by a power-on check. The checks will verify polarity and voltage specification conformance.

6.2.5.11.8 Equipment Installation. House spacecraft personnel will install the system according to engineering installation drawings. The installation will be made while the vehicle is in the house spacecraft facility in Building 290.

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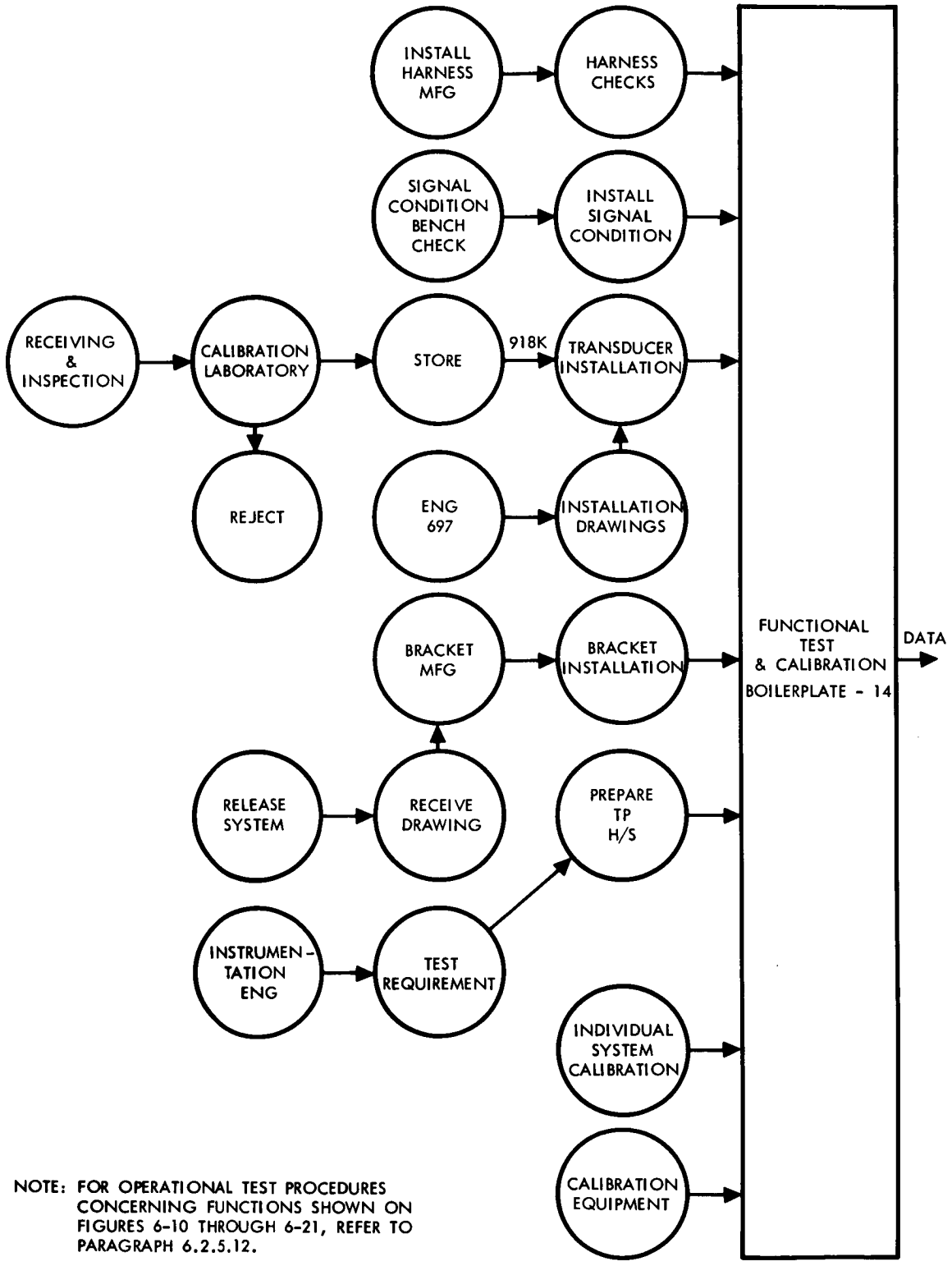

NOTE: FOR OPERATIONAL TEST PROCEDURES CONCERNING FUNCTIONS SHOWN ON FIGURES 6-10 THROUGH 6-21, REFER TO PARAGRAPH 6.2.5.12.

Figure 6-14. Transducer Test Flow

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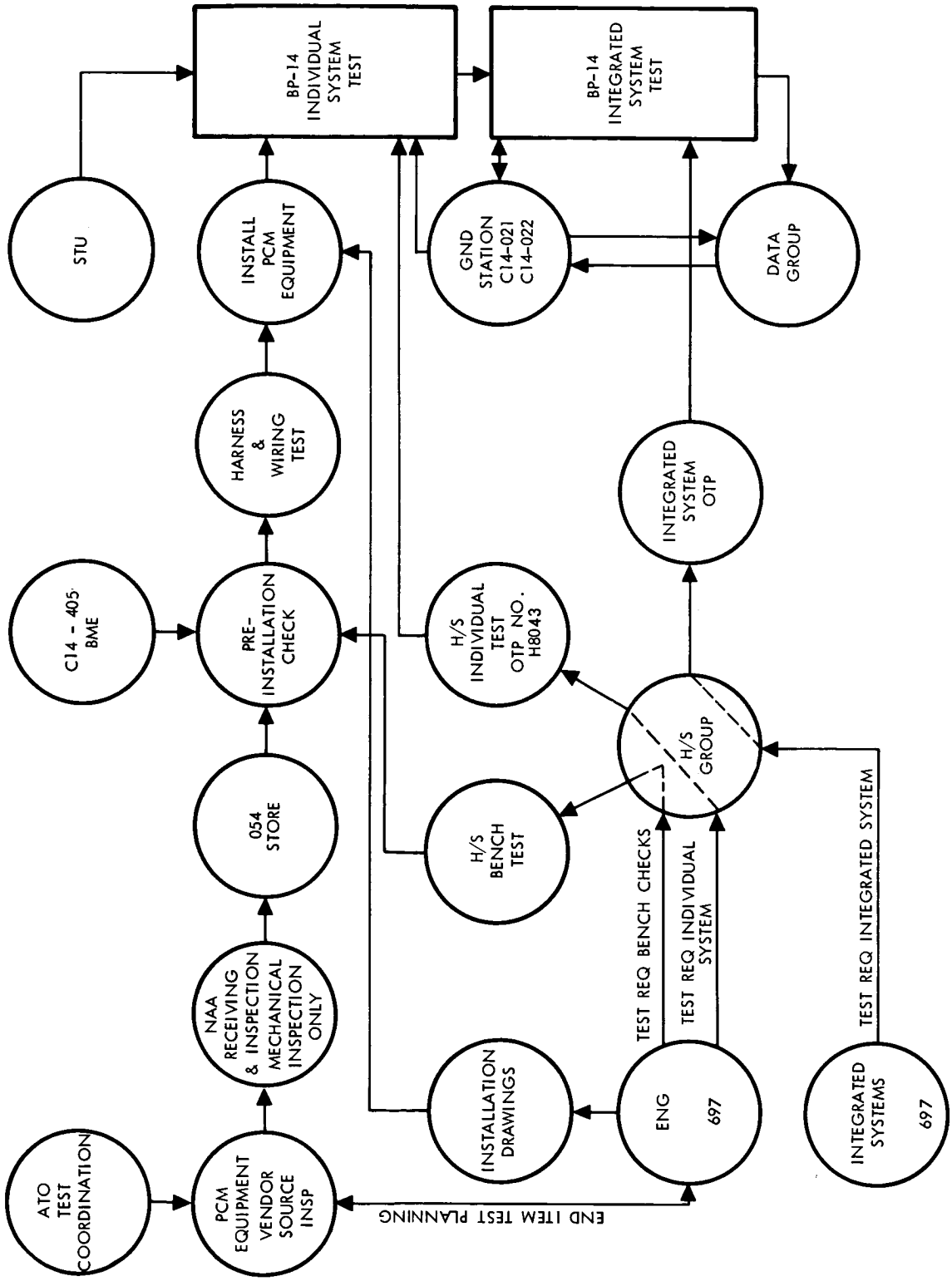

Figure 6-15. PCM Telemetry Test Flow

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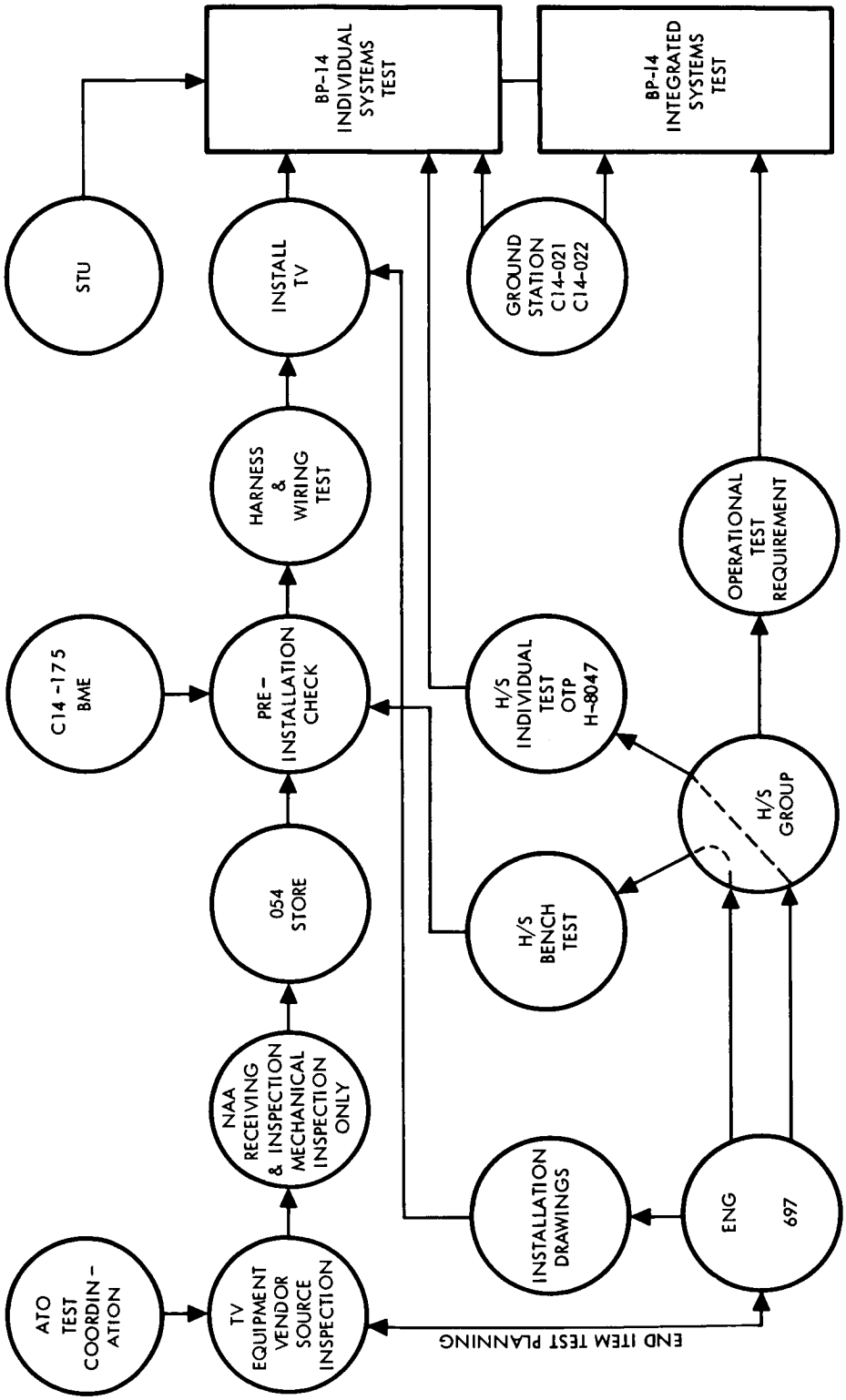

Figure 6-16. Television Test Flow

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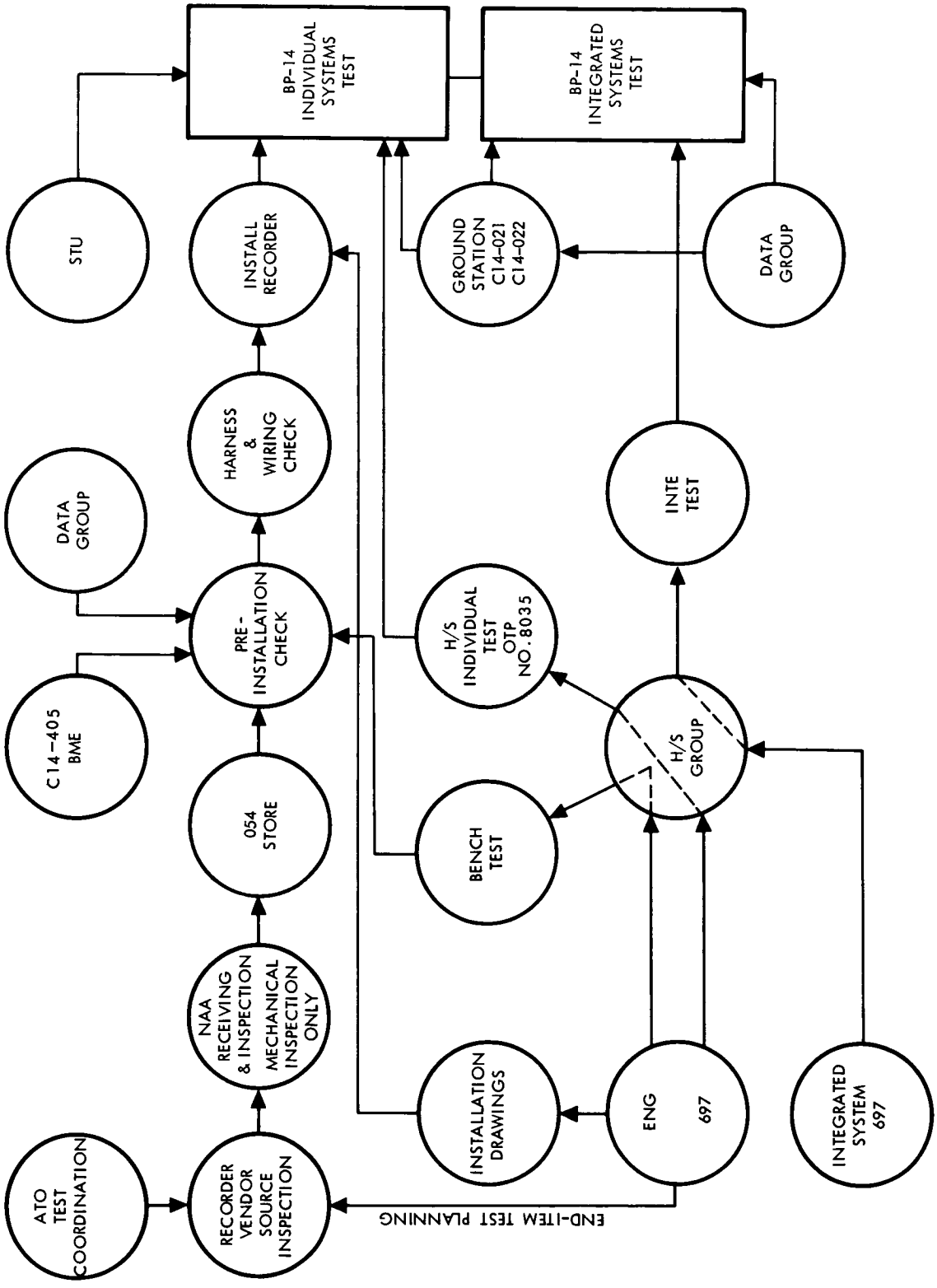

Figure 6-17. Recorder Test Flow

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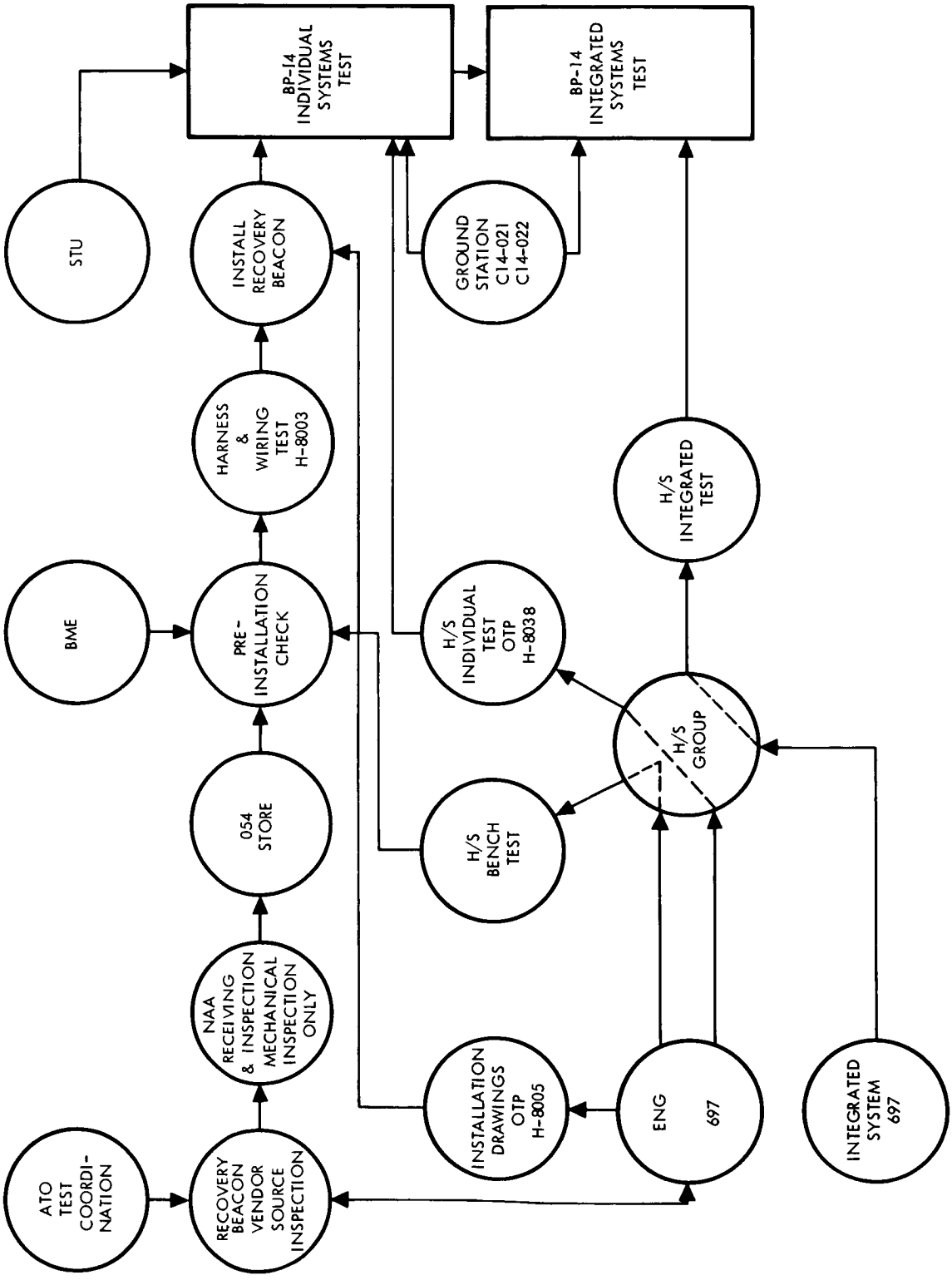

Figure 6-18. Recovery Beacon Test Flow

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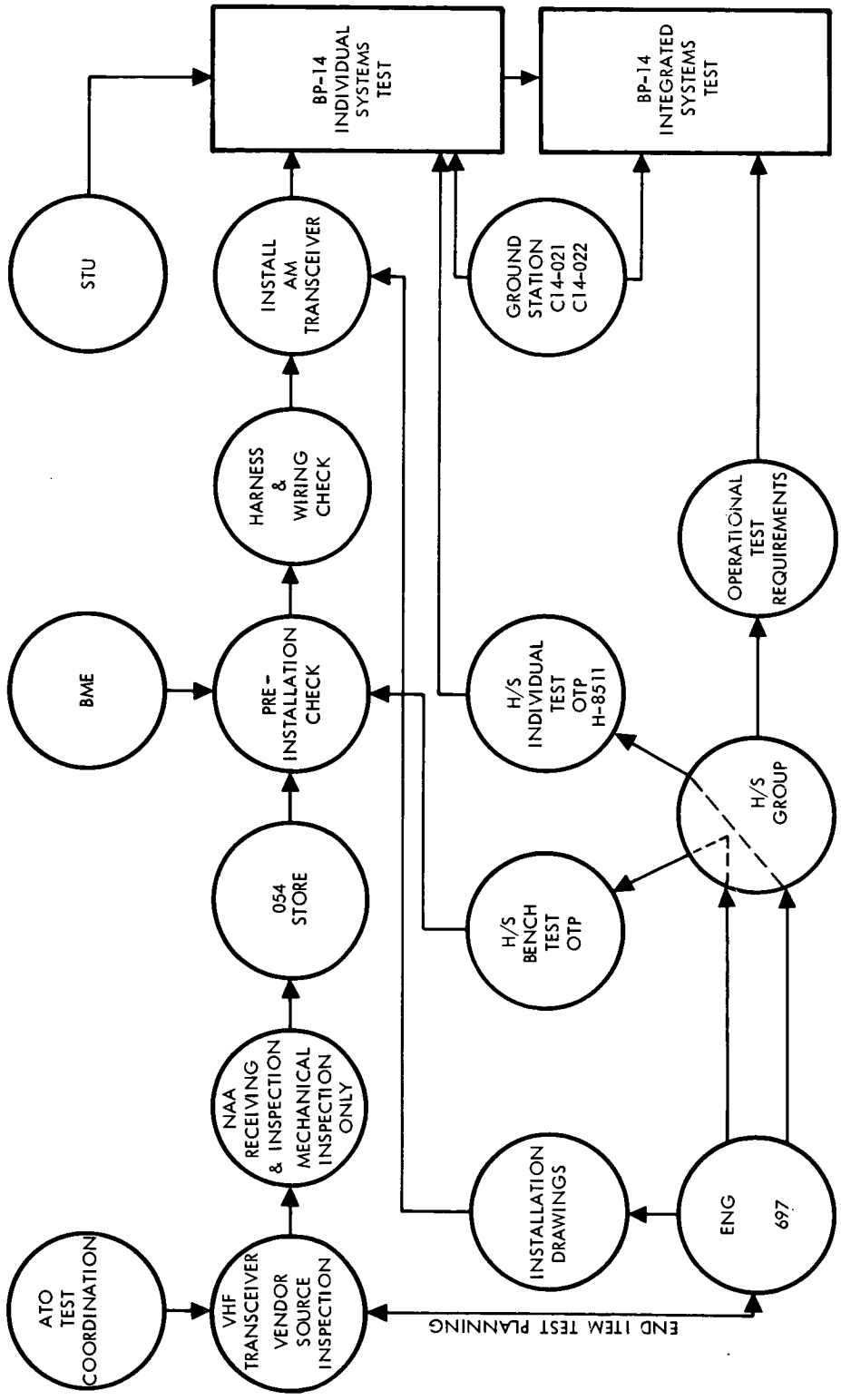

Figure 6-19. VHF AM Transceiver Test Flow

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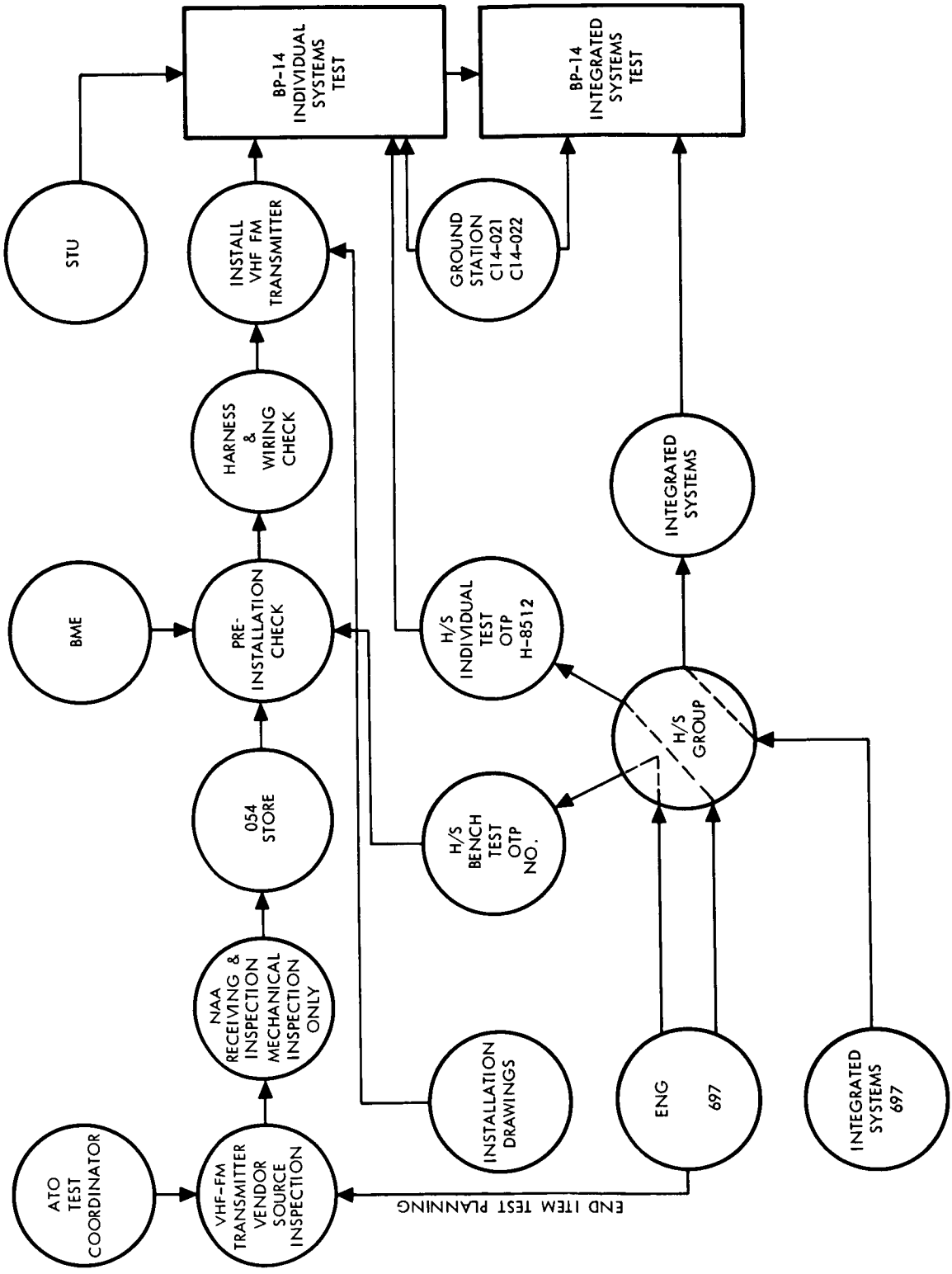

Figure 6-20. VHF FM Transmitter Test Flow

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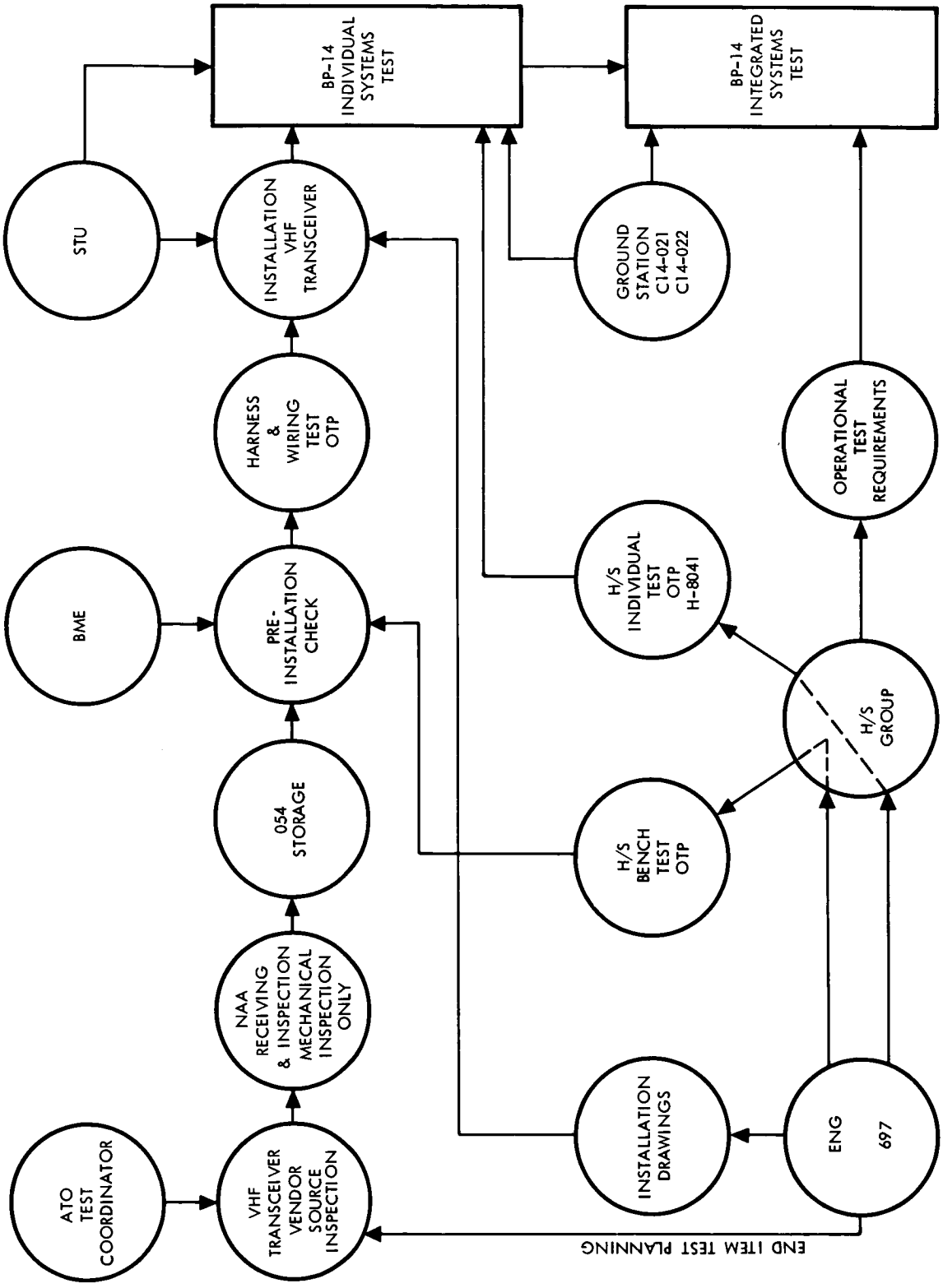

Figure 6-21. HF Transceiver Test Flow

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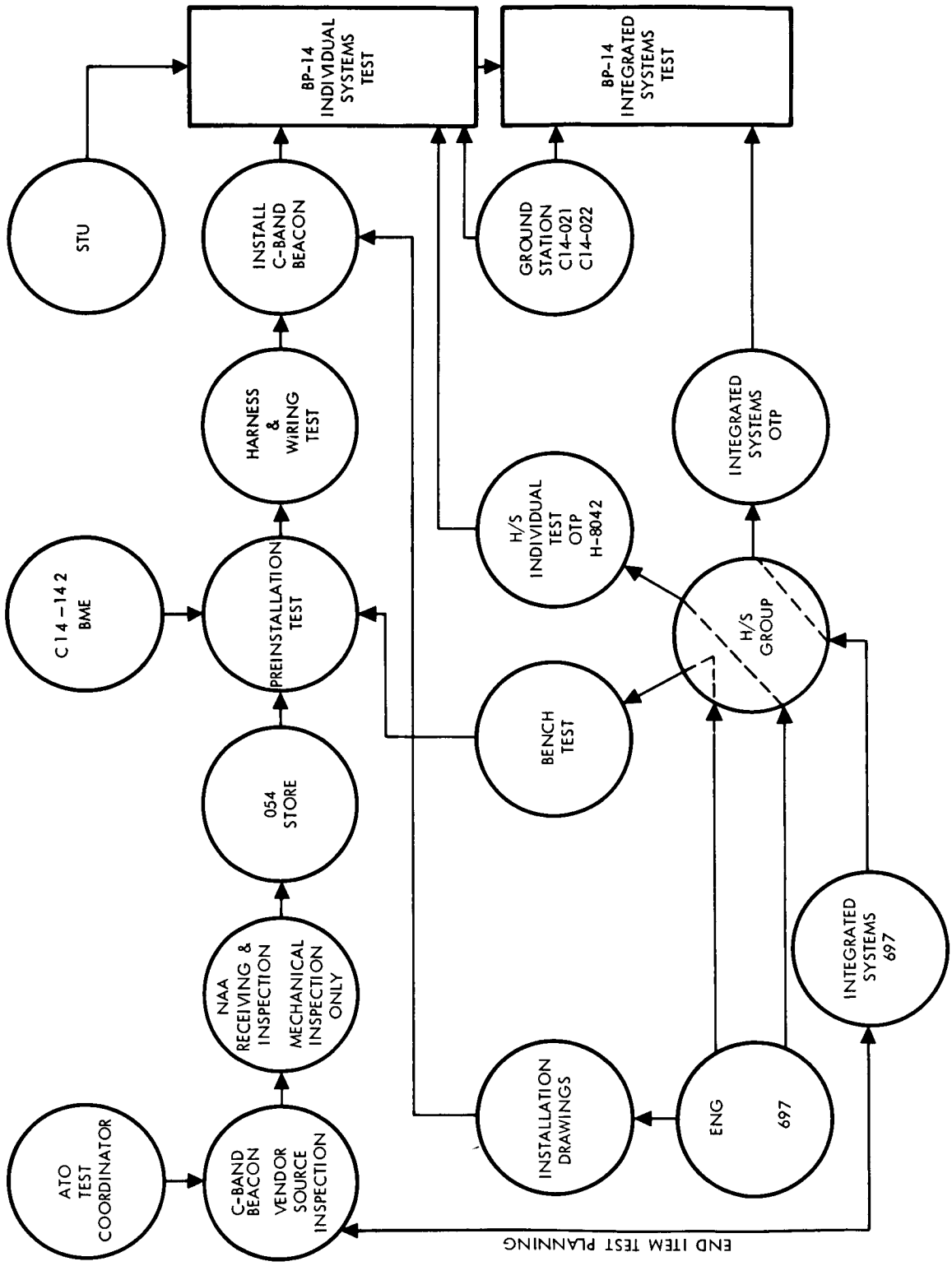

Figure 6-22. C-Band Beacon Test Flow

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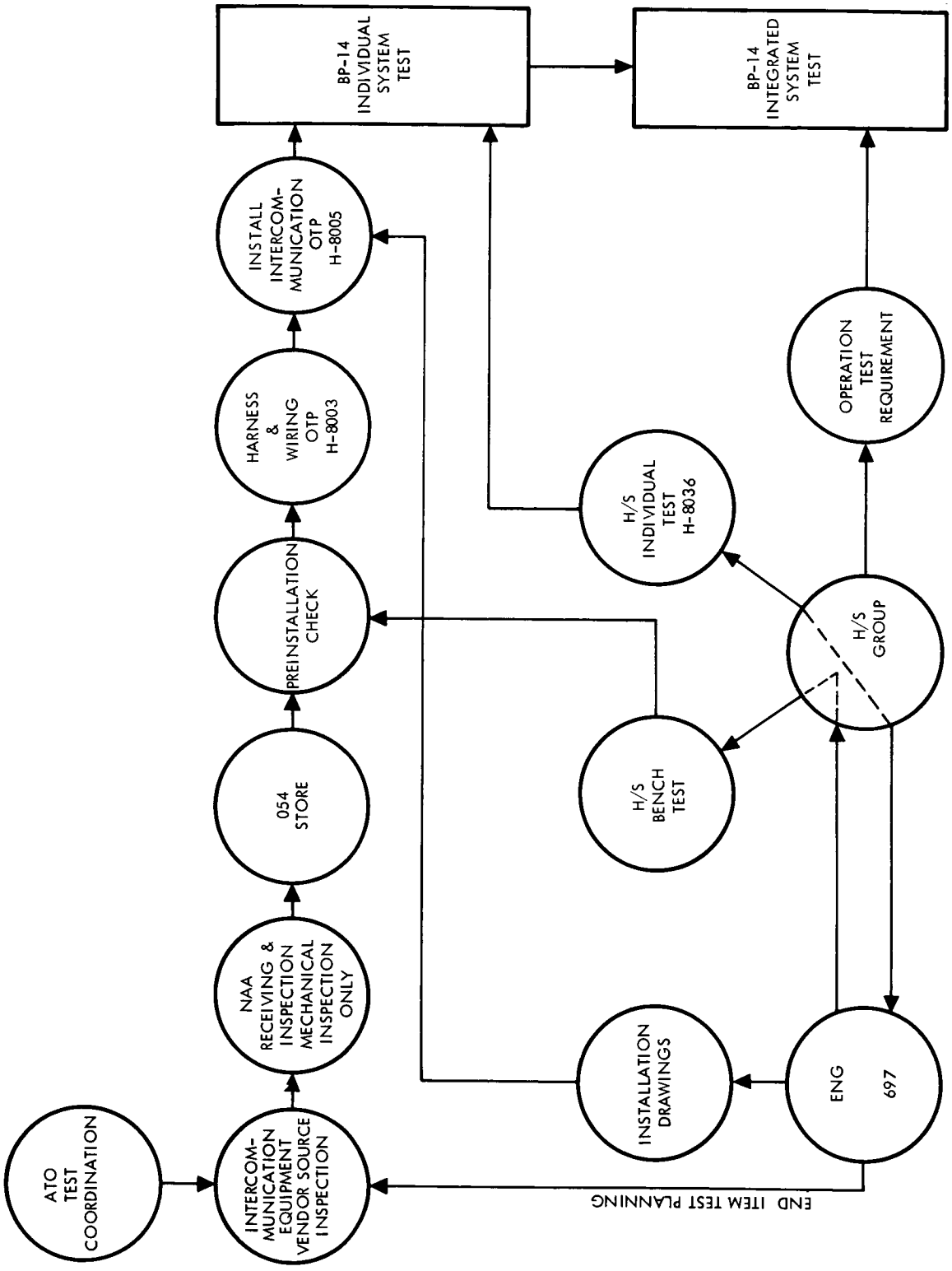

Figure 6-23. Intercommunications Equipment Test Flow

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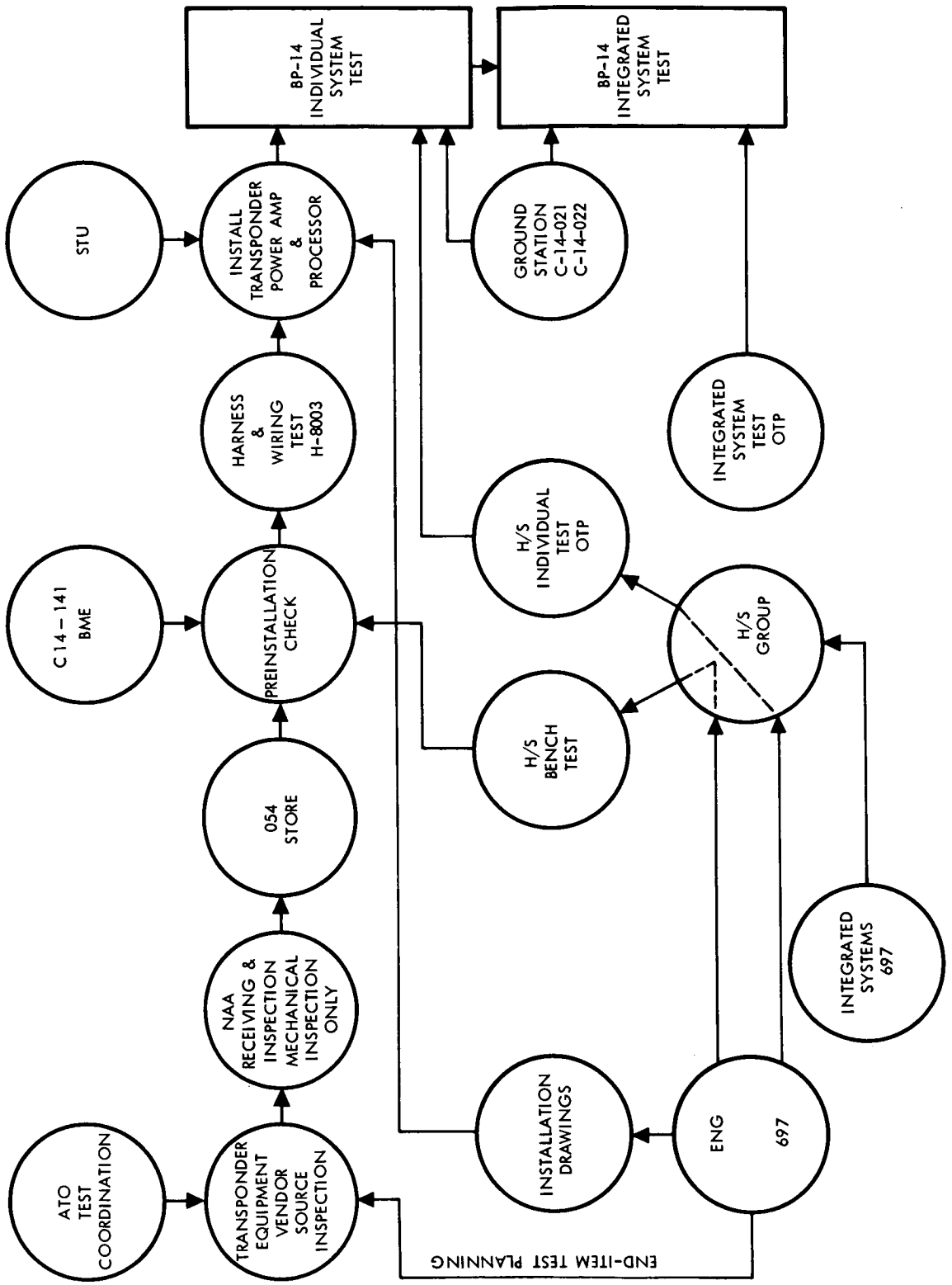

Figure 6-24. DSIF Transponder Power Amplifier and Premodulation Processor Test Flow

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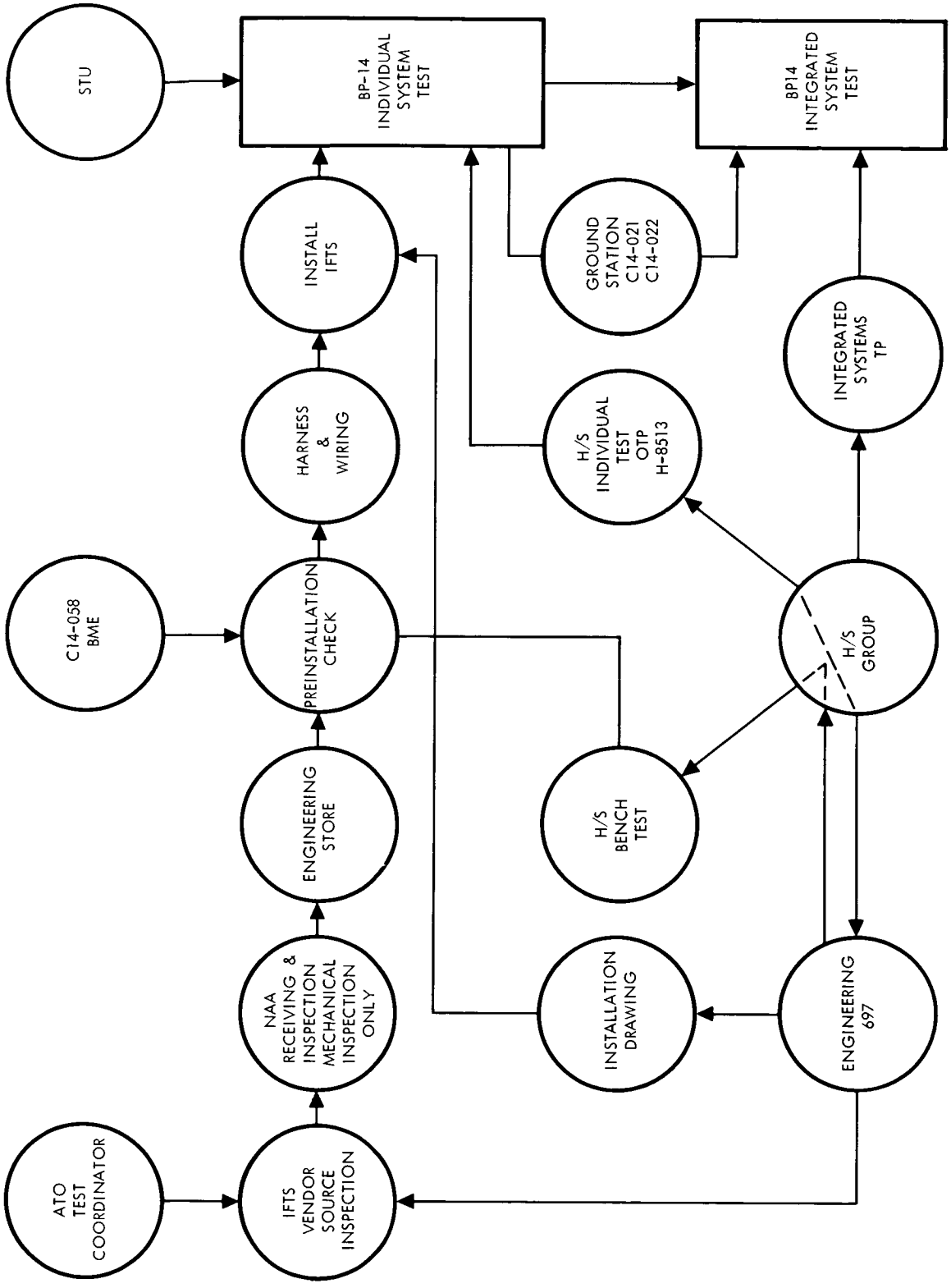

Figure 6-25. IFTS Test Flow

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6.2.5.9.4 SCS/GSE Interface (H-7503). This OTP will define the premate configuration of the STU and SCS systems. The GSE cable harness will be verified with the wire list of the spacecraft and SCS. A grounding check will be made to verify that no ground loops were introduced when mated with the GSE. GSE stimuli phasing, scale factors, and operation will be verified at this time.

6.2.5.9.5 SCS System Checkout (H-7505). This OTP will define the operation for a complete SCS checkout. Input power busses, SCS power supplies, SCS logic, failure modes, gains, and electrical phasing in various modes of operation will be verified utilizing the GSE and instrumentation. This OTP will provide the integrity of the SCS system as an identity for subsequent integrated tests with the SPS, RCS, and G&N systems.

6.2.5.9.6 SCS/RCS CM-SM (H-7506). This OTP shall verify the jet select logic for the C/M and SM RCS systems in various SCS modes of operation.

6.2.5.9.7 SCS/SPS Interface Check (H-7507). This OTP shall verify the SCS/SPS electronics for phasing and limiting characteristics during various SCS modes of operation.

6.2.5.10 Operational Test Procedures - Stabilization and Control System

Test Procedure No.	Title
H-7500	SCS preinstallation check
H-7501	SCS installation and alignment
H-7502	SCS post installation check
H-7503	SCS/GSE interface
H-7504	SCS subsystem checkout
H-7505	SCS system checkout
H-7506	SCS/RCS C/M and S/M
H-7507	SCS/SPS interface checks

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6.2.5.11.9 House Spacecraft Individual Test Operational Test Procedure. Individual test procedures will be generated using test requirements provided by Engineering. The test procedures will outline system checks after vehicle installation.

6.2.5.11.10 House Spacecraft Integrated Test Operational Test Procedure. Integrated test procedures will be established by house spacecraft test operations and used to verify system compatibility with all other systems installed in the test vehicle.

6.2.5.11.11 Ground Station. The ground station will support tests conducted in the house spacecraft facility. The ground station will provide specific data to the data group and to the system engineer. The station will record real time data and events.

6.2.5.12 Operational Test Procedures - Telecommunications System

Test Procedure No.	Title
H-8500	S-Band antenna measurements in-vehicle checkout
H-8501	HF, VHF and UHF antenna measurements in-vehicle checkout
H-8503	C-Band beacon antenna measurements in-vehicle checkout
H-8505	R&D telemeter in-vehicle checkout
H-8506	USBE high-gain antenna measurements and operation in-vehicle checkout
H-8507	Collins signal conditioner checkout
H-8508	Permod-Processor checkout
H-8509	Communications and instrumentation systems in-vehicle checkout
H-8035	Data storage system in-vehicle checkout
H-8036	Audio control and intercommunication system in-vehicle checkout
H-8510	USBE system in-vehicle checkout

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Test Procedure No.	Title
H-8038	VHF recovery beacon in-vehicle checkout
H-8511	VHF-AM transmitter and receiver in-vehicle checkout
H-8512	VHF-FM transmitter in-vehicle checkout
H-8041	HF transceiver in-vehicle checkout
H-8042	C-band transponder in-vehicle checkout
H-8043	PCM telemeter in-vehicle checkout
H-8513	IFTS in-vehicle checkout
H-8514	Combined TM measurement system in-vehicle checkout
H-8515	VCO modulator package checkout
H-8047	Television system in-vehicle checkout
H-8516	Flight technology instrumentation in-vehicle checkout
H-8517	Crew safety instrumentation in-vehicle checkout
H-8518	Central timing in-vehicle checkout
H-8519	SPS instrumentation in-vehicle checkout
H-8520	RCS-C/M instrumentation in-vehicle checkout
H-8521	RCS-S/M instrumentation in-vehicle checkout
H-8522	Structural low-voltage temperatures plus zone box in-vehicle checkout
H-8523	Structural high-voltage temperature in-vehicle checkout
H-8524	Structural low-level strain plus 10-volt power supply in-vehicle checkout

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Test Procedure No.	Title
H-8525	Structural high-level strain in-vehicle checkout
H-8526	Structural flux in-vehicle checkout
H-8527	Structural calorimeter in-vehicle checkout
H-8528	Structural pressures in-vehicle checkout
H-8529	Structural ablation plus 5-volt power supply in-vehicle checkout
H-8530	Structural CHAR plus 5-volt power supply in-vehicle checkout
H-8531	UHF up-data link in-vehicle checkout
H-8532	Operation procedure data acquisition equipment

6.2.5.13 G&N System (Figure 6-26)

6.2.5.13.1 Pre-Installation Checks.

6.2.5.13.1.1 The spacecraft G&N mounting brackets and surfaces will be inspected prior to the installation of G&N hardware, referencing structure assembly prints and G&N hardware assembly prints. Checks will also be made for cable routing holes, coolant connectors and lines, checkmounts, cable and coolant line clamps, and clearance for optics.

6.2.5.13.1.2 The compatibility between interfaces of the G&N system and the spacecraft harness will be verified prior to system installation. System engineers will compare, wire by wire, the spacecraft harness wire list with the specific AGE model and modification being installed.

6.2.5.13.1.3 House spacecraft engineers will observe the final sell-off of the G&N system in the Downey MTT laboratory. Following the successful sell-off, house spacecraft engineers will observe the transfer of G&N units to the transportation cart. They will evaluate handling methods, insure safety of critical items for transport, and ascertain that IMU temperature control is maintained - all prior to house spacecraft acceptance of the G&N system.

6.2.5.13.2 Spacecraft Installation (OTP-H-6500). The test procedure will define the steps required for complete installation, mechanical alignment, and fit check of the G&N system. It will call out the handling

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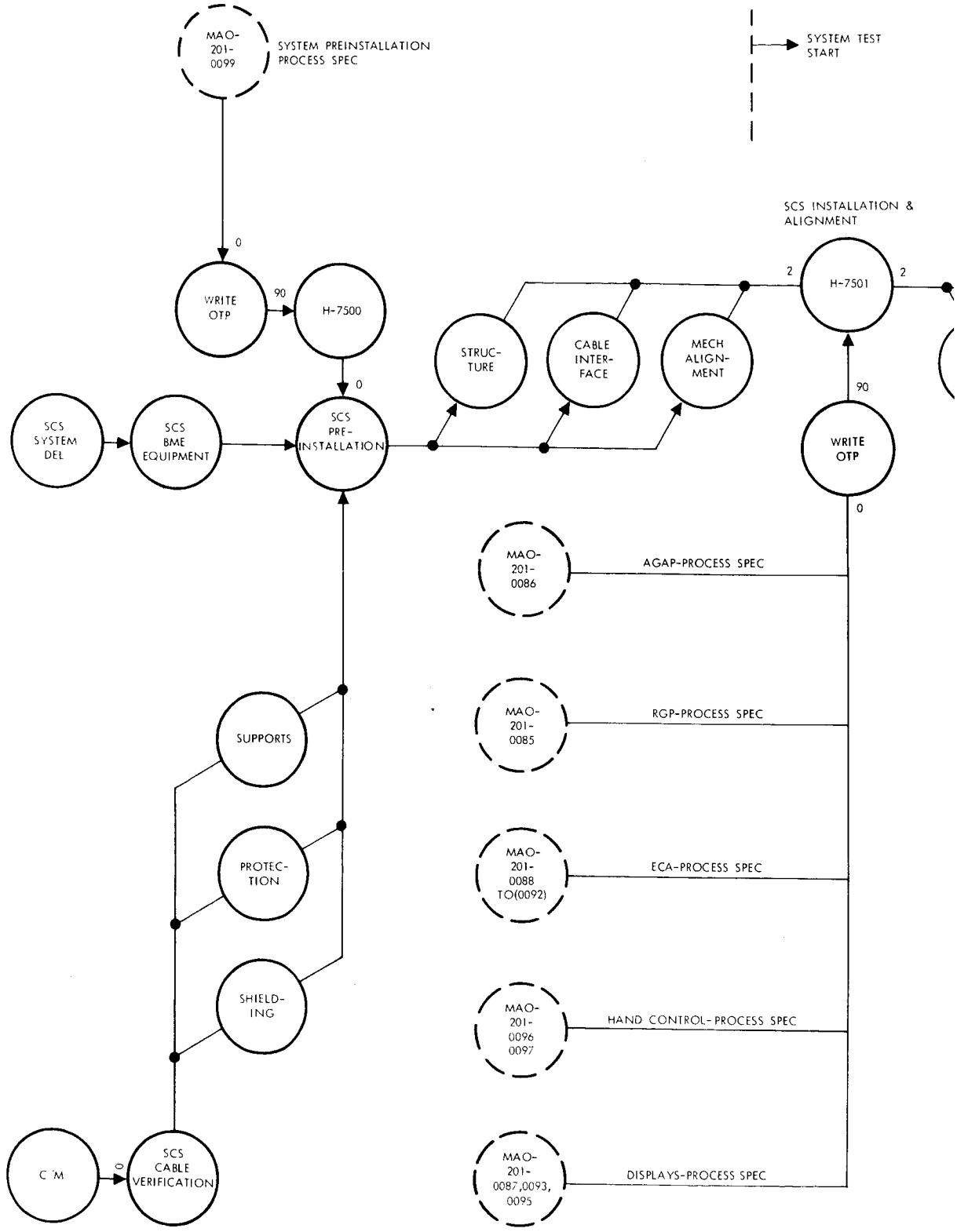
MAO-201-0099
SYSTEM PREINSTALLATION PROCESS SPEC
SYSTEM TEST START
SCS INSTALLATION & ALIGNMENT
0
WRITE OTP
90
H-7500
0
SCS SYSTEM DEL
SCS BME EQUIPMENT
SCS PRE-INSTALLATION
STRUC-TURE
CABLE INTER-FACE
MECH ALIGN-MENT
2
H-7501
2
90
WRITE OTP
0
MAO-201-0086
AGAP-PROCESS SPEC
MAO-201-0085
RGP-PROCESS SPEC
MAO-201-0088 TO(0092)
ECA-PROCESS SPEC
MAO-201-0096 0097
HAND CONTROL-PROCESS SPEC
MAO-201-0087,0093, 0095
DISPLAYS-PROCESS SPEC
SUPPORTS
PROTEC-TION
SHIELD-ING
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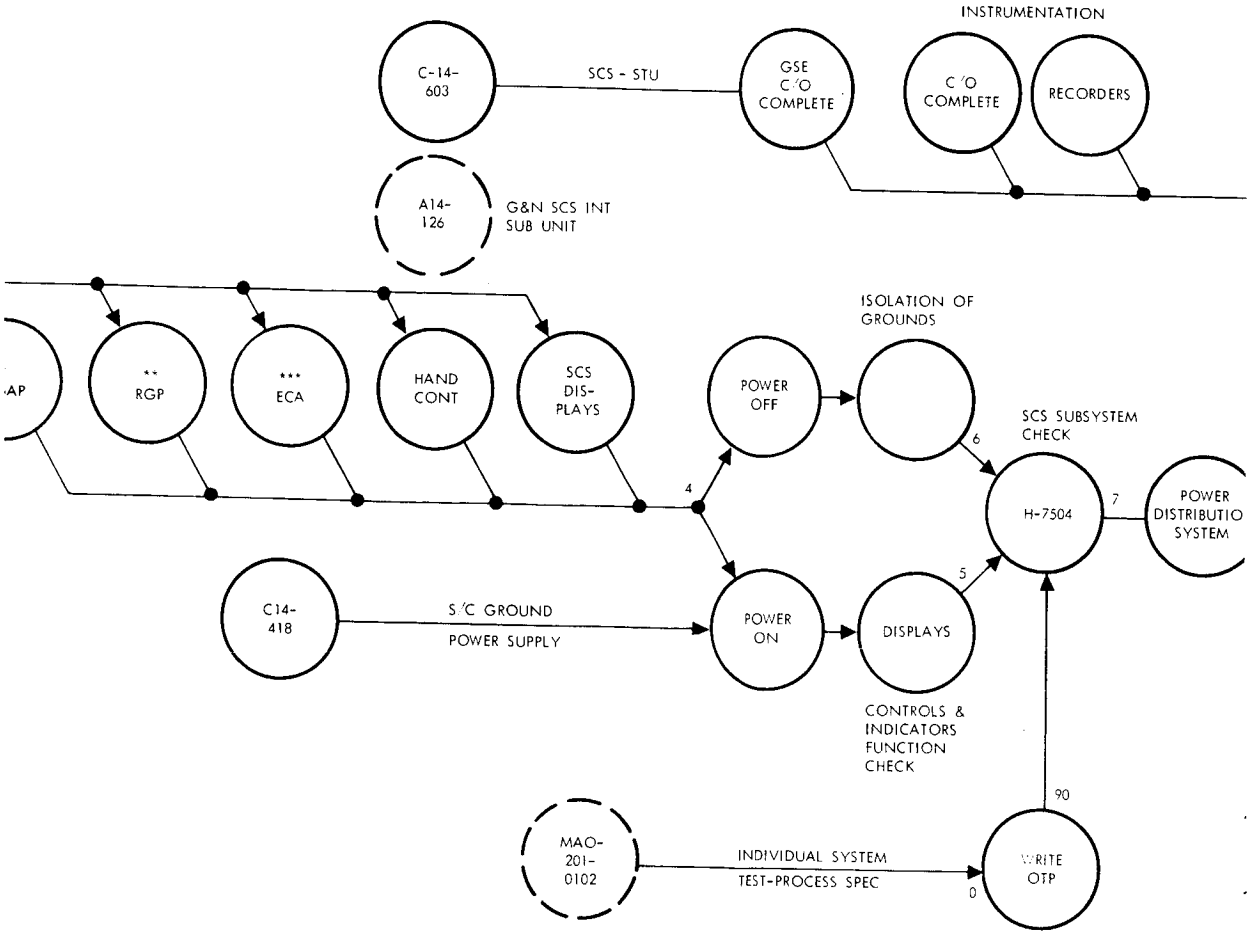
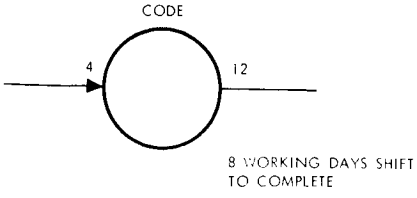
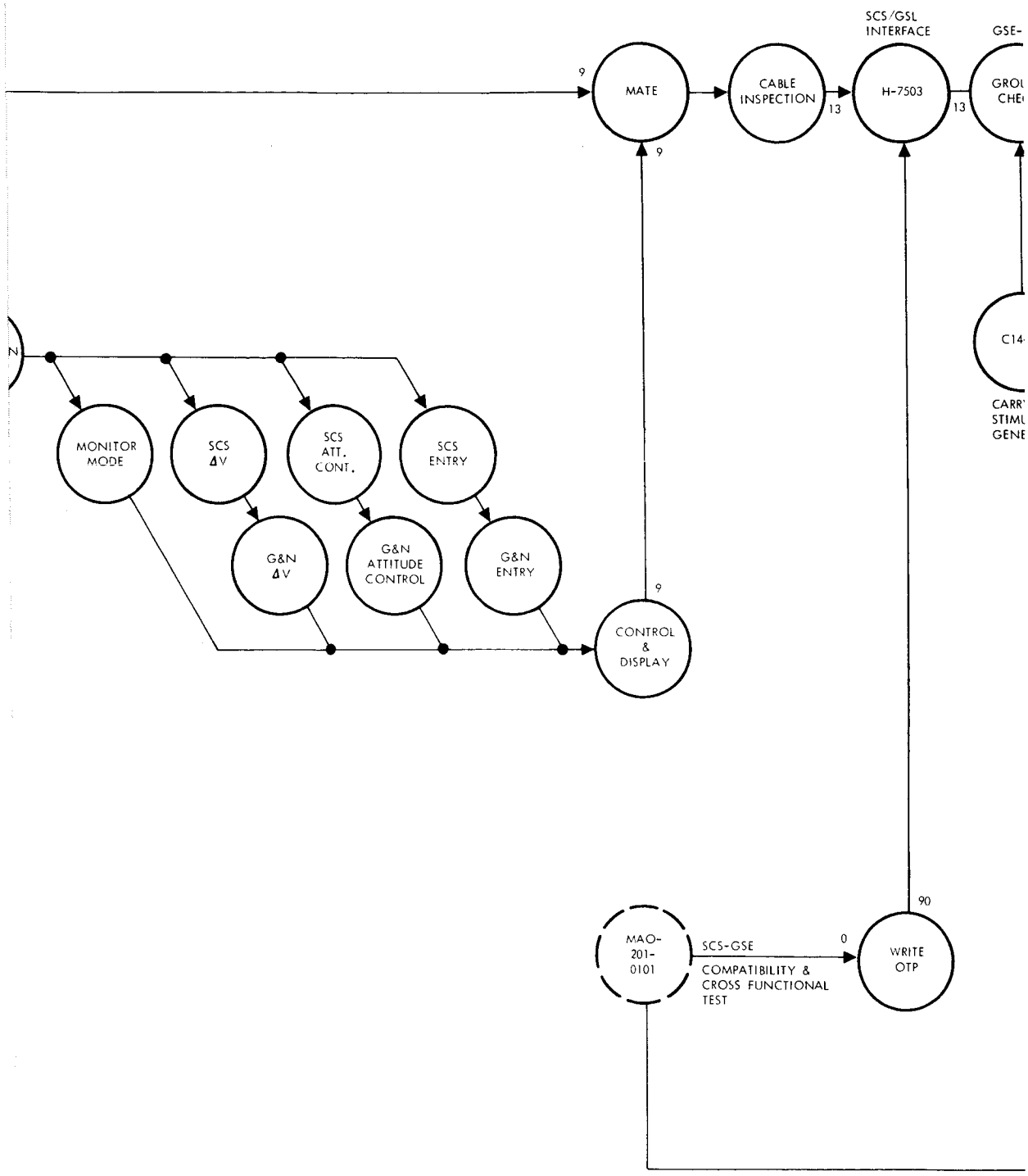
0
SCS CABLE VERIFICATION



NOTE:
* AGAP-ANGLE GYRO & ACCELEROMETER PACKAGE
** RGP -RATE GYRO PACKAGE
*** ECA -ELECTRONIC CONTROL ASSEMBLY




SCS/GSL INTERFACE
GSE-
9
MATE
CABLE INSPECTION
13
H-7503
13
GROU
CHE
9
C14
CARR
STIMU
GENE
N
MONITOR MODE
SCS ΔV
SCS ATT. CONT.
SCS ENTRY
G&N ΔV
G&N ATTITUDE CONTROL
G&N ENTRY
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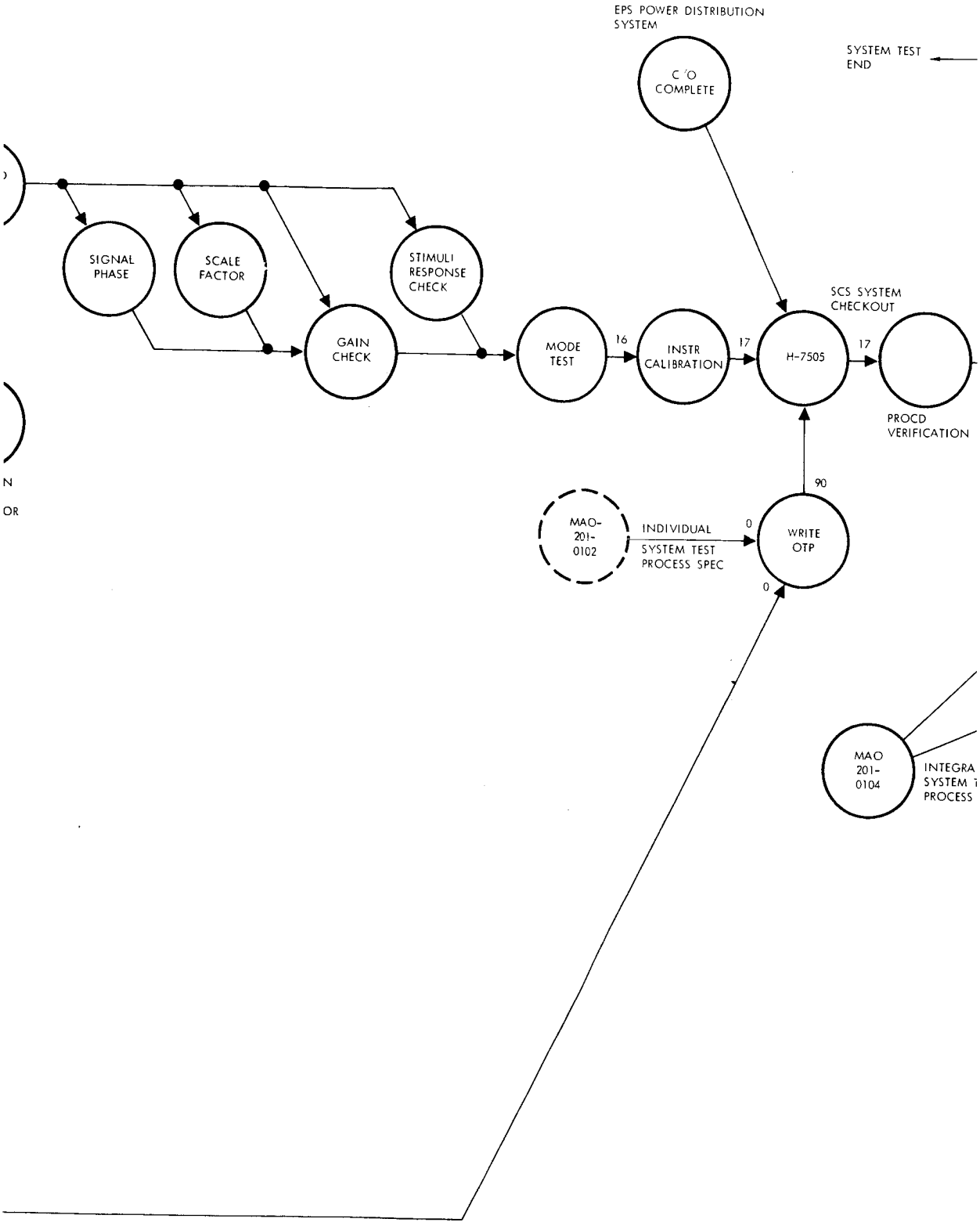
CONTROL & DISPLAY
90
MAO-201-0101
SCS-GSE
0
WRITE OTP
COMPATIBILITY & CROSS FUNCTIONAL TEST

NORTH


EPS POWER DISTRIBUTION SYSTEM
C 'O COMPLETE
SYSTEM TEST END
SIGNAL PHASE
SCALE FACTOR
STIMULI RESPONSE CHECK
GAIN CHECK
MODE TEST
16
INSTR CALIBRATION
17
H-7505
17
SCS SYSTEM CHECKOUT
PROCD VERIFICATION
90
MAO-201-0102
INDIVIDUAL SYSTEM TEST PROCESS SPEC
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WRITE OTP
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MAO 201-0104
INTEGRA
SYSTEM
PROCESS
N
OR

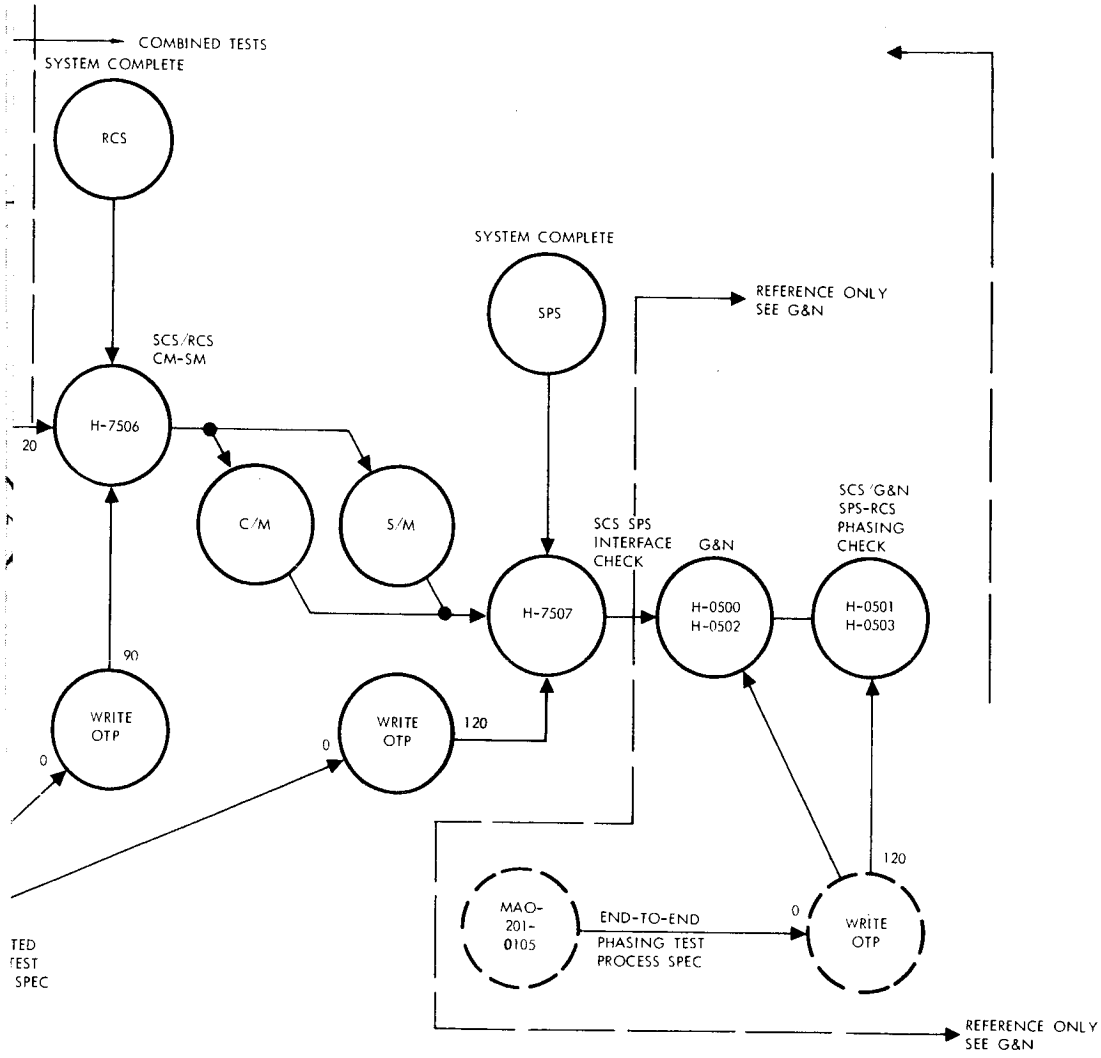

Figure 6-26. Guidance and Navigation Installation and Checkout (Boilerplate 14)

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equipment, the transfer of G&N units to command module mounting brackets, and outline the precautions required in mating these units to the brackets and fixed connectors. An evaluation will be made of special handling requirements. Steps will be provided for inspection of mounted hardware for stress and ease of installation and removal. The procedure will also provide the cabling order, coolant connections, and give instructions on IMU temperature protection during the installation period.

6.2.5.13.3 IMU Temperature Control (Past Installation, OTP-H-6501). This procedure describes the use of the inertial components temperature controller, the temperature alarm system, the limits of safety for the IMU, and remedial steps to be taken in case of alarm.

6.2.5.13.4 G&N-GSE Compatibility (OTP-H-6502). The compatibility between interfaces of the G&N system and the STU (plus PACE and STU carry-on equipment) will be verified prior to interconnecting. System engineers will compare actual wiring of the specific model and modification STU with the specific model and modification AGE installed in the spacecraft. This procedure will define the "premate-with-STU" switch configuration for the G&N control and display panels and the "premate-with-G&N" switch configuration for the STU. Additional considerations involving carry-on equipment and special test cables or devices will be outlined.

6.2.5.13.5 Power Application and Temperature Control (OTP-H-6503). This procedure will define the steps required to apply power to the G&N system to ascertain that the IMU temperature is being controlled in IMU STANDBY, to verify all G&N voltages in IMU OPERATE, OPTICS ON, AGE POWER ON, and to verify IMU temperature control when G&N power is fully applied. Input power busses will be varied between upper and lower limits and the resultant performance, with respect to G&N voltage and phase limits, will be evaluated.

6.2.5.13.6 Operational Checkout of G&N System (OTP-H-6504). This procedure will provide the checkout procedure for demonstrating proper operation of the installed G&N system. It will be written in discrete sections for ease of utilization during the testing sequence. The sections will include individual modes of operation, the guidance computer, the optics, gyro, and platform drift, gimbal friction, PIPA scale factor, local leveling and gyro compassing, etc. The procedure will seek to determine the conformance to mission requirements of the various modes of operation. Aging phenomena of the G&N system will be observed. The end objective is to insure proper design and operational integration of the G&N system with the spacecraft.

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6.2.5.13.7 Preliminary G&N-SCS Interface and Phasing Checks (OTP-H-6505). This procedure will describe the interfaces between the mated G&N and SCS. Signals to be checked include minimum impulse, attitude, attitude error, engine on, etc. Phasing of the signals supplied to SCS will be verified. Noise levels and transients will be monitored.

6.2.5.13.8 Unmated G&N/SCS/CM-RCS Interface Checks (OTP-H-0500). This is a test series to prove the compatibility between the G&N system and the command module SCS and RCS. In addition to checking the interfaces, signal phasing will be proven.

6.2.5.13.9 Dynamic G&N/SCS/SM-RCS/SPS Checkout (OTP-H-0501). This test series will prove the over-all vehicle compatibility and phasing with the C/M and S/M electrically mated. The procedure will check for ground loops, investigate noise levels and transients, and determine if loading conditions occur.

6.2.5.13.10 G&N/SCS/RCS/SPS Phasing Proof (OTP-H-0502). This test requires orienting the vehicle through discrete angles to prove body axis phasing requirements. A table of action-reaction requirements will be validated.

6.2.5.14 Operational Test Procedures - Guidance and Navigation System

Test Procedure No.	Title
H-6500	G&N installation
H-6501	G&N post installation
H-6502	G&N/STU interface (simulators)
H-6503	G&N subsystem checkout
H-6504	G&N system checkout
H-6505	G&N/SCS interface checkout

[redacted]

6.2.5.15 Integrated Systems Tests

After each system is subjected to a combined system checkout and test, as described in the forgoing paragraphs, the integrated systems test phase will begin. These tests will involve an entire system checkout with related and associated GSE to evaluate and determine the ability of the spacecraft systems to operate as a unit. The tests will verify design changes, interfaces, and the ability of the GSE to detect and isolate malfunctions, and will make other verifications and evaluations in support of the first manned flights.

6.3 CONFIGURATION

6.3.1 Test Vehicles (Figure 6-27)

House spacecraft 1 (B-14) will be a skeletal structure with removable skins to allow for mounting systems in their proper location. The command module, service module, and spacecraft adapter will be of this configuration. The spacecraft adapter will adapt the service module to the C-1 boilerplate structure. An escape tower of spacecraft structure will be utilized, and complete systems will be required. In the place of operational propulsion devices, expended or reject equipment will be used. Instrumentation operational measurement capability with provisions for additional test points in the line will be provided.

The command module, service module, spacecraft adapter, and escape tower configuration for house spacecraft 2 (Airframe 006) will be spacecraft structures. The command module will be equipped with a heat shield. The house spacecraft 2 will be equipped with complete systems. Launch escape motors and other propulsion devices will be simulated or will be expended or rejected equipment. Complete instrumentation capability will be required, including additional test points in and above the master measurement lists coordinated by ATO. The vehicle will also be equipped with instrumented anthropomorphic dummies. Refer to Table 6-1 for definitions, objectives, and requirements.

6.3.2 Configuration Control

The configuration of the house spacecraft vehicles will be maintained under rigid control. House spacecraft engineers will maintain a status board for applicable modules and GSE. Documentation, including CVR's established by Apollo Engineering and ATO, will be utilized. Program and schedule coordination is essential for maintaining up-to-date system status.

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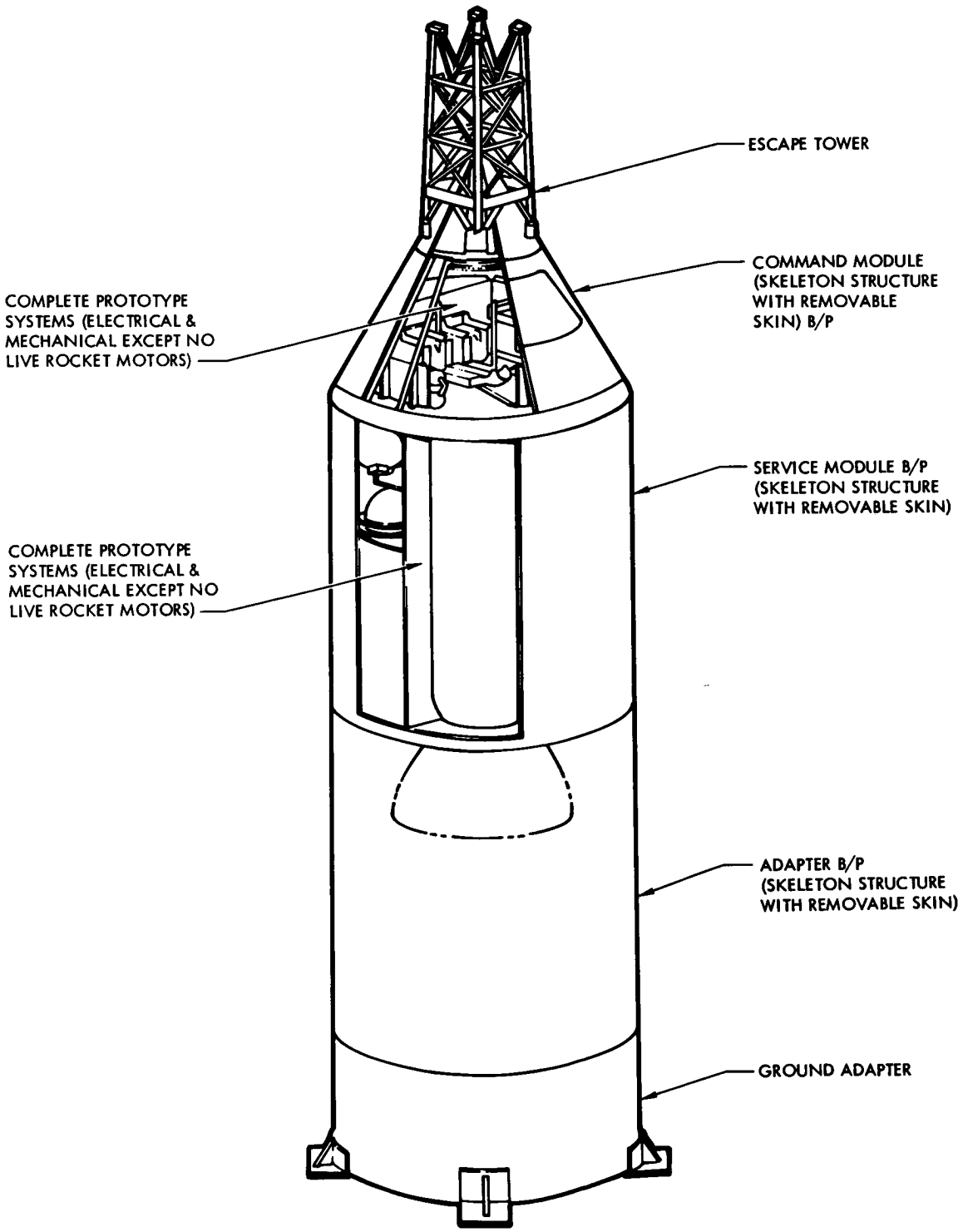

Figure 6-27. Boilerplate 14

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Configuration control is imposed through the S&ID CVR system to ensure reliability, interchangeability, compatibility, and maintainability. Status record documentation provided by the S&ID Program Control and Quality Control Groups will also be used. Coordination with respect to parts availability and EO action relative to other spacecraft systems and GSE will be considered in relation to house spacecraft configuration changes.

6.3.3 Modifications

Certain modifications may be made during the testing process without the release of engineering documents but with engineering approval. When these tests are completed, the system affected will be returned to its original configuration or held in its modified configuration pending EO authorization.

6.3.4 Maintenance

Due to the long testing program, a periodic maintenance schedule will be set up to maintain all servicing, repairs, and modifications, necessary to keep the spacecraft and GSE hardware in proper operational condition.

6.3.5 Configuration Requirements

6.3.5.1 General.

B-14 simulates the configuration of the Apollo spacecraft and has complete spacecraft systems installed except as modified herein. The boilerplate contains structural provisions for complete, partial, and/or simulated systems as defined herein. B-14 consists of escape tower (spacecraft structure - no rocket motors), command module, service module, S/C adapter, and ground adapter (GSE).

6.3.5.1.1 Command Module. The structure of B-14 C/M will be of spacecraft configuration with a skeletal structure and removable outer skin panel. The C/M outer mold line will not be offset as is the spacecraft C/M mold line. B-14 will have provisions for mounting all systems. The configuration of B-14 will be in accordance with S&ID drawing B16-000002-261.

6.3.5.1.1.1 Cabin Housing. The cabin housing will be a skeletal structure with removable outer skin consisting of the forward crew compartment and the aft crew compartment. The structure will be aluminum, consisting of the forward bulkhead, longerons, mid-ring, aft bulkhead, and removable aluminum skin.

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6.3.5.1.1.2 Main Hatch. The main hatch will be used for normal ingress and egress and consists of an opening only, without a cover.

6.3.5.1.1.3 Windows. B-14 C/M will be provided with windows to simulate the spacecraft windows, located as in the spacecraft.

6.3.5.1.1.4 Forward Access Way. The design will simulate the S/C forward compartment. The access way is a tubular structure of aluminum attached to the C/M forward bulkhead.

6.3.5.1.1.5 Aft Heat Shield. The heat shield will simulate the configuration of the S/C heat shield. The inner and outer skins are of glass laminations with a core of aluminum honeycomb. The shield will be mounted by three dummy struts to simulate S/C design.

6.3.5.1.1.6 Forward Compartment. The forward compartment will simulate S/C configuration. The design will also include provisions for installing subsystems as in the spacecraft.

6.3.5.1.1.7 Access. Access panels will be provided to permit ready access to the rear of all equipment bays from the exterior of the module.

6.3.5.1.2 Service Module. The structure of B-14 S/M is a skeletal aluminum structure, as required. The S/M will have removable aluminum skins on the outer structure for the mounting of systems. The mating of the S/M to the C/M and to the S/C adapter is by means of the separation systems. The S/M configuration is in accordance with B17-000002-171.

6.3.5.1.3 S/C Adapter. B-14 adapter will be a skeletal aluminum structure, as required. Mating to the S/M and GSE ground adapter, which simulates the top of S-IV, will be by means of the separation system and will be bolted instead of riveted as would be the actual S/C. Configuration of the B-14 adapter is in accordance with B18-000002-191.

6.3.5.1.4 Launch Escape Tower. The launch escape tower will be a spacecraft escape tower, without rocket motors. The configuration of B-14 escape tower is in accordance with V15-300100.

6.3.5.2 Equipment Installed

6.3.5.2.1 C/M Reaction Control System. B-14 will be of spacecraft configuration with the following exceptions. The C/M reaction control system will utilize one spacecraft module with a mock-up of the remaining module including exact spacecraft electrical functions and components. Rejected or test expended motors will be utilized.

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6.3.5.2.2 S/M Reaction Control System. B-14 will be of spacecraft configuration with the following exceptions. The S/M reaction control system will utilize one spacecraft configuration module with mock-ups of the remaining three, including exact spacecraft electrical functions and components. Rejected or test expended motors will be utilized.

6.3.5.2.3 Service Propulsion System. B-14 will be of spacecraft configuration with the following exceptions. The SPS will include one fuel, one oxidizer, and one pressure vessel of battleship construction. The remaining vessels will be mock-ups with exact spacecraft plumbing, electrical functions, and components.

6.3.5.2.4 Environmental Control System. The ECS for B-14 will be the same as in the S/C with the following exceptions. The ECS will include the complete cold plate equipment cooling loop; however, water-glycol will be supplied to this loop from a ground support heat exchanger. The S/M space radiators will be eliminated. In lieu of the space radiators, a simple closed-loop circuit will be provided, so that complete radiator switching circuitry can be duplicated.

Cryogenic tanks will be simulated by mock-ups provided with complete S/C configuration plumbing and a line through the mock-up tanks from the fill connectors to the regulators. All functioning items, such as valves, regulators, etc., will be of S/C configuration. Those environmental control system items associated with the waste management system, oxygen system, suit air circuit, and water system will be provided. All electrical functions and/or components throughout the ECS will be duplicated.

6.3.5.2.5 Mechanical Separation Systems. For functional simulation in house spacecraft operations, high-pressure stored gas and/or other means of simulation will be used to actuate the separation systems on B-14. No pyrotechnics will be utilized in this boilerplate.

6.3.5.2.5.1 Tower Separation System. This system for B-14 is of spacecraft configuration. A clean separation on all four tower legs will be functionally simulated during house spacecraft operations.

6.3.5.2.5.2 C/M to S/M Separation System. This system for B-14 will be of spacecraft configuration. Functional simulation of the separation by in-house 150 psi gas or by other means will be provided during house spacecraft operations.

6.3.5.2.5.3 S/M to S/C Adapter Separation System. This system is of spacecraft configuration and will simulate functional and electrical firing circuitry during house spacecraft operations. Bolts will be used in lieu of rivets to facilitate repeated separations.

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6.3.5.2.5.4 S/C Adapter to Ground Adapter Separation System. This system will be of spacecraft configuration and simulate functional and electrical firing circuitry during house spacecraft operations. The B-14 S/C adapter will be attached to the ground adapter, which simulates the S-IV interface, and will be bolted instead of riveted.

6.3.5.2.5.5 Forward Heat Shield Separation System. This system for B-14 will be of spacecraft configuration. Separation of the forward heat shield from the C/M will be simulated by utilization of 150 psi gas or other means. All electrical functions will also be simulated.

6.3.5.2.6 Electrical Power System. The B-14 electrical power system consists of fuel cells, mechanical accessories, solid-state inverters, battery chargers, distribution systems, control subsystems, and illumination subsystems, as in the spacecraft.

6.3.5.2.7 Crew Provisions.

6.3.5.2.7.1 Crew Couches. These are simulated spacecraft couches with dummy shock struts for the crew impact attenuation system.

6.3.5.2.7.2 Relief Fixtures. B-14 will be provided with fixtures only. Associated equipment, such as tubing and tanks, will be omitted.

6.3.5.2.7.3 Lighting Equipment. B-14 C/M lighting equipment will be of spacecraft configuration.

6.3.5.2.7.4 Personnel Communications. B-14 personnel communications will be of spacecraft configuration.

6.3.5.2.7.5 Survival Equipment. Simulated (dummy packages) spacecraft survival equipment will be required for B-14. This includes both sea and land survival equipment.

6.3.5.2.7.6 Restraint Subsystem. Restraint subsystems will be provided for crew members, as in the spacecraft. The systems will include harness restraint, foot restraint, arm restraint, and hand grips.

6.3.5.2.8 Guidance and Navigation System. B-14 will have a complete guidance and navigation system, such as used in the Apollo spacecraft.

6.3.5.2.9 Stabilization and Control System. The stabilization and control system for B-14 will be of spacecraft design. The system will consists of sensing elements, electronic circuitry, and control elements necessary to simulate the stabilizing and controlling of the vehicle.

[redacted]

6.3.5.2.10 Earth Landing System. A spacecraft earth landing system will be installed in B-14 in the forward compartment. The earth landing system will be in accordance with B16-957102. Operation of the earth landing system will be electrically simulated and include dummy chute packs.

6.3.5.2.11 Controls and Displays. Controls and displays will conform to the spacecraft configuration. B-14 will include the following:

1. Primary panel arrangements. This panel consists of pilot's control panel, co-pilot's control panel, and the engineer's control panel.
2. Couch controls
3. Left-hand consoles
4. Right-hand consoles
5. Lower equipment bay
6. Upper equipment bay
7. Left-hand equipment bay
8. Right-hand equipment bay
9. In-flight test panels
10. Cabin oxygen outlets

6.3.5.2.12 Electronic Interface. The electronic interfaces of B-14 will be as in the Apollo spacecraft except as mentioned herein.

6.3.5.2.13 Instrumentation. See SID 62-585, Apollo Hardware Utilization List. The list will be identical to that list for AFRM 009, whenever applicable, and will be upgraded for subsequent flight configurations.

6.3.5.2.14 Communications. Spacecraft communication equipment will be required for B-14. See SID 62-585, Apollo Hardware Utilization List.

6.3.5.3 Special Test Requirements

6.3.5.3.1 Ground Support Equipment (GSE). The ground support equipment used for handling, servicing, and checkout of B-14 will be referenced to SID 62-417, GSE Planning and Requirements. The GSE requirements will be kept up-to-date, whenever applicable for B-14, relative to addition of equipment or deletion of equipment.

6.3.5.3.2 Weight Data. The mass and center of gravity of B-14 will be determined after construction.

[redacted]

6.3.5.3.3 Design Criteria. Factors on limit load to yield and factors on on limit load to ultimate will be 1.0 and 1.5, respectively. Flexible hose, tubing, and fittings less than 1.5 inches in diameter will have a proof pressure of 2.0 times the limit pressure and a burst pressure of 4.0 times the limit pressure. Flexible hose, tubing and fittings greater than 1.5 inches in diameter will have a proof pressure of 1.5 times the limit pressure and a burst pressure of 2.5 times the limit pressure.

Special handling can be afforded B-14, where necessary. There is no requirement to consider air or truck transportation load criteria in design. The handling loads specified in paragraph 3.2.7.1 of Exhibit "B" of the technical specification for hoisting, jacking, and hauling (by slow moving dolly only) suffice for handling loads design criteria.

To the extent feasible, house spacecraft 14 will conform to electromagnetic interference (EMI) control in the design and fabrication phases of all equipment used. Furthermore, compatibility tests will then be performed to gauge the effectiveness of this control.

Testing to determine interference susceptibility and tolerance levels will be accomplished on all installed equipment, as time permits, and corrective measures will be devised and implemented. This will provide pertinent information necessary to implement effective EMI control on the flight vehicles.

6.3.5.3.4 Preparation for Delivery. This item has not yet been determined.

6.3.5.3.5 Environmental Requirements. B-14 will be operated and maintained in a white room facility.

6.3.5.3.6 Flight Usage. There will be no flight usage.

6.3.5.3.7 Test Responsibility. Test responsibility is assigned as follows:

1. Requirements: Engineering

2. Planning: Engineering and Apollo Test and Operations

3. Conduct: Apollo Test and Operations

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Table 6-1. House Spacecraft No. 2 - Definitions, Objectives, and Requirements

1. Definition: House spacecraft 2 consists of a spacecraft command module, spacecraft service module, spacecraft adapter, and spacecraft launch escape tower

2. Mission - General: Verification of systems performance and compatibility in and between major modules, associated GSE, and support of Airframe 008

3. Test Objectives:

   3.1 House Spacecraft Objectives:

      3.1.1 Verify performance of major systems
      3.1.2 Verify systems integration within major modules
      3.1.3 Verify systems integration between major modules
      3.1.4 Verify and evaluate GSE compatibility
      3.1.5 Evaluate in-flight maintenance capability
      3.1.6 Confirm development design changes prior to inclusion in actual flight systems
      3.1.7 Develop integrated checkout procedures
      3.1.8 Evaluate and develop operational procedures for vehicle and mission
      3.1.9 Verify performance to design specifications, including reliability

   3.2 Vibration and Acoustics Test Objectives:

      3.2.1 Prelaunch
      3.2.2 Launch
      3.2.3 Boost
      3.2.4 Separation
      3.2.5 Earth orbit
      3.2.6 Lunar and cislunar environment
      3.2.7 Reentry
      3.2.8 Earth landing
      3.2.9 Recovery

4. Configurational Requirements:

   4.1 C/M (spacecraft structure) with ablative heat shield
   4.2 S/M (spacecraft structure)
   4.3 Spacecraft adapter (spacecraft structure)

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Table 6-1. House Spacecraft No. 2 - Definitions, Objectives, and Requirements (Cont)

4.4 Launch escape tower (spacecraft structure)

4.5 Test articles will have complete spacecraft systems with LES motors simulated:

4.5.1 Launch escape motor
4.5.2 Jettison motor
4.5.3 Fixed thrust reaction rocket

4.6 Complete instrumentation capability will be required, including additional test points in and above the master measurement lists coordinated by ATO.

4.7 Anthropomorphic dummies (instrumented)

5. Special Test Requirements:

5.1 House Spacecraft Requirements:

5.1.1 GSE will be required for checkout, servicing, and handling.
5.1.2 Facility will require handling and storage capability for all systems, fluids, and gases (except those that are toxic or hazardous).
5.1.3 Exhaust and venting systems will be required.
5.1.4 Continuous updating of all systems to mission phase configurations will be required.

5.2 Vibration and Acoustics Test Requirements:

5.2.1 Vibration (S&ID)
5.2.2 Shock (S&ID)
5.2.3 Acoustics (pending investigation of wind tunnel exit or rocket engine exhaust suitability)

6. Test Responsibility:

6.1 House spacecraft Responsibility:

6.1.1 Requirements: Engineering
6.1.2 Planning: Engineering and ATO
6.1.3 Conduct: ATO supported by Engineering

6.2 Vibration and Acoustics Test Responsibility:

6.2.1 Requirements: Engineering, ATO, NASA, and associate contractors
6.2.2 Planning: Engineering, ATO, NASA, and associate contractors support tests under direction of S&ID

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Model Number	Nomenclature
C14-075	Propulsion system checkout group
C14-079	Propulsion system, BME
C14-084	Fuel cell power plant test stand
C14-089	Mobile data recorder
C14-092	Stabilization and control system, BME
C14-095	Stabilization and control system auxiliary, BME
C14-110	Environmental control system low pressure gaseous B/M test stand
C14-120	Environmental control system liquid test stand
C14-121	ECS major assembly, BME
C14-141	DSIF transponder and power amplifier, BME
C14-142	C-band transponder equipment, BME
C14-143	Communications and antenna equipment, BME
C14-163	Service module SPS propellant and quantity sensing system, BME
C14-166	R&D C-band coupler
C14-167	Service module RCS propellant and quantity gauging system, BME
C14-175	TV system BME
C14-178	Electrical cable set
C14-183	Cryogenic subsystem (BME)
C14-200	Carry-on command system decoder
C14-201	Carry-on command unit

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Model Number	Nomenclature
C14-202	Carry-on PACE-S/C interface "J" box
C14-210	Carry-on PCM system
C14-211	Carry-on signal conditioner and sampling unit 1
C14-212	Carry-on signal conditioner and sampling unit 2
C14-213	Carry-on signal conditioner and sampling unit 3
C14-214	Carry-on signal conditioner and sampling unit 4
C14-215	Carry-on signal conditioner and sampling unit 5
C14-220	Carry-on stimuli generator
C14-230	Data interleaving and command system
C14-231	External digital test command unit
C14-240	Servicing equipment PACE adapter
C14-241	Service equipment digital command system
C14-405	SITE - SC instrument test equipment
C14-407	Central timing equipment
C14-408	Thrust chamber assembly align
C14-413	LO_2 cryogenic storage subsystem BM equipment
C14-415	ECS water (BME)
C14-416	ECS water/glycol (BME)
C14-418	S/C ground power supply
C14-426	Pressure calibration unit
C14-427	Temperature calibration unit
C14-428	Flow calibration unit

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Model Number	Nomenclature
A14-029	GSE verifications substitute unit
A14-031	Command module fluid system substitute unit
A14-032	Service module fluid system substitute unit
A14-033	Suit loop stimuli generator
A14-034	Pressure distribution unit
A14-035	Vacuum cleaner
A14-037	Adapter and duct set (with A14-011)
A14-043	Protective closure, nozzle extension
A14-044	Nozzle closure (duct cover)
A14-045	Nozzle plug
A14-046	Control-crane, auxiliary
A14-048	Earth landing system, substitute unit
A14-051	Command module substitute unit
A14-052	Temperature controller (Fuel cell)
A14-053	Protective cover (fuel cell)
A14-054	Cover protective, LH_2 tanks
A14-055	Cover, protective, LO_2 tanks
A14-056	Link, gimbal locking (SPS)
A14-059	Fuel cell radiator sub unit
A14-060	Nozzle extension closure SPS
A14-062	Adapter sub unit

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Model Number	Nomenclature
A14-074	Load bank electrical
A14-084	Fuel cell substitute unit
A14-087	Inverter substitute unit
A14-125	Test set nozzle extension flange, leak test
A14-126	G&N/SCS interface substitute unit
A14-127	Nozzle extension inertia simulator
A14-128	Parachute system installation kit
A14-130	Nonsparking wrench set
A14-131	Nozzle plug, valve seal leak check
A14-135	C/M optical alignment support
A14-137	C/M substitute unit controller
A14-138	S/M substitute unit controller
C14-009	Crew systems checkout group
C14-017	Service propulsion engine alignment set
C14-021	Telemetry ground station (PAM/FM/FM)
C14-022	Telemetry ground station (PCM/FM)
C14-032	Antenna checkout group
C14-040	Command module and service module electrical power system, BME
C14-049	Command module and service module reaction control, BME
C14-058	In-flight test and maintenance system, BME

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6.4 INSTRUMENTATION REQUIREMENTS

6.4.1 Instrumentation Configuration

The house spacecraft instrumentation and communications systems will initially be equivalent to the systems installed on Airframe 009. These systems will be continually updated to the configuration of the latest flyable spacecraft.

Special instrumentation will be required, such as transducers, signal conditioning equipment, and recording equipment, peculiar only to the house spacecraft for support of engineering test requests. This special instrumentation will be utilized to investigate problem areas, develop proposed design changes, and perform prolonged evaluation of these changes.

Systems tests will be performed using checkout criteria equivalent to those used on current spacecraft configurations. In addition, tests will be performed utilizing modified criteria where changes in instrumentation, such as in sensor location, range, type, or method of acquisition, may be adopted.

6.4.2 Test and Calibration Procedures

End instruments or sensors will be provided by the Apollo Telecommunication Group. Initial requirements will be established by a coordinated effort between ATO and the engineering organization. End instruments will initially be routed to the Engineering Development Laboratory for a functional analysis and calibration verification and documentation. Calibration documentation will be detailed on IBM cards; each end instrument will be accompanied with its own card.

Installation of instrumentation on the test vehicle will be coordinated with the Apollo Telecommunications Group and with the various design groups concerned.

A system calibration for each type of measurement and for the associated signal conditioning equipment will be performed upon completion of installation. At this time a reverification of instrumentation sensors with the IBM documentation cards will be made

6.4.3 Data Acquisition and Recording

Systems performance data will be transmitted by coaxial cable (hardline) and by telemetry air link, as required, to the data acquisition and recording station in Building 290. This station will be capable of receiving both PAM/FM/FM and operational PCM signals and converting them to a

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proper format for recording. Magnetic tape recorders will be provided for simultaneous recording of all received data. Special measurements may be hardlined to the recording station for recording on graphic recorders or magnetic tape recorders. Optical oscillograph and event recorders will also be available in this station for real-time observation and quick-look playback. Two mobile data-recording consoles will be available in the test vehicle area; each will contain an oscillograph and an event recorder to provide quick-look data during special tests. Final data reduction of detailed combined systems tests will be accomplished by the Apollo data engineering station.

6.4.4 Master Measurement List

The Apollo instrumentation and data list as outlined for the first manned flight will be utilized as the basis for flight measurements, prelaunch checkout, inflight test, and astronaut display consideration in house spacecraft testing. Measurements are itemized in SID 63-564-1.

Due to test limitations, certain measurements that are directly connected to specific systems will be excluded from the list. This list will be revised periodically to meet changes and additions.

6.5 SUPPORT REQUIREMENTS

6.5.1 Support Equipment

The following equipment is required for house spacecraft 1 (B-14) operations.

Model Number	Nomenclature
A14-001	Launch escape tower substitute unit
A14-003	Pyrotechnic initiators substitute unit
A14-011	Ground cooling cart
A14-016	S/M Intermodule substitute unit
A14-019	Disconnect set, umbilical (fluid and electrical)
A14-026	Cap and plug set
A14-027	Adapter cap and plug set

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Model Number	Nomenclature
C14-429	UDL bench maintenance equipment
C14-441	Display and control system BM equipment
C14-442	Radio frequency system checkout unit
C14-444	FDS control unit SPS oxidizer
C14-445	FDS control unit SPS fuel
C14-446	FDS control unit C/M-RCS fuel
C14-447	FDS control unit S/M-RCS fuel
C14-448	FDS control unit RCS oxidizer
C14-449	FDS control unit helium
C14-450	External signal conditioner and PCM checkout unit
C14-451	ELS sequence pressure stimuli generator
C14-452	ELS sequence controller test stand
C14-453	High-gain antenna checkout unit
C14-454	Propellant quantity gaging system
C14-455	SPS checkout and monitoring remote control rack
C14-456	TM/STU signal isolation and distribution
C14-460	Mission sequence BM equipment
C14-466	Electrical junction box
C14-467	Breakout box test unit C/M and S/M adapter
C14-468	Freon pressurization unit
C14-469	Test set C/M test point access
C14-471	RCS nozzle flow sensor set

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Model Number	Nomenclature
C14-475	Carry-on STU signal conditioner
C14-476	Fluid distribution control unit LH_2
C14-477	Fluid distribution control unit LO_2
C14-478	Fluid distribution control unit water-glycol
C14-479	Fluid distribution control unit potable water
C14-480	Initiator stimuli unit
C14-483	RCS valve driver and monitoring unit
C14-484	S/M external signal conditioner
C14-600	Electrical power system
C14-601	Fuel cell support unit
C14-602	SPS checkout and firing unit
C14-603	SCS test unit
C14-604	G&N, test unit
C14-605	C/M-RCS checkout and firing console
C14-606	S/M-RCS checkout and firing console
C14-608	Fuel cell and cryogenics system
C14-611	STU - communication and data system
C14-612	STU - LES, ELS and crew safety system
C14-613	STU - test directors console
C14-614	STU - ECS
C14-615	STU - cryogenic oxygen servicing unit

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Model Number	Nomenclature
H14-002	Sling launch escape tower
H14-018	Escape tower support
H14-019	Command module equipment handling set
H14-021	GSE handling cart
H14-022	Service module sling
H14-024	Service propulsion motor sling
H14-030	Service module support
H14-031	Base support stand
H14-035	Maintenance stand
H14-042	Hoist beam, SM spacecraft adapter
H14-044	Parachute handling sling
H14-052	Positioning trailer, narrow base
H14-9056	Heat shield sling
H14-057	Forward compartment shield sling
H14-060	Fuel and oxidizer tank sling
H14-072	Mission propulsion engine support
H14-9073	Spacecraft sling (without LES)
H14-080	Fuel cell shipping container
H14-086	C/M support base
H14-089	Polarity checker
H14-098	Handling and installation set, reaction control system
H14-100	Workstand (B-2)

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Model Number	Nomenclature
H14-101	Workstand (B-1)
H14-102	Propellant tank sling
H14-103	Propellant tank dolly
H14-105	F-2 fixture dolly
H14-113	Sling S/M panel
H14-114	S/M panel storage rack
H14-115	S/M equipment install fixture
H14-116	Forward heat shield rack
H14-118	Container, shipping LO_2 tank
H14-119	Container, shipping LH_2 tank
H14-120	SPS engine support
H14-121	S/M equipment dolly
H14-124	Workstand, spacecraft integrated system test
H14-132	Dolly SPS engine
H14-134	Support base, integrated system test
H14-150	Storage rack, removable panels C/M
H14-152	Cable arm and tray set RF system checkout
S14-001	Module leak test unit
S14-002	N_2O_4 transfer unit
S14-003	Mass spectrometer leak tester
S14-005	Water transfer unit
S14-008	50-50 UDMH and N_2H_4 transfer unit
S14-009	Helium transfer unit

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Model Number	Nomenclature
S14-014	Fluid distribution system (house spacecraft)
S14-015	Battery charging unit
S14-019	Ethylene glycol water transfer unit
S14-022	Helium booster unit
S14-023	Pressure maintenance unit
S14-026	LH_2 transfer unit
S14-032	LO_2 transfer unit
S14-053	Ethylene glycol fluid trim control set
S14-054	Fuel cell power plant glycol service unit
S14-056	Mass spectrometer - hydrogen
S14-057	RCS oxidizer servicing unit
A14-058	Fuel ready storage unit
S14-059	Oxidizer ready storage unit
S14-062	Helium ready storage unit
S14-063	S/M-RCS servicing unit
S14-064	C/M-RCS servicing unit
S14-069	Moisture monitor unit
S14-071	Brazing unit
S14-076	Mobile GN_2 bottle rack
S14-079	Module leak test unit portable
S14-083	Portable LN_2 dewar
S14-084	Halogen leak detector unit
S14-091	Battery conditioner

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6.5.2 Facilities

The house spacecraft program will be accomplished primarily in Building 290 adjacent to Building 6. The program will utilize a high-bay area of approximately 5500 square feet in Building 290 (see Figure 6-28). The facility will also house the house spacecraft system support area of approximately 8500 square feet, which will be shared with other ATO operations. In addition, the house spacecraft program will utilize the Engineering Development Laboratory for vibration test and the Los Angeles Division chamber for acoustic tests. For additional house spacecraft facility requirements, refer to Section I of SID 62-153, Facilities Plan.

6.6 SAFETY REQUIREMENTS

The house spacecraft safety program will fulfill the requirements of the established safety policies of NAA.

In addition, the program will include certain standards of safety, sanitation, and health in accordance with federal, state, county, and city laws and regulations.

The following list of safety codes, regulations, and organizations issuing safety specifications will govern the interim and Building 290 facilities.

1. California Administrative Code (Title 8)
2. TB Med. 223, Respiratory Protective Devices
3. TB Med. 242, Health Hazards from Propellants, Fuels, and Oxidizers
4. TM 3-220, Decontamination
5. TB 3-250 Cl, 2, 3, Storage and Shipment of Dangerous Chemicals
6. 32-1, Ground Safety Manual (Air Force)
7. 58-4, Responsibilities of Missile Accident Prevention Program Regulation
8. USAF Fire Protection Program
9. ASME Code for Unfired Pressure Vessels

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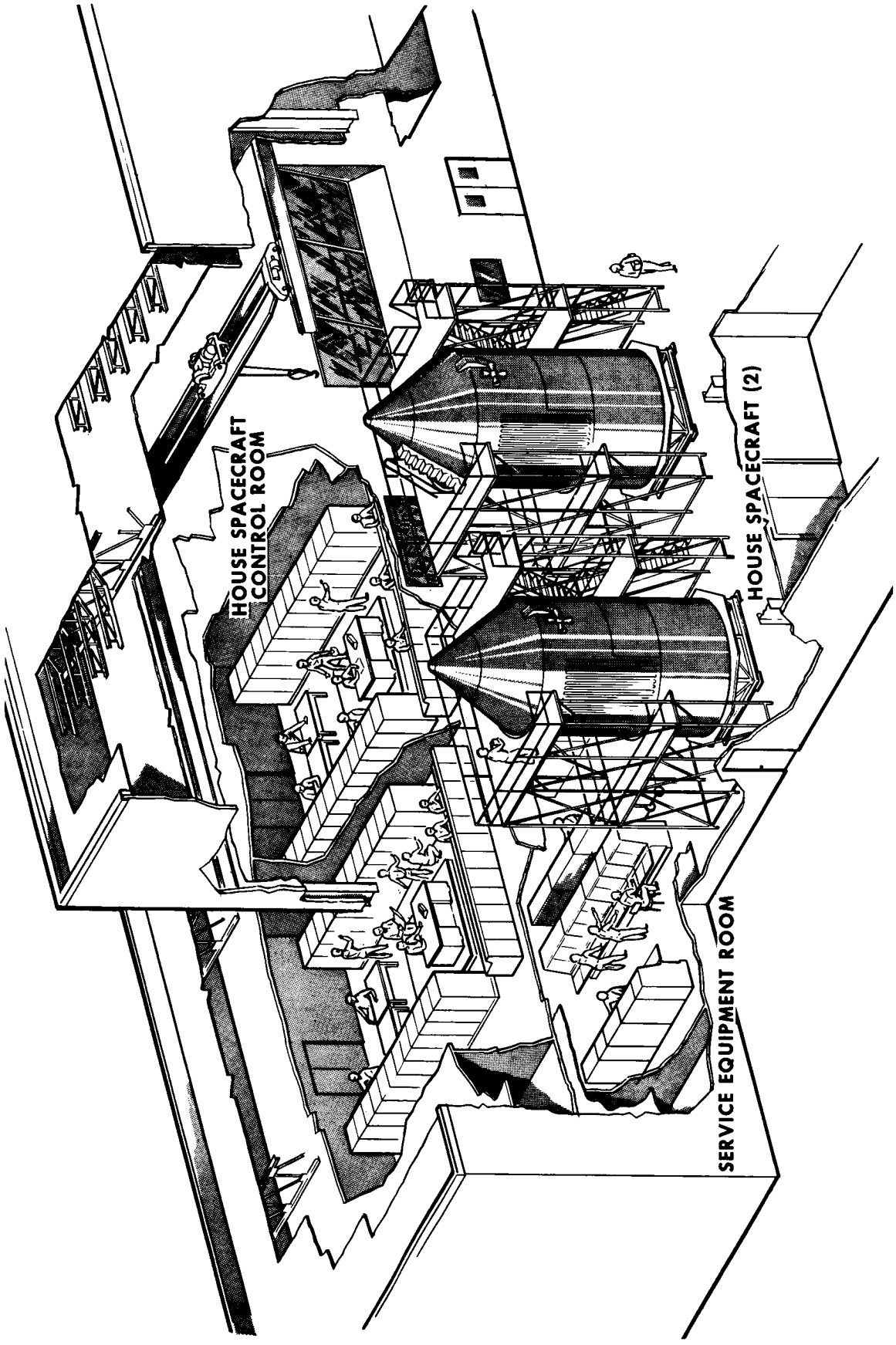

Figure 6-28. House Spacecraft Test Area in Building 290

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10. American Petroleum Institute

11. National Safety Council

12. America Standards Association

13. U. S. Army Ordnance Code

14. USAF Technical Orders for Safety

15. Walsh-Healy Public Contracts Act

16. NAA Safety Standards 500-F-1 through 500-F-13

The house spacecraft organization will provide and maintain modern safety devices and equipment for all employees engaged in work, when such devices are deemed necessary. Personnel safety devices which will be used are:

Hard hats
Goggles
Safety glasses
Face shield
Ear plugs
Gloves (cotton, leather, asbestos, and rubber)
Protective clothing
Boots (decontamination purposes)

6.7 DATA HANDLING AND ANALYSIS

6.7.1 Analysis and Evaluation

Raw test data will be analyzed and evaluated by personnel from the requesting Apollo engineering group, the data engineering group, and the responsible house spacecraft engineers. These groups will utilize data from tape recordings and will use computerized data results to a depth compatible with the required evaluation.

6.7.2 Test Reporting

All tests will be documented. The documentation will include a thorough description of the test, a presentation of test data, and an evaluation of those data. Preliminary reports will be issued on all test results that indicate need for immediate engineering action. Final formal test reports will be issued that will include a presentation of the results obtained in analysis and evaluation.

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6.7.3 Data Handling and Flow

Data will be acquired by hardline and RF link during the tests. These data will be recorded on magnetic tape for subsequent playbacks. Quick-look oscillograph and strip-chart records will be prepared during and immediately after a test to establish trends, obtain relative magnitudes, and detect problem areas. Upon completion of each individual test, data will be prepared for preliminary engineering review. These data will be completely identified, so that trends can be confirmed and so that areas of further reduction can be selected and initiated. Final processing will entail absolute magnitudes and computations for engineering distribution and for formal reporting. Physical data storage will include provisions for ready access and rapid retrieval.

6.7.4 Calibration Data

Calibrations are required for scaling of data. Instrument calibration data will accompany each piece of instrumentation delivered to ATO. These data will be verified upon installation of the instrumentation in the test vehicle. The updated calibration data will then be supplied to the data engineer for utilization in data reduction.

These data will be processed through a computer to produce a fitted calibration curve and oscillograph reading card and to update the master calibration tape. The curves and cards will be utilized for automatic data reduction.

6.8 GSE DETAILED TEST PLANS

6.8.1 Introduction

This section describes the GSE objectives, requirements, facilities utilization, and test phasing necessary in supporting detailed test plans for Boilerplate 14 equipment. The GSE detailed test program will cover requirements from acceptance through self-checkout, item verification, system phasing demonstration, and analysis and evaluation of GSE performance criteria.

6.8.1.1 Purpose

The purpose of this test plan is to provide background information for the GSE program development. The purpose of the GSE test procedure is to determine the feasibility of design, compatibility, performance, and interface of each item of GSE itself and its associated servicing equipment, facility, and spacecraft systems.

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6.8.1.2 Scope

The detailed test plan will establish the GSE objectives to provide over-all GSE performance requirements and interface information as necessary to accomplish checkout. From this plan, detailed test procedures will be developed, where necessary, providing a checkout sequence for the GSE item. The GSE test procedures for each item will be developed as the detailed information becomes available.

6.8.1.3 Amendments

Amendments to the detailed test plan will be incorporated on a quarterly basis, reflecting approved changes.

6.8.1.4 GSE Test Priorities

Based on GSE deliveries and GSE needs to support spacecraft systems, a GSE testing schedule will be developed in which priorities are assigned as follows:

1. Support of installing spacecraft system
2. Support of GSE-facility and associate GSE (compatibility)
3. Support of checkout spacecraft system
4. Test requirements

6.8.2 GSE Objectives

In demonstrating the GSE system performance it is necessary to establish objectives which will provide ground rules for testing. The test objectives for the GSE program are as follows:

1. Assure proper performance of GSE components and subsystems
2. Evaluate requested design modifications
3. Verify conformance to design specifications
4. Evaluate adequacy of GSE to detect and isolate malfunctions
5. Evaluate interface with other GSE and facilities
6. Develop operational procedures

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7. Prove GSE interface with spacecraft systems and facilities

8. Assess compatibility with spacecraft systems

9. Verify safety parameters

6.8.3 Program Requirements

6.8.3.1 General

The program requirements for boilerplate 14 are contained in SID 62-109, Volume V, Section 6.0. This report contains a detailed test plan with operating procedures and support requirements to accomplish house spacecraft checkout.

6.8.3.2 GSE Delivery

Based on spacecraft system deliveries and program testing requirements, a date of delivery for each item of GSE to support the Boilerplate 14 test program is established. Paragraph 6.5.1 contains the GSE requirements for Boilerplate 14.

6.8.3.3 GSE Phasing Plan

Figures 6-29 and 6-30 are phasing charts showing receipt and planned usage of the GSE.

6.8.4 Facilities

House spacecraft 1, Boilerplate 14, will be delivered to ATO House Spacecraft Group by S&ID Manufacturing. Available spacecraft systems will be installed in the boilerplate, and available GSE will be self-checked and will be used to support installation of spacecraft systems. Building 290 will provide facilities for checkout control rooms, service equipment rooms, telemetry rooms, work stands, base supports, and facility controls to support GSE and systems checkout.

6.8.5 Safety Requirements

Refer to Paragraph 6.6.

6.8.6 Procedures

Refer to Paragraph 6.2.4.

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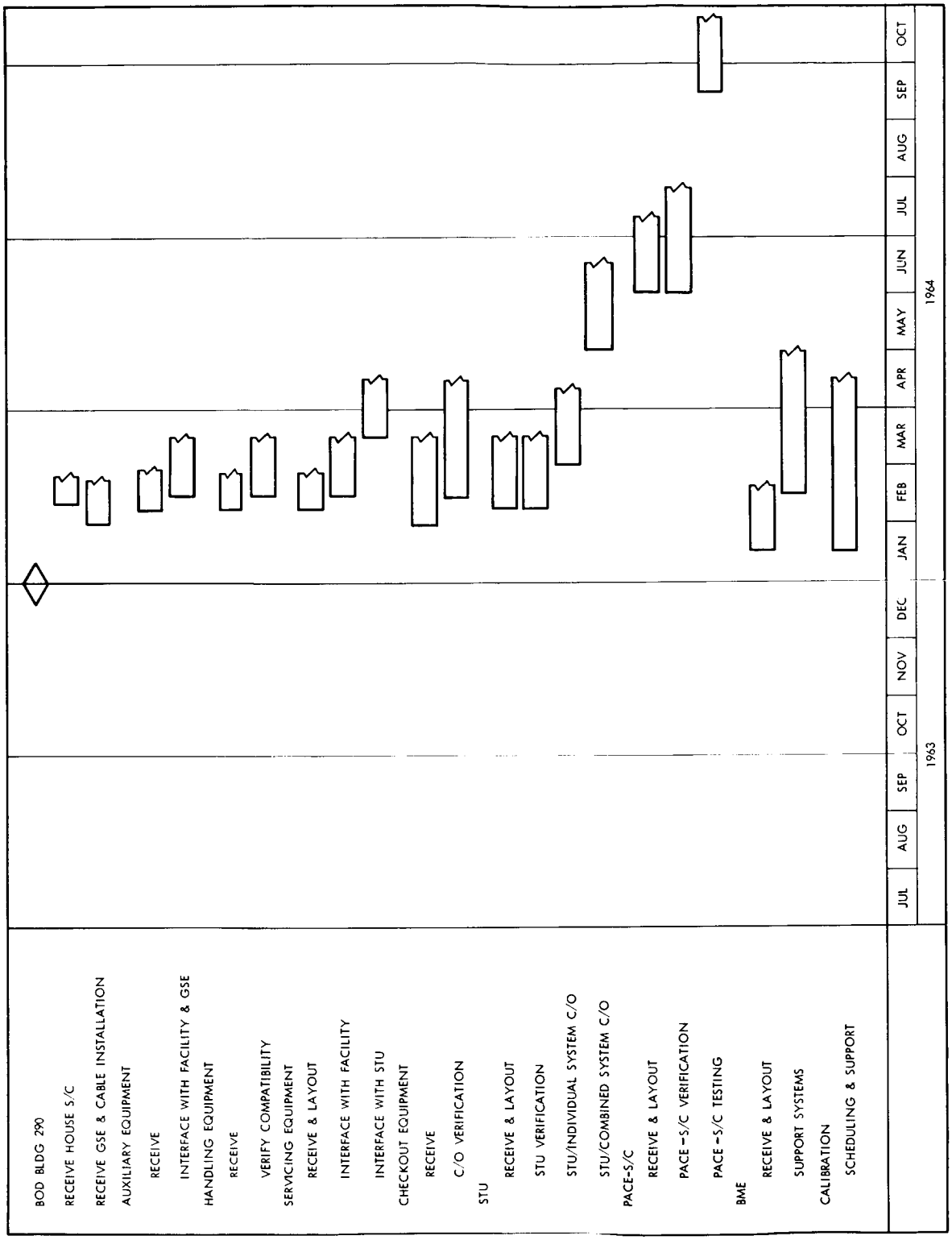

Figure 6-29. GSE Phasing Plan

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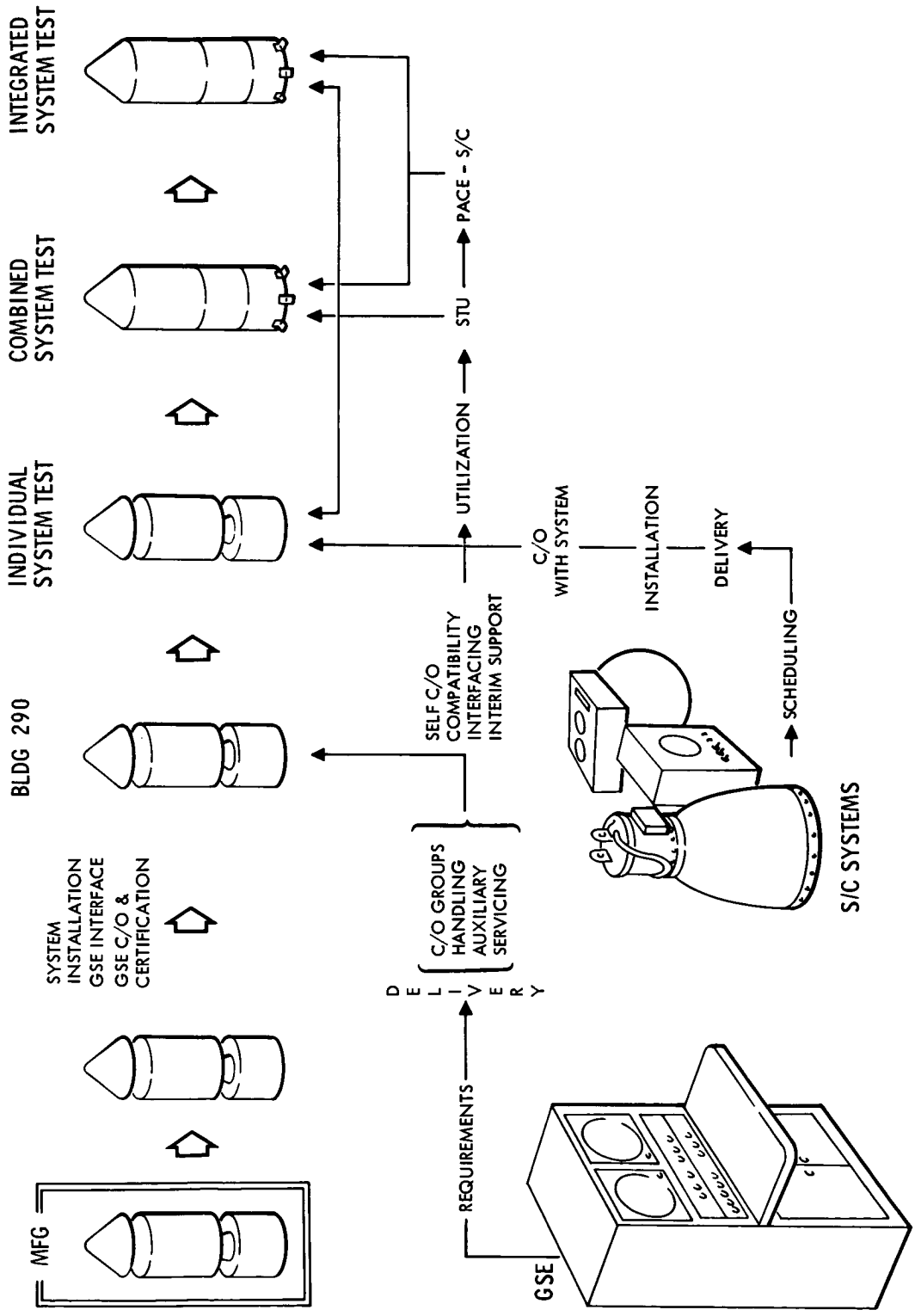

Figure 6-30. GSE Utilization

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6.8.7 General GSE Test Phasing

In general, GSE will follow the same path from receipt checkout through interfacing with spacecraft systems. The general flow structure which GSE will follow is given in the following paragraphs.

6.8.7.1 Receipt of GSE

Upon receipt, all items of GSE will be visually inspected for damage and obvious defects. At this time accountability for all associated equipment and known shortages will be recorded, and necessary measures will be taken to obtain complete GSE systems packages.

6.8.7.2 Installation

After a visual check, each item must be checked for compatibility with the facility (Building 290), confirming location, position, and facilities electrical and fluid interfaces.

6.8.7.3 GSE Self-Checkout

Certain items will undergo self-checkout prior to any spacecraft system checkout or other GSE integration. This checkout will consist of a continuity check, a potential verification check, and any other self-checking methods necessary to show that the GSE item will function properly. The individual GSE test plan and test procedures will be used in establishing and performing the self-checkout.

6.8.7.4 System Phasing

After a self-checkout of each item, it will in some cases be necessary to interface the GSE with its associated servicing equipment or be cross checked, prior to spacecraft system hook-up. When the GSE is performing properly, system interfacing may be accomplished.

6.8.7.5 Test Scheduling

Based on spacecraft systems availability and the GSE necessary to support the spacecraft system, a testing schedule will be developed.

6.8.7.6 Individual System Testing

Individual system tests will be performed after spacecraft systems have been installed in the spacecraft. These tests will determine individual spacecraft system performance, as well as GSE-spacecraft system compatibility, and will continue throughout the house spacecraft program as

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necessary to eliminate malfunctions and to checkout modifications to either GSE or spacecraft systems.

6.8.7.7 Combined System Testing

Combined system tests will involve a building block program, interfacing two or more spacecraft systems and GSE. Combined testing will provide for greater application of the auxiliary and servicing equipment, verifying their interfacing with the spacecraft system and GSE. The STU will be used to conduct both individual and combined system tests.

6.8.7.8 Integrated System Testing

Integrated system tests will follow the combined system tests. They will be conducted in an automatic mode, using computer programming to establish and verify integrated spacecraft systems interfacing and to develop sequence operations for complete spacecraft systems checkout. The PACE-S/C will be utilized in conducting these tests.

6.8.7.9 Maintenance Phasing

During all phases of testing, various GSE modifications and calibrations will be necessary. These will be accomplished, as well as malfunction isolation, with the GSE item itself. GSE self-checkout capabilities will facilitate this type of detection and calibration verification. A detail maintenance plan for the house spacecraft will be developed.

6.8.8 Detailed Tests

6.8.8.1 General

A GSE test procedure will be the guide for a systematic sequence checkout of each unit of GSE. It will be essential to verify GSE design characteristics and performance capabilities.

6.8.8.2 Objectives

The basis for objectives in establishing test procedures for all GSE will be as follows:

1. Define and prove performance of the circuit and mechanical functional characteristics

2. Determine and evaluate functional parameters and values, such as stability characteristics, environmental conditions, stress values, signal conditions, etc.

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3. Perform full scale evaluation of the GSE employing available self-checkout capabilities and various measuring devices.

4. Demonstrate GSE - facility compatibility and interfacing as necessary to facilitate checkout and operation

6.8.8.3 Operational Test Procedures

6.8.8.3.1 Requirements. Operational test procedures will be required to facilitate sequential testing at various levels. These test procedures will be developed for areas such as installation in facility, components compatibility, and interfacing with associated GSE. The guide for preparation and implementation of operational test procedures is contained in ATO Job Instruction Manual 110.

6.8.8.3.2 GSE OTP Requirements for STU Verification.

Test Procedure No.	Title
H-9500	Electrical power STU C14-600 and associated GSE checkout
H-9501	Fuel cell heater support STU C14-601 and associated GSE checkout
H-9502	Fuel cell and cryogenic system STU C14-608 and associated GSE checkout
H-9503	ECS/STU C14-614 and associated GSE checkout
H-9504	SCS/STU C14-603 and associated GSE checkout
H-9505	RCS/C/M and fire control STU C14-605 and associated GSE checkout
H-9506	RCS/S/M and fire control STU C14-606, and associated GSE checkout
H-9507	SPS and firing unit STU C14-602 and associated GSE checkout
H-9508	Communications and data subsystem STU C14-611, RF systems checkout, unit STU C14-442, and associated GSE checkout

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Test Procedure No.	Title
H-9509	Guidance and control system STU C14-604 and associated GSE checkout
H-9510	Sequential systems STU C14-612 checkout
H-9511	Cryogenic LO_2 servicing STU C14-615 and associated GSE checkout
H-9512	Test director's console C14-613 and associated GSE checkout

6.8.9 GSE Utilization

6.8.9.1 Individual Systems Test

After installation of spacecraft systems in the spacecraft, individual system testing will be accomplished. During this phase, GSE will be interfaced with spacecraft systems to detect and isolate systems malfunctions and to verify GSE compatibility with these systems and facilities. STU and its associated servicing equipment will be utilized during this testing phase. The test objectives are to:

1. Verify individual major system performance
2. Assure proper performance of components and subsystems
3. Verify system conformance to design specifications
4. Assess GSE compatibility with systems
5. Evaluate requested design modifications
6. Determine malfunction modes, limits, and trends
7. Evaluate GSE capability to detect and isolate malfunctions

6.8.9.2 Combined System Testing

In order to evaluate system compatibility and GSE adequacy, it is necessary to exercise the spacecraft systems in a combined system test checkout. The purpose of this combined system testing is to evaluate, verify, and demonstrate systems and GSE compatibility. Individual systems checkout and GSE verification will be accomplished during the individual systems checkout testing phase.

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The objectives of the combined system testing are to:

1. Verify systems integration in and between major modules
2. Evaluate adequacy of GSE to detect and isolate system failure
3. Establish reliability and confidence levels during simulated flight missions
4. Evaluate in-flight maintenance capability
5. Determine electromagnetic susceptibility levels
6. Confirm design modifications as developed during systems and GSE evaluation
7. Determine acceptability of design specifications
8. Determine system reliability as a function of operating time, specific functional limits, and environmental conditions
9. Develop systems checkout procedures
10. Verify that all equipment, procedures, and checkout environments are designed for optimum crew safety

To accomplish these objectives, it is necessary to have an adequate GSE checkout group to detect and isolate system malfunctions, as well as facilitate combined checkout of systems. This GSE checkout group (STU) will contain checkout consoles with electrical and mechanical devices to stimulate the spacecraft systems and condition their responses for operator analysis. The STU checkout group will provide the capability of local/manual selection for appropriate interconnections with spacecraft systems to permit the entire vehicle or any portion of it to be tested. Test setup, test procedures, intersystem calibration and alignment, and engineering modifications will be accomplished during this testing phase and will verify the mechanical and electrical interfaces of the spacecraft systems. The high degree of flexibility of STU design will provide for intersystem detection and isolation of malfunctioning equipment and permit spacecraft/GSE integration and verification. STU will be used for local/manual test operations required in integrated systems tests. The STU checkout equipment will be located in the control room, and the service equipment will be located in the service equipment room in Building 290.

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The monitoring and control functions contained in the following equipment are required for the STU checkout group

Model Number	Nomenclature
C14-442	STU - RF systems checkout unit
C14-600	STU - EPS checkout unit
C14-601	STU - fuel cell support checkout unit
C14-602	STU - SPS checkout and firing
C14-603	STU - SCS
C14-604	STU - guidance and navigation system
C14-605	STU - C/M-RCS checkout and fire console
C14-606	STU - S/M-RCS checkout and fire console
C14-608	STU - fuel cell and cryogenics system
C14-611	STU - communication and data system
C14-612	STU = LES, ELS, and crew safety system
C14-613	STU - test director's console
C14-614	STU - ECS
C14-615	STU - cryogenic LO_2 servicing

The combined system testing will be accomplished as second phase testing in Building 290 and will verify that the systems are functioning properly both individually and as combined systems prior to the use of PACE-S/C. Figure 6-31 is a simplified block diagram of a typical combined system test setup.

6.8.9.3 Integrated Systems Test

Integrated system tests are tests to establish and verify the flight readiness of the spacecraft. The objective is to enhance the probability of mission success. STU will be used for local/manual operational checkout of the integrated system tests, prior to the utilization of PACE-S/C.

[redacted]

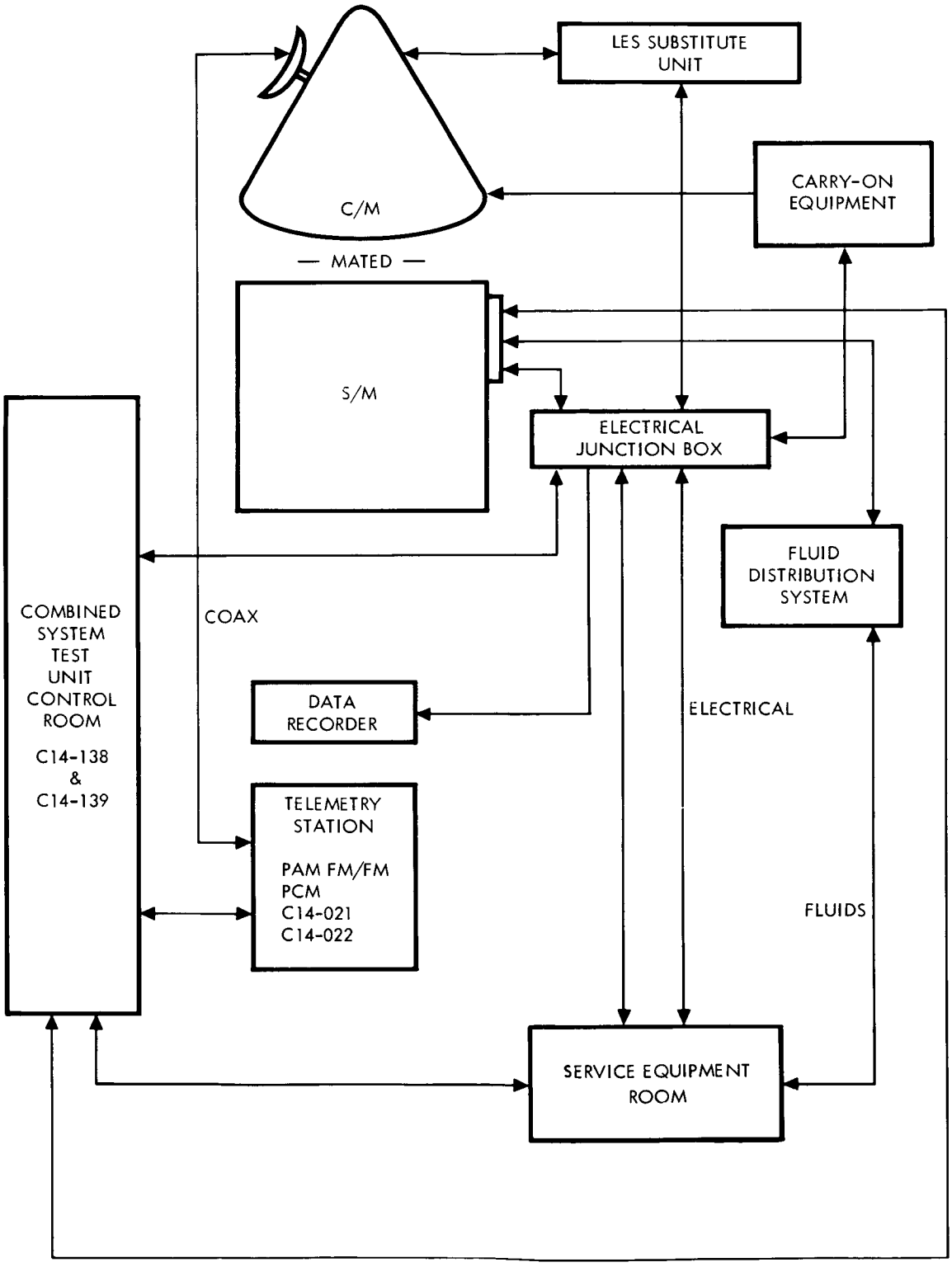

Figure 6-31. Typical Combined System Test Setup (Simplified)

[redacted]

PACE-S/C will have manual and automatic test modes capable of functional checkout, verification of the spacecraft, and certification and maintenance of spacecraft flight readiness. PACE-S/C will be operated from a control room in Building 290 and will be used for operational checkout of the spacecraft for malfunction detection and isolation to the level of replaceable subsystem units. The capability of the PACE-S/C equipment to validate many parameters and detect out-of-sequence events is a primary requirement in achieving high confidence levels. During the checkout phase, the operating procedures will be updated and verified.

A complete set of PACE-S/C equipment is required for house spacecraft 1 activities and consists of the following groups:

1. Spacecraft carry-on command and response system
2. Digital test command and response systems
3. Servicing equipment
4. PACE-S/C control room consoles and computer complex

Figure 6-32 is a simplified block diagram of a typical PACE-S/C integrated systems test setup.

6.8.10 GSE Training

The majority of training will be on-the-job training utilizing actual hardware. Throughout the testing program, there will be various spacecraft systems and GSE training courses provided by S&ID and subcontractors. Some subcontractors will provide training and familiarization courses at their plants. As information on courses becomes available, a schedule will be developed to provide course quotas for GSE personnel.

6.8.11 Documents

The basic documents to be used in carrying out the GSE test plan will be the GSE unit instruction manuals provided by subcontractors or contractors and various S&ID-GSE documents, including:

SID 62-50	Apollo GSE Specifications
SID 62-417	GSE Planning and Requirements
SID 62-1367	Apollo Checkout and GSE Concept

[redacted]

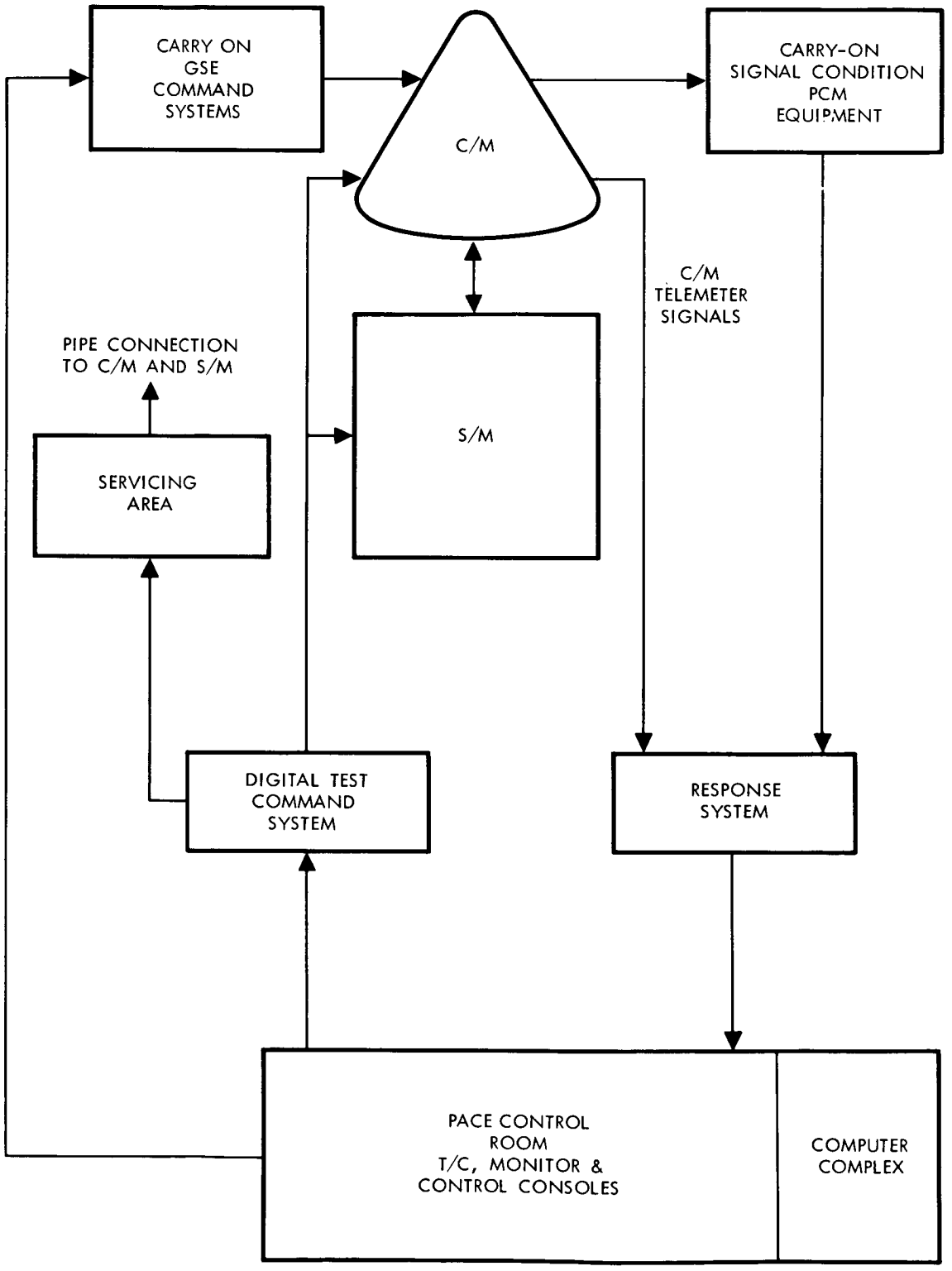

Figure 6-32. Spacecraft Integrated Systems Test Setup (Simplified)

[redacted]

[redacted]

SID 62-109-5	General Test Plan Apollo
SID 62-702-2	Apollo Maintenance Plan
SID 62-1450	Apollo Ground Support Equipment Plan
SID 62-243	GSE End Item Shop Release Report

Additional NASA documents and military specifications applicable to the testing program will be added as they become available. There will be a complete blueprint file containing wire diagrams and detailed schematics on the GSE available in Building 290 to support the units.

[redacted]

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NOMENCLATURE

A listing of the special nomenclature and abbreviations used in this report is presented. These listings may appear interchangeably with their full definitions in the text. Accepted abbreviations for units of physical measurement such as volts, ohms, etc. are not included.

Abbreviation	Definition
AEDC	Arnold Engineering Development Center
AFMTC	Air Force Missile Test Center
AFRM	Airframe
AGAP	Attitude gyro and accelerometer package
AGC	Aerojet-General Corporation
AGC	Automatic gain control
AGC	Apollo guidance computer
AGREE	Advisory group on reliability of electronic equipment
AMR	Atlantic Missile Range
ATO	Apollo Test and Operations
BAL	Balance
BCD	Binary coded decimal
B-#	Boilerplate - # (with specific number)
B/M	Bench maintenance
BMAG	Body-mounted attitude gyros
BOD	Beneficial occupancy date
B/P	Boilerplate

[redacted]

[redacted]

Abbreviation	Definition
CCMTA	Cape Canaveral Missile Test Annex
C&D	Controls and displays
CDS	Communications and data subsystems
CDU	Coupling display unit
CG	Center of gravity
C&IS	Communications and instrumentation system
C/M	Command module
C/O	Checkout
C-O	Crew operated
CP	Control panel
CTU	Central timing unit
CVR	Change verification record
DEA	Display electronic assemblies
DF	Direction finding
DOD	Department of Defense
DOF	Degrees of freedom
DP	Design proof
DPT	Design proof test
DSIF	Deep Space Instrumentation Facility

[redacted]

[redacted] [redacted]

Abbreviation	Definition
DVD	Differential velocity display
EBW	Exploding bridge wire
ECA	Electronic control assembly
ECS	Environmental control system
EDL	Engineering Development Laboratory (S&ID Dny)
ELS	Earth landing system
EMI	Electromagnetic interference
EPS	Electrical power system
ET	Escape tower
FDAI	Flight director attitude indicator
FM	Frequency modulation
FAX	Facsimile transmission
G, g	Acceleration of gravity
G&NS	Guidance and navigation system
GOSS	Ground operational support system
GP	General purpose
GPI	Gimbal position indicator
GSE	Ground support equipment
HAA	High-altitude abort
HBW	Hot bridge wire
H/A	Hazardous area

[redacted]

Abbreviation	Definition
IFT&M	In-flight test and maintenance
IMCC	Integrated Mission Control Center
IMU	Inertial measurements unit
INT	Interior
INST REF	Instrument reference
IRIG	Inter-range instrumentation group
L-	Time before launch (days)
LAD	Los Angeles Division (or NAA)
L/D	Length-diameter ratio
LEM	Lunar excursion module
LEV	Launch escape vehicle
LES	Launch escape system
LJII	Little Joe II
LOR	Lunar orbit rendezvous
LSS	Life support system
L/V	Launch vehicle
MDSS	Mission data support system
M-#	Mock-up - # (with specific number)
Max q	Maximum dynamic pressure
MEE	Mission essential equipment

[redacted]

[redacted]

Abbreviation	Definition
MIT	Massachusetts Institute of Technology
MLT	Mission life test
MNEE	Mission non-essential equipment
MSC	Manned Spacecraft Center (NASA, Houston, Texas)
MTBF	Mean time before failure
MTTR	Mean time to repair
NAA	North American Aviation
NASA	National Aeronautics and Space Administration
O/F	Oxidizer-to-fuel ratio
OPS	Operations
OTP	Operational test procedure
PA	Power amplifier
PACE-S/C	Prelaunch automatic checkout equipment - spacecraft
PAM	Pulse amplitude modulation
PCM	Pulse coded modulation
PCM	Pulse code modulator
PDM	Pulse duration modulation
P_f	Probability of failure
P_{f_p}	Probability of performance failure
P_{f_s}	Probability of stress failure
PFRT	Preliminary flight rating test
POD	Prelaunch Operations Division (NASA)

[redacted]

[redacted]

Abbreviation	Definition
P_s	Probability of success
PSA	Power and servo assembly
PTT	Push to talk
PUCS	Propellant utilization control system
P&WA	Pratt & Whitney Aircraft
R/B	Radar beacon
R/C	Radio command
RCC	Range control center
RCS	Reaction control system
R&D	Research and development
REG	Regulator
RF	Radio frequency
RFI	Radio frequency interference
RFWAR	Requirements for work and resources
RGP	Rate gyro package
R&Z	Range and zero
SA	Saturn Apollo
SCAT	Space communications and tracking
SCD	Specification control drawing
SCIP	Self-contain instrumentation package
SCO	Subcarrier oscillator
SCR	Silicon-controlled rectifier

[redacted]

Abbreviation	Definition
SCT	Scanning telescope
S/C	Spacecraft
S/C_a	Spacecraft adapter
SCS	Stabilization and control system
SEP	Space electronic package
S&ID	Space and Information Systems Division (or NAA)
S/M	Service module
SOL	Solenoid
SOFAR	Sound fixing and ranging
SPS	Service propulsion system
STU	Systems test unit
SXT	Sextant
T-	Time before launch
T-O	Time of launch
T+	Time after launch
T/M	Telemeter
TP	Test Point
TPA	Test preparation area
TPS	Thermal protection system
T/R	Transmitter receiver (combination in two packages)
TWT	Traveling wave tube
TWX	Teletype wire transmission
UDMH	Unsymmetrical dimethyl hydrazine

[redacted]

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Abbreviation	Definition
VCO	Voltage controlled oscillator
VLF	Vertical launch facility
VSWR	Voltage standing wave ratio
WSMR	White Sands Missile Range
XCVR	Transceiver (transmitter receiver in one package)

[redacted]

DEFINITION OF TERMS

ABLATE	To carry away; to remove by cutting or erosion, melting or evaporation. To undergo ablation; to become melted or vaporized and removed at a very high temperature.
ABORT	An uncompleted missile flight or an uncompleted hold-down test resulting from a failure of equipment or of a system other than the one undergoing test. In a tactical operation (simulated or real) a missile failure either on the ground or in flight; a missile that fails to complete a programmed flight.
ADAPTER	Flange or extension of a vehicle stage or section providing a means of fitting another stage or section to it.
AEROBALLISTICS	Term derived from aerodynamics and ballistics, dealing primarily with the motion of bodies whose flight path is determined by applying the principle of both sciences to different portions of the path.
AEROTHERMODYNAMIC BORDER	Area above an altitude of about 100 miles where the atmosphere becomes so rarefied that there is no longer any significant heat-generating air friction on the skin of vehicles.
AIRFRAME	Assembled structural and aerodynamic components of an aircraft or missile.
ALBEDO	The ratio of light reflecting from an unpolished surface to the light falling upon it. Term is used in reference to light reflected from the moon or planets.
AMBIENT CONDITIONS	Environmental conditions such as pressure or temperature; naturally existing conditions.
ANTHROPOMORPHIC	Human-like; related to or designed for the human body.

[redacted]

APOLLO	NASA designation for follow-up manned space-flight program to Project Mercury manned orbital mission. Apollo spacecraft is to be suitable for manned earth-orbiting laboratory, manned circumlunar flight, manned lunar landing, and return.
ATLANTIC MISSILE RANGE (AMR)	A 5000- to 6000-mile instrumented range for testing ballistic and guided missiles located between Cape Canaveral, Florida, and a point beyond Ascension Auxiliary AFB, near the middle of the South Atlantic.
ATTITUDE	Orientation of an air vehicle as determined by the inclination of its axis to a frame of reference, usually the earth.
ATTITUDE JETS	Sometimes called steering jets, attitude-control jets or roll, pitch, and yaw jets; fixed or movable gas nozzles on a rocket, missile, or satellite operated continuously or intermittently to change attitude or position.
AXIS, AXES	Reference axes in the Apollo spacecraft are as follows:
X-axis	The X-axis is parallel to the nominal launch axis and is positive in the direction of initial flight.
Y-axis	The Y-axis is normal to the X-axis and is positive to the right of a crewman when the crewman is in his seat facing toward positive "X."
Z-axis	The Z-axis is normal to both the X- and Y-axes and is positive in the direction of the crewman's feet when he is in his seat.
BACKUP	Designed to immediately follow an earlier space system or a project to complement the latter or take advantage of new techniques and processes; a system that can replace a failed system.

[redacted]

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BENCH MAINTENANCE EQUIPMENT	Equipment supporting component and subsystem testing; facilities capable of isolating, defining, and providing remedial action to malfunctions.
BIOMEDICINE	Combined discipline of biology and medicine for analysis of human tolerances to and protection against environmental variances.
BOILERPLATE	Simulated module for predevelopmental and developmental tests leading to the design of the spacecraft module.
BOOSTER ENGINE	An engine, especially a booster rocket, that adds thrust to the thrust of the sustainer engine, or provides propulsion for a special phase of flight.
BREADBOARD MODEL	An assembly of preliminary circuits and parts to prove the feasibility of a device, circuits, equipment, system or principle in rough or breadboard form without regard to the eventual over-all design or form of parts.
BRIDGE WIRE	The ignition resistor filament. The bridge wire heats the primary explosive to initiate the explosion.
CELESTIAL GUIDANCE	Mechanically or electrically recorded navigational tables, computers, and other instruments and devices that sight stars, calculate position, direct, and control the spacecraft.
CENTRIFUGE	A large motor-driven apparatus with a long rotating arm at the end of which human and animal subjects or equipment can be revolved at various speeds to simulate accelerations encountered in high-performance vehicles.
CHECKOUT	A sequence of operational and calibrational tests needed to determine the condition and status of a required operation or function.

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COASTING FLIGHT	The flight of a rocket or other vehicle between burnout or thrust cutoff of one stage and ignition of another, or between final burnout and summit altitude or maximum range. Also the unpowered portion of an interplanetary flight.
COMMAND MODULE	Personnel and control vehicle in the Apollo spacecraft configuration containing command and communication facilities and crew provisions.
COMPATIBILITY	The quality that permits an item to function in harmony with other equipment and fulfill all design objectives.
CONFIGURATION	The physical nature of an item; the physical arrangement of components which comprise a spacecraft and its dimensions.
CONSOLE	Master instrument panel from which rocket and missile launchings and test are controlled; a group of controls, indicators, and similar electrical or mechanical equipment that is used to monitor readiness of and/or control specific functions such as missile checkout, countdown and launch operations.
COUNTDOWN	Series of numbered events and checks that take place from the start of rocket-launching operations until the rocket lifts off the launch stand.
CRYOGENIC FUEL	A rocket fuel that either in itself is kept at very low temperatures or combines with an oxidizer kept at very low temperatures.
CUTOFF	The shutting off of a liquid or solid-propellant combustion process of a rocket engine, causing a rapid drop toward zero thrust (intentional command action).
DEEP SPACE INSTRUMENTATION FACILITY (DSIF)	Communication equipment capable of contacting and tracking spacecraft beyond normal ranges. DSIF facilities are located at Woomera, Australia; Johannesburg, South Africa; and Goldstone, California

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DEMONSTRATE	Denotes the occurrence of an action or an event during a test. The accomplishment of this type of objective requires a qualitative answer. The answer will be derived through the relation of this action or event to some other known information or occurrence. This category of objectives implies a minimum of system instrumentation and/or that information be obtained external to the test vehicle.
DESIGN VERIFICATION TEST	Basic development test used to determine the adequacy of the design over the anticipated operating conditions. A design verification test is always conducted by Engineering and on a breadboard level.
DETERMINE	Denotes the measuring of performance of any unit or system. This category implies the quantitative investigation of over-all operation, which includes, generally, instrumentation for measuring basic inputs and outputs of the unit or system. The information obtained should indicate to what extent the system is operating as designed. The instrumentation should allow performance deficiencies to be isolated to either the system or the system inputs.
DRAG	The resistance of a body to motion in a medium such as air.
DRY WEIGHT	Weight of a rocket vehicle without its fuel and usually without payload.
EARTH LANDING SUBSYSTEM (ELS)	Acceleration-decreasing equipment for return to the earth's surface after atmospheric reentry; may consist of a parachute system, a flexible aerodynamic glider configuration, or both.
ENGINEERING DEVELOPMENT PART	A part or unit to be employed in a breadboard design.
ENVIRONMENTAL CONTROL SUBSYSTEM (ECS)	The components controlling crew conditions in the spacecraft; governing factors of atmosphere, pressure, and temperature; and providing support for spacesuit conditions in event of cabin decompression or extra vehicular operations.

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ESTABLISH	Denotes gathering information for the development of ground procedures and operating techniques. Objectives in this category are not necessarily dependent on analytic studies.
EVALUATE	Denotes the measuring of performance of any unit or system, as well as the performance and/or interaction of its sections or subsystems that are under investigation. The accomplishment of objectives of this type requires quantitative data on the performance of both the unit or system, and its sections or subsystems will be analyzed for their contribution toward performance of the unit or system. This category will provide the most detailed information of any of these categories.
FALLAWAY SECTION	Any section of a rocket vehicle that is cast off and falls away from the vehicle during flight, especially such a section that falls back to earth.
FIRST MOTION	First indication of motion of the missile or test vehicle from its launcher. Synonymous with "takeoff" for vertically launched missiles.
FLIGHT READINESS FIRINGS (FRF)	A missile system test consisting of the complete firing of the liquid-propellant engines of a rocket missile while it is restrained in its launching stand to verify the readiness of the missile for a flight test or mission.
FREE-FLIGHT TRAJECTORY (Free Fall Ellipse)	That part of a ballistic missile's trajectory that begins with thrust cutoff and ends at reentry.
FUEL CELL	A source of electrical power analogous to a common electrical cell with the reactants continually replenished from an external supply.
GAMMA RADIATION	Electromagnetic radiation having a high degree of penetration similar to X-rays originating from the nucleus.

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GEMINI	NASA follow-up program to Mercury; a two-man spacecraft to demonstrate rendezvous and docking techniques, longer orbital flights (to 14 days), controlled reentry, and landing.
GIMBALED MOTOR	A rocket motor mounted on a gimbal, i. e., on a contrivance having two mutually perpendicular axes of rotation so as to correct pitching and yawing.
GODDARD SPACE FLIGHT CENTER (GSFC)	NASA research center at Greenbelt, Maryland, named for Robert H. Goddard, American rocket pioneer.
GOLDSTONE TRACKING FACILITY	A deep space instrumentation facility located at Army's Camp Irvin, Barstow, California, using a radiotelescope and operated for NASA by Jet Propulsion Laboratory (JPL).
GO NO-GO	A missile launch controlled at the end of the countdown as to permit an instantaneous change in decision on whether or not to launch.
GROUND OPERATIONAL SUPPORT SYSTEM (GOSS)	Network of tracking stations, fixed and mobile, air, ground, and seaborne to communicate with, track, and telemeter spacecraft and satellites.
GROUND SUPPORT EQUIPMENT (GSE)	All ground equipment that is part of the complete spacecraft system and that must be furnished to ensure its support. All implements or devices required to maintain the functional operational status of the spacecraft are included. In the Apollo program, bench maintenance equipment, combined system test unit, and prelaunch automatic checkout equipment comprise the GSE.
GUIDANCE	(1) The process of intelligent gathering and maneuvering required by a missile, probe, or space ship to reach a specified destination. (2) General term includes entire scheme: sensing devices, computers, and servo systems.

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HEAT SHIELD	An ablative protective covering to ensure spacecraft and crew survival through the hypertemperatures of atmospheric reentry.
HEAT SINK	A device that absorbs heat energy.
HOT TEST	Propulsion system test conducted by actually firing the propellants. A hot test may be live, static, or conducted in a confined place.
INERTIAL GUIDANCE	An onboard guidance system for space and satellite vehicles where gyros, accelerometers, and possibly a gyro-stabilized platform satisfy guidance requirements without use of any ground-located components. The system is entirely automatic, following predetermined trajectory.
INFRARED LIGHT	Light in which the rays lie just below the red end of the visible spectrum.
INITIATOR	A primary explosive mixture used as a primer, detonator for caps which initiates the explosion of blasting propellant, bursting explosives at the desired moment.
INTERIM QUALIFIED	A term used to describe the status of a component or system scheduled for use in early flights wherein the basically essential qualification tests have been successfully completed as related to the specific flight objectives.
INVERTER	A converter to a-c power from a d-c source.
JET STEERING	The use of fixed or movable gas jets on a space weapon, ballistic missile, or sounding rocket for thrust vector control to steer it along a desired trajectory, during both propelled flight and after thrust cutoff.
KELVIN SCALE (K)	A temperature scale that used Centigrade degrees as gradients and absolute zero for zero. Zero Kelvin equals -460 F or -273 C.

[redacted]

LANGLEY RESEARCH CENTER	NASA installation in Hampton, Virginia, responsible for technical research in development and improvement in both atmospheric and space flight.
LAUNCH WINDOW	The allowable limits of launch time that will allow a spacecraft to achieve successful injection into programmed flight path.
LAUNCH ESCAPE SUBSYSTEM (LES)	The components for command module recovery in case of mission abort after launch and prior to orbit. The system consists of the launch escape motor, the launch escape tower, and the tower jettison motor.
LIQUID HYDROGEN	Liquid rocket fuel that develops a specific impulse, when oxidized by liquid oxygen, ranging between 317 and 364 seconds depending upon the mixture ratio.
LIQUID OXYGEN	Oxygen supercooled and kept under pressure so that its physical state is liquid. Used as an oxidizer in a liquid-fuel rocket.
LITTLE JOE (I, II)	A solid-rocket test vehicle developed by General Dynamics. I was used especially to test the Mercury capsule, and II will be used to test the Apollo spacecraft.
LUNAR EXCURSION MODULE	The two-man vehicle that will land on the moon after the Apollo spacecraft enters lunar orbit.
LUNAR ORBITAL RENDEZVOUS	The concept for manned lunar landing adopted by NASA wherein the lunar excursion module leaves the spacecraft, lands on the moon, and later returns to the orbiting spacecraft. The excursion module will be jettisoned as the spacecraft leaves lunar orbit.
MANNED SPACECRAFT CENTER (MSC)	NASA headquarters responsible for development and operation of manned space vehicles (Mercury, Gemini, Apollo), located in Houston, Texas.

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MARSHALL SPACE FLIGHT CENTER (MSFC)	NASA operation responsible for design and development of space launch vehicles (Saturn, Advanced Saturn, Nova), located in Huntsville, Alabama.
MOCK-UP	A full-scale, three-dimensional representation of a complete spacecraft, individual module, and/or related equipment. Based on permanence and difficulty of alteration, mock-ups are graded as "soft," "semi-hard," and "hard."
MODULE	A combination of components, contained in one package or so arranged that together they are common to one mounting, which provides a complete function. (See command module, service module, lunar excursion module, etc.)
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)	Civilian agency, sponsored by the U. S. Government, with research and development jurisdiction in aeronautical and space activities except those activities peculiar to or primarily associated with the development of weapon systems, military operations, or the defense of the United States.
NAUTICAL MILE (NM)	A measure of distance equal to 6,076.103 feet or approximately 1.15 mile.
OBTAIN DATA	Denotes gathering engineering information that is to be measured to augment the general knowledge required in the development of the over-all spacecraft. This category may also be used for supplemental investigation, such as environmental studies, ground equipment studies, etc. The degree of instrumentation is not implied by this definition.
OPTICAL STAR TRACKER	A star tracker that locks onto the light of a particular celestial body. Distinguished from a radiometric star tracker. (See star tracker.)
OXIDIZER	A rocket propellant component, such as liquid oxygen, nitric acid, fluorine, and others, that supports the combustion of a fuel.

PAD	A permanent or semipermanent load-bearing surface constructed or designed as a base upon which a launcher can be placed. Short for launch pad.
PITCH	The movement about an axis that is at once perpendicular to the Apollo longitudinal axis and horizontal to the Y-axis of the spacecraft.
PRE-QUALIFIED	A pre-qualified part or component is one that has been scheduled as the one most likely to succeed in the qualification program and will be used in production runs as well as during developmental test or early flight test prior to qualification.
PRESSURIZED SUIT	A garment designed to provide pressure upon the body so that respiratory and circulatory functions may continue normally, or nearly so, under low-pressure conditions, such as occur at high altitudes or in space without benefit of a pressurized cabin.
PROGRAMMED ROLL	An automatically controlled roll of a ballistic missile or satellite, usually executed during its vertical ascent before pitch-over.
PROGRAMMED TURN	The turn of a ballistic missile from vertical motion, after lift-off, to a curved path approximating the desired powered flight trajectory prior to the initiation of guidance.
PROPELLANT	A liquid or solid substance burned in a rocket for the purpose of developing thrust.
PROTOTYPE	A model suitable for complete evaluation of mechanical and electrical form, design, and performance. It is in final mechanical and electrical form, employing approved parts, and completely representative of the final equipment.
QUALIFICATION OF PART, COMPONENT, OR SYSTEM	A part, component, or system is considered qualified by definition after it has successfully completed all of the prescribed tests associated with relevant control specifications.

[redacted]

READOUT	A radio transmitter transmitting data either instantaneously with computation of the data or by play of a magnetic tape on which the data have been recorded.
RECOVERY	The act of retrieving a portion of a launched missile or satellite that has survived reentry.
REENTRY	Return of a part of a space vehicle to the atmosphere after flight above the sensible atmosphere.
RELIABILITY	Reliability is the probability of performing without failure a specified function, under given conditions, for a specified period of time. It deals with the failure rates in time of specified items.
RETROROCKET	Relatively small rocket unit, usually solid propellant, installed on a rocket-propelled vehicle and fired in a direction opposite to the main motion to decelerate main unit.
ROLL	The movement of Apollo about its longitudinal (X) axis.
SATURN	The sun's sixth planet. A NASA rocket engine cluster in research and development expected to develop some 1,500,000 pounds of first-stage thrust. The Apollo launch vehicle.
SEPARATION	Moment when a full stage, half stage, a warhead, or a nose cone is separated from the remainder of the rocket vehicle; the moment when staging is accomplished.
SERVICE MODULE	Apollo module carrying propulsion equipment, fuel, reaction control systems, and communications power. It is used for thrust after booster separation, mid-course correction, lunar orbit, lunar orbit ejection, and earth return midcourse correction. It is jettisoned prior to reentry.
SERVICE PROPULSION SYSTEM	Engine and associated equipment providing thrust for service module functions. (See SERVICE MODULE.)

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SOFT LANDING	Landing on the moon or other spatial body at such slow speed as to avoid damage of landing vehicle. Soft landings on moon are anticipated by use of retrorockets.
SOLAR FLARE	Solar phenomenon that gives rise to intense ultraviolet and corpuscular emission from the associated region of the sun. This affects the structure of the ionosphere and interferes with communications.
SOLID PROPELLANT	A propellant in solid condition including all the ingredients necessary for sustained chemical combustion, such as a compound of fuel and oxidizer, usually in plastic caked form. It burns on its exposed surface, generating hot exhaust gases to produce a reaction force.
SPACECRAFT	In the Apollo program, any component or combined components of the flight vehicle not part of the launch vehicle: launch escape subsystem, command module, service module, adapter, or any combination of these.
SPECIFIC IMPULSE	The thrust produced by a jet-reaction engine per unit weight of propellant burned per unit time, or per mass of working fluid passing through the engine in unit time. It is equal to thrust in pounds divided by weight flow rate in pounds per second.
STABILIZATION AND CONTROL SUBSYSTEM (SCS)	An Apollo monitor system linked to navigation and guidance system, display system, and reaction control subsystem indicating spacecraft attitude (roll, yaw, or pitch).
STAGE	In a rocket vehicle powered by successive units, one or other of the separate propulsion units.
STAGNATION POINT	The location on a surface in an airstream where the air flow is zero.

[redacted]

STAR TRACKER	A telescopic instrument on a missile or spacecraft that locks onto a celestial body and gives guidance to the missile or other object during flight.
STATIC TESTING	Testing of a missile or other device in a stationary or holddown position, to verify structural integrity, to determine the effects of limit loads, or to measure thrust.
SYSTEMS ENGINEERING	Process of applying science and technology to the study and planning of an over-all aerospace vehicle system, whereby relationships of various parts of the system and the use of various subsystems are fully planned and integrated prior to time hardware designs are committed.
TELEMETERING	The technique of recording space data by radioing an instrument reading from a rocket to a recording machine on the ground.
THEODOLITE	A sighting and measuring telescopic instrument that gives a reading on horizontal or vertical angles.
TRAJECTORY	The path described by a missile or a space vehicle.
TRANSFER ELLIPSE	Path followed by a body moving from one elliptical orbit to another.
ULLAGE	The amount of fluid by which a tank falls short of being full; the loss through evaporation, spilling, or consumption; the amount remaining that cannot be drained from an emptied tank or container.
UMBILICAL	Any one of several electrical or fluid lines connected between the ground support operation and an uprighted rocket missile or space vehicle before launch.
UNSYMMETRICAL DIMETHYLHYDRAZINE (UDMH)	Rocket fuel which with aerozine will power the Apollo spacecraft.

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VECTOR STEERING	Vernacular for a steering method where one or more thrust chambers are gimbal mounted so that the direction of the thrust force (thrust vector) may be tilted in relation to the center of gravity of the missile to produce turning.
VELOCITY VECTOR	Combination of two ballistic missile trajectory values: the speed of the missile's center of gravity at a designated point on the trajectory and angle between local vertical and the direction of the speed.
WHITE SANDS MISSILE RANGE (WSMR)	A proving ground in New Mexico under the control of the Army Ordnance Missile Command; supports Apollo abort tests.
YAW	Lateral movement of the Apollo spacecraft along the Z-axis in line of flight.

[redacted]

[redacted]

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   SID 62-109-2 Volume II Individual System Tests
   SID 62-109-3 Volume III Ground Qualification Tests
   SID 62-109-4 Volume IV Acceptance Test Plans
   SID 62-109-5 Volume V Multiple Systems Tests

6. SID 62-153 — Facilities Plan
7. SID 62-154 — Quality Control Program Plan
8. SID 62-243 — GSE End Items - Apollo
9. SID 62-244 — Spares, Systems and GSE Documentation - Apollo
10. SID 62-417 — GSE Planning and Requirements
11. SID 62-564 — GSE Requirements and Utilization for Apollo Development Program
12. SID 62-585 — Apollo Hardware Utilization List
13. SID 62-651 — Apollo Engineering Test Requirements on Test Fixture 2 and Airframe 001
14. SID 62-700-1, -2, -3 — Apollo Mission and Spacecraft General Performance Requirements and Specifications
15. SID 62-702 — Apollo Maintenance Plan

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16. SID 62-931 — Requirement for Work and Resources, White Sands Missile Range

17. SID 62-972 — Apollo Test and Operations Mission Abort Test Program - Test Support Requirements

18. SID 62-975 — Apollo Test and Operations Environmental Proof Test Support Requirements

19. SID 62-1003 — Preliminary Specification NASA-Furnished Crew Equipment Interface Requirements Project Apollo

20. SID 62-1005 — GOSS Performance and Interface Specifications

21. SID 62-1014 — Definitions and Objectives Apollo GSE

22. SID 62-1145-1 — Apollo Integrated Systems GSE Concept Boilerplate No. 6

23. SID 62-1367 — Apollo Checkout and GSE Concept

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25. SID 62-1450 — Apollo GSE Plan

26. SID 63-501 — Apollo Measurement Requirements, Airframe 001 and Test Fixture 2

27. SID 63-508 — Apollo C/M and S/M Measurement Requirements Airframe 008

28. SID 63-565 — Apollo Measurement Requirements, Boilerplate 15

29. SID 63-1040 — Apollo Simulation Plan

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Project Apollo Flight Mission Directive for Pad Abort I, NASA Project Apollo Working Paper 1049A, 24 January 1963.

Project Apollo Flight Mission Directive for Mission A-001, NASA Project Apollo Working Paper 1065, dated 31 January 1963.

Project Apollo Flight Mission Directive for Mission A-101, NASA Project Apollo Working Paper 1085, dated 31 July 1963.

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