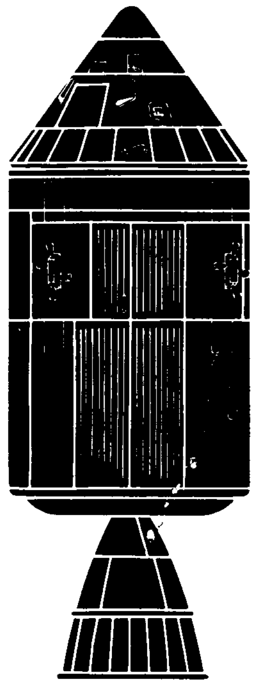
[redacted]

42

SID 65 1545



Final Report

PRELIMINARY DEFINITION PHASE
APOLLO EXTENSION SYSTEM

NORTH AMERICAN AVIATION, INC. SPACE and INFORMATION SYSTEMS DIVISION

ase I Experiments
egration-Program
alysis

(NASA-CR-117553) PRELIMINARY DEFINITION PHASE APOLLO EXTENSION SYSTEM (North American Aviation, Inc.) 119 p

N79-76229

Unclas

00/14 11418

[redacted]

C66-2994

[redacted]

CLASSIFICATION CHANGE

To UNCLASSIFIED
By authority of GDS-EO 11652 GP-4
Changed by D.L. Merritt Date 12/31/72
Classified Document Master Control Station, NASA
Scientific and Technical Information Facility

CONTRACT NAS9-5017

Copy No. 42

SID 65-1545

Final Report

Preliminary Definition Phase
Apollo Extension System

[redacted]

PHASE I EXPERIMENTS INTEGRATION
PROGRAM ANALYSIS

18 February 1966

Approved by

L.M. Tinnan
Program Development Manager

This document contains information [redacted] United States within the [redacted] Section 793 [redacted] or revelation of its contents in any [redacted]

NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION

[redacted]

[redacted]

TECHNICAL REPORT INDEX/ABSTRACT

ACCESSION NUMBER

DOCUMENT SECURITY CLASSIFICATION
[redacted]

TITLE OF DOCUMENT

PHASE I EXPERIMENTS INTEGRATION, PROGRAM ANALYSIS

LIBRARY USE ONLY

AUTHOR(S)
WOOD, L.E. * TALLMAN, S.L. * BERRY, J.R.

CODE

ORIGINATING AGENCY AND OTHER SOURCES

NAA/S&ID APOLLO EXTENSION SYSTEM

DOCUMENT NUMBER

SID65-1545

PUBLICATION DATE

CONTRACT NUMBER
NAS9-5017

DESCRIPTIVE TERMS

*PROGRAM ANALYSIS, *MANAGEMENT PLAN, *CSM DEVELOPMENT AND TEST, *MANUFACTURING, *LOGISTICS, *TEST OPERATIONS, *FACILITIES

ABSTRACT

THIS DOCUMENT DESCRIBES THE TECHNICAL AND MANAGERIAL ASPECTS RELATING TO THE INTEGRATION OF EXPERIMENTS INTO THE CSM AND LEM UTILIZING BLOCK II VEHICLES FOR AES PHASE I MISSIONS.

PROGRAM LOGIC, INTER/INTRA ORGANIZATIONAL RESPONSIBILITIES AND INTERFACES, BASELINE SCHEDULES, DEVELOPMENT AND EXPERIMENT INTEGRATION PHILOSOPHY, LOGISTICS SUPPORT, MANUFACTURING SCHEDULES AND SEQUENCE, CHECKOUT PHILOSOPHY, FACILITIES REQUIREMENTS, TEST OPERATIONS AT DOWNEY AND KSC NECESSARY TO IMPLEMENT THE PHASE I EXPERIMENT INTEGRATION PROGRAM ARE IDENTIFIED AND DESCRIBED IN DETAIL.

FORM 131-V REV. 6-64

[redacted] [redacted]

FOREWORD

This document is submitted by the Space and Information Systems Division (S&ID) of North American Aviation, Incorporated, to the National Aeronautics and Space Administration Manned Spacecraft Center in partial fulfillment of the final reporting requirements of Contract NAS9-5017, "Preliminary Definition Study for Utilization of CSM for AES."

Reports being submitted under the subject contract are listed below. Data resulting from subcontractor studies or provided by other sources external to S&ID are included in the appropriate volumes. The reader is urged to refer to other documents in the final report series for further information not contained in this document.

Report No.	Title
SID 65-1145	Master Program Plan (Preliminary)
SID 65-1146	Manufacturing Plan (Preliminary)
SID 65-1147	Facilities Plan (Preliminary)
SID 65-1148	General Test Plan (Preliminary)
SID 65-1150	Configuration Management Plan (Preliminary)
SID 65-1151	Baseline Ground Operations Requirements Plan
SID 65-1517	Program Summary
SID 65-1518	Technical Summary
SID 65-1519	Subsystems Summary
SID 65-1520	Guidance and Control System
SID 65-1521	Communications and Data System
SID 65-1522	Instrumentations, Displays, and Controls
SID 65-1523	Environmental Control and Life Support Systems
SID 65-1524	Thermal Analysis
SID 65-1525	Power Generation and Distribution Systems
SID 65-1526	Cryogenic Storage System
SID 65-1527	Service Propulsion System
SID 65-1528	Reaction Control System
SID 65-1529	Spacecraft Design Summary
SID 65-1530	Structural Loads and Criteria
SID 65-1531	Structural Analysis
SID 65-1532	Mass Properties
SID 65-1533	Earth Recovery System
SID 65-1534	Systems Analysis Summary
SID 65-1535	Reliability Summary
SID 65-1536	Experimenters Design Guide

[redacted]

[redacted] [redacted]

Report No.	Title
SID 65-1537	Experiment Identification Descriptions
SID 65-1539	Ground Support and Logistics
SID 65-1541	Interface Methodology
SID 65-1542	Functional Flow Diagrams—Lunar Polar Orbit Reference Mission
SID 65-1543-1	Allis-Chalmers Fuel Cell Study—Technical Summary
SID 65-1543-2	Allis-Chalmers Fuel Cell Study—Program Analysis
SID 65-1544-1	Land Landing System—Technical Summary
SID 65-1544-2	Land Landing System—Program Analysis
SID 65-1545-1	Phase I Experiments Integration—Program Analysis
SID 65-1545-2	Phase I Experiments Integration—Cost Data
SID 65-1546	Final Briefing
SID 65-1547	Performance Analysis Phase II Flights
SID 65-1571	Program Costs
SID 65-1723	Mission Description—Flight 211
SID 65-1724	Mission Description—Flight 507
SID 65-1725	Mission Description—Flight 509
SID 65-1726	Mission Description—Flight 511
SID 65-1727	Mission Description—Flights 214/215
SID 65-1728	Mission Description—Flights 216/217

CONTENTS

ILLUSTRATIONS

INTRODUCTION

This document describes the analyses of program elements related to the planning of AES Phase I missions, and to the development and integration of the experiment payloads into those Apollo Block II CSM's designated for such missions. Preliminary plans are defined for program implementation of the technical activity described in the "Experimenters Design Guide", SID 65-1536, and "Experiment Identification Descriptions", SID 65-1537. Program costs associated with these plans are presented in SID 65-1571-1, "Program Costs Supplement."

The program management approach is derived from the AES organization's mission planning/technical definition relationship to the Apollo Program organization, with the latter being responsible for implementation of the missions. On this basis, organizational responsibilities and inter- and intra-organizational interface and coordination requirements are defined, master schedules and management procedures developed, and Phase I Program plans, and their implementation, described.

Starting with the top-level Phase I mission functional flow analyses, the mission parameters are identified and the development and test requirements established. Manufacturing effort associated with modification to the Block II CSM and the fabrication of modification kits is defined, and the effect of the experiments and CSM changes on checkout of the spacecraft at Downey and KSC described. Using GAEC data, integrated operations of the CSM and LEM Lab at KSC are analyzed and planned.

Support planning covering facilities requirements, and the logistics activities related to experiments payload integration support, supplies and spares, experiment maintainability, packaging and handling, site activation, training, maintenance, and technical data provisions are also presented.

MANAGEMENT PLAN

The basic NAS 9-5017 contract activity defines the AES CSM configuration for the extended missions, and the associated program data. Because of the relatively short time remaining prior to the Phase I flights, Addendum I studies define these missions in sufficient detail so that long lead time development of experiments can be initiated, individual mission plans can be generated, and support requirements identified.

STUDY OBJECTIVES/BASELINES

Study objectives were aligned to produce a detailed analysis of engineering and program definition data relating to the Phase I missions of the AES Program. Detailed engineering analyses are contained in the mission description documents listed below. The program analysis contained in this document is based on, and/or is in consonance with, the following schedules, S&ID planning documents, ground rules and assumptions.

Schedules

Apollo Master Development Schedule - MDS 8, Rev. 3 (Figure 1)

AES Development Operations Phase - Master Development Schedule 11-1 (Figure 2)

AES Development Operations Phase - Master Development Schedule 11-2 (Figure 3)

Planning Documents

AES Master Program Plan (Preliminary), SID 65-1145

AES Phase I Mission Descriptions, SID 65-1723 through 1728

Apollo Support Plan, SID 62-702-1

Apollo Maintenance Plan, SID 62-702-2

Apollo Training Plan, SID 62-162

[redacted]

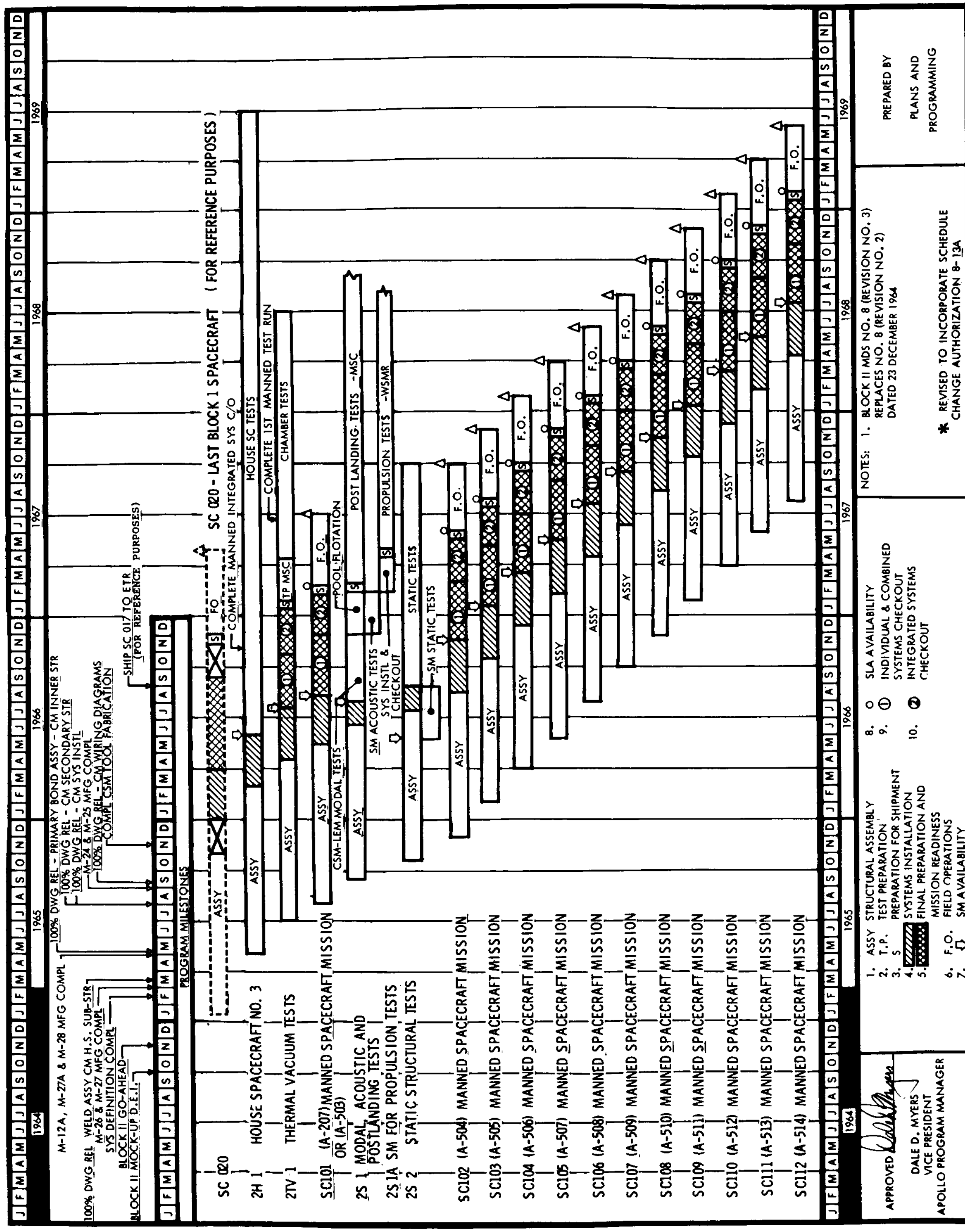


Figure 1. Apollo Master Development Schedule No. 8 Block II

[redacted]

[redacted]

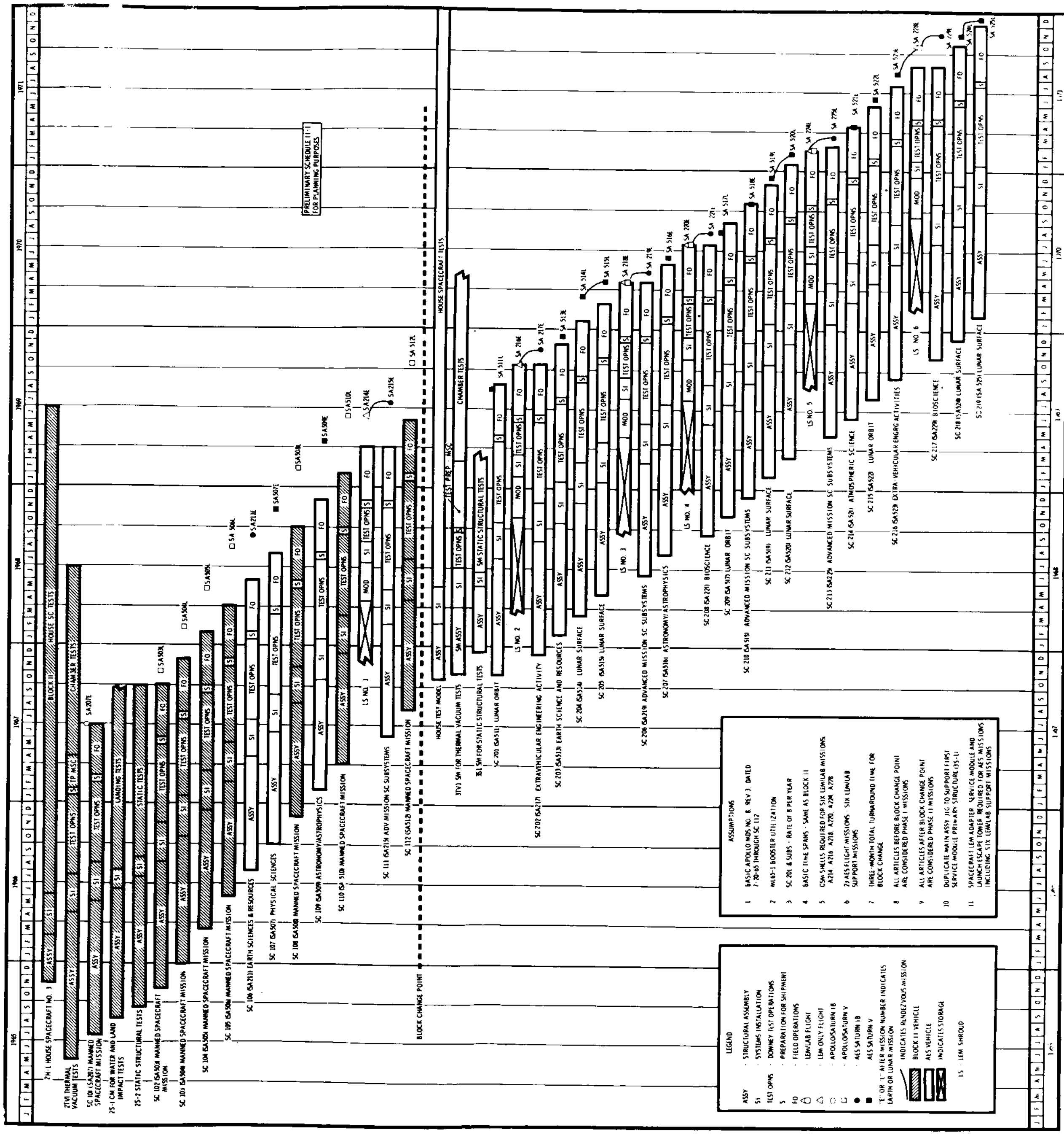


Figure 2. AES Development Operations Phase Master Development Schedule 11-1

[redacted]

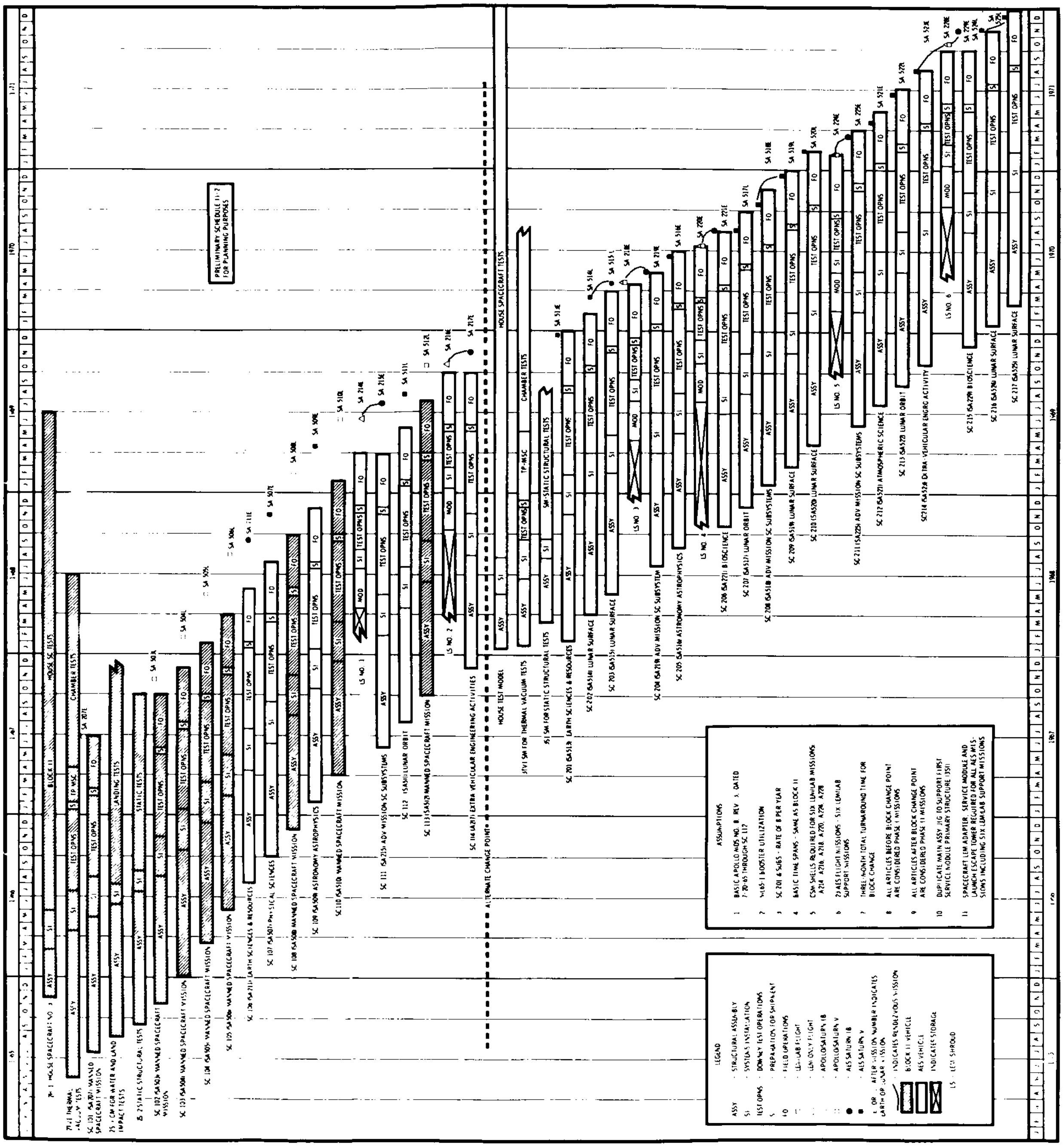


Figure 3. AES Development Operations Phase Master Development Schedule 11-2

[redacted]

AES Baseline Ground Operations Requirements Plan, SID 65-1151

Apollo Facility Plan

Apollo Manufacturing Plan

AES General Test Plan (Preliminary), SID 65-1148

GAEC Phase B Final Report

Guidelines and assumptions more specific to the Phase I Experiment Payload Integration Program Analysis are:

S/C block changeover point is SC 114 as reflected in Schedule 11-2 (Figure 3)

In-line factory spacecraft changes will be made at Downey only to the extent necessary to satisfy Phase I missions long lead time requirements.

No spacecraft changes will be made at Downey that will impact lunar mission objectives.

CSM modification at KSC will be affected by use of modification kits.

Phase I Mission Schedules

By definition, Phase I AES missions are those utilizing Block II spacecraft. The Development/Operations Phase Master Development Schedule 11-1 (Figure 2) portrays turn-around time, processing time, and in-work spans for assembly, subsystem installation, mission readiness checkout operations, and field prelaunch operations for each spacecraft. In addition, booster launch dates are shown for reference purposes. The rationale of the Master Development Schedule reflects the basic policy of the AES program, which states that maximum use be made of Apollo hardware and technology in the development of the extended mission capability spacecraft on a noninterference basis with the Apollo program. This is clearly shown on the schedule displaying the Apollo Block II program and delineating the earliest feasible AES block change point at SC 112.

A second version, the Development/Operations Phase Master Development Schedule 11-2 (Figure 3), illustrates alternate planning specifically to ML 65-1. On Schedule 11-2, the alternate block change point is shown at SC 114, utilization of six Block II spacecraft for Phase I missions necessitates the procurement of two additional Block II vehicles after Apollo Spacecraft 112. This document will refer to MDS 11-2 throughout although the same logic and precepts will apply to the four Block II vehicles for Phase I missions shown in schedule MDS 11-1 .

[redacted]

Experiment Integration Management

Experiment Integration Philosophy

Schedule interfaces between the experimenter and the CSM contractor are illustrated in Figure 4. It shows major milestones identified in accommodating the experiment into the CSM with minimum program impact. Some of the earlier milestones are necessary to affect proper CSM resource allocation and control measures and provide for smooth integration of the experiment into the Apollo program. A brief review of the schedule identifies three categories or cases of experiment accommodation: (1) experiments requiring in-line factory major modifications of the CSM; (2) experiments requiring in-line factory partial modification of the CSM with subsequent kit installation of experiment equipment either during the CSM factory checkout or in the field; and (3) experiments requiring only field modification of the CSM and kit installation of the experiment equipment.

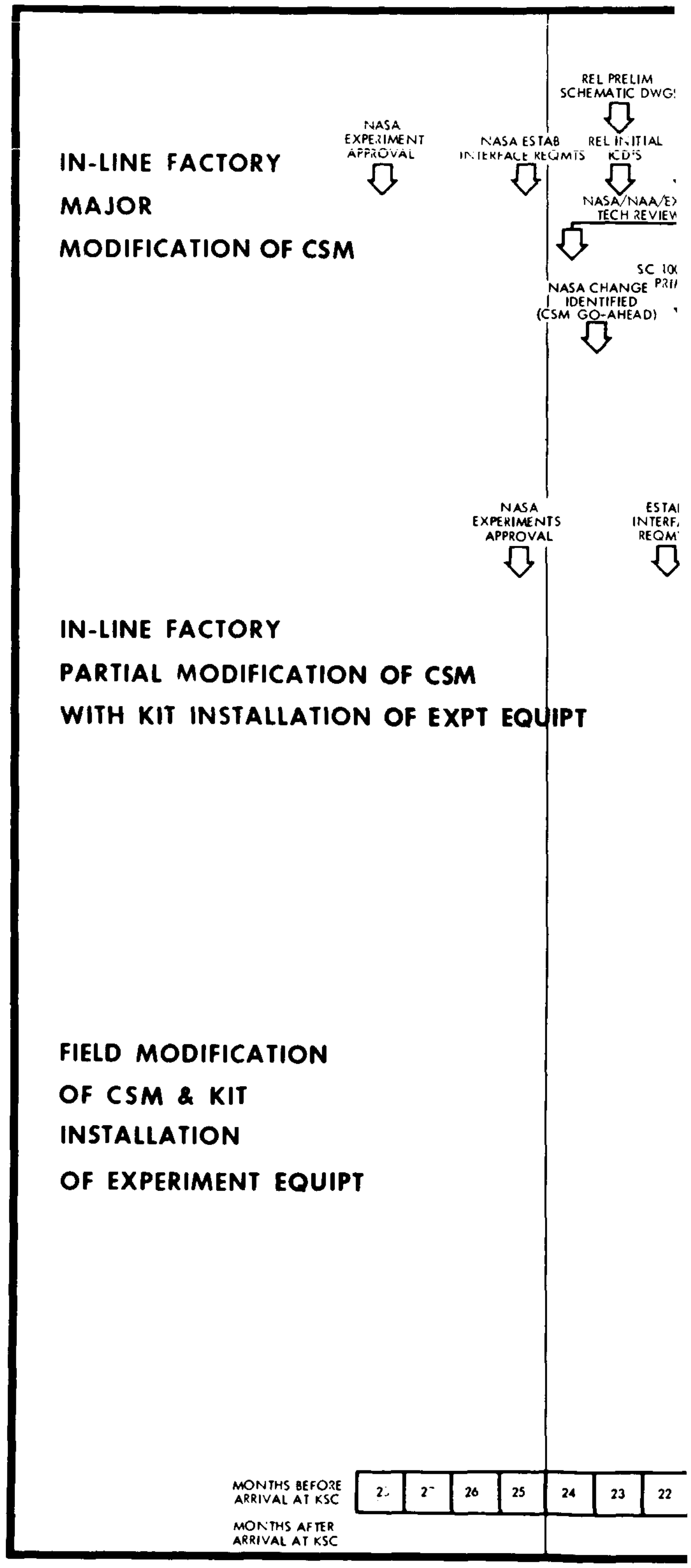
Present plans are that modifications to the spacecraft (both CSM and LEM) to accommodate the AES experiment missions and the installation of the experiment equipment, will be carried out at KSC in order not to compromise possible use of the spacecraft for an Apollo mission (case 3). However, all possible planning should be done before arrival at KSC. That is, accommodation kits for the spacecraft should be designed and manufactured. In addition, experiment equipment interfaces with the spacecraft should be checked out at the spacecraft contractor's facility (case 2). Case 1 represents a worst case, where an experiment requires modification of some of the basic CSM provisions and is important enough to warrant definite commitment of the spacecraft to this mission.

These three categories are predicated on certain levels of modifications, and are reflected in the schedules. Brief descriptions of the three cases follow.

In-line factory major modifcations are those that would require additional new assembly and bond tooling, as well as detail tools. The additional tooling would be required by the CSM contractor to support the reconfiguration of the command module secondary structure to provide the capability for accepting the experiment packages. This category would require the earliest definition of experiments because of the lead time required to support tool fabrication and detail parts. The service module would require major structural changes in Sector I for incorporation of changes to outer shell panel and interior arrangement for support of experiment equipment. It would also provide necessary subsystem equipment to accomplish deployment and ejection of equipment as required.

In-line factory partial modification with kit installation would provide a limited time for CSM fabrication of a few assembly and detail tools and templates necessary to incorporate experiment packages without affecting secondary structure. Some modification of the service module structure in the area of Sector I would be needed to incorporate minor provisions for experiment equipment.

[redacted]


REL PRELIM SCHEMATIC DWG!
NASA EXPERIMENT APPROVAL
NASA ESTAB INTERFACE REQMTS
REL INITIAL ICD'S
NASA/NAA/E
TECH REVIEW
IN-LINE FACTORY
MAJOR
MODIFICATION OF CSM
NASA CHANGE IDENTIFIED (CSM GO-AHEAD)
NASA EXPERIMENTS APPROVAL
ESTA INTERF REQM
IN-LINE FACTORY
PARTIAL MODIFICATION OF CSM
WITH KIT INSTALLATION OF EXPT EQUIPT
FIELD MODIFICATION
OF CSM & KIT
INSTALLATION
OF EXPERIMENT EQUIPT
MONTHS BEFORE ARRIVAL AT KSC
26
25
24
23
22
MONTHS AFTER ARRIVAL AT KSC

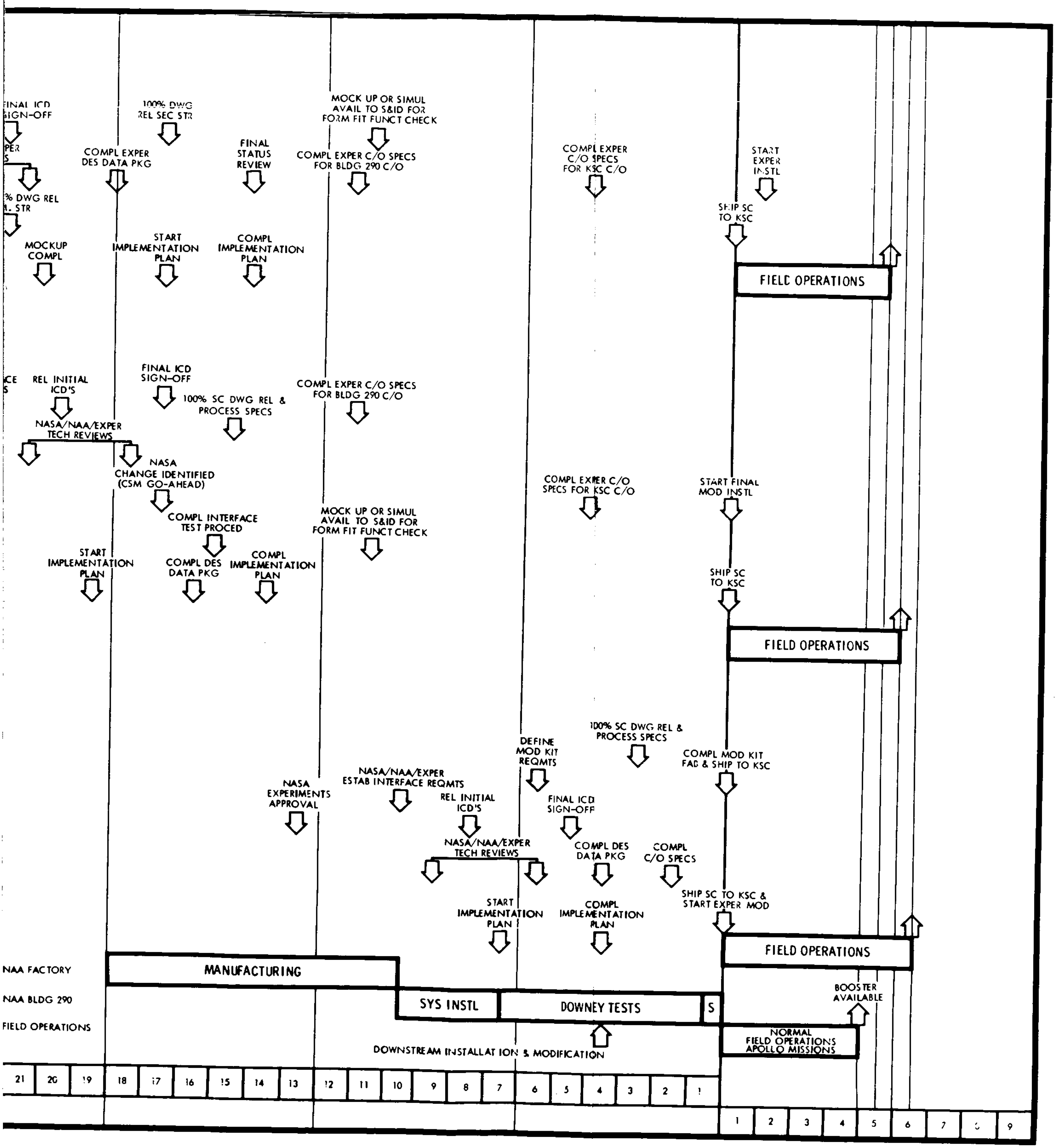


Figure 4. Preliminary Experimenter/CSM Contractor Interface Schedule

Field modification by kit installation means that no fabrication of assembly or detail tools to support experiment packages are required. The total installation would be accomplished during those periods in the field operations that would result in suitable phasing of the integrated operations.

As shown in Figure 5, Phase I Mission Vehicles are in some instances interleaved with Apollo mission vehicles. In the event of contingencies or routine Apollo replanning, it may be necessary to use a designated Phase I mission spacecraft for one of the Apollo missions. For this reason it is presently planned that any AES modifcation of a Block II spacecraft to accommodate experiments installation, and the actual installation of experiments, shall be accomplished after arrival of the spacecraft at KSC. However, those spacecraft changes that either must be made early because of lead time constraints or because of manufacturing sequence restrictions, will be in-line factory modifications at Downey, providing such changes do not detract from use of the CSM for lunar missions. Other CSM changes will be affected at KSC by kit modification as described in the Logistics Support Section. Analysis of those experiments identified to date indicate compatibility with this approach.

Installation at KSC does not, of course, preclude the need for detailed experiment integration design studies, spacecraft modification kit and resultant fabrication design planning and implementation; test planning; mission housekeeping and experiment operation analyses; and experiment installation/checkout implementation planning, sufficiently far in advance of spacecraft ship dates to ensure Phase I mission success.

Program Flow

Figure 6 illustrates the Phase I Missions Program Flow showing program phased responsibilities between the NASA/AES and Apollo and S&ID/AES and Apollo organizations. The complex interface of responsibilities necessary to assure comprehensive implementation of Phase I Mission Integration is described below:

The S&ID AES organization will provide NASA with mission plans support for each Phase I mission, and will serve as a management-support-engineering team to the Apollo organization relative to identification of requirements and planning for implementation of NASA-directed changes to the basic Apollo contract for integration of Phase I mission requirements into designated Block II spacecraft. The S&ID Apollo organization will implement Phase I AES activities in the same manner as currently contracted for in the Land Landing Mission. This process will be initiated by identification and preparation of pertinent data and recommendations to NASA by the S&ID AES organization in the form of a draft Request for Engineering Change Proposal (RECP). In addition, appropriate NAA AES coordination with the Apollo organization will be accomplished to utilize Apollo baseline data and to advise S&ID Apollo personnel of potential forthcoming changes to the Block II spacecraft designated for AES Phase I missions. The official implementation of these requirements by the S&ID Apollo organization will be affected by the NASA apollo program office after the transmittal of the RECP

[redacted]

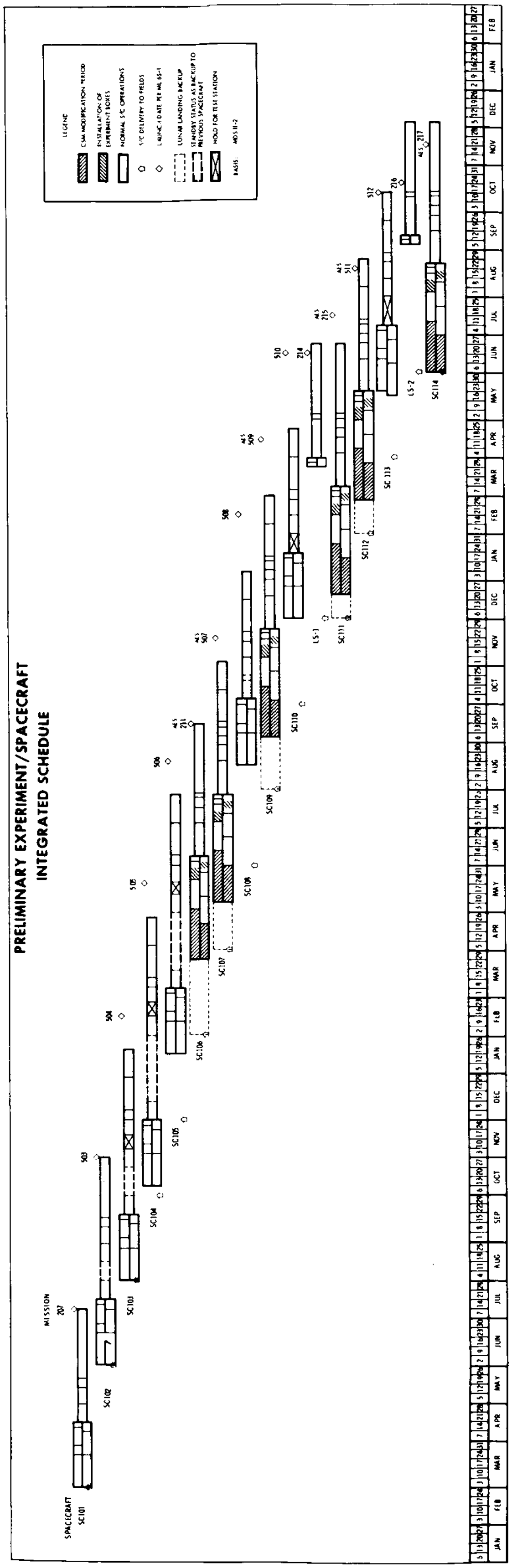
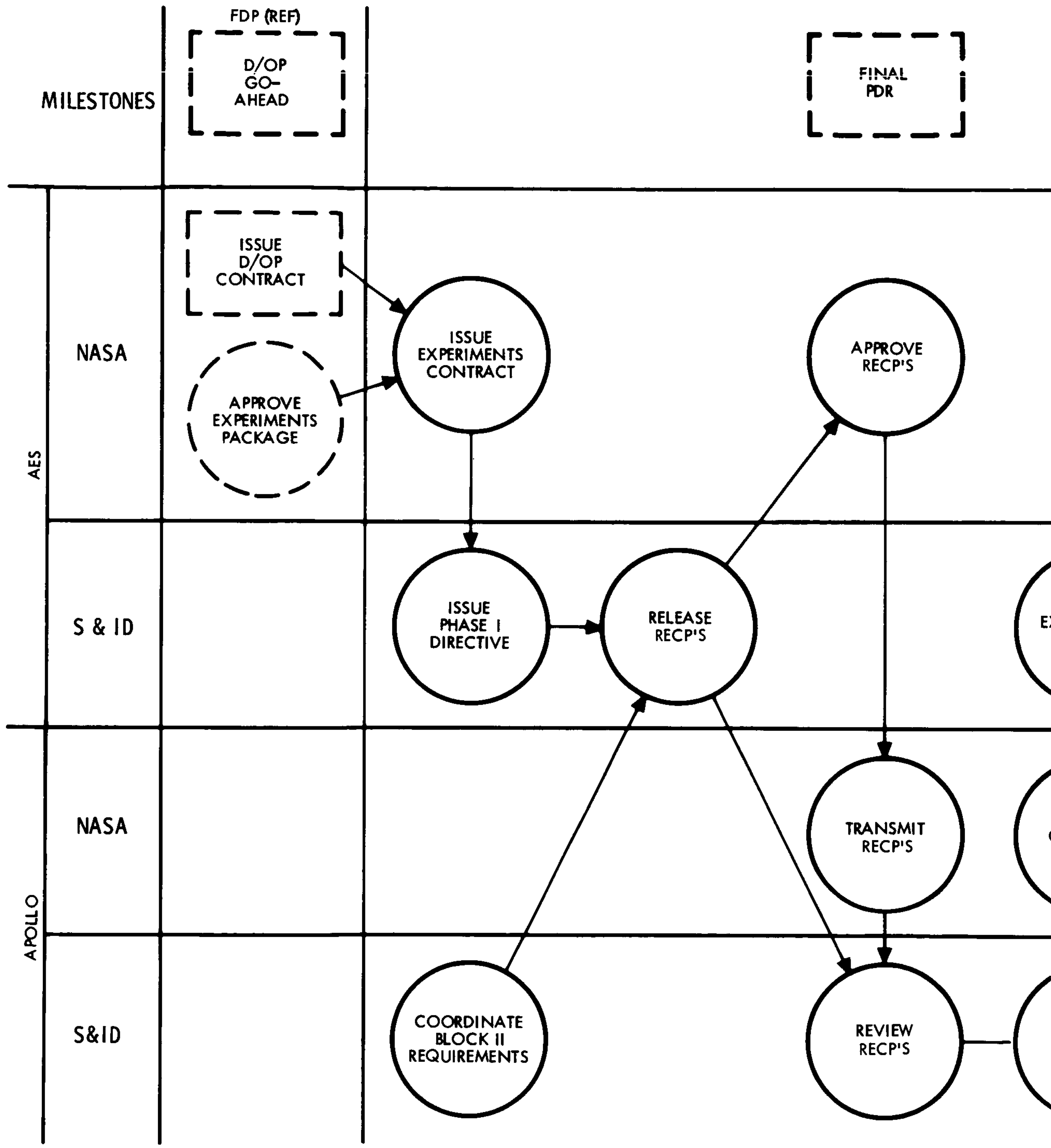


Figure 5. Preliminary Experiment/Spacecraft Integration Schedule

[redacted]

[redacted]



FDP (REF)
D/OP GO-AHEAD
MILESTONES
FINAL PDR
ISSUE D/OP CONTRACT
NASA
ISSUE EXPERIMENTS CONTRACT
APPROVE RECP'S
APPROVE EXPERIMENTS PACKAGE
AES
S & ID
ISSUE PHASE I DIRECTIVE
RELEASE RECP'S
NASA
TRANSMIT RECP'S
APOLLO
S&ID
COORDINATE BLOCK II REQUIREMENTS
REVIEW RECP'S

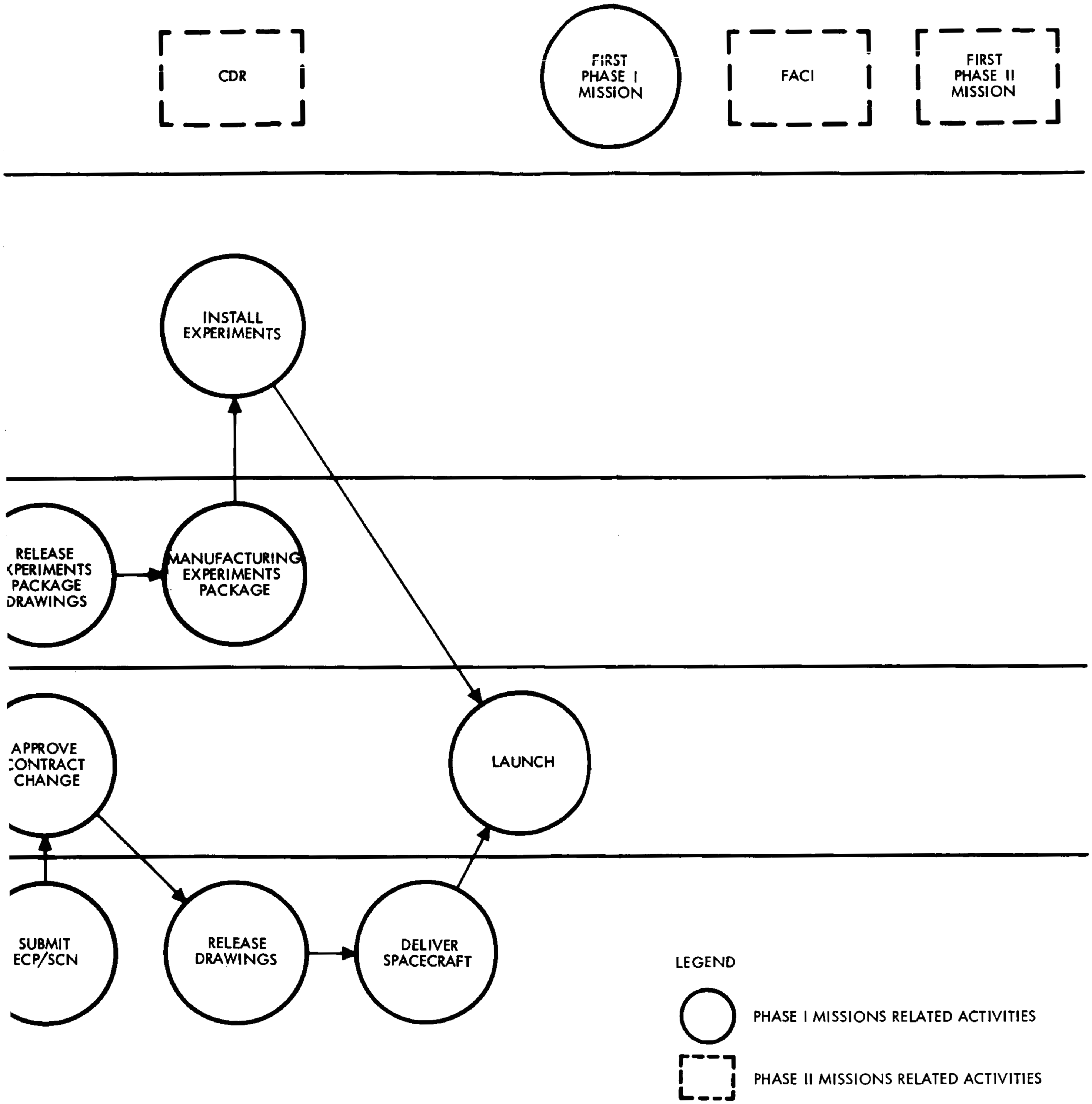


Figure 6. Program Flow, Development Operations Phase, Phase I Missions

documentation from the NASA AES program office.

Phase I RECP Action

Figure 7 portrays in further detail the Phase I RECP activity referred to in the previous paragraph. The required engineering change proposal (ECP) approval dates are keyed to the lead times necessary to implement secondary structure fabrication, systems installation, test operations, and field operations which will satisfy mission objectives for each designated Phase I spacecraft.

PHASE I PROGRAM PLANS

The tasks for assembly, systems installation, test, and field operations for AES Phase I Block II mission spacecraft will be accomplished by the S&ID Apollo organization, as explained in the previous section, entitled "Program Flow." Consequently, the Apollo program plans delineated in exhibit I to Apollo Contract NAS9-150 will be used (modified as necessary) for these Block II spacecraft wherever possible. Any necessary modifications to present Block II program plans will be effected by the S&ID Apollo organization with the management/engineering coordination and assistance provided by the S&ID AES organization. However, because AES Phase I mission objectives are not included in the Apollo mission, mission descriptions (one for each AES Phase I vehicle) and a Block II baseline GORP, having a supplement for each AES Phase I vehicle, will be prepared by the S&ID AES organization. These AES plans, their availability, and first implementation are shown in Figure 8.

Brief descriptions of the AES plans for Phase I missions are discussed in the following paragraphs.

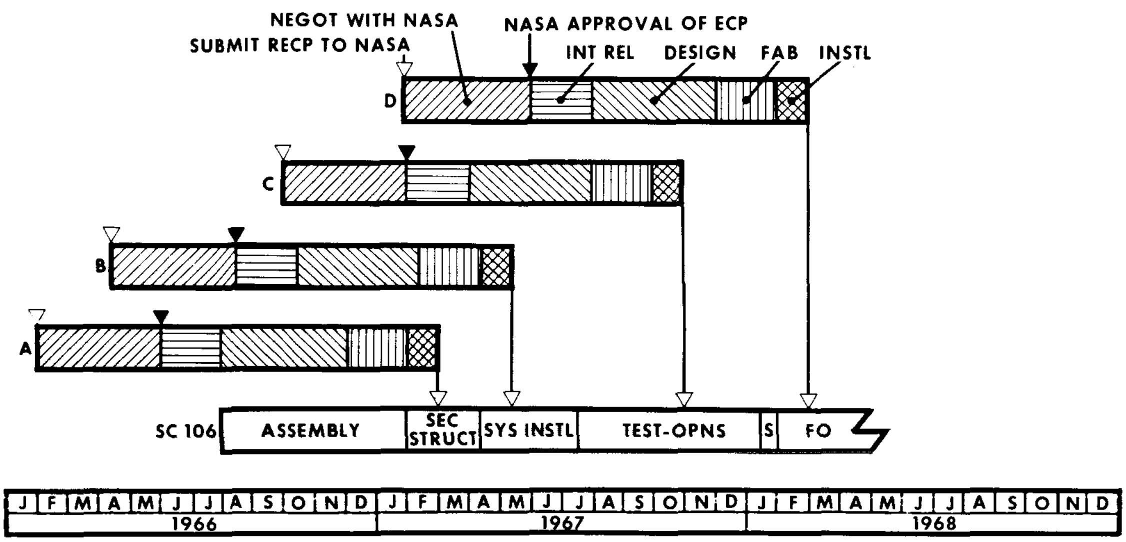
Block II Baseline Ground Operations Requirement Plan (GORP)

Ground operation descriptions and technical data in the GORP encompass all events and tasks required to ensure that spacecraft systems are operating within specified limits up to the point of launch. Ground operations data contained in the document provide a baseline for the establishment of AES vehicle and mission requirements for the preparation of operational test plans, process specifications, and operational checkout procedures. The GORP presents overall engineering requirements for ground operations subsequent to manufacturing completion, starting with installed systems test in Building 290, Downey, through launch. In support of tests and operations, current descriptive information is included pertaining to checkout and operations requirements, spacecraft flow, and specific sequences of accomplishment of these operations. Supporting facilities utilization descriptions are included for visualization of the various operations.

GORP Supplements

The GORP supplements augment the baseline GORP by defining ground operations requirements oriented specifically to each AES flight. Additions, deletions, and modifications to the baseline document are delineated in

[redacted]



REQD ECP APPROVAL DATES

SPCFT	A	B	C	D
106	JUNE 66	AUG 66	FEB 67	JUNE 67
107	AUG 66	OCT 66	APR 67	AUG 67
109	DEC 66	FEB 67	AUG 67	DEC 67
111	APR 67	JUNE 67	DEC 67	APR 68

Figure 7. Phase I RECP Action

[redacted]

[redacted]

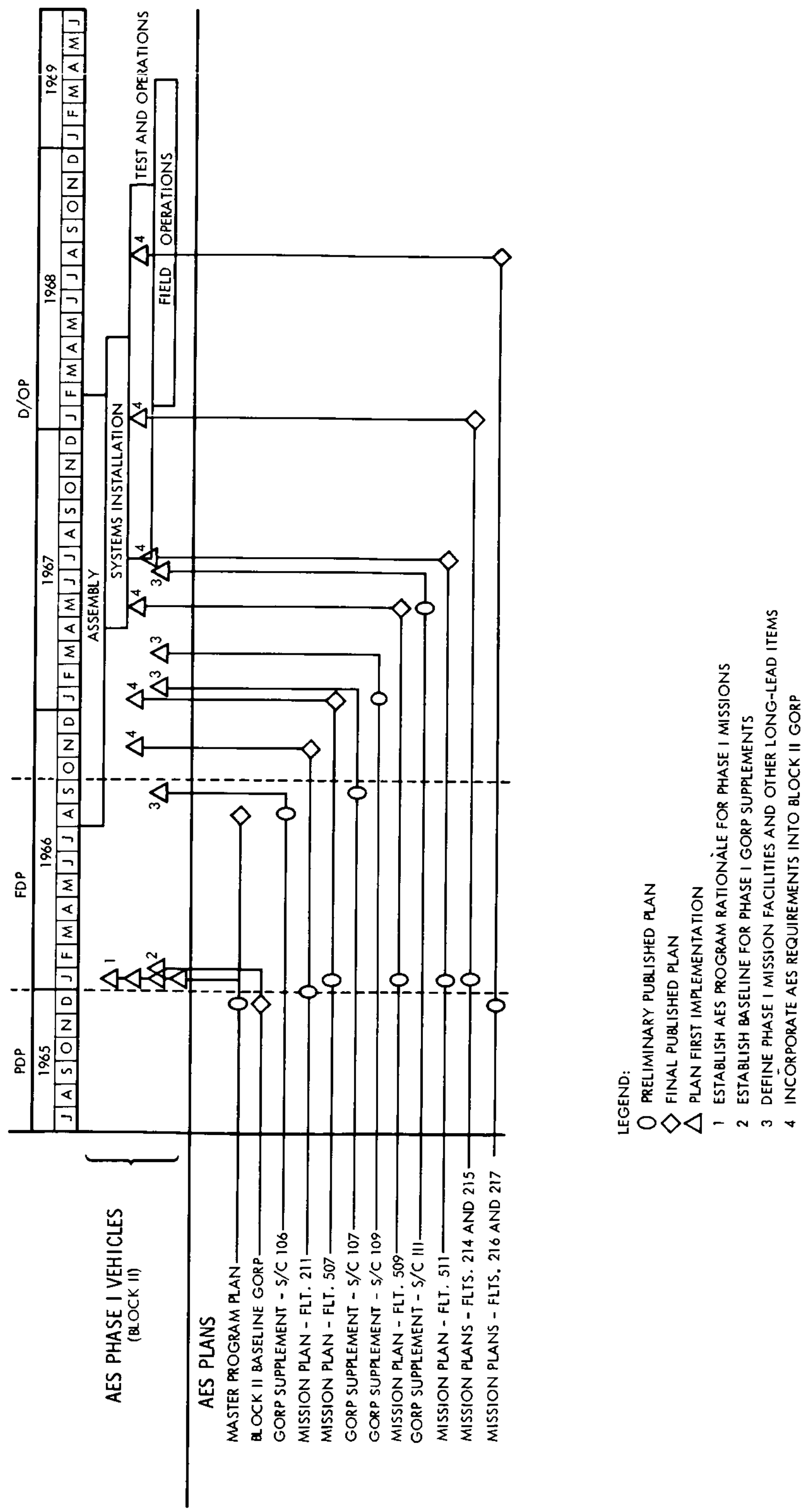


Figure 8. AES Program Plans (Phase I Missions) Availability and First Implementation

[redacted]

[redacted]

[redacted]

consonance with the specific vehicle payload, subsystem, experiment integration, and mission requirements.

Mission Description Documents

A Mission Description Document, provided for each AES vehicle, describes overall spacecraft (CSM and LEM Lab) mission plans and operating procedures subsequent to installed system tests at NAA sites through post-recovery. These documents identify the primary and secondary mission objectives to delineate unused capability of the system. The vehicle configuration, including the launch vehicle, spacecraft, and payloads, is defined. Specific mission configuration, configuration aspects of experiment integration for the CSM and LEM components, as well as experimental and experiment support equipment associated with the payload are described. Operational profiles for launch, orbit, recovery, and abort are included in the documents in addition to payload support requirements for track, relative data acquisition, and crew operations and schedules. Ground operational support requirements are specified, including transport, launch, prelaunch, experiment checkout, mission control, and recovery operations. The mission description documents are the working documents for implementation of AES mission activities and define operational requirements and spacecraft operating constraints. These documents will provide a basis for establishment of mission directives by NASA.

[redacted] [redacted]

CSM DEVELOPMENT AND TEST

MISSION DESCRIPTIONS

As previously stated, Phase I missions will use essentially unmodified Block II vehicles and will, therefore, be nominally of 14 days or less duration. Experimental assignments for each Phase I flight were initially provided by NASA to both S&ID and Grumman for integration into the CSM and LEM, and later finalized by the Mission Planning Task Force, in which S&ID was responsible for the coordination and establishment of each of the mission plans. A primary ground rule relating to CSM experiments integration prohibited modification of the CSM except for minor umbilical and bracketry additions.

Descriptions of Phase I missions presently planned are shown in Figures 9 through 16 and summarized in Table 1. Vehicle designations are based on Development/Operations Phase MDS 11-2 (Figure 3). Experiments, mission objectives, mission duration, booster designations and spacecraft configurations are shown for each flight. Detailed mission plans are described in specific mission descriptions contained in SID documents 65-1723, -1724, -1725, -1726, -1727, and -1728, for missions 211, 507, 509, 511, 214/215, and 216/217, respectively.

Each experiment package including self contained subsystems will be delivered flight-ready for installation in the spacecraft. Development testing and qualification of the experiment package will have been conducted by the experiment contractor to assure fulfillment of mission objectives. The CSM contractor may furnish mounting and thermal control hardware, cabling, controls and displays, plumbing and ordnance devices required to integrate the experiment package with the spacecraft.

FUNCTIONAL FLOW

Figure 17 identifies the functional flow of major operations that must be accomplished to achieve Phase I mission objectives. Starting block 11.0 relates to analysis and definition of design requirements and fabrication of hardware required to support the mission(s) in consonance with previously identified experiment payload requirements and spacecraft configuration.

Blocks 10.0, 9.0, 8.0, and 7.0 encompass the ground operational requirements prior to liftoff. Following completion of assembly, checkout and prelaunch operations (Block 7.0), booster ignition initiates basic flight operations (Block 4.0). Functional Blocks 3.0, 4.0, or 5.0 are completed on or before descent and touchdown after which the performance of post-landing recovery operations (2.0) and post-mission evaluation (1.0) complete the mission. Block 6.0 encompasses all MSFN ground functions required to support flight mission (4.0) and recovery operations.

[redacted]

[redacted]

[redacted]

Table 1. Phase I Mission and Flight Summary

Flight No.	Config.	Orbit N. Mi/Incl. N. (deg)	Duration (days)	Prime Purpose	Vehicles	Booster Avail. Date	Remarks
211	CSM	200 E/90	14	Flight operations/ technology	SC 106	Sept. '68	SM pallet, bio-medical
507	CSM/LEM	200 E/90	14	Earth sensing/ lunar survey systems checkout	SC 107	Nov. '68	Lunar survey system, bio-medical
509	CSM/LEM	19350 E/O	14	Astronomy	SC 109	April '69	Astronomical experiments orientation system, bio-medical, astronomy
214	LEM	200 E/28. 5	--	--	LEM	June '69-	Unmanned LEM launch
215	CSM	200 E/28. 5	14	--	SC 111	July '69	Rendezvous with 214
511	CSM/LEM	30 L/10	14	Lunar mapping and survey	SC 113	Aug. '69	Lunar survey system, biomedical
216	LEM	200 E/28. 5	--	--	LEM	Oct. '69-	Unmanned LEM launch
217	CSM	200 E/28. 5	14	--	SC 114	Nov. '69	Rendezvous with 216

[redacted]

[redacted]

MISSION: 211 EARTH POLAR ORBIT

MISSION TITLE: FLIGHT OPERATIONS/TECHNOLOGY

DURATION: 14 DAYS (PHASE I MISSION)

CREW: THREE

OBJECTIVES: PERFORMANCE OF COMMAND MODULE BIOMEDICAL AND PHYSICAL SCIENCE EXPERIMENTS IN EARTH ORBIT. THIS MISSION WILL CARRY AN EXPERIMENT PALLET IN BAY 1. DEMONSTRATE MANNED, SATURN 1B LAUNCHED POLAR ORBIT OPERATIONS AND SUPPORT.

EXPERIMENTS:

- M-4 PHONOCARDIOGRAPHY
- M-5 BODY FLUID BIOASSAYS
- M-7 CALCIUM BALANCE STUDY
- M-8 SLEEP ANALYSIS
- M-11 CYTOGENETIC BLOOD STUDIES
- M-12 EXERCISE ERGOMETER
- M-17 THORACIC BLOOD FLOW
- M-18 VECTORCARDIOGRAPHY
- M-19 METABOLIC RATE MEASUREMENT
- M-20 PULMONARY FUNCTION
- M-22 RED BLOOD CELL SURVIVAL
- M-23 LOWER BODY NEGATIVE PRESSURE
- 0107 VENOUS COMPLIANCE
- 0109 PULMONARY DYNAMICS
- 0110 VENTILATORY GAS EXCHANGE
- 0114 GASTROINTESTINAL MOTILITY
- • TYPICAL CANIDATE EXPERIMENTS FOR THE PALLETS ARE:
  1. RADAR SCATTERING CROSS-SECTION MEASUREMENTS OF TERRAIN
  2. TEMPERATURE SOUNDING OF THE ATMOSPHERE
  3. ULTRAVIOLET MAPPING OF CELESTIAL SPHERE IN THE 1230Å TO 1700Å BAND
  4. X-RAY ASTRONOMY
  5. SPARK CHAMBER FOR GALACTIC GAMMA-RAY
  6. NUCLEAR EMULSION
  7. MEASUREMENT OF ATMOSPHERIC IODINE FROM ORBIT
  8. ZERO GRAVITY STUDIES OF PHYSICAL PROPERTIES
  9. FROG OTOLITH FUNCTIONS DURING ZERO GRAVITY

CONFIGURATION: CSM (SC 106)
SM BAY I PALLET*
BOOSTER: SATURN IB

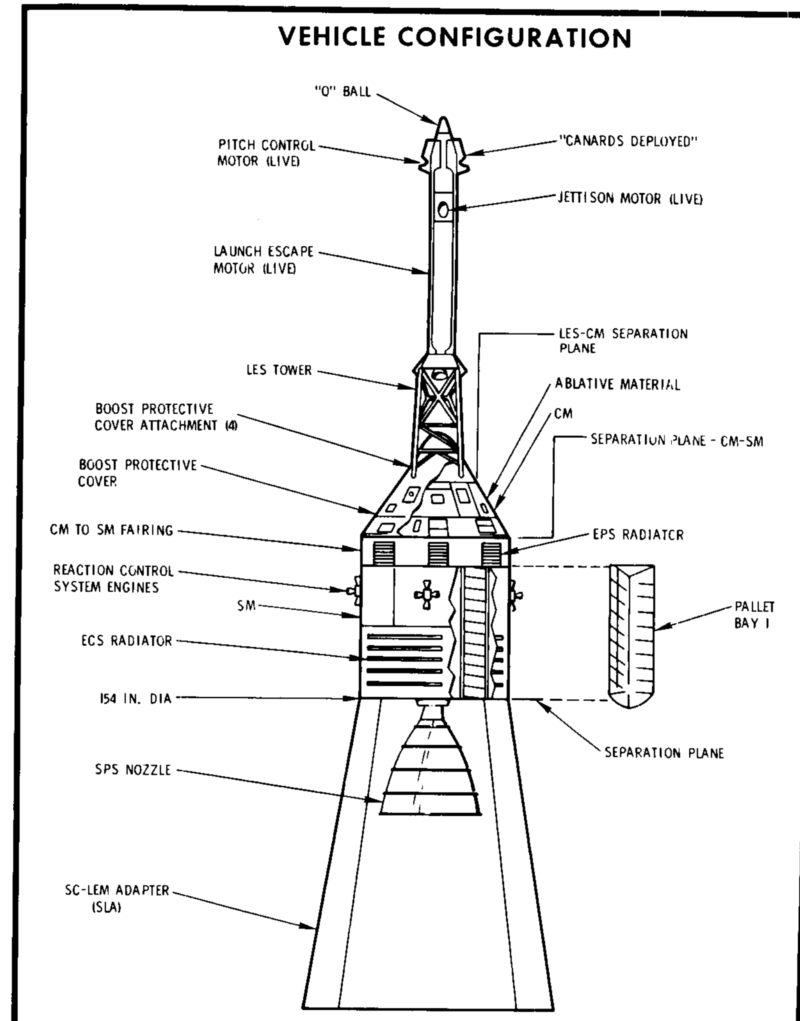


Figure 9. Flight 211 Mission Description

[redacted]

[redacted]

MISSION: 507 EARTH POLAR ORBIT

MISSION TITLE: EARTH SENSING & LUNAR EQUIPMENT QUALIFICATION

DURATION: 14 DAYS (PHASE I MISSION)

CREW: THREE

OBJECTIVES: THIS FLIGHT QUALIFIES SENSORS USED FOR IDENTIFICATION OF CHARACTERISTIC MULTISPECTRAL SIGNATURES OF BIOLOGICAL, GEOLOGICAL & OCEAN SURFACE AREAS. THIS FLIGHT WILL QUALIFY THE MSF NO. 1 FOR LUNAR MAPPING & SURVEY USE: CONSEQUENTLY MANNED SURVEY TECHNIQUES FOR HIGH RESOLUTION EARTH MAPPING WILL BE DEMONSTRATED. THE ENTIRE EARTH IS MAPPED IN VARIOUS EMITTED RADIO FREQUENCY BANDS OF MAN-MADE ORIGIN. WEATHER PHENOMENA ARE ALSO TO BE STUDIED DURING THIS FLIGHT.

EXPERIMENTS:

M-5 BODY FLUID BIOASSAYS
M-8 SLEEP ANALYSIS
M-18 VECTORCARDIOGRAPHY
M-20 PULMONARY FUNCTION
M-23 LOWER BODY NEGATIVE PRESSURE
0103 CIRCULATORY DYNAMICS
0104 WORK CAPACITY
0105 BLOOD VOLUME CHANGES
0106 CAROTID BARORECEPTOR
0107 VENOUS COMPLIANCE
0108 CIRCULATORY REFLEX CHANGES
0111 MUSCLES MASS & STRENGTH
0112 MINERAL METABOLISM
0113 NUTRITIONAL STATUS
0117 ENDOCRINE FUNCTION
0118 HEMIC CELL
0119 HEMATOLOGICAL DEFENSES
0120 HEMOSTASIS
0201 SENSORY & PERCEPTUAL PROCESS
0202 PSYCHOMOTOR FUNCTIONING
0203 HIGHER MENTAL PROCESSES
1001 SYNOPTIC WEATHER PHOTOGRAPHY

BAY 1 LUNAR ORBIT SURVEY:

LUNAR MAPPING & SURVEY PHOTOGRAPHY (MSF-1)

LEM (GRUMMAN RESP. CONTRACTOR)
PHOTOGRAPHIC INVESTIGATION ASSEMBLY NO 2 & NO 3
VIEWFINDER
LUNAR SENSOR EXPERIMENTS

CONFIGURATION: CSM (SC 107)(UNMODIFIED)
LEM
SM BAY 1 WITH MSF-1
BOOSTER: SATURN V

VEHICLE CONFIGURATION

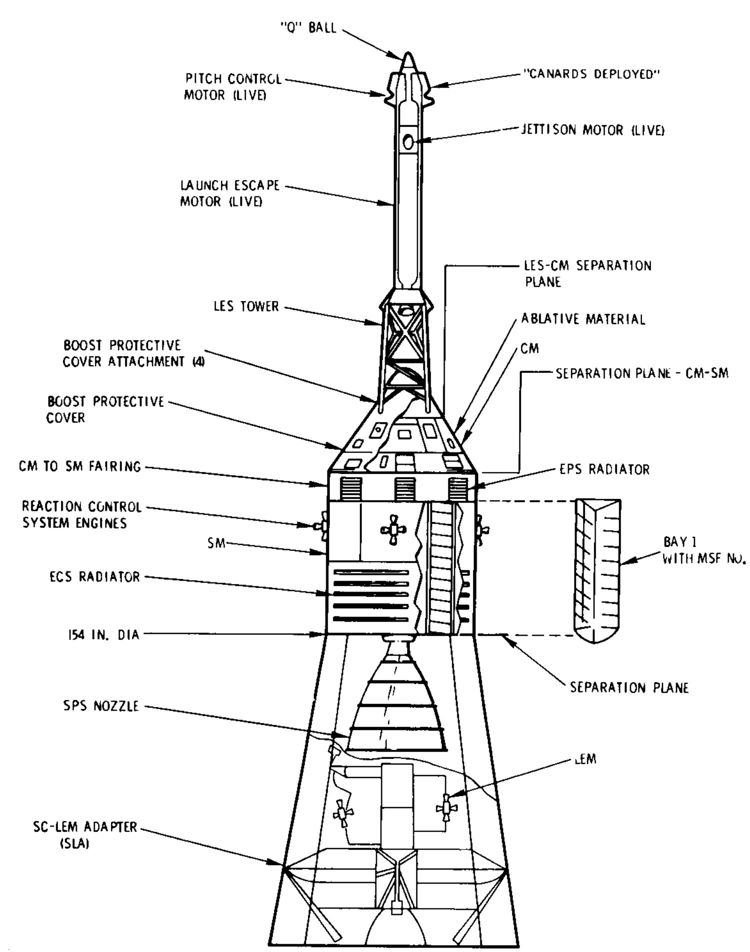


Figure 10. Flight 507 Mission Description

[redacted]

[redacted]

MISSION: 509 EARTH SYNCH. ORBIT

MISSION TITLE: ASTRONOMY

DURATION: 14 DAYS (PHASE I MISSION)

CREW : THREE

OBJECTIVES: THE SENSORS ON THIS FLIGHT EXAMINE THE EMITTED RADIATION & OTHER PHENOMENA OF THE SUN & STARS
CONDUCT BIOMEDICAL EXPERIMENTS

EXPERIMENTS :

M-5 BODY FLUID BIOASSAYS
M-8 SLEEP ANALYSIS
0107 VENOUS COMPLIANCE
0109 PULMONARY DYNAMICS
0110 VENTILATORY GAS EXCHANGE
0114 GASTROINTESTINAL MOTILITY
0115 THERMAL REGULATION
0117 ENDOCRINE FUNCTION
0118 HEMIC CELL
0119 HEMATOLOGICAL DEFENSES
0120 HEMOSTASIS
0201 SENSORY & PERCEPTUAL PROCESS
0203 HIGHER MENTAL PROCESSES
1001 UV STELLAR PHOTOGRAPHY
BAY1 ASTRONOMICAL EXPERIMENTS ORIENTATION SYSTEM
LEM (GRUMMAN RESPONSIBLE CONTRACTOR)
RADIO ASTRONOMY
SMALL MANEUVERABLE SATELLITE
X-RAY ASTRONOMY
MARTIAN ATMOSPHERE
FAR UV IMAGE CONVERTER FOR STELLAR ASTRONOMY
ARTIFICAL COMETS
MAGNETOMETER

CONFIGURATION: CSM (SC109)
LEM
SM BAY 1 WITH ASTRONOMICAL ORIENTATION SYSTEM
BOOSTER: SATURN V

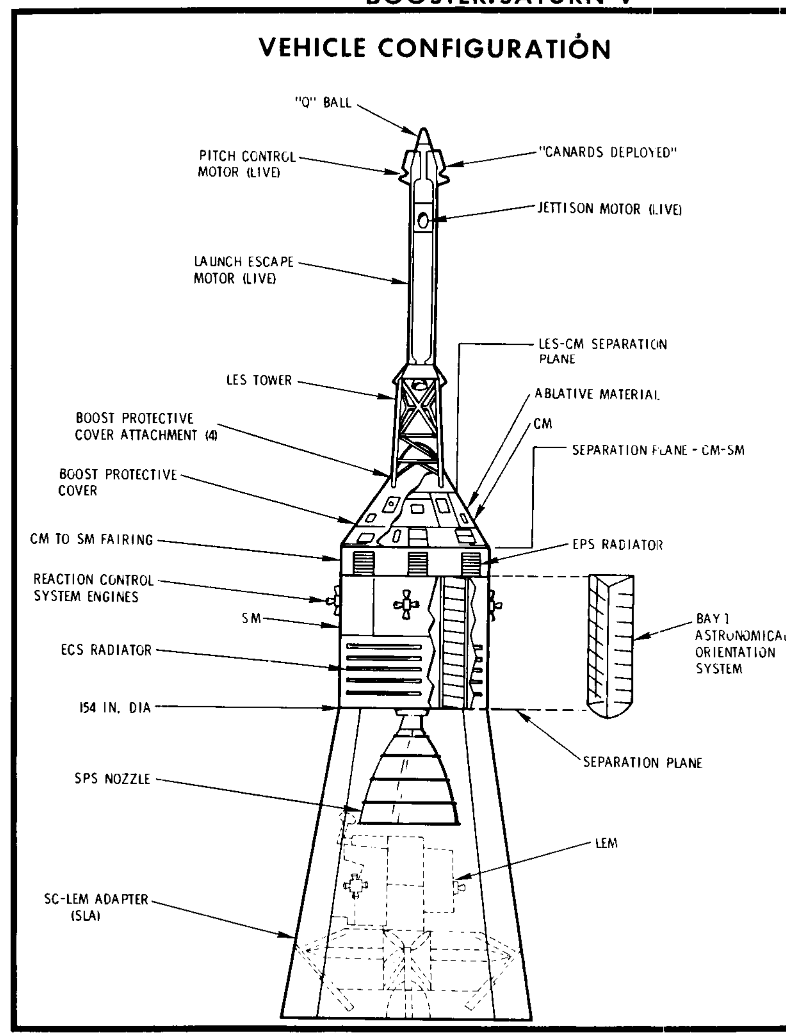


Figure 11. Flight 509 Mission Description

[redacted]

[redacted]

MISSION: 214 EARTH ORBITAL

MISSION TITLE: ADVANCED MISSION SC SUBSYSTEMS

DURATION: 14 DAYS (PHASE I MISSION)

CREW: 0

OBJECTIVES: PASSIVE TARGET VEHICLE IN RENDEZVOUS WITH SA-215. ACCOMMODATE SPACE OPERATIONS AND TECHNOLOGY EXPERIMENTS.

EXPERIMENTS: (GRUMMAN RESPONSIBLE CONTRACTOR)

- RADIATION ENVIRONMENT MONITORING
- CAPILLARITY STUDIES
- DEPLOYMENT OF R.F. REFLECTIVE STRUCTURES
- ON BOARD GUIDANCE & NAVIGATION SYSTEMS
- ORBITAL MANEUVERING & DOCKING
- CONTROL MOMENT GYRO
- OPTICAL GUIDANCE SYSTEM FOR RENDEZVOUS
- PROPELLANT HANDLING

CONFIGURATION: BOILERPLATE CSM
LEM (INERT A/S & D/S PROPULSION)
BOOSTER: SATURN IB

VEHICLE CONFIGURATION

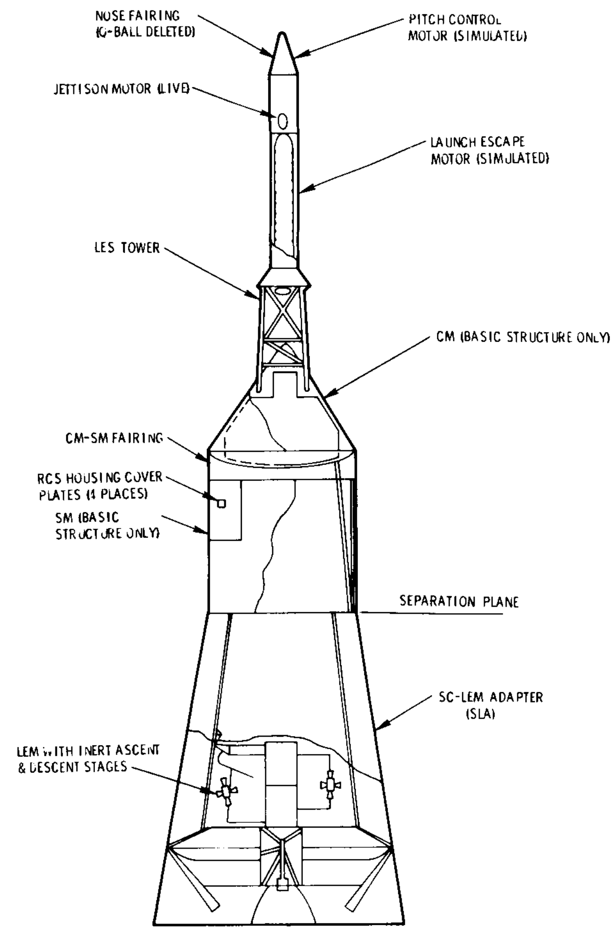


Figure 12. Flight 214 Mission Description

[redacted]

MISSION: 215 EARTH ORBITAL

MISSION TITLE: ADVANCED MISSION SC SUBSYSTEMS

DURATION: 14 DAYS (PHASE I MISSION)

CREW: THREE

CONFIGURATION: CSM (SC III)

BOOSTER: SATURN IB

OBJECTIVES:

RENDEZVOUS WITH SA-214. CONDUCT BIOMEDICAL EXPERIMENTS AND LEM LAB EXPERIMENTS AFTER RENDEZVOUS.

EXPERIMENTS:

- M-5 BODY FLUID BIOASSAYS
- 0118 HEMIC CELL
- 0119 HEMATOLOGICAL DEFENSES
- 0120 HEMOSTASIS
- 0203 HIGHER MENTAL PROCESSES

VEHICLE CONFIGURATION

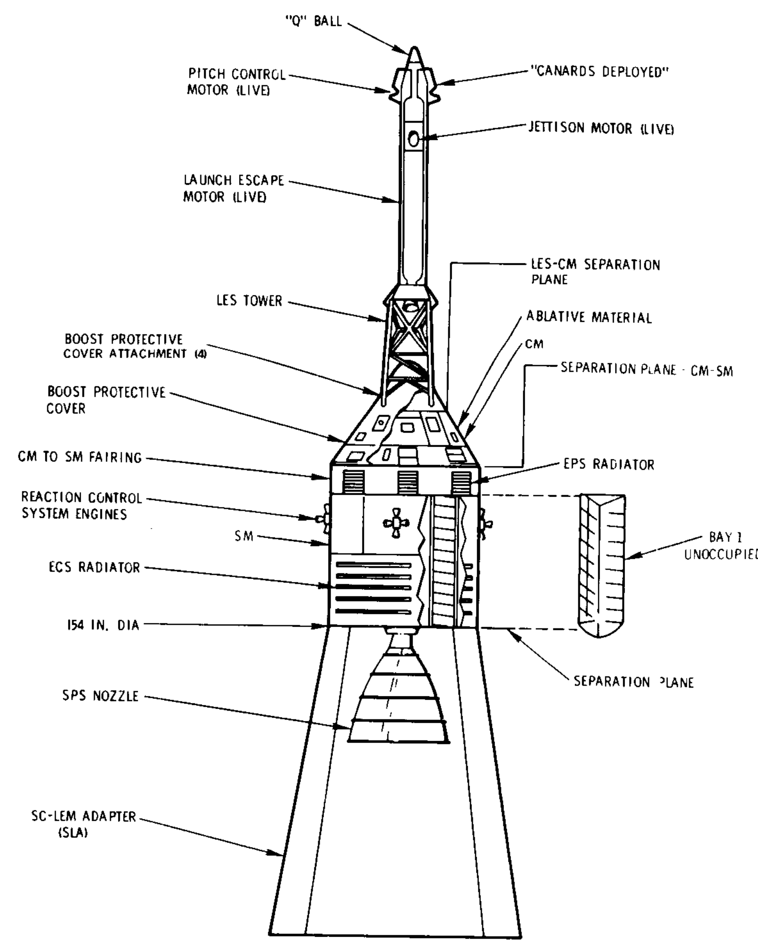


Figure 13. Flight 215 Mission Description

[redacted]

MISSION: 511 LUNAR ORBIT LOW INCLINATION

MISSION TITLE: LUNAR SURVEY AND MAPPING

DURATION: 14 DAYS (PHASE 1 MISSION)

CREW: THREE

OBJECTIVES: THIS FLIGHT WILL EMPLOY THE MSF NO. 1 FOR LUNAR MAPPING AND SURVEY. THE SENSORS ON THIS FLIGHT EXAMINE THE CHARACTERISTICS OF THE MOON BY PHOTOGRAPHIC, INFRARED, MICROWAVE, RADAR, UV, X-RAY, GAMMA RAY, GRAVITY SENSING, AND ASSOCIATED TECHNIQUES. PROBES ARE USED TO EXAMINE UNIQUE SURFACE FEATURES.

EXPERIMENTS:

M-5	BODY FLUID BIOASSAYS
M-8	SLEEP ANALYSIS
0103	CIRCULATORY DYNAMICS
0104	WORK CAPACITY
0105	BLOOD VOLUME CHANGES
0106	CAROTID BARORECEPTOR
0107	VENOUS COMPLIANCE
0109	PULMONARY DYNAMICS
0110	VENTILATORY GAS EXCHANGE
0111	MUSCLES MASS & STRENGTH
0112	MINERAL METABOLISM
0113	NUTRITIONAL STATUS
0114	GASTROINTESTINAL MOTILITY
0115	THERMAL REGULATION
0117	ENDOCRINE FUNCTION
0118	HEMIC CELL
0119	HEMATOLOGICAL DEFENSES
0120	HEMOSTASIS
0201	SENSORY & PERCEPTUAL PROCESS
0202	PSYCHOMOTOR FUNCTIONING
0203	HIGHER MENTAL PROCESSES
BAY 1	LUNAR ORBIT SURVEY LUNAR MAPPING & SURVEY PHOTOGRAPHY (MSF-1)
LEM	PHOTOGRAPHIC INVESTIGATION ASSEMBLY NO. 2 & NO 3 LUNAR SURFACE PROBES VIEWFINDER

CONFIGURATION: CSM
LEM
SM BAY 1 WITH MSF-1
BOOSTER: SATURN V

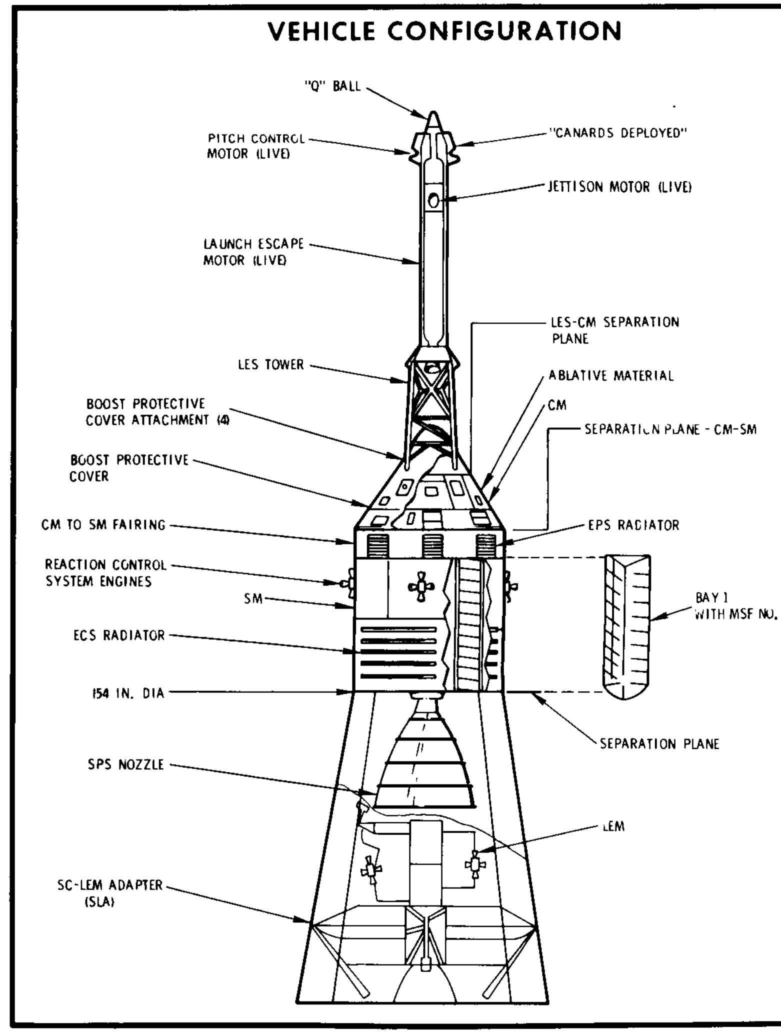


Figure 14. Flight 511 Mission Description

[redacted]

[redacted]

MISSION: 216 EARTH ORBITAL

MISSION TITLE: EXTRAVEHICULAR ENGINEERING ACTIVITIES

DURATION: 14 DAYS (PHASE I MISSION)

CREW: 0

OBJECTIVES: PASSIVE TARGET VEHICLE IN RENDEZVOUS WITH SA-215. ACCOMMODATE SPACE OPERATIONS AND TECHNOLOGY EXPERIMENTS.

EXPERIMENTS: (GRUMMAN RESPONSIBLE CONTRACTOR)

- RADIATION ENVIRONMENT MONITORING
- CAPILLARITY STUDIES
- EXTENDABLE ROD PERFORMANCE TEST
- EVALUATION OF SPACE SUITS
- MANNED LOCOMOTION AND MANEUVERING CAPABILITY
- EMERGENCY TECHNIQUES FOR RESCUE
- DEVELOPMENT OF PERSONAL CARGO TRANSFER OPERATIONS
- EXPENDABLE AIRLOCK
- PROPELLANT HANDLING

CONFIGURATION: BOILERPLATE CSM
LEM (INERT A/S &
D/S PROPULSION)
BOOSTER: SATURN IB

VEHICLE CONFIGURATION

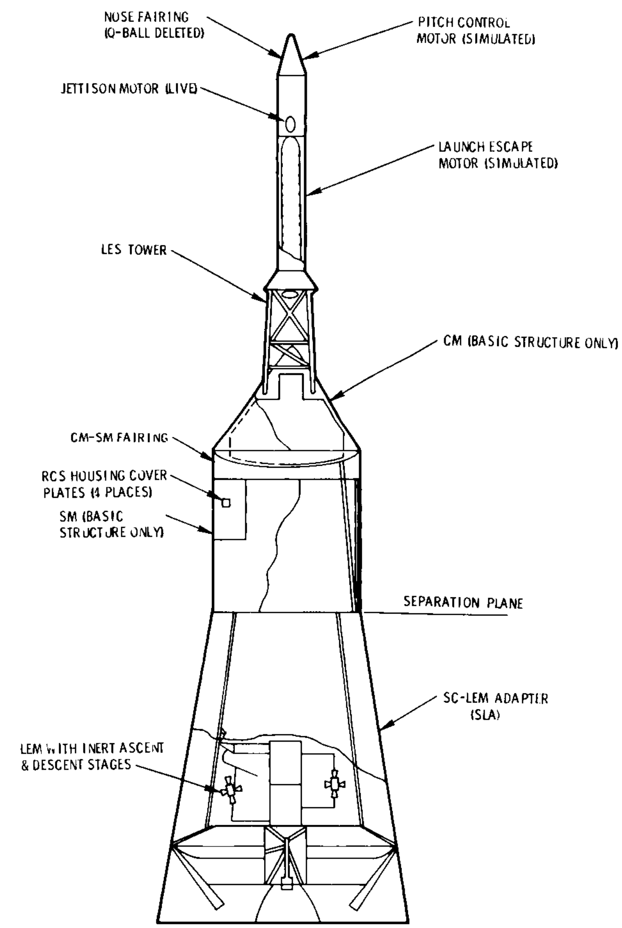


Figure 15. Flight 216 Mission Description

[redacted]

[redacted]

MISSION: 217 EARTH ORBITAL

MISSION TITLE: EXTRAVEHICULAR ENGINEERING ACTIVITIES

DURATION: 14 DAYS (PHASE I MISSION)

CREW: THREE

CONFIGURATION: CSM (SC 114)

BOOSTER: SATURN IB

OBJECTIVES:

RENDEZVOUS WITH SA-214. CONDUCT BIOMEDICAL EXPERIMENTS AND LEM LAB EXPERIMENTS AFTER RENDEZVOUS.

EXPERIMENTS:

M-5 BODY FLUID BIOASSAYS
M-8 SLEEP ANALYSIS
0103 CIRCULATROY DYNAMICS
0104 WORK CAPACITY
0105 BLOOD VOLUME CHANGES
0106 CAROTID BARORECEPTOR
0108 CIRCULATORY REFLEX CHANGES
0111 MUSCLES MASS AND STRENGTH
0112 MINERAL METABOLISM
0113 NUTRITIONAL STATUS
0117 ENDOCRINE FUNCTION
0118 HEMIC CELL
0119 HEMATOLOGICAL DEFENSES
0120 HEMOSTASIS
0201 SENSORY AND PERCEPTUAL PROCESS
0202 PSYCHOMOTOR FUNCTIONING
0203 HIGHER METAL PROCESSES

VEHICLE CONFIGURATION

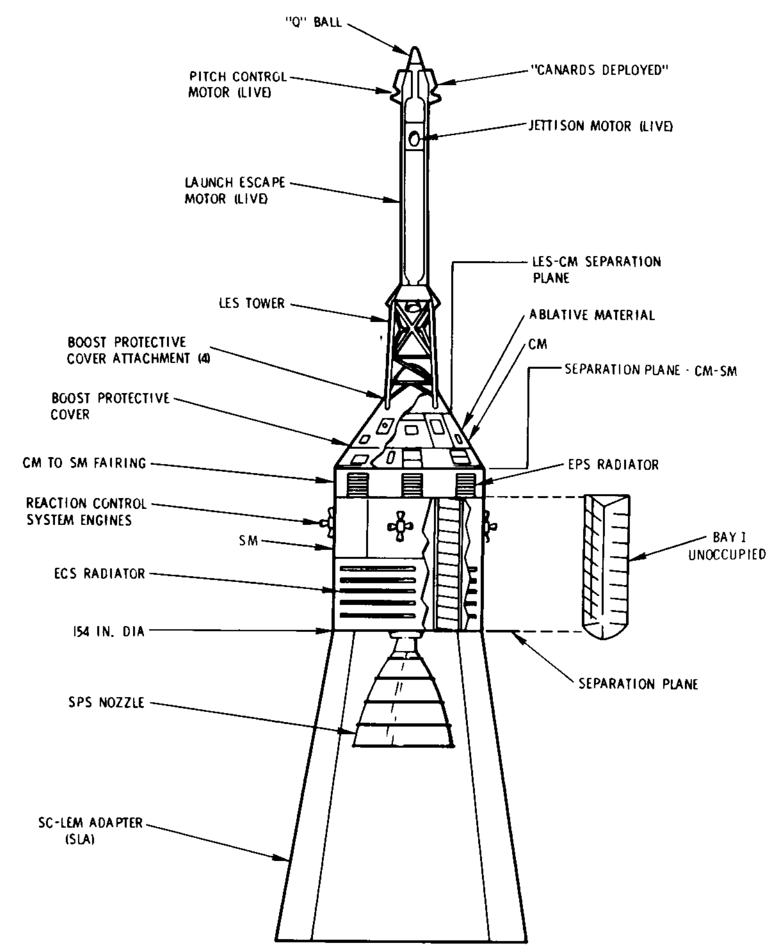
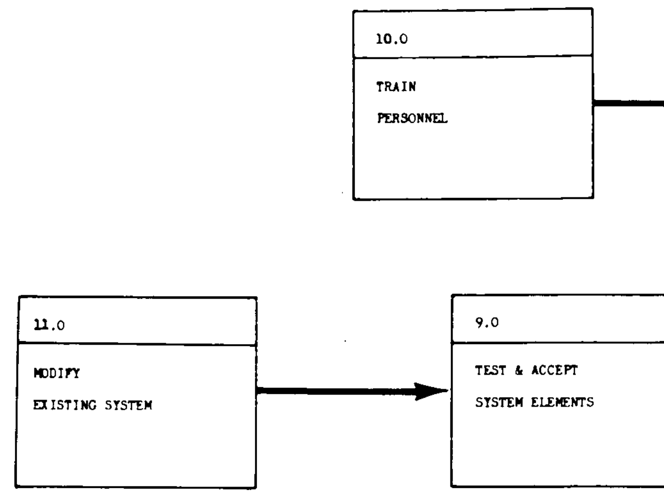


Figure 16. Flight 217 Mission Description

[redacted]

[redacted]


10.0
TRAIN
PERSONNEL
11.0
MODIFY
EXISTING SYSTEM
9.0
TEST & ACCEPT
SYSTEM ELEMENTS

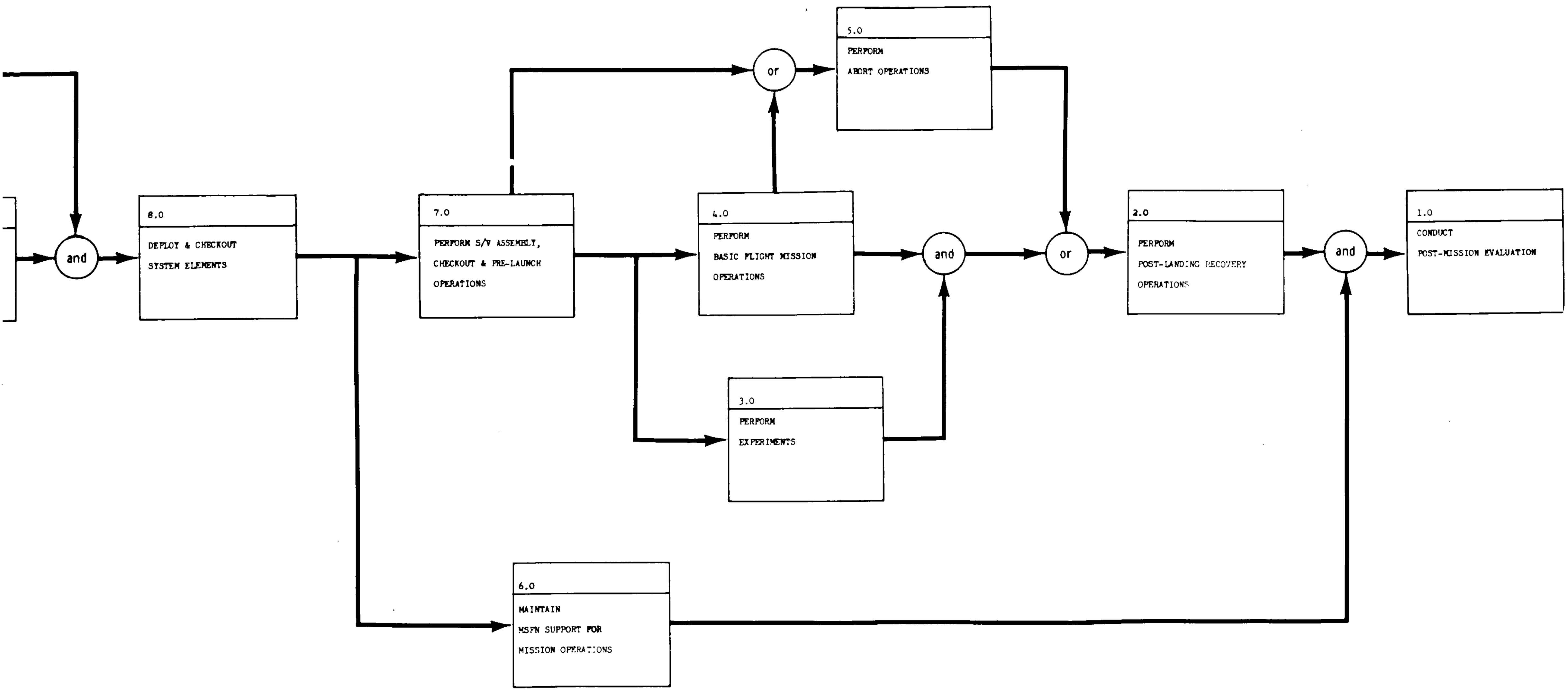


Figure 17. Top Level Functional Flow

Additional first and second level functional flow diagrams relating to test, acceptance, checkout and prelaunch activities maybe found in the "Test and Operations" section.

TESTING

Development Testing

Components for structural mounting of experiment packages in the spacecraft and for connecting with Apollo subsystems would be developed by the CSM contractor for each mission. Uniformity of hardware would be achieved wherever possible to minimize development and qualification testing. Testing of each type of component would be performed as part of the respective CSM subsystem development plan (i.e., structures, Guidance, Navigation and Control, Electrical Power System, ordnance, etc.). The test logic and development phase schedule associated with each group of experiments would be included in the experiment implementation plan for each flight vehicle.

Test Levels

Development issues that must be resolved by test or by a combination of analysis and test would be resolved at the lowest practicable testing level necessary to satisfy CSM design, construction, and quality assurance provisions. Development testing includes structural and dynamic tests of components or sections of components to determine or verify strength allowables where design data are not available or are not directly applicable.

Components

All cables, connectors, displays, instrumentation, etc., would use the same materials, parts, and design standards as those for other Apollo CSM applications. Therefore, no development or qualification tests would be required. The functional performance of these items would be verified in manufacturing tests. Other component-level testing may be performed on attachment fittings, mounting brackets, access panels, etc., as required.

Subassemblies

Subassembly testing **may** include verification and qualification of release mechanisms, airlock mechanisms, ordnance devices, etc. Qualification testing should be conducted at the subassembly level or higher for structural and mechanical hardware required to support experiment operations.

Qualification

CSM subsystems such as structural, mechanical, electrical power, guidance/navigation/control, reaction control, etc., may be modified to account for interface requirements created by inclusion of experiments. Changes in environments generated by these modifications may require partial or full requalification, depending on the extent of such changes.

Components and subassemblies may be considered qualified in cases where requirements are met because of similarity to previously qualified CSM hardware.

Integrated Tests

Integrated system checkout and testing may be performed on CSM ground test vehicles to demonstrate compatibility of GSE with spacecraft and experiments and to demonstrate system performance and ability during simulated mission sequences.

Ground Vehicle Integrated Tests

The presently planned schedules of Block II Apollo ground test vehicles would permit their use in the experiment subsystem development in support of Block II spacecraft on which experiments may be installed. The test program may include verification of hardware form and fit, installation procedures, GSE functions, equipment maintainability, and integrated operations.

Ground Operations

Ground operations include the installation of experiment equipment and the checkout and test procedures conducted on the equipment after it is integrated in the spacecraft. These functions must be integrated with Apollo program ground operations so as to minimize schedule impact and not interfere with normal spacecraft buildup and checkout. To the extent possible, operations required on the experiment equipment will be conducted in conjunction with parallel operations on the spacecraft.

Checkout Philosophy

Particular effort should be made to plan test and checkout operations on experimental hardware to minimize the overall impact on the Apollo program. Achievement of test objectives that do not require exercising spacecraft systems and do not depend on the interface between the experiment equipment and the spacecraft should be achieved before installation of the experiment equipment. Checkout operations performed after installation should be planned so that experiment equipment tests will be performed in conjunction with similar tests of other spacecraft subsystems.

Checkout procedures should not be designed to be dependent on use of spacecraft GSE or test equipment unless prior concurrence has been obtained from the Apollo CSM contractor and NASA. Special GSE required for experiment checkout will be delivered to NASA and provided to the CSM contractor as required.

Test Program

The test program is divided into two phases. The first includes testing aimed at development and qualification of the experiment and the second includes acquisition of test results or test data generated during the AES flights. Experiment equipment to be used during these flights must

[redacted]

be tested to verify that no loads or conditions are imposed in excess of those proved acceptable for Block II missions.

The type of extent of testing depends on the experiment equipment design, function during the mission, location in the spacecraft, and duration of operation. Tests that might be required include parameter variations (inputs, loads, and internal), life and reliability, electromagnetic interference generation, electromagnetic interference susceptibility, nuclear radiation, solar radiation, vibration, acoustic, acceleration, shock, vacuum and/or pressure, temperature extremes and cycling, humidity, fungus, salt spray, and corrosive material effects.

Ground Testing

The purpose of ground testing various items of equipment is to verify that the items perform as intended in their operational environment, to qualify the items for use, and to verify flight readiness. The AES CSM General Test Plan delineates the general test requirements. Test requirements for specific vehicles will be described in the individual vehicle test plans.

All experiment equipment must be qualified to show (within a confidence level yet to be established) that: (1) their performance will not be degraded in the planned environment (i.e., oxygen, radiation and space, etc.); and (2) that they will not adversely affect mission success and crew safety. Crew safety is an especially important consideration. The following general test ground rules are established:

1. The experiments to be installed must be designed to be within system limitations.

2. Minimum change will be made to any system housing experiments. Allowable modifications include installation of the mounting structure for the experiments, electrical wiring and connection for the experiments, limited controls for the pallet experiments, and the minimal necessary interface modifications between CSM and lunar excursion module (LEM) imposed by LEM experiment integration.

3. Interface testing will be required for the pallet and for experiments on the pallet to be installed in the SM. When it is integrated with the SM, it will be assumed that the pallet is a self-contained unit, that the pallet structure and systems have been qualified by the associate contractors, and that they meet AES mission requirements.

Development Tests

Design development tests should be conducted on materials, components, partial experiment equipment, and complete equipment to determine if the selected design concepts and equipment are capable of satisfying the specified design requirements and environmental criteria.

[redacted]

Structural tests will be needed to qualify load-carrying members to withstand launch and prolonged in-space powered flight environments, and where applicable, reentry and landing conditions.

Environmental proof tests will be needed to verify that the experiment equipment items will not be degraded in the prolonged space environment and will meet performance requirements.

Integrated tests of experiment equipment operating with simulated spacecraft or ground support equipment input and loads will be needed to verify that the experiment equipment will meet performance and compatibility requirements when interacting with other spacecraft and system elements (including ground equipment, telemetry, inflight recorders, etc.). Simulation is explained under a subsequent section.

Qualification Tests

Qualification tests must be conducted on components and equipment fabricated with the same tooling, processes, and procedures intended to be used for production to assure that they are capable of satisfying the requirements of the applicable drawings, specifications, design requirements, and environmental criteria.

SPECIFICATIONS

During FDP, the CSM contractor will prepare the following specifications to establish the performance and interface requirements:

GFE Apollo CSM Performance and Interface Specification (Group A)

GFE LEM Lab Performance and Interface Specification (Group A)

GFE Experiment Equipment Performance and Interface Specification (General Requirements).

For the purpose of the program:

Group A equipment is generally described as follows: brackets, electrical power, environment, weight, volume, etc.

Group B equipment would include the various experiments design requirements (by experiment), categorized to the Group A requirements.

Utilizing this method of categorizing Group A and B requirements will provide the capability of changing experiments, or groups of experiments, per mission, with a minimum of modification. Therefore, included with each experiment package should be the identification of the final point prior to launch, when each experiment could be installed with minimum disruption to the countdown (e.g., to minimize the requirement to repeat any portion of the countdown).

[redacted]

[redacted]

Establishing the identified Performance and Interface Specifications will provide the capability of communication between the CSM contractor and the LEM and various experiment contractors within the confines of their respective contracts. Further communication at a detail level is provided by Interface Control Documents (ICD's), providing that the content of the ICD's does not affect the Contract End Item Specifications of the respective contractors once the requirements of the P&I specifications have been incorporated.

MANUFACTURING

The major manufacturing effort expended in support of the Phase I Experiment Integration will be to provide fabrication support of modification kits. Since all specific experiment components will be installed at KSC, the present Block II manufacturing installation sequence will experience only a minor variation such as incorporation of additional wires into the electrical harnesses and CSM umbilical to accommodate the terminals reserved for experiments.

The areas of the CSM requiring modification to accept the proposed AES Phase I experiments have been identified and the scope of modification estimated. The baseline for the manufacturing analysis is that defined by the engineering design integration conceptual analysis.

Since the structural and systems modification requirements for each flight mission are similar, the changes listed in this study are considered applicable to each flight mission. The present concept to install the pallet only in Flight 211 would not negate the above baseline. The structural pallet mounting provision would be identical in all service modules.

COMMAND MODULE

The necessary controls and displays for the numerous bio-medical experiments and their components and astronomical experiments planned for the Phase I missions will be housed in the command module. The command module areas affected are the lower equipment bay, right hand equipment bay, and aft bulkhead storage area.

The lower equipment bay aft compartment, between the girth shelf (approximately Xc=42.0) and the battery shelf (approximately Xc=20) will require an extensive equipment rearrangement (Figure 18). Apollo Block II equipment, such as the scientific equipment sequence camera, still camera, film and tape, rock boxes, etc., will be removed since they are not part of Phase I flight mission requirements. AES Phase I experiments equipment, such as the centrifuge, electrocardiograph, impedance pneumograph, thermister assembly, vision analyzer, acceleration chair, goniometer, integrated performance test panel, electromyograph, etc., will be installed to perform the flight mission requirements. To satisfy this rearrangement, this support structure requires modification.

The existing systems support structure configuration will be utilized with no changes. All new requirements will be designed to use the present attach provisions.

Two new equipment shelves will be required in the area of the Block II rock boxes, and these shelves will be fastened to the present vertical frame without modifying the attach provisions.

[redacted]

[redacted]

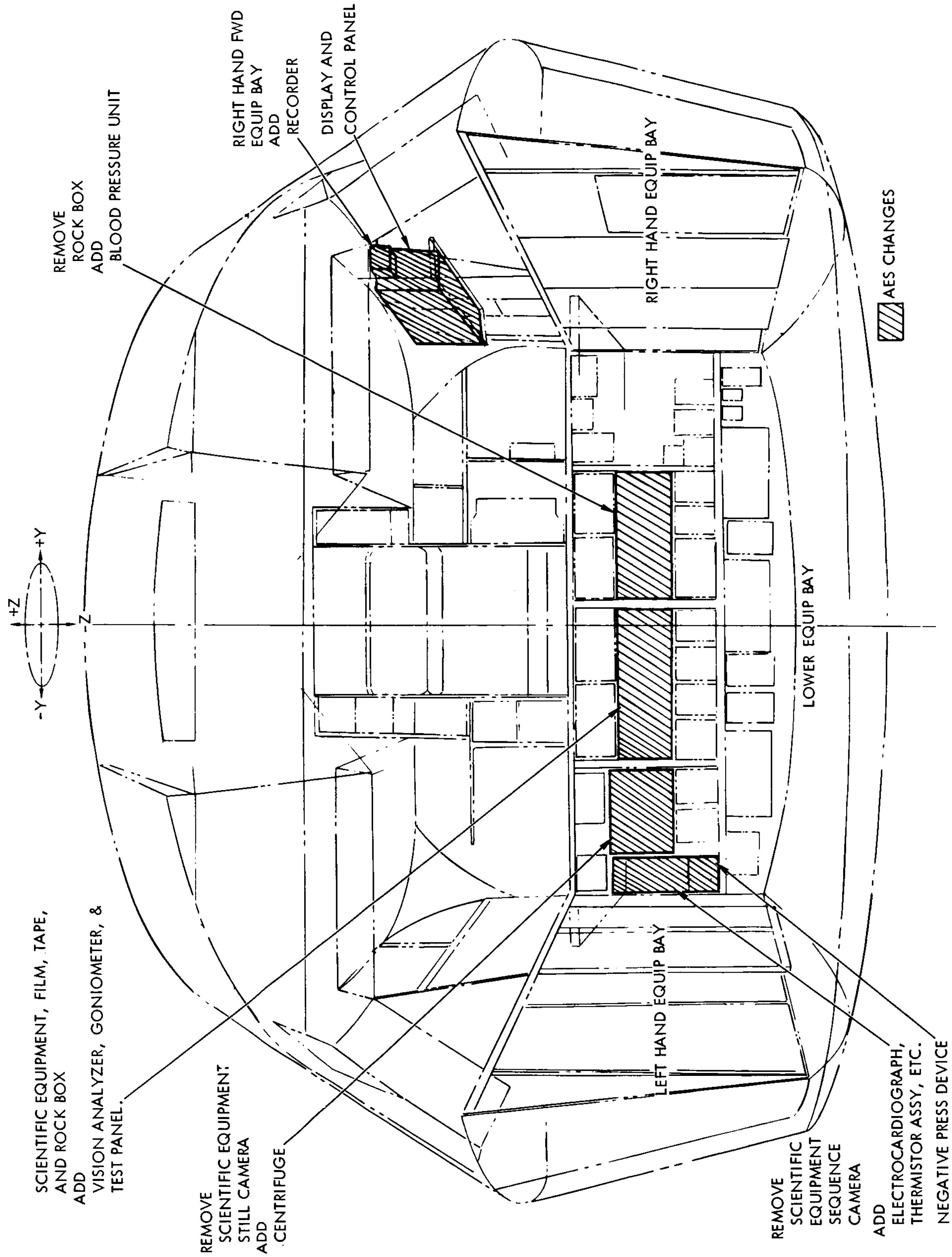


Figure 18. Basic Apollo Block II CM Inner Structure Equipment Bays

[redacted]

As many as thirteen new equipment containers will be required to house the experiments components. These containers are conventionally constructed sheetmetal boxes.

The tooling requirements will include new detail tooling and assembly jigs for the shelf assemblies and equipment containers. Apply jigs, coordinated to master tooling, are required for drilling the attachment hole patterns.

The right hand forward equipment bay, between approximately Xc=55.0 and Xc=65.0, will be modified to accommodate the installation of a tape recorder and a Phase I experiments display panel for housing the various experiments controls and displays (Figure 18). To meet these requirements, the systems support structure shelf panel, located approximately Xc=65.0, must be revised to add matching attach holes for installing the tape recorder. The shelf must accommodate the installation of the display panel which has rotating and adjusting capabilities.

A structure assembly will be fabricated to mount the experiments display panel to the systems support structure. This assembly is designed to provide for the display panel to be stored in an Xc plane until required in flight and then be swung out in a Yc plane while in use. The panel will be adjustable inboard and outboard as needed.

An electrical harness revision is required to accommodate the additional controls, displays, and the tape recorder.

The tooling requirements will include conventional detail tools and templates for fabrication of all new detail components for the display panel and mounting assembly, and rework of the shelf. Additional requirements include master tools for coordination of the component attach hole patterns; an assembly jig for assembly of the display mounting structure; numerical control tapes for machining the systems support structure shelf and the display panel plate; apply jigs for drilling all attach holes; and jig boards for electrical wire harness assemblies.

The aft bulkhead storage area will be modified to provide storage for Phase I experiments such as muscle assessment assembly, spectrocolorimeter, refractometer, etc. Additional sheetmetal storage containers will be attached to the aft bulkhead.

The tooling requirements will include new assembly jigs for assembly of storage containers, apply jigs for locating and installing bracket attach members, and drill jigs for drilling attach hole patterns.

SERVICE MODULE

The AES Phase I experiments assigned to the service module are housed in the Sector I region. The baseline criteria indicates that all experiments will be self-contained. Therefore, the only changes outside of Sector I will be the CSM umbilical requirements for controls and display provisions.

[redacted]

Structural and Systems Changes

The service module Sector I outer panel will be modified for each Phase I flight mission to provide for the differences in mission assignments; however, certain basic panel requirements are applicable to all missions.

The basic Apollo Block II panel configuration provisions, including the panel attach bolt hole pattern to the primary structure, must be maintained.

The requirements for a jettisonable Sector I outer panel for most Phase I missions necessitates the addition of a pyrotechnic separation system. This would require a machined channel fitting around the periphery of the panel and an attach bolt hole pattern in the fitting and panel. A panel recess would be required in the forward outer corners to accommodate the pallet attachment fittings. A new edge member configuration would be required to include a relief for explosive separation. In addition, a number of access doors would be necessary for pallet experiment accessibility prior to launch.

The tooling requirements will include the following: a new bond jig and glide sheets for assembly of the outer cover panel, and new bond jigs for assembly of access panels; apply jigs for drilling matching attach hole patterns for attachment of pyrotechnic separation system and access panels; master tooling to coordinate attach hole patterns and interfaces; detail tooling for fabrication of detail parts; and prefit and trim jigs for final trim of assemblies.

Pallet Installation and Ejection Provisions

The service module Sector I must be modified to accommodate the installation of the planned Phase I experiments pallet which will house the experiment components. Pallet ejection provisions have been projected in the structural modifications (Figure 19).

A machined pallet roller support rail, machined explosive bolt attach fitting, and ejection ram attach fitting must be added to the service module aft bulkhead. These fittings will be bolted to the aft bulkhead and located in accordance with the pallet thruster ejection assembly. A machined beam extending across the Sector I interior web will be added. This beam will include pickup socket recesses in two places to receive the pallet 9° Fabroid lined cone fittings. Matched tooling will coordinate the pallet to the service module. Attach fittings will be bolted to radial beams numbers 1 and 6.

Two machined fittings with pickup socket recesses will be required in the forward-outer corners of Sector I. These fittings will be attached by bolts to the radial beams. Matched tooling will locate these fittings to assure proper pallet and service module interface.

Tooling requirements will include numerical control tapes for machined fittings, master tooling for coordination of attach hole patterns and interfaces, and apply jigs for locating and drilling fittings and holes in aft bulkhead and radial beams numbers 1 and 6.

[redacted]

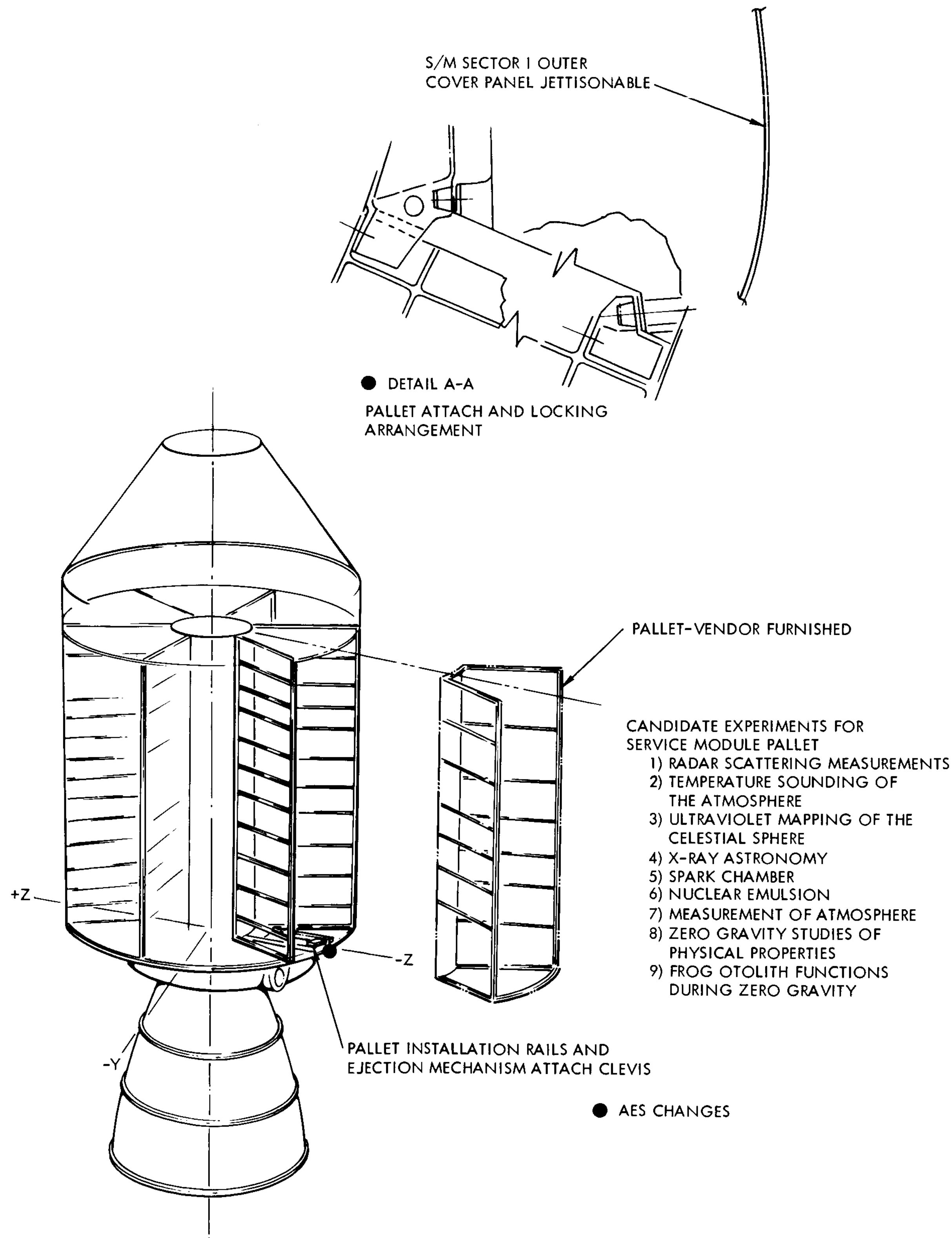


Figure 19. Basic Apollo Block II SM Structure

[redacted] [redacted]

[redacted]

CSM/Pallet Umbilical

The experiments located in the service module Sector I require controls and displays to be located in the command module. An umbilical for transmission of electrical impulse input and readout will be required between the pallet and the service module. It is assumed that the wires in the existing CSM umbilical, assigned to Sector I, will satisfy the present requirements.

The pallet may be programmed to be jettisoned after use on at least one mission. Therefore, the need for a cable harness separation mechanism exists. All tooling for installation of experiment provisions will be provided with the manufactured and purchased "kit" details, assemblies, and components for test site use.

INSTALLATION SEQUENCE ANALYSIS

Installation performed at the launch site is described in the Test and Operations and the Logistics sections of this plan.

SCHEDULING

As stated under "Approach", the baseline schedules used for evaluation of Phase I missions are Apollo schedule MDS 8, Rev. 3, and AES Development/Operations Phase MDS 11-2, dated 4 November 1965. The vehicles affected are SC 106 (SA 211), SC 107 (SA 507), SC 109 (SA 509), SC 111 (SA 215), SC 112 (SA 511), and SC 114 (SA 217). The major area in manufacturing requiring schedule coordination will be in tool fabrication to support the CSM modification requirements. Tooling will first be required to be completed in support of SC 106 (SA 211), based on the assumption that structural and systems modification requirements will be similar for each flight mission.

No basic change to Apollo Block II systems installation is anticipated; however, schedule consideration will be necessary for the programming of additional wire harness requirements to support experiment components.

Schedules depicting the estimated time for accomplishing the manufacturing tasks will be prepared when experiments equipment requirements are defined in sufficient detail to determine specific tools and installation requirements. As shown in the Preliminary Experimenter/CSM Contractor Interface Schedule (Figure 4), identification of modification changes by NASA must take place before detailed manufacturing schedules can be completed. For major modifications requiring extensive tool fabrication, notification is needed approximately ten to twelve months prior to incorporation of structural changes.

[redacted]

TEST OPERATIONS

The CSM and LEM-Laboratory factory checkout and field operations and spacecraft modification requirements were studied by NAA and GAEC respectively. The Laboratory operations discussions below were extracted from the AES-Lunar Excursion Module Phase B Final Report. Preliminary integration of the Lab and CSM plans are reflected in the CSM field operations discussions. Baseline data is provided for mutual FDP study cf schedule and test operations interface problem areas not yet resolved. The combined facility/equipment support requirements, optimum KSC master schedule (integrated LAB, Launch Vehicle and CSM schedule potential) and final implementation plan for integrated EMC test of the combined Lab-CSM spacecraft must be finalized during FDP.

CSM

The CSM Baseline Ground Operations Requirements for AES Phase I Spacecraft are defined in SID 65-1151 GORP, which provides the basis for definition, planning, and performance of required spacecraft ground test and operations. Requirements generated for individual AES Phase I spacecraft are given in the respective Mission Description documents. Pertinent information has been summarized herein to describe the operations that were evaluated in respect to checkout and operations required for the AES Phase I missions that are in addition to the basic Apollo Block II CSM. The Downey operations are discussed for future consideration of in-line provisioning for AES missions.

NAA Downey Operations (CSM Flight Spacecraft Acceptance Test)

The checkout functional flow for Downey test operations is shown in Figure 20. These operations are primarily conducted in the Installation and Checkout facility, Building 290. While the current baseline plan for AES Phase I mission assumes no spacecraft changes in-line during manufacturing and factory checkout, the test functions performed in Building 290 are summarized below to provide the basis for discussing impact if this baseline changes.

Test Operations to be performed at Downey start with the beginning of installed systems test and assume that manufacturing operations are complete. The checkout operations is designed to verify, within the limit of local safety ordnances, that the spacecraft system is physically and functionally capable of performing the assigned flight mission. In the case of AES Phase I experiments, this would include form, fit and functional checkout of any applicable wiring, mounting provisions or components installed during manufacturing. The significant Downey operations functions are summarized below with potential AES Phase I mission requirements impact being noted.

LES/CM/SM Installed Systems Test

The objective of these tests is to demonstrate the functional capability of the SC systems by exercising them to their design limits. All system interfaces are verified except for fluid inter-connections between the CM and SM. The modules are installed on separate stands in the integrated test station. The CM is complete except for the aft heat shield and ELS parachute system. The SM is complet except for the High Gain Antenna (HGA) and SPS nozzle extension. The LES is complete except for the pyrotechnics, solid fuel motors, and Q-ball. The modules are mated together electrically by extender cables.

Functional checkout of the spacecraft begins with verifying the ECS water glycol system capability to provide cooling support to the subsystems. Checkout of the subsystems then follows a logical buildup from individual subsystem and combinations to an integrated system level. For excample, the RCS subsystem, SCS and G&N are tested together following individual checkout. The related Controls and Displays and instrumentation are verified at the same time as the subsystem. At conclusion of these tests, the spacecraft is verified ready for final integrated systems checkout.

Provisions for AES Phase I experiments pyaloads installed during manufacturing will be checked, in so far as practical, during this period. The objective would be to verify interfaces with individual spacecraft subsystems. In addition, checkout during this period will allow verification of wiring connection quality during the subsequent Quality Verification Vibration Tests.

Quality Verification Vibration Tests (QVVT)

QVVT is performed immediately following Installed Systems checkout. The spacecraft remains in the unstacked electrically-mated configuration. The subsystem operation is interrogated to verify satisfactory operation while the spacecraft is subjected to low-level vibration. The integrity of electrical connectors, solder joints, and mechanical mounts is verified.

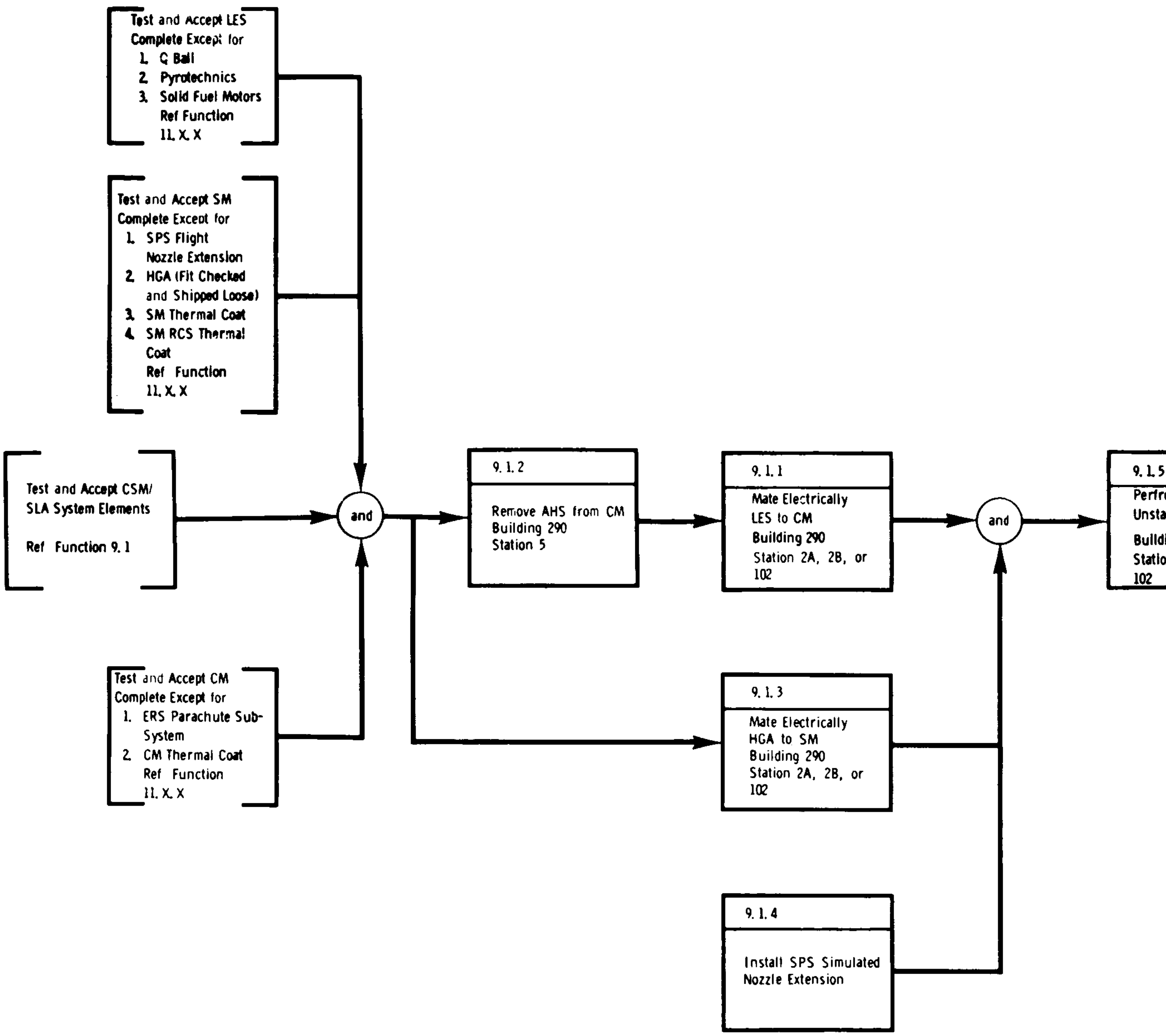
Wiring associated with AES Phase I mission requirements should also be verified under these environmental conditions. The requirements for inclusion of actual experiments in this test was not assessed, therefore, should be identified for future study. There would be no impact on the QVVT test time, but prior installation and checkout of experiment elements would be required.

Downstream CM and SM Configuration Update Period

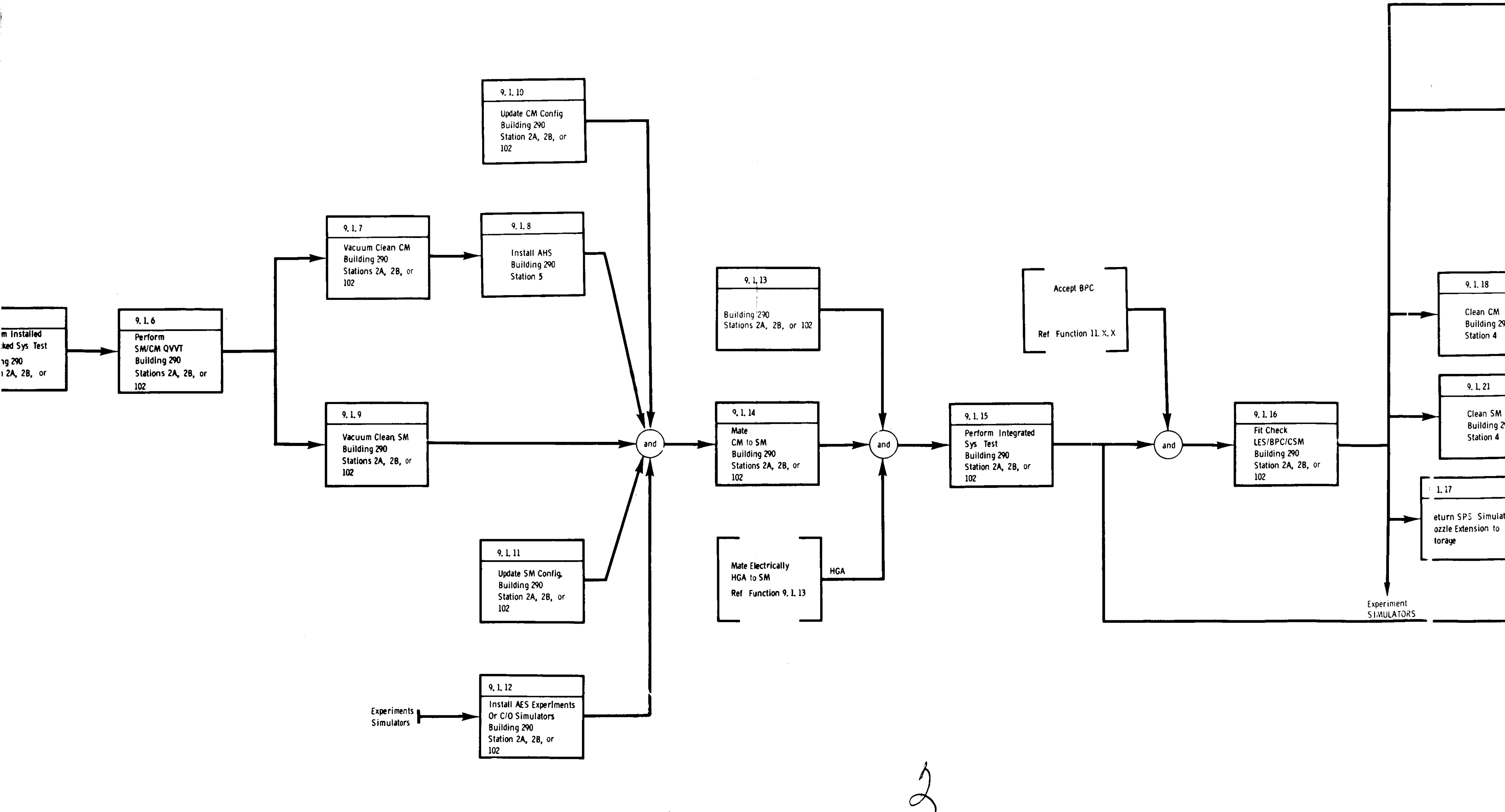
The CM is moved to the heat shield installation station where the aft heat shield is installed preparatory to mating the CM and SM for integrated systems tests.

Outstanding Engineering Orders (EO's) or late equipment are incorporated in the CM and SM prior to CSM mating. The objective is to prepare the spacecraft for the final mission readiness verification during integrated systems tests.

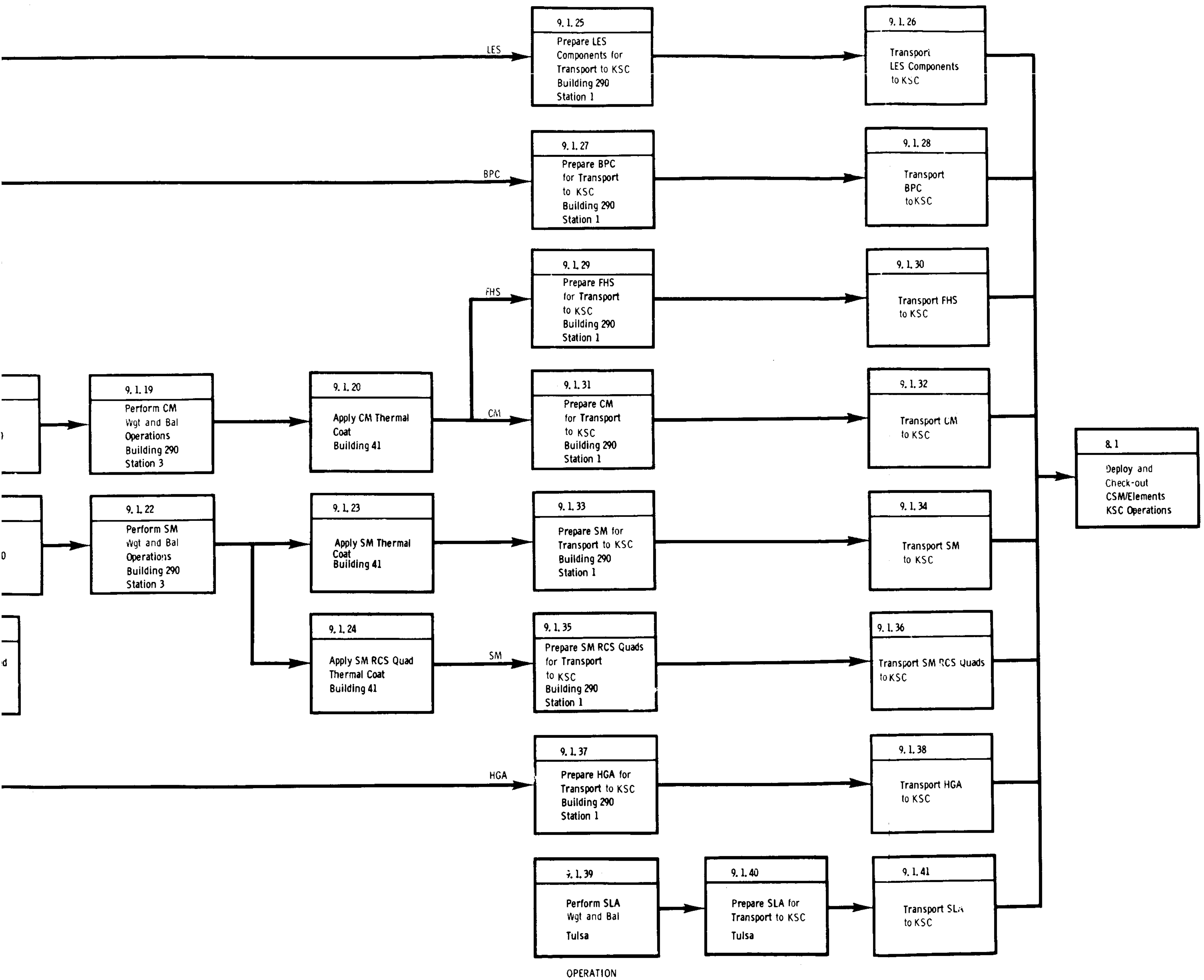
[redacted]



Test and Accept LES Complete Except for
1. Q Ball
2. Pyrotechnics
3. Solid Fuel Motors
Ref Function 11. X. X
Test and Accept SM Complete Except for
1. SPS Flight Nozzle Extension
2. HGA (Fit Checked and Shipped Loose)
3. SM Thermal Coat
4. SM RCS Thermal Coat
Ref Function 11. X. X
Test and Accept CSM/ SLA System Elements
Ref Function 9. 1
Test and Accept CM Complete Except for
1. ERS Parachute Sub-System
2. CM Thermal Coat
Ref Function 11. X. X
and
9. 1. 2
Remove AHS from CM Building 290 Station 5
9. 1. 1
Mate Electrically LES to CM Building 290 Station 2A, 2B, or 102
9. 1. 3
Mate Electrically HGA to SM Building 290 Station 2A, 2B, or 102
9. 1. 4
Install SPS Simulated Nozzle Extension
and
9. 1. 5
102



m Installed
ked Sys Test
ng 290
2A, 2B, or
9. 1. 6
Perform
SM/CM QVVT
Building 290
Stations 2A, 2B, or
102
9. 1. 7
Vacuum Clean CM
Building 290
Stations 2A, 2B, or
102
9. 1. 8
Install AHS
Building 290
Station 5
9. 1. 10
Update CM Config
Building 290
Station 2A, 2B, or
102
9. 1. 9
Vacuum Clean SM
Building 290
Stations 2A, 2B, or
102
9. 1. 11
Update SM Config
Building 290
Station 2A, 2B, or
102
Experiments
Simulators
9. 1. 12
Install AES Experiments
Or C/O Simulators
Building 290
Station 2A, 2B, or
102
and
9. 1. 13
Building 290
Stations 2A, 2B, or 102
9. 1. 14
Mate
CM to SM
Building 290
Stations 2A, 2B, or
102
Mate Electrically
HGA to SM
Ref Function 9. 1. 13
HGA
and
9. 1. 15
Perform Integrated
Sys Test
Building 290
Station 2A, 2B, or
102
Accept BPC
Ref Function 11. X. X
and
9. 1. 16
Fit Check
LES/BPC/CSM
Building 290
Station 2A, 2B, or
102
9. 1. 18
Clean CM
Building 2
Station 4
9. 1. 21
Clean SM
Building 2
Station 4
1. 17
eturn SPS Simula
ozzle Extension to
torage
Experiment
SIMULATORS
2



LEGEND

Command and Service Module Functions and Support Functions

Reference Function

ABBREVIATIONS

AHS	Aft Heat Shield
BPC	Boost Protective Cover
CM	Command Module
CSM	Mated Command and Service Module
FHS	Forward HeatShield
KSC	Kennedy Space Center, Florida
HGA	High Gain Antenna
LES	Launch Escape System
QVVT	Qualification Vibration Validation Test
RCS	Reaction Control System
SLA	Spacecraft/LEM Adapter
SM	Service Module

NOTES

AES Experiment Requirements to be Determined.

This Drawing is Based on AES Flight Mission Planning Data as Follows:

LV Configuration	S-IB
SC Configuration	CSM Only

Figure 20. Second-Level Functional Flow 9.1, Test and Acceptance CSM System Elements

3

 [redacted]

All AES/Phase I payload functional interfaces with the CSM systems installed at Downey will be verified during the Integrated Systems Tests. Therefore, related experiment packages or functional (electrical) substitute simulators not previously installed will be installed during the configuration update period.

CM and SM Mating

The CM and SM are electrically and mechanically mated. The LES is electrically mated to the CM. The CSM, GSE and ACE-SC are prepared for integrated system tests.

The only effect of experiments will be additional interconnects and continuity checks with the GSE and ACE-SC.

Integrated System Tests

This test serves as a basis for spacecraft acceptance (DD250 sell off). Following mating, the CSM to checkout station (supporting GSE and ACE-SC) are re-verified as are the spacecraft subsystems. Changes or equipment incorporated during the configuration update period will be given a complete functional checkout before start of the actual integrated system checkout.

The Integrated Systems checkout consists of end-to-end testing of the complete spacecraft systems while being operated in simulated mission modes. Test sequences will include all abort modes, countdown simulation, and flight mission simulation. The flight mission simulation, duplicates the flight operations sequences, but not necessarily in real time. Both plugs-in and plugs-out tests are performed. The latter is performed on fuel cell power with a substitute flight crew to allow disconnect from gound systems.

AES Phase I mission payload items incorporated in-line at Downey would be operated in support of these tests. To establish integrated test validity, experiment packages or simulators would require prior installed system functional checkout at the applicable component or subsystem level.

CM and SM Cleaning

The modules are individually cleaned to remove all foreign material. This is performed by rotating (tumbling) the module in the cleaning positioner to dislodge particles so that they may be removed by vacuum process.

Experiment packages not required for CSM weight and balance, will be removed prior to this test.

Weight and Balance

The CM and SM are separately weighed to verify the weight and center of gravity to be within specified limits. Both horizontal and vertical checks are performed.

[redacted]

Experiment mass simulators will be used in lieu of experiments whenever support of weight and balance operations are necessary. Definition of specific requirements was beyond the scope of the PDP study.

Apply CSM Thermal Coat

The thermal coat is applied to the CM and SM just prior to preparing for shipment. No added requirement is anticipated for AES missions.

Preparation for Shipment

The spacecraft elements are preserved and packaged for shipment to KSC. No special requirements were established for AES Phase I mission payload considerations.

<u>KSC Field Operations</u>

The baseline checkout functional flow for the AES Phase I CSM pre-launch operations is shown in Figure 21. The Space Vehicle Assembly, checkout and Pre-Launch Operations functional flow established for the spacecraft is shown in Figures 22 and 23 for Saturn IB and Saturn V missions respectively. This study covered program planning factors associated with these operations. Although many of the functions are not directly affected by the AES Phase I payload, they were included in analysis of scheduling, facility utilization, and overall programs flow through KSC.

The spacecraft KSC operations are summarized below including installation and checkout requirements added by the AES Phase I payloads. Functions which were added include spacecraft modification, experiment installation, installed experiment checkout, and additional integrated systems tests. The checkout requirements included in these descriptions were based on the criteria specified in the CSM Development & Test section.

SPS Static Firing Tests

The objective of these tests is to verify flight readiness of the complete service propulsion systems. Leak and functional tests are performed including a live firing of the SPS.

The SPS static firing is not directly affected by the AES Phase I mission requirements. The test will be performed after the modification period, as close to launch as possible.

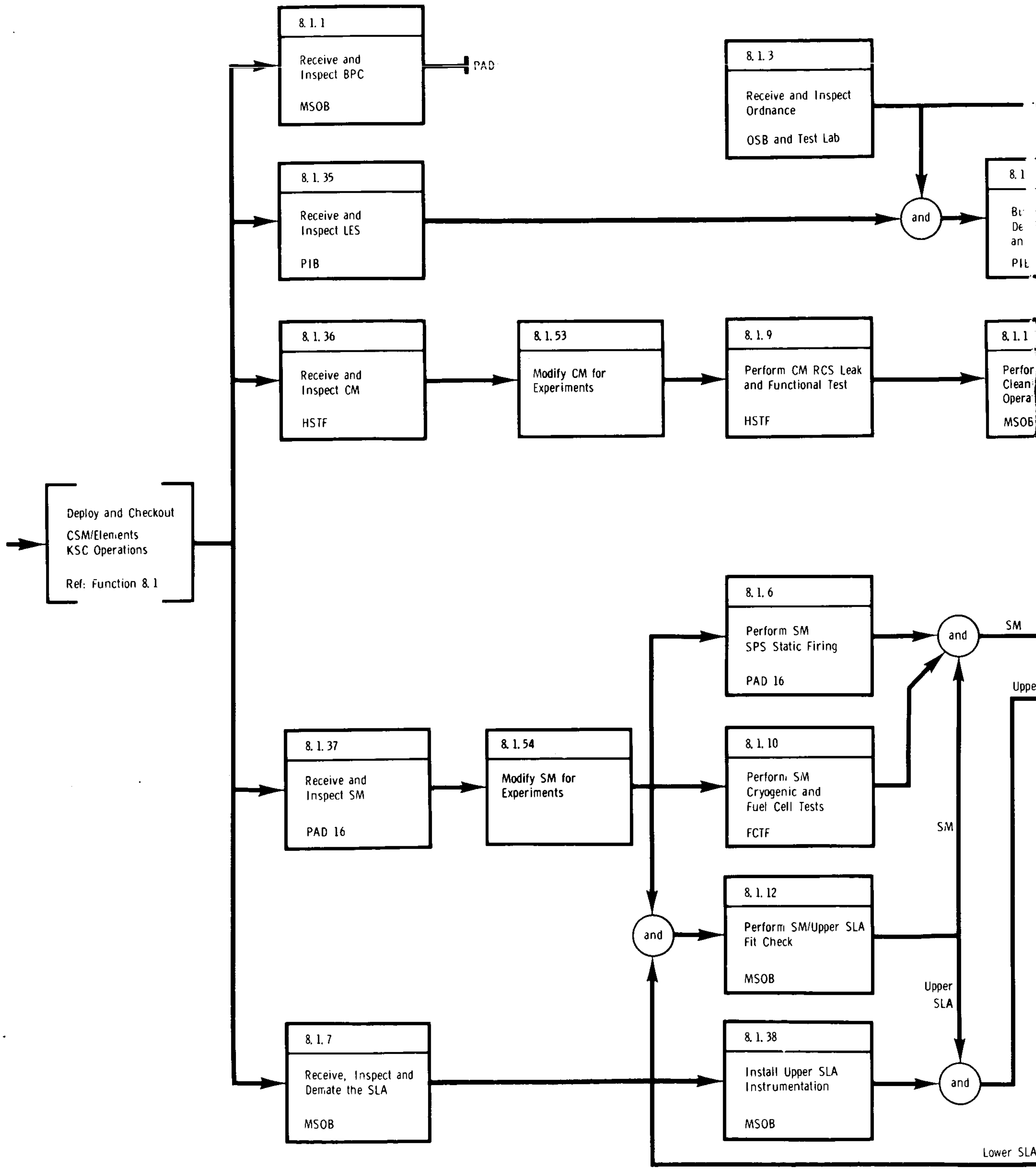
Fuel Cell and Cryogenic Systems Tests

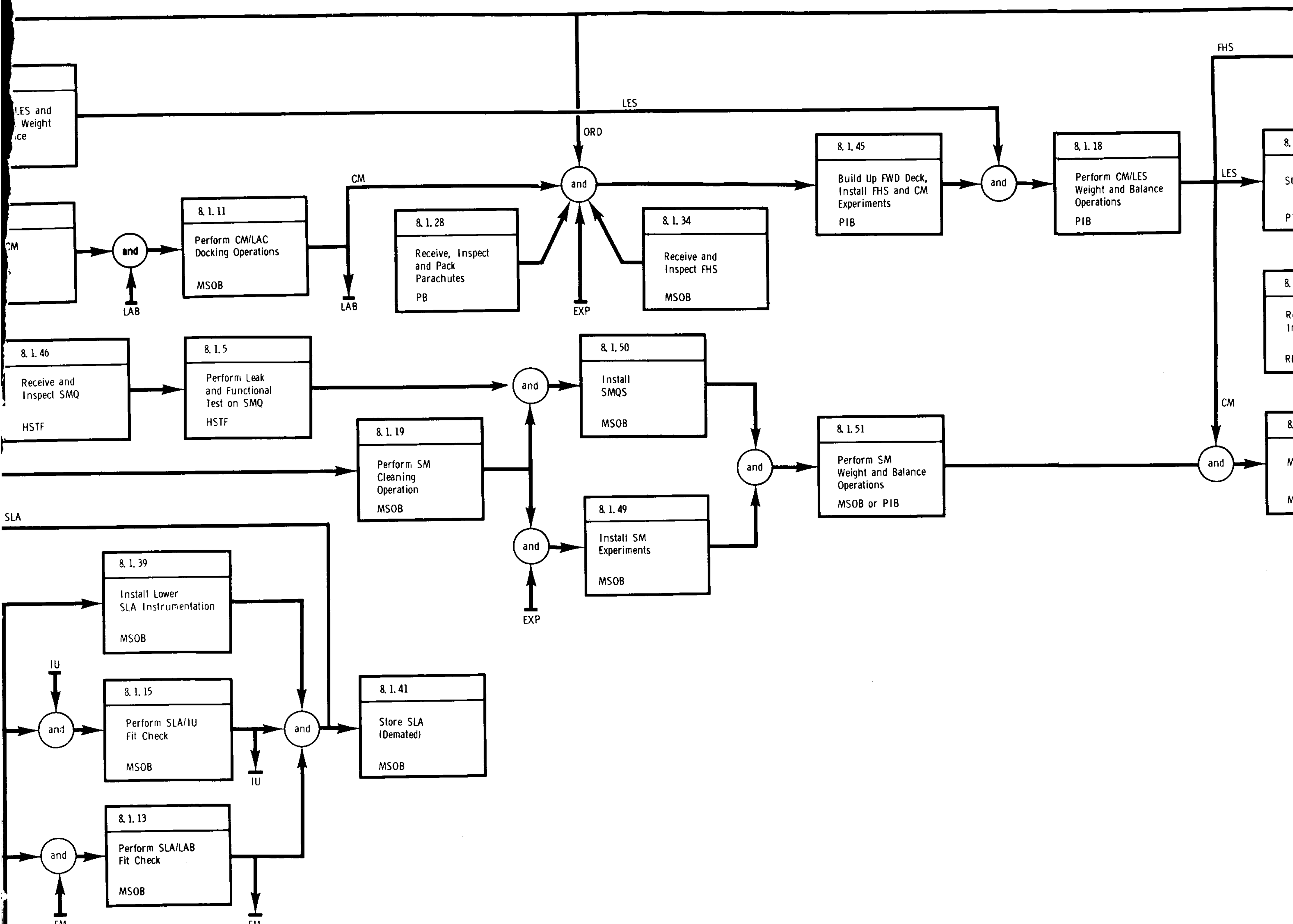
Leak and functional tests of the fuel cell and cryogenic systems will be performed in the Fuel Cell System Test Facility (sometimes referred to as the Cryogenic Test Building). The SM will be moved tothe FCSTF after completion of the SPS static firing tests. Pressure and leak tests will be performed on the EDS and the fuel cells will be operated to verify functional performance.

AES Phase I mission requirements will not affect thest tests.

[redacted]

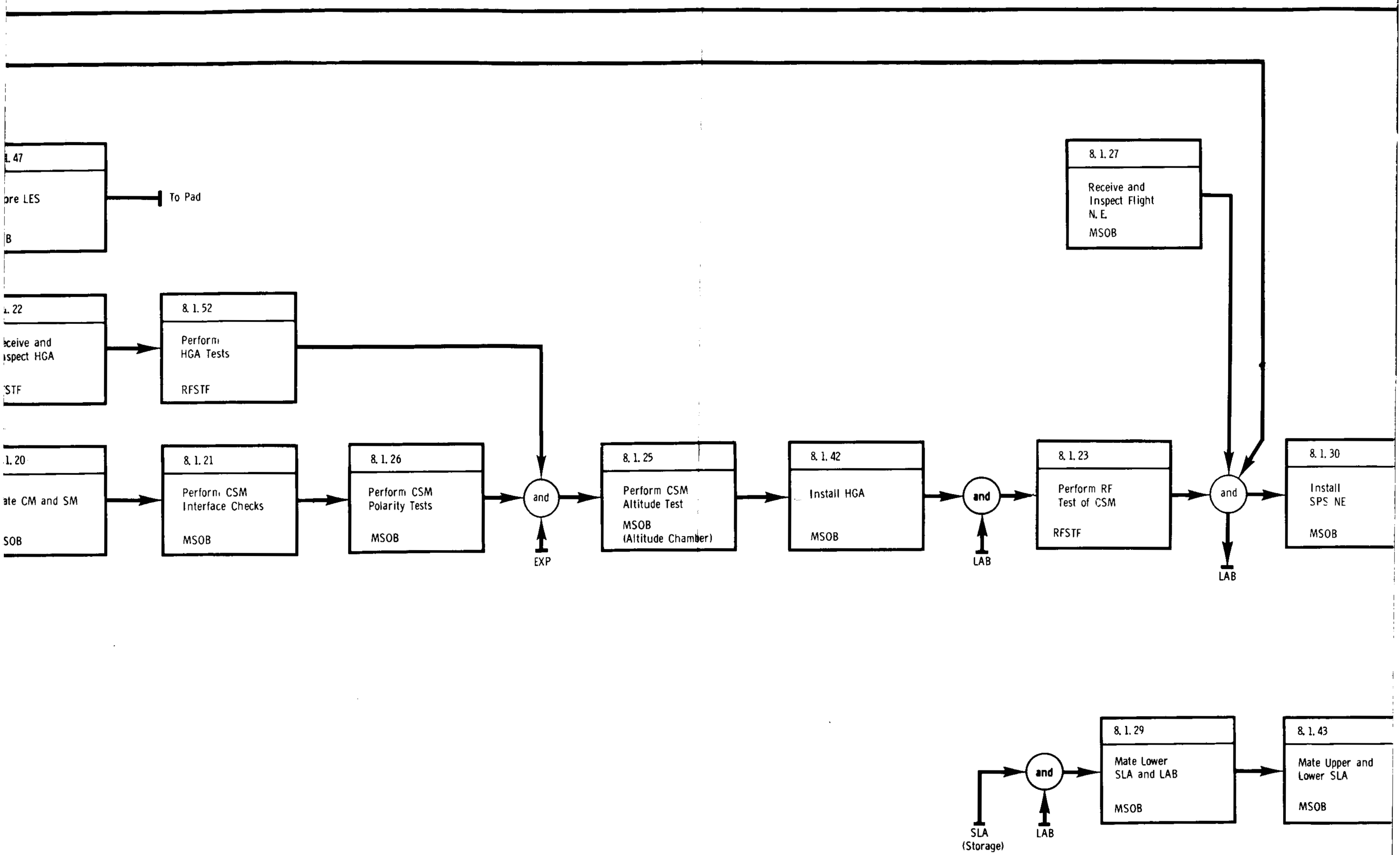
[redacted]


Deploy and Checkout
CSM/Elements
KSC Operations
Ref: Function 8.1
8.1.1
Receive and Inspect BPC
MSOB
PAD
8.1.35
Receive and Inspect LES
PIB
8.1.36
Receive and Inspect CM
HSTF
8.1.53
Modify CM for Experiments
8.1.9
Perform CM RCS Leak and Functional Test
HSTF
8.1.3
Receive and Inspect Ordnance
OSB and Test Lab
and
8.1.37
Receive and Inspect SM
PAD 16
8.1.54
Modify SM for Experiments
8.1.6
Perform SM SPS Static Firing
PAD 16
8.1.10
Perform SM Cryogenic and Fuel Cell Tests
FCTF
8.1.12
Perform SM/Upper SLA Fit Check
MSOB
8.1.7
Receive, Inspect and Demate the SLA
MSOB
8.1.38
Install Upper SLA Instrumentation
MSOB
and
and
and
SM
SM
Upper SLA
Lower SLA

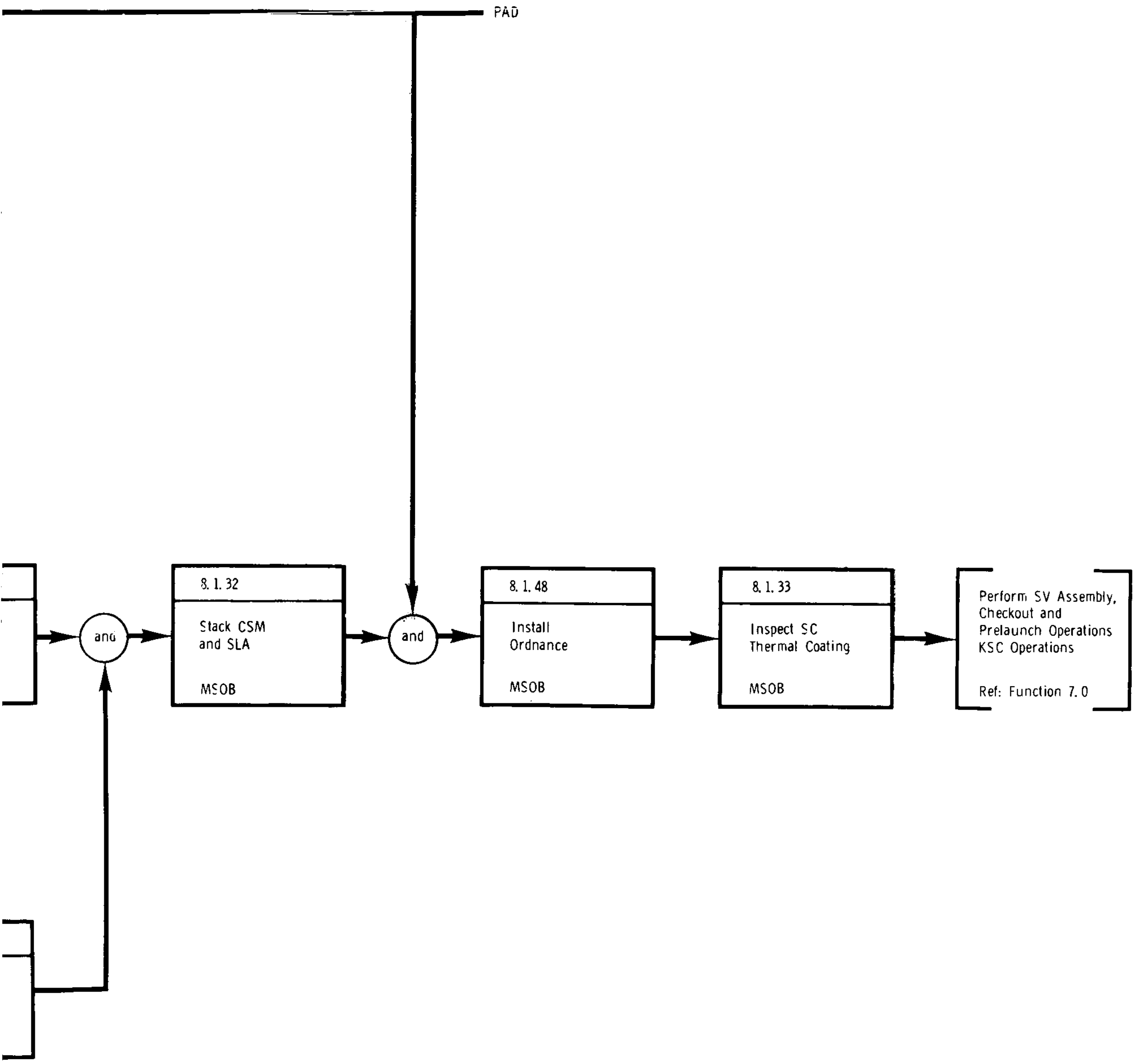


LES and
Weight
ce
CM
LAB
8.1.11
Perform CM/LAC
Docking Operations
MSOB
CM
LAB
8.1.28
Receive, Inspect
and Pack
Parachutes
PB
ORD
EXP
8.1.34
Receive and
Inspect FHS
MSOB
LES
8.1.45
Build Up FWD Deck,
Install FHS and CM
Experiments
PIB
8.1.18
Perform CM/LES
Weight and Balance
Operations
PIB
FHS
LES
CM
8.1.46
Receive and
Inspect SMQ
HSTF
8.1.5
Perform Leak
and Functional
Test on SMQ
HSTF
8.1.50
Install
SMQS
MSOB
8.1.19
Perform SM
Cleaning
Operation
MSOB
8.1.49
Install SM
Experiments
MSOB
EXP
8.1.51
Perform SM
Weight and Balance
Operations
MSOB or PIB
SLA
8.1.39
Install Lower
SLA Instrumentation
MSOB
IU
8.1.15
Perform SLA/IU
Fit Check
MSOB
IU
8.1.41
Store SLA
(Demated)
MSOB
8.1.13
Perform SLA/LAB
Fit Check
MSOB
EM
EM
and

2



1. 47
ore LES
B
To Pad
1. 22
eceive and
nspect HGA
STF
8. 1. 52
Perform
HGA Tests
RFSTF
1. 20
ate CM and SM
SOB
8. 1. 21
Perform CSM
Interface Checks
MSOB
8. 1. 26
Perform CSM
Polarity Tests
MSOB
and
EXP
8. 1. 25
Perform CSM
Altitude Test
MSOB
(Altitude Chamber)
8. 1. 42
Install HGA
MSOB
and
LAB
8. 1. 23
Perform RF
Test of CSM
RFSTF
8. 1. 27
Receive and
Inspect Flight
N. E.
MSOB
and
LAB
8. 1. 30
Install
SPS NE
MSOB
SLA
(Storage)
and
LAB
8. 1. 29
Mate Lower
SLA and LAB
MSOB
8. 1. 43
Mate Upper and
Lower SLA
MSOB



LEGEND

Command and Service Module Functions and Support Functions

Reference Functions

FACILITY ABBREVIATIONS

OSB . . . . Ordnance Storage Building
PIB . . . . Pyrotechnic Installation Building
HSTF. . . . Hypergolic System Test Facility
PAD 16. . . Propulsion Test Complex (Pad 16)
MSOB . . . Manned Spacecraft Operations Building
RFSTF . . . RF System Test Facility
PB. . . . . Parachute Building
FCTF . . . . Fuel Cell Systems Test Facility

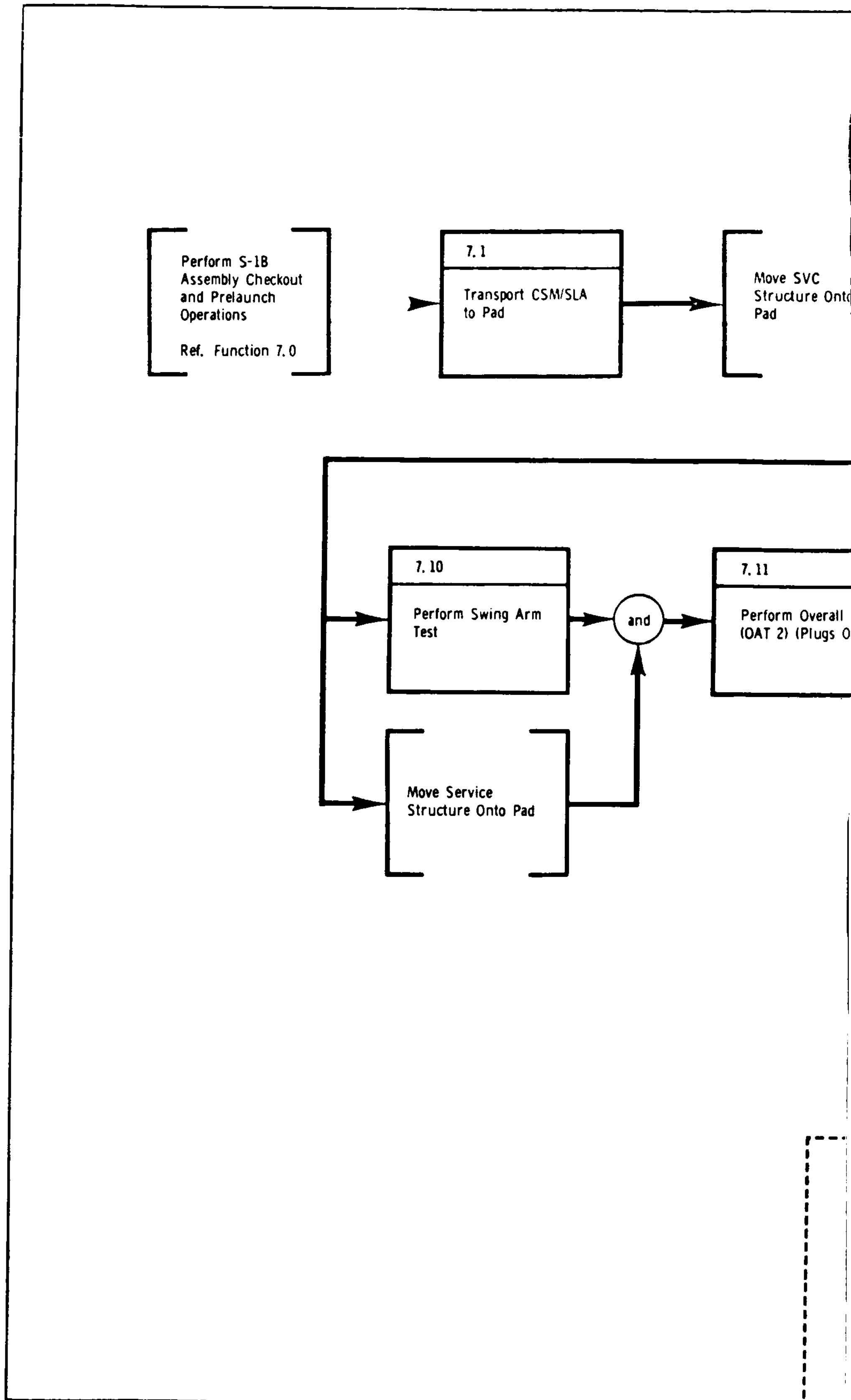
VEHICLE ABBREVIATIONS

LES. . . . . Launch Escape System
FHS . . . . Forward Heat Shield
CM . . . . Command Module
SMQ . . . . SM Quads
SM . . . . Service Module
SLA . . . . SC/LEM Adapter
SPS . . . . Service Propulsion System
SC. . . . . Spacecraft
RCS . . . . Reaction Control System
HGA . . . . High Gain Antenna
CSM . . . . CM and SM
IU . . . . . Instrument Unit
NE . . . . . Nozzle Extension

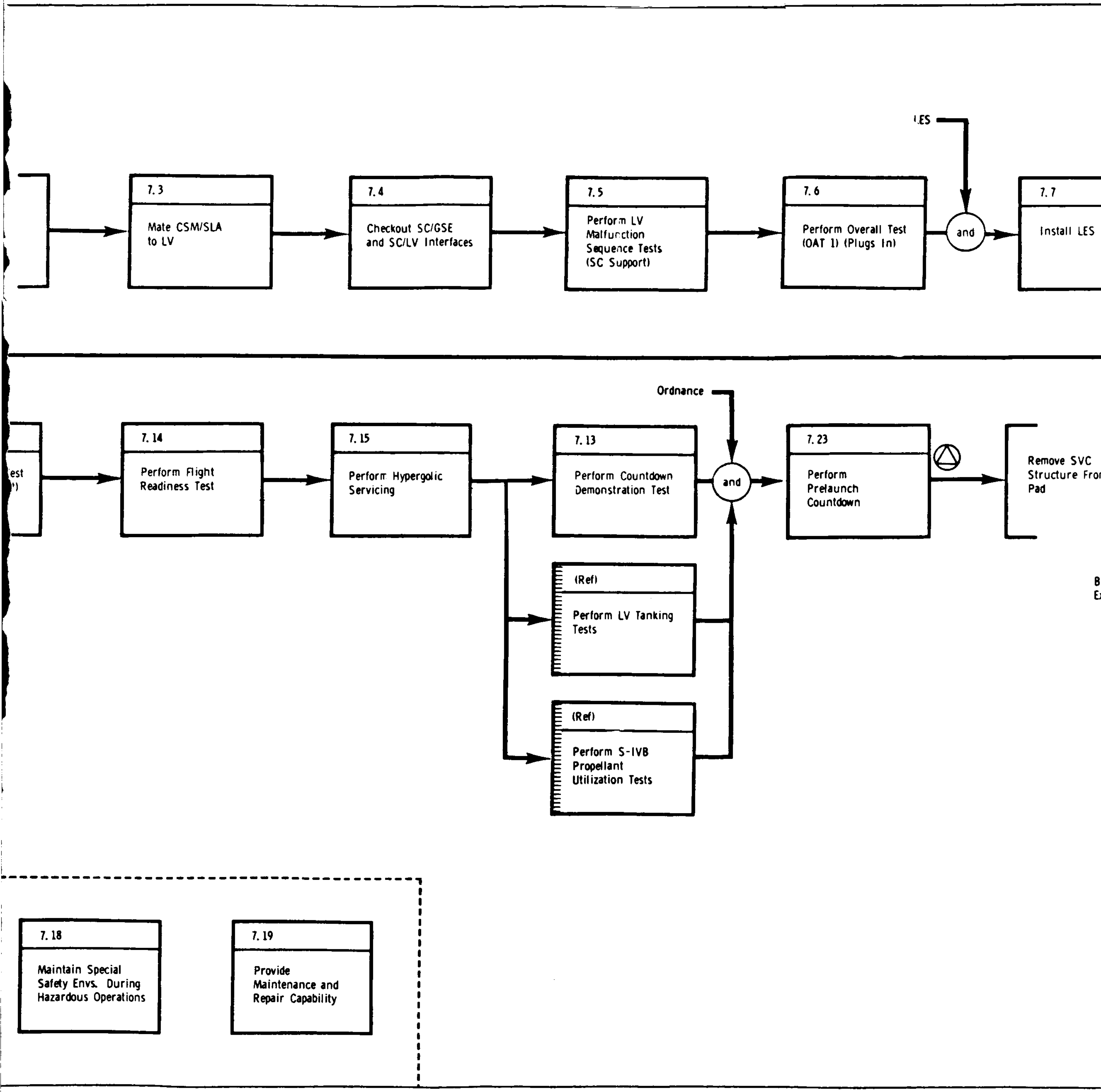
Figure 21. Second-Level Functional Flow 8.1 Deploy and Checkout CSM Elements

4

[redacted]



Perform S-1B Assembly Checkout and Prelaunch Operations
Ref. Function 7.0
7.1
Transport CSM/SLA to Pad
Move SVC Structure Onto Pad
7.10
Perform Swing Arm Test
and
7.11
Perform Overall
(OAT 2) (Plugs O
Move Service Structure Onto Pad


LES
7.3
Mate CSM/SLA to LV
7.4
Checkout SC/GSE and SC/LV Interfaces
7.5
Perform LV Malfunction Sequence Tests (SC Support)
7.6
Perform Overall Test (OAT 1) (Plugs In)
and
7.7
Install LES
Ordnance
7.14
Perform Flight Readiness Test
7.15
Perform Hypergolic Servicing
7.13
Perform Countdown Demonstration Test
(Ref)
Perform LV Tanking Tests
(Ref)
Perform S-IVB Propellant Utilization Tests
and
7.23
Perform Prelaunch Countdown
Remove SVC Structure From Pad
7.18
Maintain Special Safety Envs. During Hazardous Operations
7.19
Provide Maintenance and Repair Capability

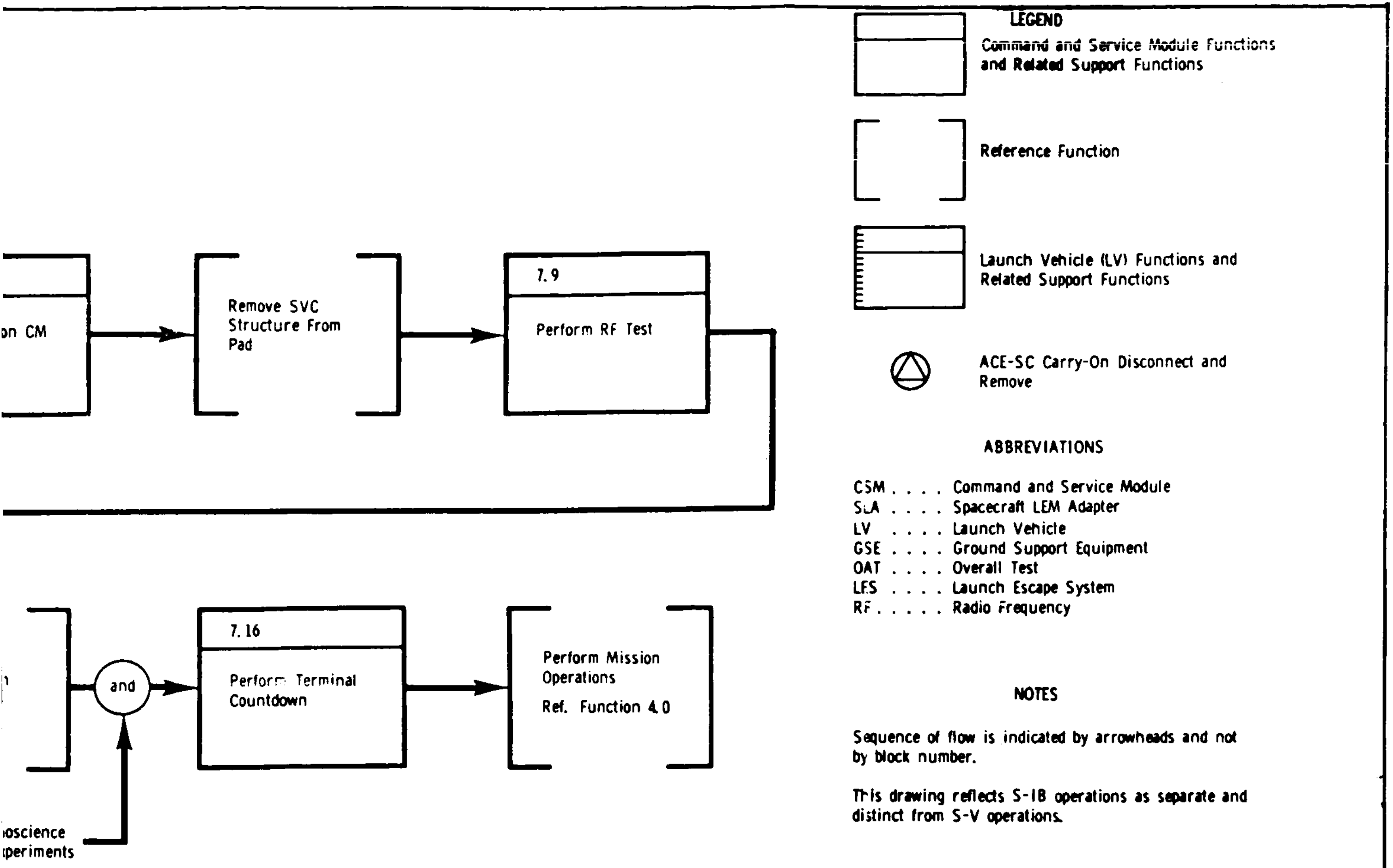
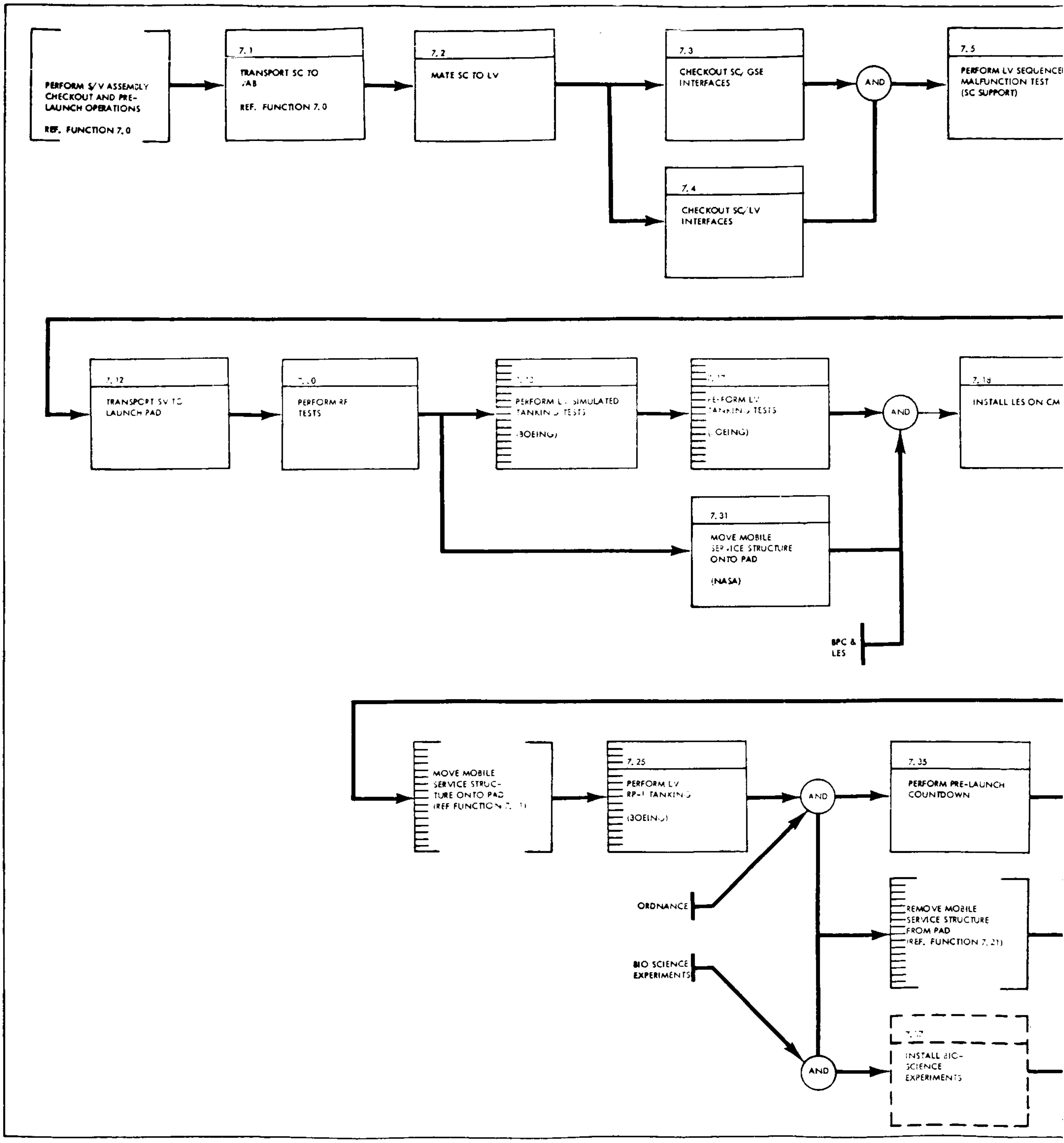


Figure 22. First-Level Functional Flow 7.0, Perform Saturn V Assembly Check-out and Prelaunch Operations, Launch Complex 37 (Saturn 1B Vehicles)

[redacted]



PERFORM S/V ASSEMBLY CHECKOUT AND PRE-LAUNCH OPERATIONS
REF. FUNCTION 7.0
7.1
TRANSPORT SC TO
REF. FUNCTION 7.0
7.2
MATE SC TO LV
7.3
CHECKOUT SC/ GSE INTERFACES
7.4
CHECKOUT SC/LV INTERFACES
AND
7.5
PERFORM LV SEQUENCE MALFUNCTION TEST (SC SUPPORT)
7.12
TRANSPORT SV TO LAUNCH PAD
PERFORM RF TESTS
SIMULATED
TESTS
AND
INSTALL LES ON CM
7.31
MOVE MOBILE
STRUCTURE
ONTO PAD
(NASA)
BPC &
LES
MOVE MOBILE SERVICE STRUC-TURE ONTO PAD
7.25
PERFORM LV
AND
7.35
PERFORM PRE-LAUNCH COUNTDOWN
ORDNANCE
BIO SCIENCE EXPERIMENTS
REMOVE MOBILE SERVICE STRUCTURE FROM PAD
AND
EXPERIMENTS

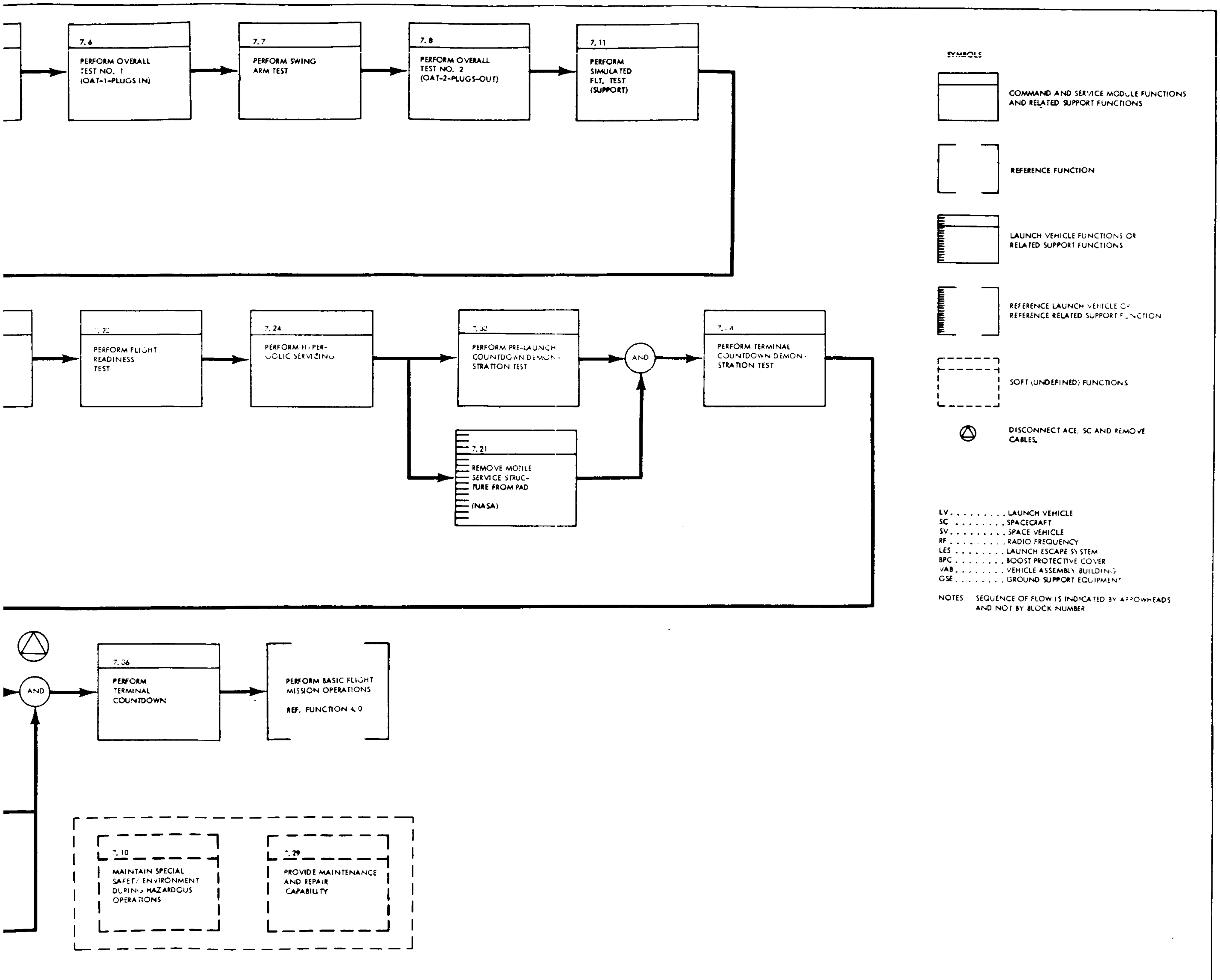


Figure 23. First-Level Functional Flow 7.0, Perform Saturn V Assembly Check-out and Prelaunch Operations, Launch Complex 39 (Saturn V Vehicles)

[redacted]

[redacted]

RCS Leak and Functional Tests

The CM and the SM Quads will undergo RCS tests in the Hypergolic Test Facility. Since these tests are run concurrently, both cells of the HTB are utilized. Pressure and leak tests will be performed using helium. Proper functioning of valves and regulators will be verified and engine valve signatures will be determined. The CM will be moved to the MSOB upon completion of these tests. The Quads will be stored until installation in the SM.

AES Phase I mission payload requirements do not affect these tests.

SM Experiment Installation

The experiment checkout requirements dictate installation of experiments before mated CSM testing in order to encompass the interfaces during integrated systems testing. The SM experiments will be installed as a single assembly fitting in Sector I. This will either be performed in the MSOB or an equivalent clean room environment. This installation is an added function to the basic Block II spacecraft flow. A power-on continuity test ("smoke test") will be performed to verify the interface connections.

SM Weight and Balance

Upon completion of the experiments instllation, the RCS quad will be installed and a weight and balance check will be performed on the SM. The weight and balance fixture is located in the pyrotechnic installation building. Both a horizontal and vertical weight operation will be performed to establish the center of gravity. Actual experiment elements will be substituted by mass simulators when mandatory.

CM Experiment Installation and Top Deck Buildup

These are discussed together since they may be partially performed concurrently. The CM will be positioned in the MSOB or equivalent clean room environment for the experiment installation. The ELS ordnance installation requires use of the Pyrotechnic Installation Building (PIB). The parachutes, ordnance, experiments and forward heat shield installation will be completed before weight and balance.

The experiment CM interface connections will be verified by a power-on continuity tests as part of the installation function.

CM-LEM Laboratory Docking Check

At the earliest point convenient to the LEM LAB and CM operations flow, the two modules will be fit checked in the docked configuration. The LAB ascent stage is lowered (inverted) at a simulated zero "g" condition until the capture latches of the CM probe engage the drogue. The probe is then retracted so that the ascent stage is lowered to a soft docked position. The ascent stage is pressurized to five psi before the modules are hard-latched. The probe and drogue are removed and stored in the CM. Tests include leaks check of the interface seal, circuit analyzer check of the electrical umbilical and crew sight alignment. The probe and drogue are reinstalled and delatching operations checked.

These tests will vary from a normal lunar landing mission only in the increased interface through the electrical umbilical.

The docking check is not constrained by any previous CM or LAB checkout. It will be scheduled for a time that does not interrupt a test series on either module.

CM-LES Weight and Balance

A weight and balance check will be made on the CM following experiment installation and forward deck buildup. The weight and vertical, lateral and longitudinal center of gravity will be verified to be within specified tolerances. These tests will be performed using the weight and balance fixtures in the PIB.

The LEX, having previously undergone weight and balance checks, will be mated to the CM in a vertical attitude. The CM-LES will then be weighed, and the LES thrust vector alignment will be checked.

The AES Phase I payload installations are involved in this test in that the experiments or substitute mass simulators must be installed to achieve the required accuracy in determining weight and balance.

Mate CM and SM

The SM will be positioned on the polarity fixture in the integrated test stand (Stokes #2). The CM will be mated to SM and alignment of the mated modules will be verified.

The AES Phase I payload involvement is related to scheduling installation. Experiments which interface with CSM subsystems are required in the integrated tests which follow CSM mating. Later installation would require repeat of portions of the integrated test operations. The CM-SM mate is therefore a key function in experiment/spacecraft interface scheduling.

CSM-Station Cable Up and CSM Interface Verification

The first operation to be performed in the mated CSM in the integrated test station is to make and check the interface with all support equipment and facilities. The ACE-SC carry-on will be installed and all GSE will be connected. The spacecraft ECS system will be serviced and checked. Continuity and spacecraft systems control and monitor interface with ground systems will be verified. The CSM electrical power distribution will also be verified. The CM to SM interface connections will be verified. Subsystem connections broken during experiment installation will also be verified to be properly reconnected. These tests will be completed before initiation of functional checkout of spacecraft subsystems or experiments.

[redacted] [redacted]

Installed Experiment Checkout

The individual experiments will be verified to function properly installed in the CSM and as influenced by interfaces such as electrical power supplied from the CSM EPS. The experiments will, in so far as possible, be manually operated. ACE-SC will be used to monitor experiment output parameters and, if necessary, to supply stimuli to experiments. End-to-end tests will be performed to verify that the experiment performs within specified limits and experiment measurements are properly transported and recorded by the supporting data collection and storage system. These tests will be completed before initiating CSM integrated systems testing with experiments included.

CSM Integrated Systems and Polarity Tests

The objective of the integrated systems tests is to demonstrate operational performance capability of the integrated spacecraft subsystems, including experiments, during simulated abort and mission sequences. The objective of the polarity test is to verify end-to-end phasing of the attitude control, thrust vector control and delta "V" flight subsystems.

During integrated systems tests, the subsystems are operated, as nearly as possible, in the modes and input sequences of the phase of mission being simulated. Response of each of the subsystems are monitored to verify the correct timing and sequence of operation. Test sequences will be run of each abort mode. The mission simulation will include all sequences, and redundant modes or systems, from countdown through earth recovery. The systems will be operated from the CM controls. Experiment functions will be integrated with the spacecraft systems operation in the normal flight sequence.

The polarity test is performed by providing rotational inputs from the polarity fixture. The end-to-end polarity of the thrust vector control loop is verified.

Altitude Test

The altitude tests, performed in the chamber in the MSOB, are made to verify spacecraft operation at altitude. The CSM is manned by three astronauts and altitude runs are performed at 250,000 feet. ECS, fuel cell operation and structural integrity are verified. The spacecraft radiators, evaporators, and cold plates provide the temperature characteristics of the water-glycol of the ECS and fuel cells structure leak rate is determined. Simulated flight sequences will be made to verify systems operation at altitude. Experiment operation and environmental control will be demonstrated under the 250,000 foot altitude and cold plate environment of the chamber.

CSM RF Systems Test

The objective of these tests is to verify operation of the CSM RF systems. Voltage standing wave ratio (VSWR) checks will be made on all antennae including experiment data transmitting systems. Telecommunications systems output frequency and power will be measured. The high gain antenna (HGA) will be installed and boresighted. A functional check will be performed on the

[redacted] [redacted]

[redacted] [redacted]

X-band transponder. Uplink reception will be measured. The system performance and absence of adverse interaction between the various RF systems will be demonstrated.

The CSM RF test may be conducted in combined RF tests with the LAB. A requirement for a docked interface test was identified for the rendezvous missions which requires use of the RF Systems Test Facility (RFSTF). Although the CSM RF tests could be implemented in the MSOB, use of the RFSTF and combined test with the LAB enhances checkout. Requirements for RF and EMC test of the CSM-LAB interfaces requires further analysis before the test operations can be fully defined.

CSM-LAB Interface Test

Although electrical interfaces between the CSM and Laboratory will be tested as in the RF tests, requirements have not been fully defined. The supply of power from the LAB to the CSM or rendezvous missions, introduces increased potential for adverse interactions and ground loop problems. A docked compatibility test is planned. Since RF impingements may produce ground return impedance changes, this test should include RF system operation.

CSM-LAB interface testing on non-rendezvous flights is less severe. Initial plans were to conduct an electrical interface test in a simulated (cable connected) docked configuration in the MSOB. However, due to identification of a requirement to implement capability for EMC testing at the RFSTF on two missions, it is recommended that use of this capability for all AES/Phase I missions be considered.

It should be noted that in the GORP, SID 65-1151, this test is included in the spacecraft final mating function 8.1.32 (Figure 21.).

Stack CSM-SLA-LAB

The LAB is mated to the lower SLA in the Stokes stand #2. The spacecraft to launch vehicle separation circuit is given and end-to-end check by cable connection from the CSM on an adjacent stand. The upper SLA and CSM are then mated to the lower SLA/LAB modules. The stacked spacecraft is then ready for mating with the launch vehicle.

Impact of AES Phase I Payload on Block II CSM Operations Schedules

Installation and checkout requirements for incorporation of the AES Phase I experiment payloads discussed above will increase the overall operations time spans. The total impact will depend upon the extent of applicable installation and checkout performed at Downey. This will be determined when final installation scheduling is resolved based on the trade-offs discussed in section

[redacted]

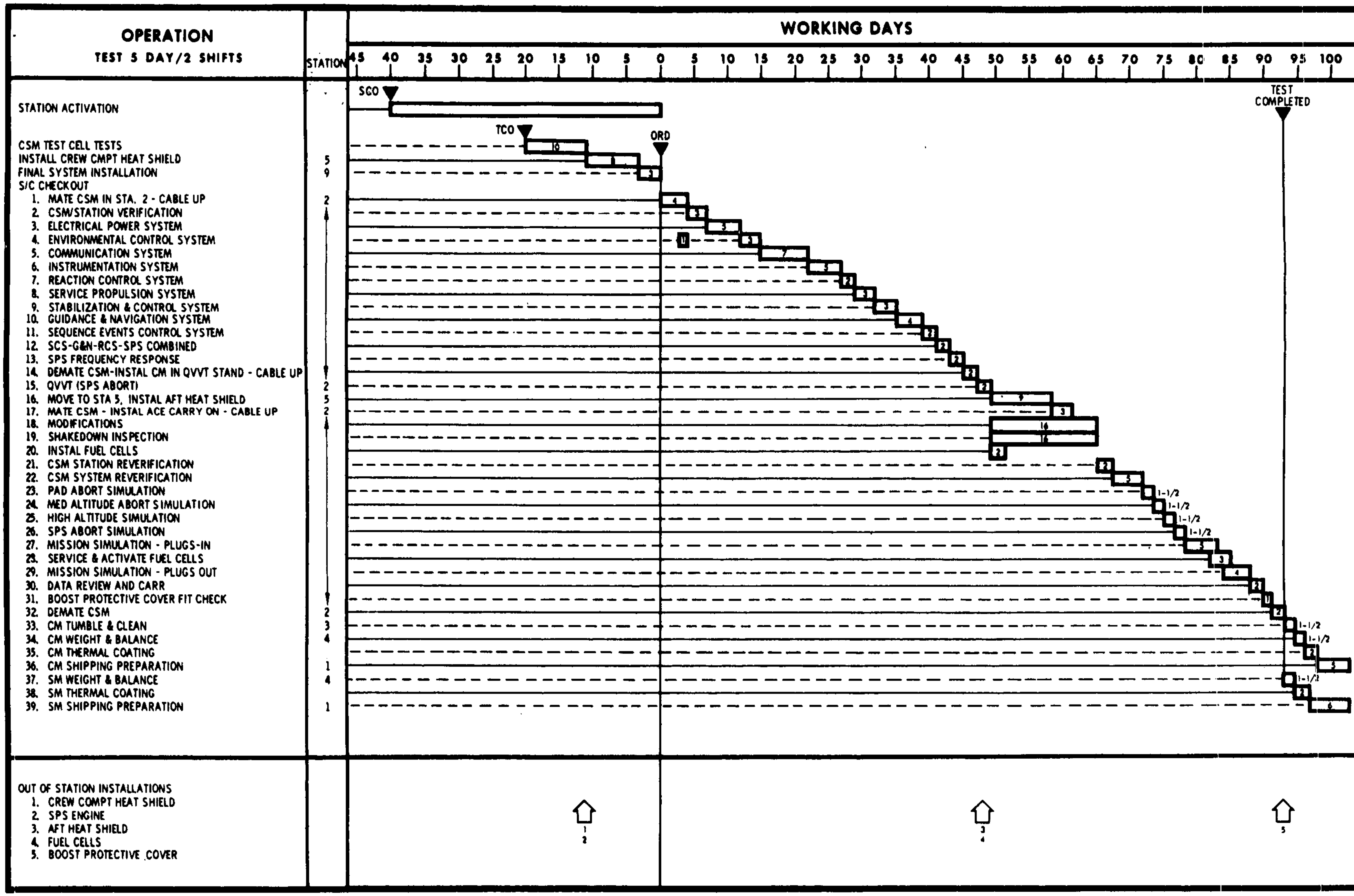


Figure 24. Typical Block II Spacecraft, Downey Check-out Schedule

In-line installation to full capability for the AES Phase I mission without compromise of the lunar landing performance is unlikely. However, the related impact on the Downey and field operations was evaluated. Potentially, up to four weeks would be added to the typical Block II CSM Downey Operations schedule shown in Figure 24. Experiment packages or simulators would be installed and the spacecraft system interfaces would be tested, including AES mission simulation during integrated systems testing. This represents the worse case for Downey Operations since the impact decreases with decreased in-line provisioning for incorporation of the experiment payload.

The case of maximum in-line provisioning at Downey gives the minimum impact to the field schedules. The experiment payload installation at KSC would be limited to final experiment package installation. The time required for checkout of the experiment payloads should be minimum because of prior checkout at Downey. Figure 25 gives a preliminary estimated of the affect of the AES mission requirements on the basic Block II CSM field operations schedule for this case.

It is anticipated that the optimum plan will be to perform partial in-line configuring of the spacecraft toward incorporation of the experiments. This would consist of mounting and wiring provisions and equipment rearrangement which did not compromise the lunar landing capability. These installations should be checked out during spacecraft acceptance tests by use of actual experiment packages or simulators, thus would potentially add about three weeks to the Downey Operations time. Field modification would consist of installation of (as a kit) experiment mounts and cabling not installed due either to design lead time benefits or consideration of lunar landing mission performance. This type of installation plus installation of experiment packages, which functionally interfaced with the spacecraft systems would add about fifteen work days to the basic CSM field schedule. An additional ten to fifteen work days would be added to the preluanch checkout time for installed experiment checkout, experiment inclusion in integrated systems tests and functional interface test with the LEM laboratory. This results in a five and one half month KSC schedule as shown in Figure 26.

Figures 27, 28, 29, which show the integrated CSM and LEM Laboratory schedules for the individual AES Phase I missions, include a period considered adequate for the maximum practical field modification of the CSM. Field modification should not include major structural changes, changes to the CM-SM umbilical, or cause extensive disassembly which would invalidate prior subsystems checkout. These schedules assume that the scope of effort at KSC differs from a basic lunar landing mission as follows:

CSM Modification

- Add wires from CM terminal end of the CM-SM umbilical to controls and display
- Add wires for CM experiments
- Add wires in SM
- Install experiment control and display panel
- Install experiment mounting brackets and support in CM and SM
- Perform continuity checks on wiring changes

[redacted]

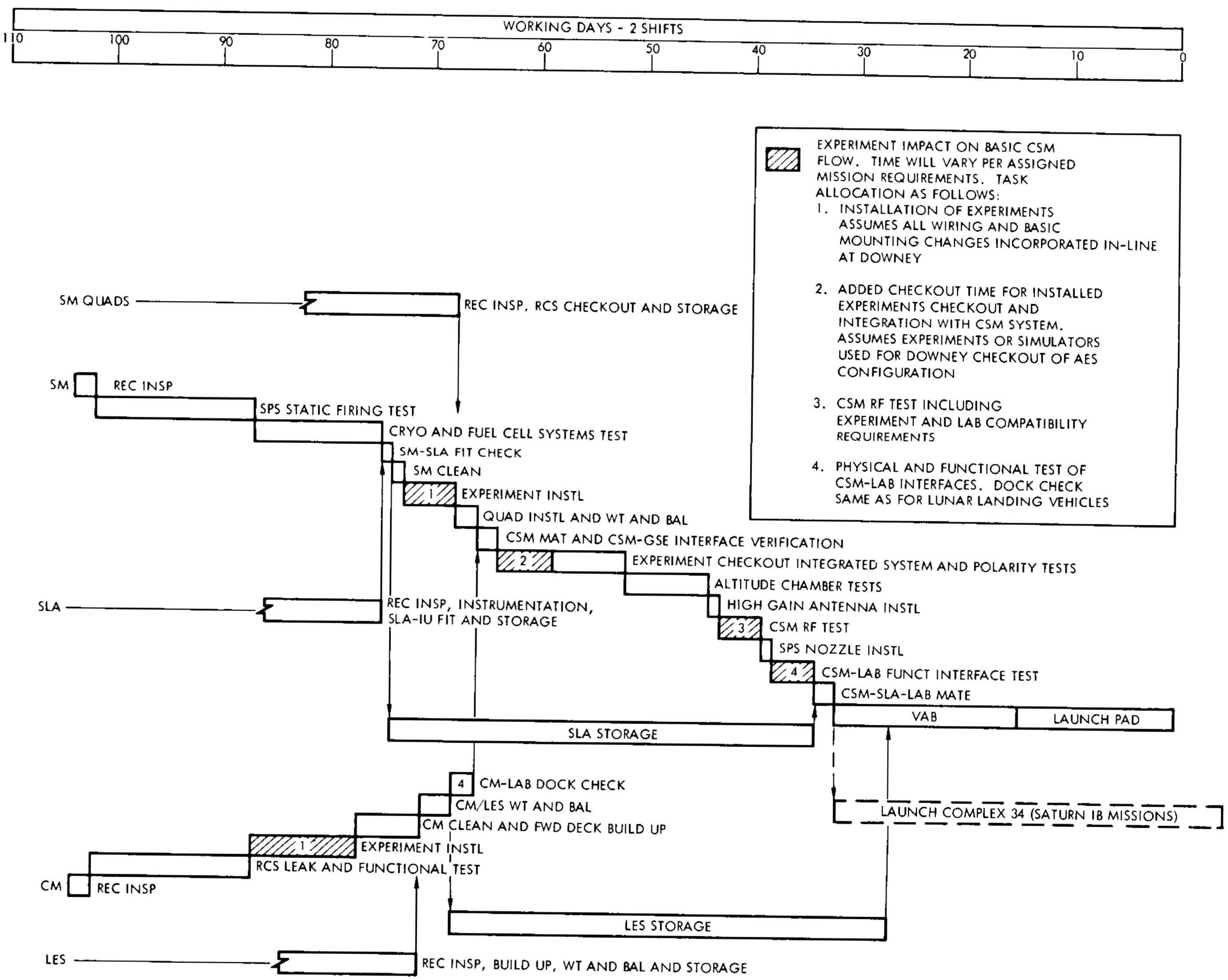


Figure 25. Preliminary AES Phase I CSM KSC Schedule, Complete In-line Configuration at Downey

[redacted]

[redacted]

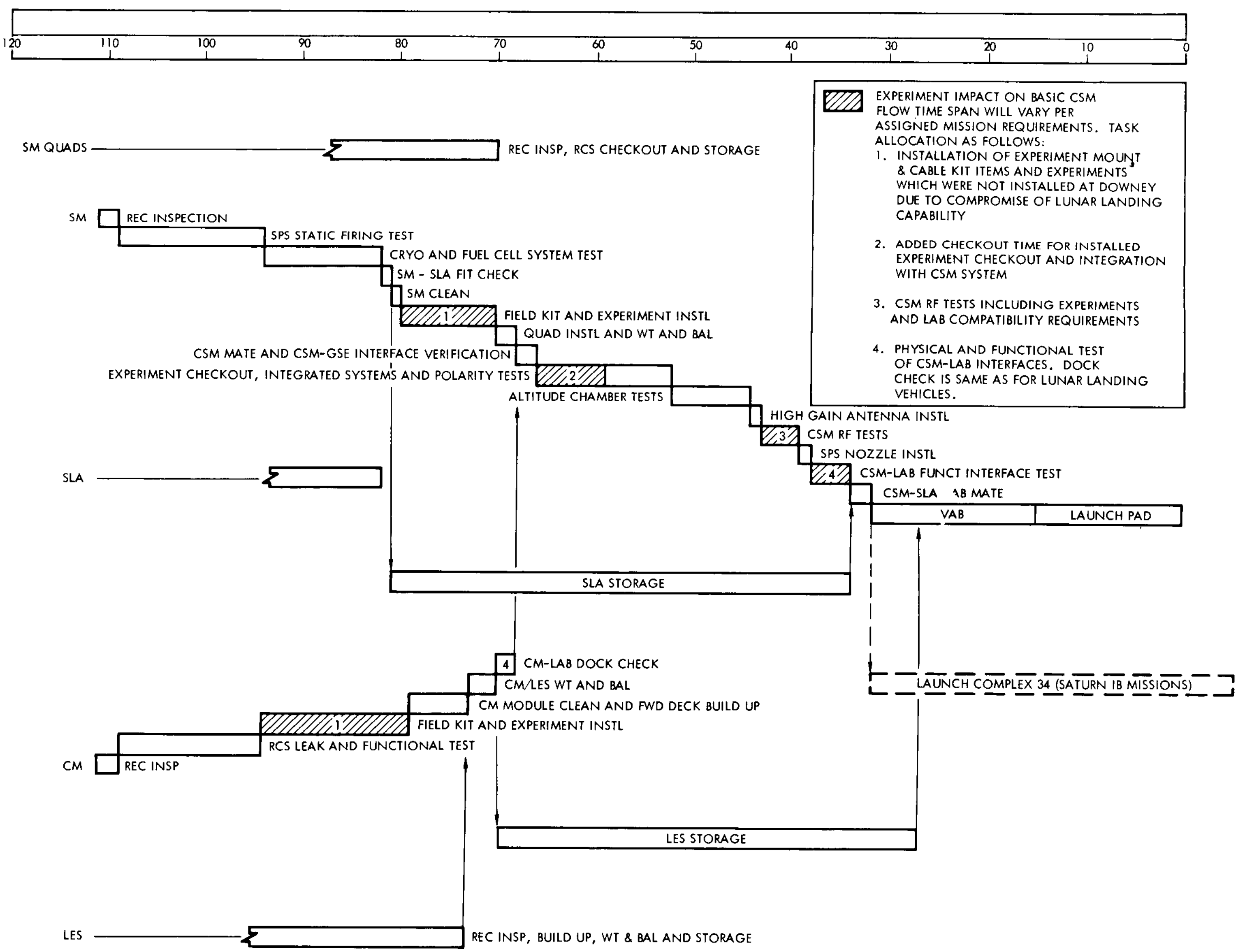


Figure 26. Preliminary AES Phase I CSM KSC Schedule, Partial In-line Configuration at Downey

[redacted]

[redacted]

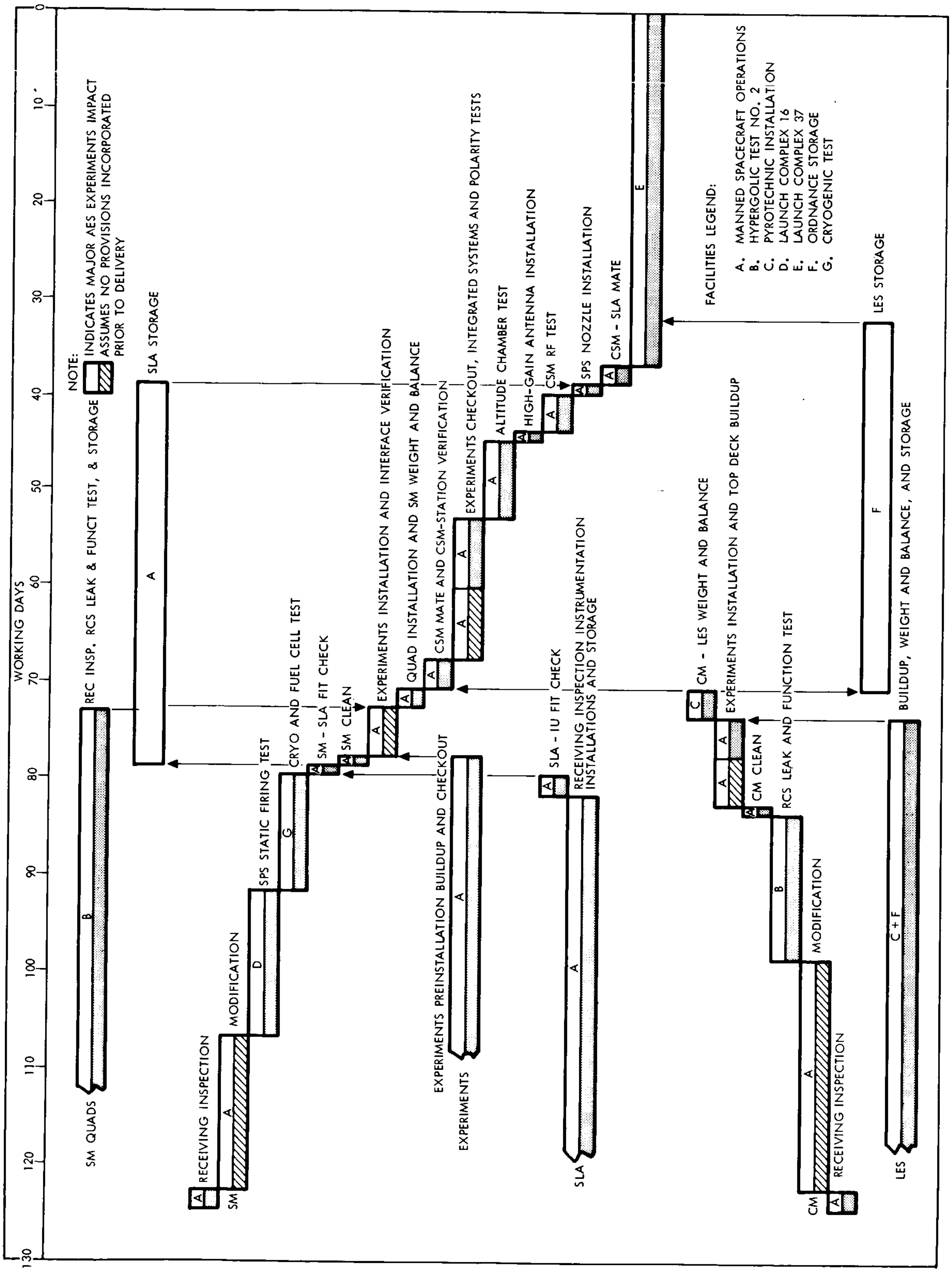


Figure 27. Preliminary KSC Operations Flow - Mission 211

[redacted]

[redacted]

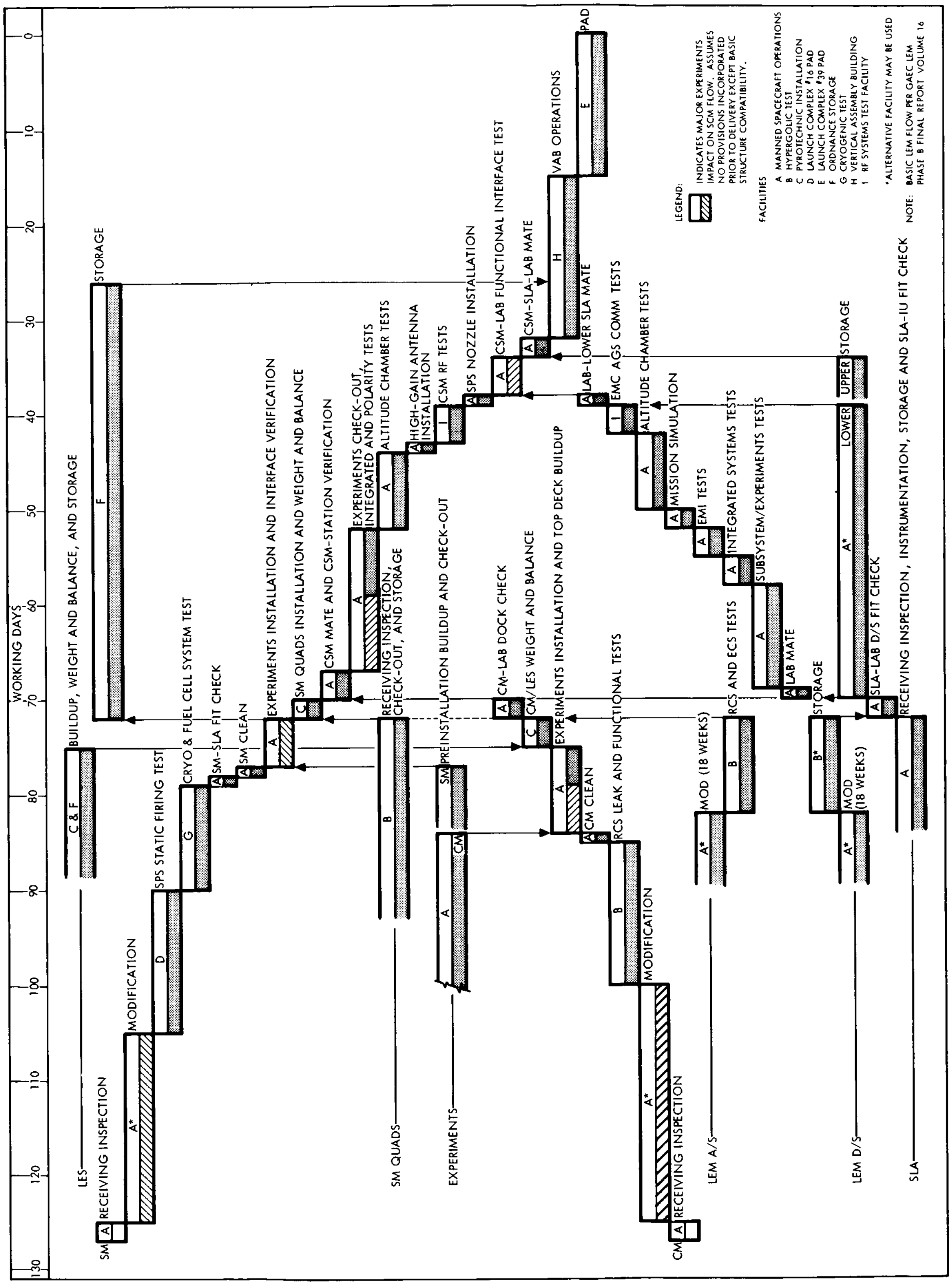


Figure 28. Preliminary Integrated KSC Operations Flow - Saturn V Missions

[redacted]

[redacted]

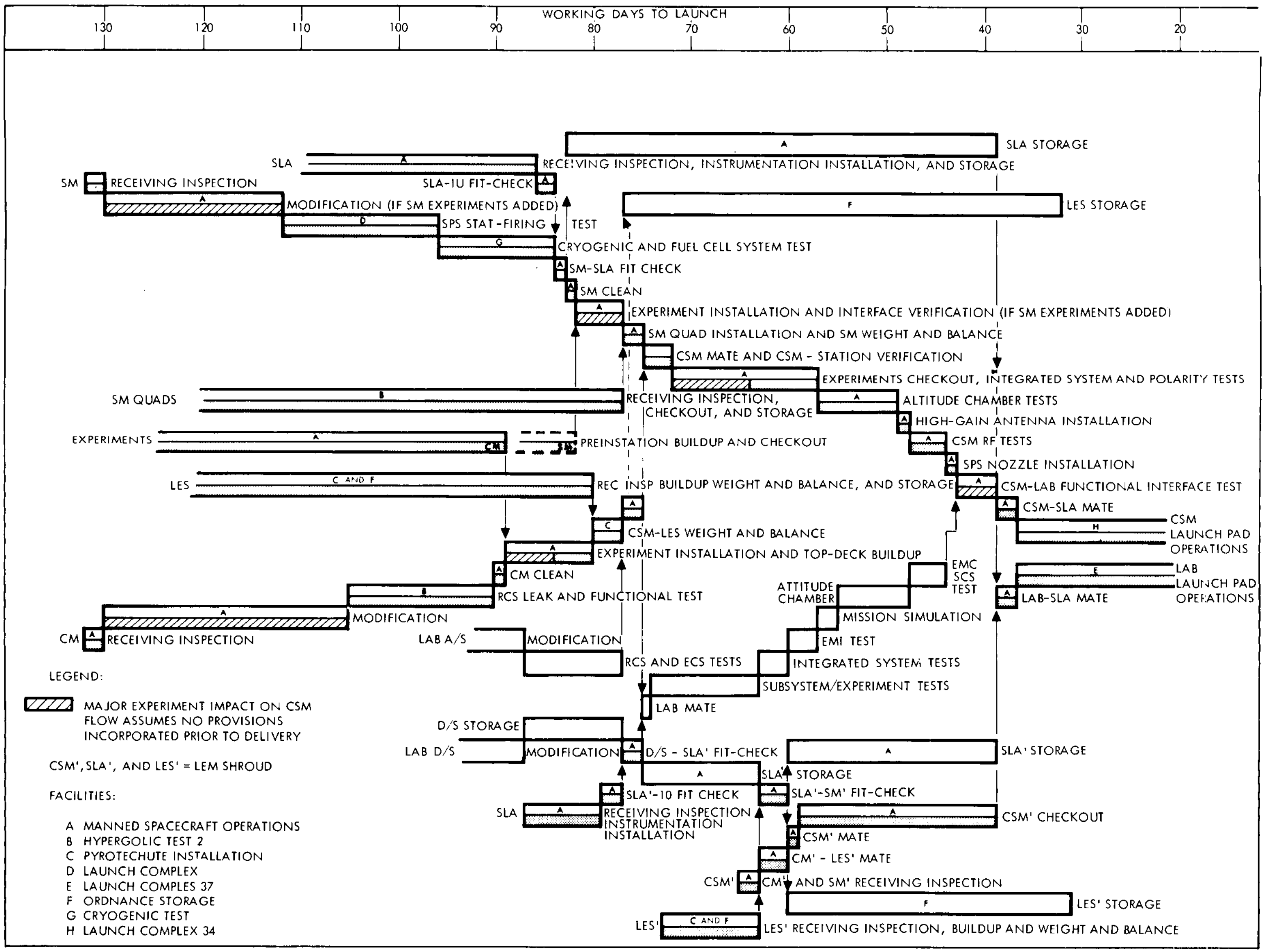


Figure 29. Preliminary Integrated KSC Operations Flow - Rendezvous Missions

[redacted]

CSM Experiments Installation and Verification
- Install experiment packages
- Connect to CSM wiring
- Conduct power-on experiment-SC interface continuity check

CSM Experiments Checkout and CSM-Experiments Integrated Systems Tests
- Conduct installed experiments functional checkout
- Conduct experiments-CSM interface checkout and integrated systems tests
- Conduct experiment checks as required during CSM polarity test, altitude chamber tests and RF systems tests

CSM-LEM Integrated Checkout
- Electromagnetic Compatibility Test of the combined RF systems
- Functional Interface Test performed by calbe connected simulation of docked configuration

Modification of the CSM must be initiated at least six months prior to launch. Five weeks and four weeks are allowed for modification of the CM and SM respectively. These time spans include consideration of problems associated with accessibility and cleanlines.. The modification period includes installation of the mounting devices and wiring for experiments, installation of experiment support subsystems, minor rearrangement of equipments in CM, and continuity verification of wire changes. It assumes the basic capability of the structure and primary wire harnesses to accept experiment payloads is incorporated in the CSM before delivery. Five additional days are scheduled for experiment package installation and basic power on interface continuity check before module close out for CM-SM mating. Twelve days were added to the mated Block II CSM checkout time in the MSOB to provide for installed experiments checkout, test integration of experiments with the CSM and interface testing with the laboratory. Four days were added for the RF compatibility test with the laboratory. It is noted that no time allowance was included for revalidation of CSM systems because of removal for modification access.

The individual mission schedules will be updated as mis sion configuration requirements and optimum design for in-line configuring of the basic spacecraft modules is further defined.

LEM LABORATORY

The AES Phsse I LEM Laboratory ground operations planning is based on the study guideline requiring all Phase I vehicles to be fabricated and delivered to the field in the LEM configuration. The LEM vehicle will be subsequently modified to the assigned AES mission laboratory configuration at KSC. The ground operations requirements for each Phase I laboratory flight vehicle is defined in the respective Mission Description document. Information contained herein was extracted from the AES Lunar Excursion Module Phase B final reports (Volumes XVI, XVII, XIX and XXI) and from the GAEC letters providing inputs to the Mission Description documents and from the Experimenter's Handbook - LEM Utilization AES/Grumman Design 378B.

Factory Checkout

Factory checkout of the LEM vehicle used on AES Phase I missions will be performed to the normal LEM requirements defined in the LEM Ground Operations Requirements Plan, GAEC report number LPL 610 3C. Manufacturing and acceptance test at Bethpage must be accelerated for earlier delivery of LEM 5 and subsequent vehicles to accomplish the required integration. This revised master schedule gives a constant manufacturing load which provides vehicles for AES missions in time to perform about four months modification at KSC.

KSC Field Operations

Modification (Manufacturing Final Assembly and Acceptance of Laboratory Configuration

The Phase I Laboratories will be modified at KSC in accordance with the stated ground rules. The spacecraft will be delivered to KSC as "full-up" LEM vehicles and will be modified to the required AES flight configuration by: (1) removal of unnecessary hardware plumbing and wiring, (2) installation of new and modification of existing systems, and (3) installation of laboratory experiments. These operations are indicated in Figures 30 through 33. The stripdown will remove subsystem hardware from the structure in such a way that neither the structure nor the equipment will be damaged. Fluid lines and electrical harnesses will be removed where practical or will be capped and secured if removal jeopardizes pressure shell or system integrity. Modification of systems and installation of experiments must be conducted simultaneously to provide maximum manpower utilization and to reduce over-all schedule flow time.

Detailed information on the stripdown and reassemble process is included in Volume XVII of the referenced GAEC reports.

This modification process requires periodic verification tests during the conversion and acceptance tests after its completion. These tests are limited strictly to those functions affected by the modifications since they are in addition to the usual LEM factory acceptance tests and the KSC prelaunch checkout sequence. The following assumptions made for purposes of defining these acceptance tests:

> Modification from LEM to the recommended Lab configuration and installation of experiment lines and equipment proceeds together and is checked out together.
>
> Changes in acceptance test equipment or programs for the combined checkout on a preflight basis are payload integration tasks.

Pre-Launch Operations

The pre-launch checkout of the AES Phase I Laboratory will be consistent with the concepts and criteria established for the Apollo program. Since the AES mission operations are interspersed with the Lunar Landing Program, undue deviation from the basic LEM concepts would result in increased impact

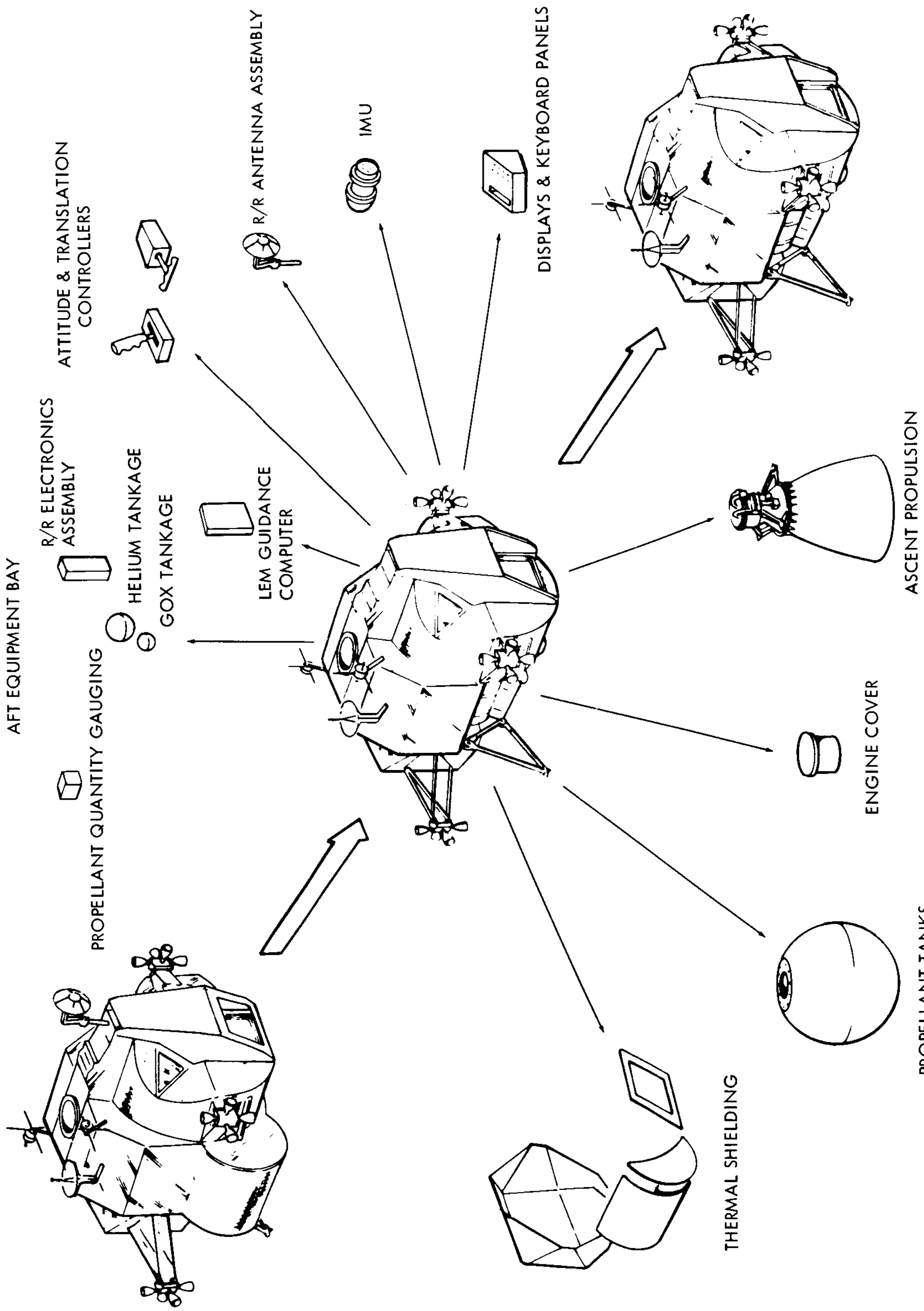


Figure 30. Phase I Laboratory Ascent Stage Disassembly

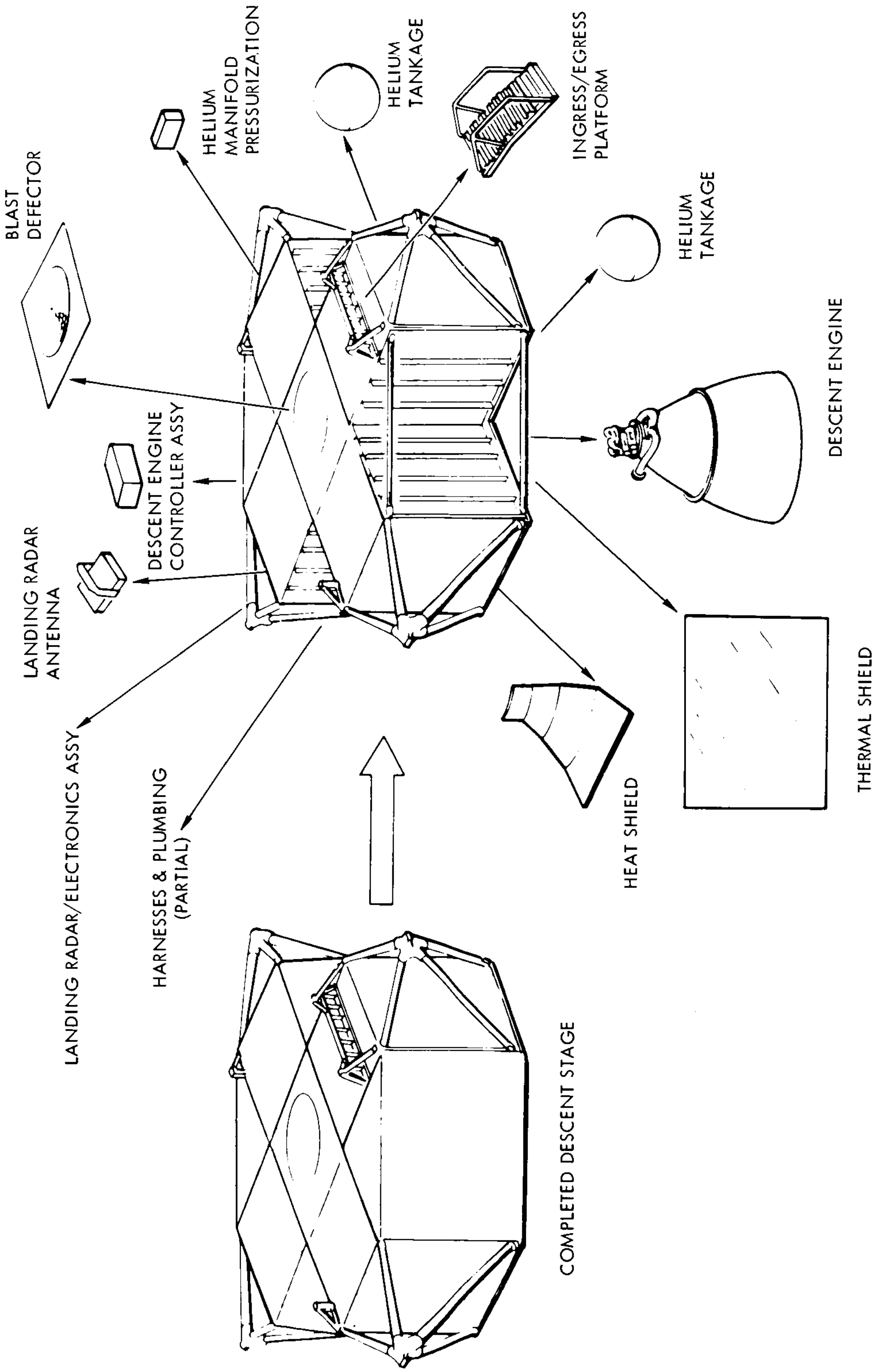


Figure 31. Phase I Laboratory Descent Stage Disassembly

[redacted]

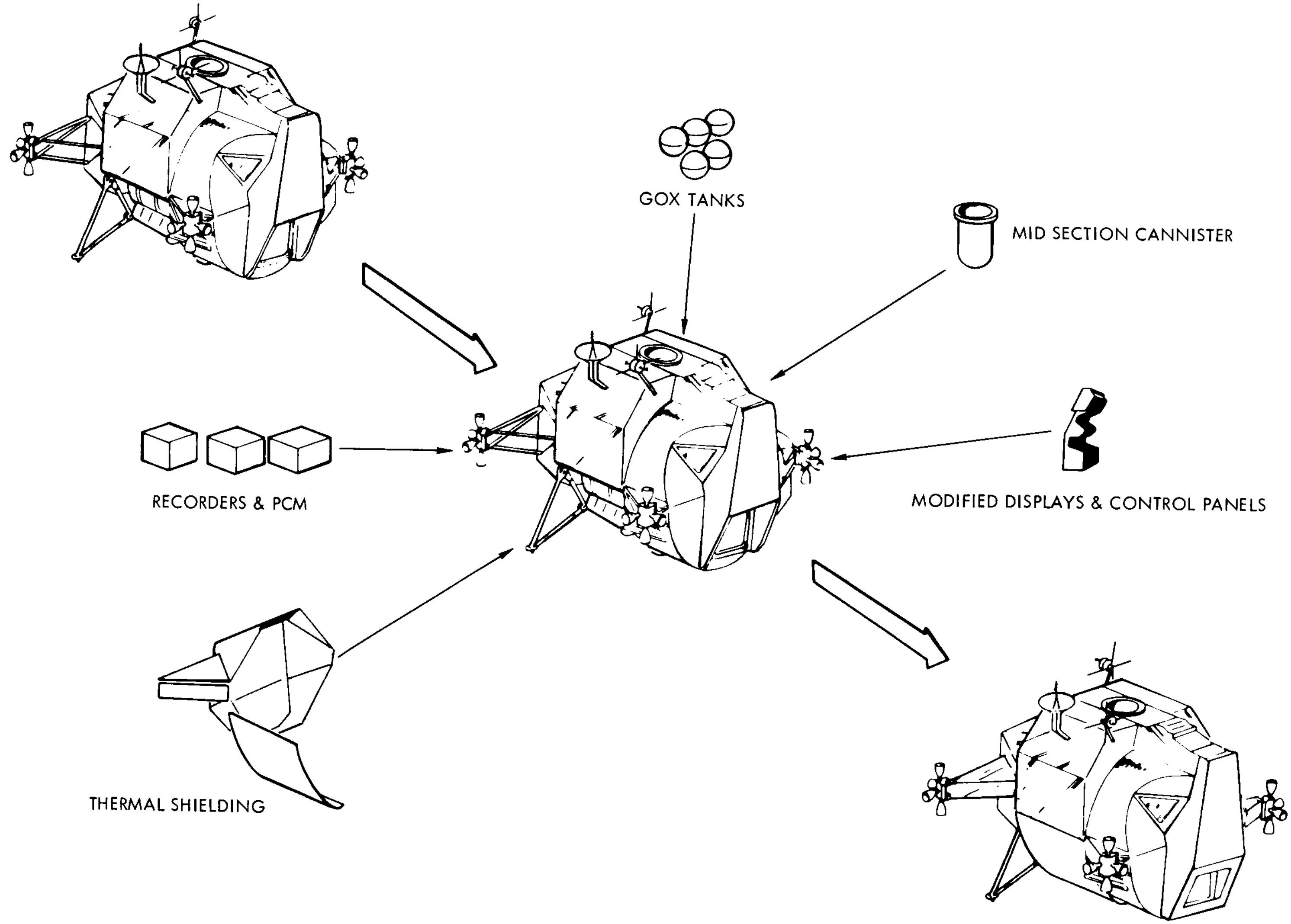


Figure 32. Phase I Laboratory Ascent Stage Final Assembly Flow

[redacted]

[redacted]

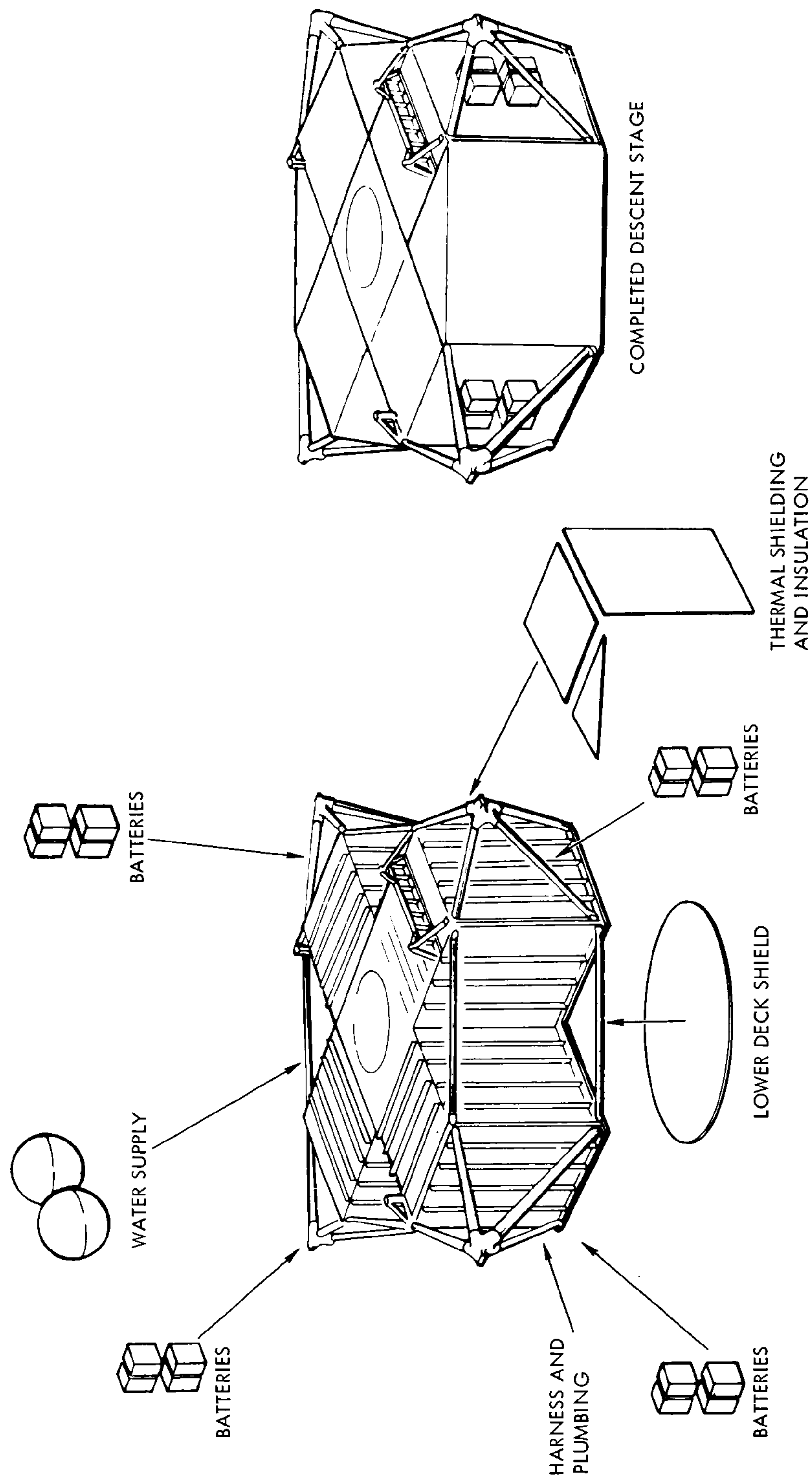


Figure 33. Phase I Laboratory Descent Stage Final Assembly Flow

[redacted]

[redacted]

(schedule and expenditures) for incorporation of the AES mission payloads. Experiment requirements will of course mandate certain changes and the requirement to perform formal acceptance test is included because of KSC modification.

The prelaunch operations planned for the laboratory are based on the following ground rules and assumptions.

1. It is assumed that the Phase I Labs have been modified from the basic LEM at KSC before the start of prelaunch checkout.

2. The experimenter will checkout his own experiment package, using bench test equipment, to the degree possible in an earth environment, prior to installation in the vehicle.

3. The Lab flight configuration has been verified as part of the overall Lab Ground Development Test Program.

4. EMI testing will be accomplished for each mission-vehicle/experiment package at the system test level.

5. Experiments requiring active thermal control will be supported by the ECS thermal control loop.

6. When total experiment checkout cannot be accomplished, component checkout within the experiment package will be conducted prior to installation and an integrated checkout will be performed after installation.

7. End-to-end testing will be employed as the basic testing approach to prelaunch checkout. End-to-end testing is defined as applying an input stimulus (or set of stimuli) to an identifiable functional flow path or paths, within the system under test, and measuring the system response at the end of that flow path or paths.

8. It is recognized that while end-to-end testing is the best approach for an overall prelaunch checkout it will be necessary, in order to achieve all of the prelaunch checkout objectives, to deviate from the basic approach in certain cases. These cases will be justified on an individual basis.

9. Prelaunch checkout shall be performed at as high an assembly level as possible with the objective of maximum probability of malfunction detection.

10. The capability shall exist to isolate a fault to a replaceable unit when a malfunction is detected. Exceptions must be justified on the basis of significant reduction in weight or complexity of flight equipment.

11. Electrical, mechanical and fluid connections of flight equipment shall not be disconnected for equipment checkout after the vehicle has been assembled and mated.

12. All interfaces, both internal to the spacecraft and external, shall be verified.

13. Spacecraft telemetry (flight PCM) will be utilized during prelaunch checkout to the extent possible with no ACE carry-on duplication except for those checkout measurements that require an accuracy beyond the capability of the flight PCM subsystem.

14. Measurements that are required for prelaunch checkout will be available in real-time to ACE-S/C.

15. Maximum utilization, consistent with safety, will be made of astronauts or equivalents and onboard controls and displays during checkout.

16. Maximum utilization will be made in the prelaunch checkout program of all information and knowledge gained during the ground development program.

17. Common checkout logic will be provided at all "checkout" locations for equivalent levels of test.

<u>RCS and ECS Fluid Systems Checkout</u>. Upon completion of the KSC modification, the ascent stage will be transported to the West Call of the HTB. Checkout and servicing of the ECS Heat Transport Section will be performed to provide coolant capability during subsequebt tests. Leak and functional checks will be performed on the RCS, Oxygen Supply and Cabin Pressurization Section and Water Management Section plumbing. The ascent stage will then be transported to the MSOB.

<u>Cleaning, Dock Check and Mate</u>. After the ascent stage is transported to the MSOB it will be installed in the cleaning fixture, inverted and then moved to the docking fixture, for the LAB-CSM docking test. Upon completion of the docking test the ascent stage will be moved to the cleaning fixture for reinversion and Water Management, Heat Transport and Oxygen Supply and Cabin Pressurization Sections checkout. The ascent stage will then be prepared for mating with the descent stage.

<u>SLA Descent Stage Fit Check</u>. After completion of the KSC modification period the Lab descent stage will be stored until required for SLA fit check in the MSOB. No specific area has been designated for storage.

Jpon arrival of the descent stage at the MSOB it will be transported to the SLA stand for a descent stage/SLA fit check. The stage will then be moved to the proper work stand for mating with the ascent stage. The Heat Transport and Water Management Sections of the ECS will be checked prior to mating the descent and ascent stages.

Installed System and Integrated Systems Tests (Including Experiments). The objective of these tests is to verify, in an ambient environment, the proper functioning of individual systems and integrated systems. Checkout at the subsystems level is required on Phase I Labs because of encompassing the formal acceptance test requirements due to field modification.

After mating, the Heat Transport Section will be leak checked and serviced. The Power Distribution Section and Instrumentation Subsystem capability to support vehicle testing will be verified. Checks will be made to verify Alignment Optical Telescope calibration and the alignment of the S-Band antenna and experiment equipment. Electrical and electronic subsystem tests, GNCS polarity, and experiment verification will be performed.

The Phase I Labs will undergo a complete vehicle system integrated checkout. All vehicle electronic subsystems will be operated in an integrated fashion so that all possible system modes are verified. A "plugs out" vehicle EMC test will be performed in a shielded chamber. ~~To demonstrate~~ the ability of the electrical and electronic subsystems to work together as a system, a mission-oriented "plugs out" test will be performed. The AES Lab will then be installed in the altitude chamber.

Altitude Chamber Tests. After installation in the altitude chamber, ECS, cabin leak, and hatch operation tests will be performed prior to evacuating the chamber. The chamber will be evacuated with the Lab unmanned, and ECS functional tests will be performed to demonstrate the capability of the ECS to support manned altitude tests. The structural integrity of the Lab, during emergency re-pressurization of the chamber, will be demonstrated in the unmanned altitude run. The manned altitude tests will demonstrate ECS and Crew Provisions capabilities with a man in the loop. After the manned altitude tests the vehicle will be deserviced and transported to the RFSTF.

RF Systems and CSM-Lab Electrical Interface Tests. The vehicle will be mounted on the RFSTF three-axis positioner. A communication test with the MSFN will be performed to verify the compatibility between the Lab Communication Subsystem and MSFN. The S-band steerable antenna will be functionally tested, utilizing an S-band source located at some distance from the vehicle, and motion inputs to the positioner. An AGS dynamic test will be performed with the use of the three-axis positioner. The vehicle will be oriented to various positions so that a gross determination of ASA scale factors can be made. Lab EMC and Lab/CSM tests will be performed at the RFSTF (see prior paragraph, "CSM-Lab Interface Test).

[redacted]

Upon completion of testing at the RFSTF, the vehicle will be transported to the MSOB.

Spacecraft Stacking. The Lab will be installed on a workstand in the MSOB. Pyrotechnic circuitry will be verified and the explosive devices (minus initiators) mechanically installed. After thermal shield installation and exterior refurbishment, the Lab will be mated with the CSM/SLA in the SLA stand. For Saturn IB missions, the mated spacecraft (Lab/SLA/Boilerplate CSM) will be transported to LC-37. For Saturn V missions the spacecraft (Lab/SLA/CSM) will be transported to the VAB.

LEM Vehicle Schedules

The LEM/AES Integrated Manufacturing Schedule, Figure 34, indicates the phasing required to integrate the AES/LEM spacecraft into the presently planned Apollo LEM program without impairing the LEM schedule. The schedule meets the planned launch dates of ML65-1. As shown, the Phase I Laboratory vehicles require rescheduling of LEM 5 and subsequent to earlier completion dates in order to accomplish the required integration. This plan permits a constant manufacturing rate for efficient resources utilization which provides LEM to KSC in time to allow for modification to the Lab configuration.

The Phase I Laboratory Modification Schedules, Figures 35 and 36 are based on the study guideline requiring all Phase I vehicles to be fabricated and assembled to the LEM configuration at Bethpage and subsequently modified to each particular laboratory flight configuration at KSC. This schedule was developed to accomplish the maximum modification of the LEM vehicle within the available time period prior to the start of the prelaunch checkout. The manufacturing tasks at KSC will be limited to removal and installation of system components. No fabrication is anticipated for the KSC complex as "kits" will be manufactured and the mechanical interfaces controlled at Bethpage. The modification flow provides for a minimum of vehicle movements and mating-demating operations, and assumes that all experimentation packages will be installed simultaneously with the system and subsystem installation operations. The experiments are required to be "bolt-on" type with self-contained thermal management systems for those experiments which cannot use available cold plates, and all mounting or additional supporting structure is to be supplied by the experimentor. All electrical harnesses or plumbing lines external to the experiment package envelope will be a Grumman responsibility. If the experiment installation effort is other than described or cannot be performed in parallel, the modification schedule will require an increase to provide the required period.

The factory testing of the modified vehicle prior to delivery for prelaunch checkout has been minimized to delete any efforts that are duplicated in the checkout schedule. The Formal Engineering Acceptance Test will be integrated into the prelaunch testing schedule to reduce the Acceptance Checkout Equipment (ACE) utilization loading and reduce the modification cycle.

[redacted]

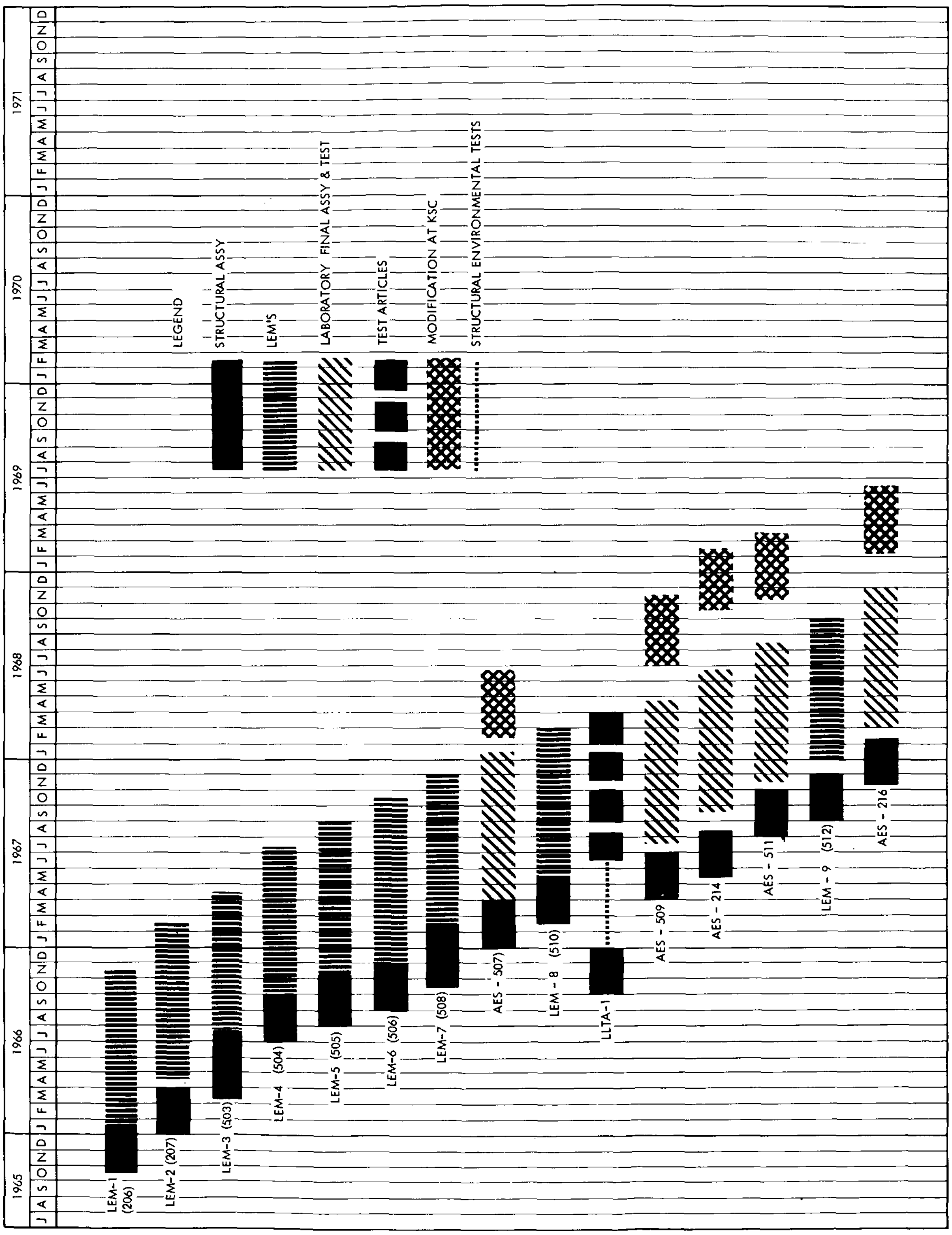


Figure 34. LEM/AES Integrated Phase I Manufacturing Plan

[redacted]

[redacted]

NOTE: Five two-shift work days per week.

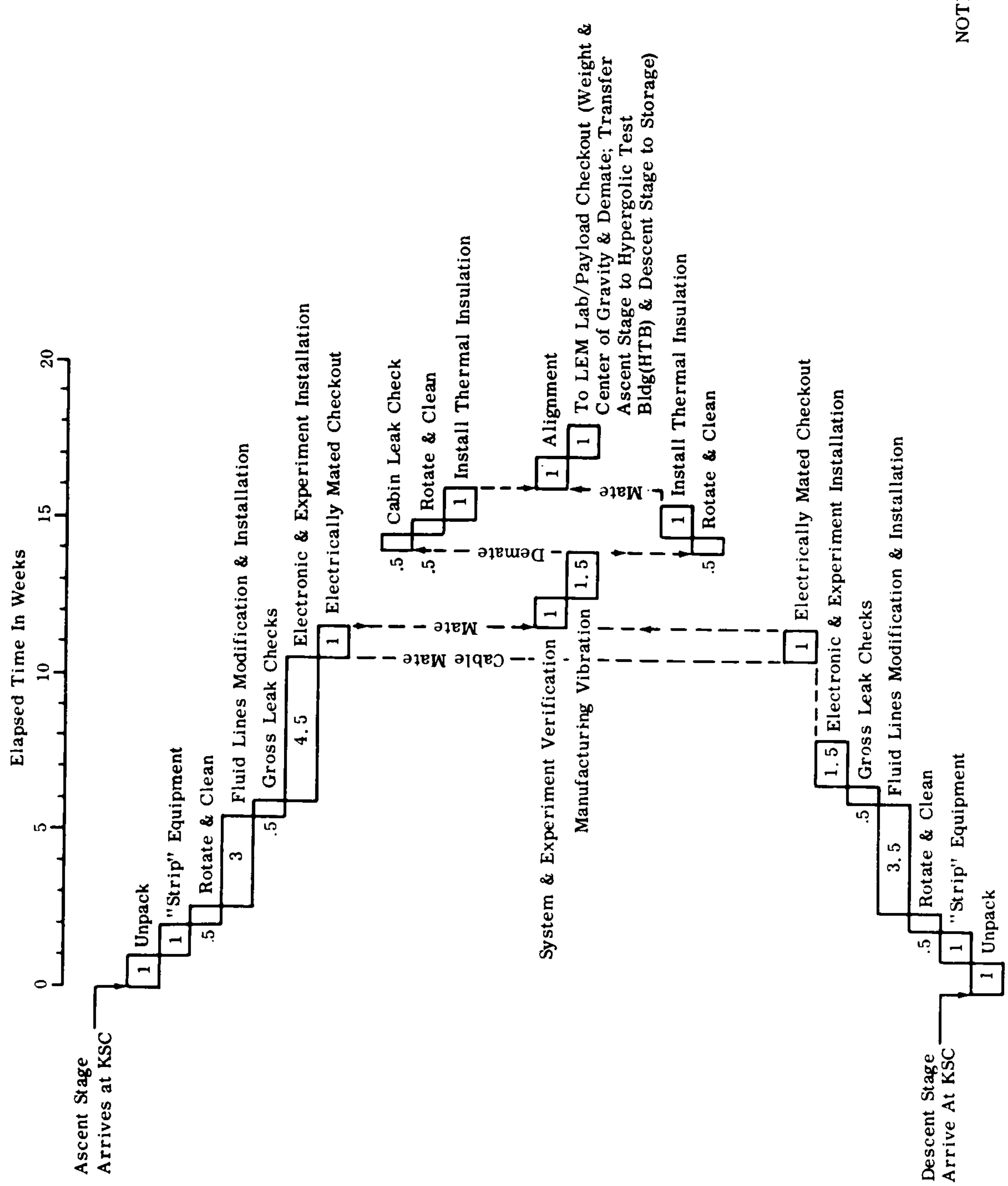


Figure 35. Phase I Laboratory/Payload Final Assembly and Acceptance Flow

[redacted]

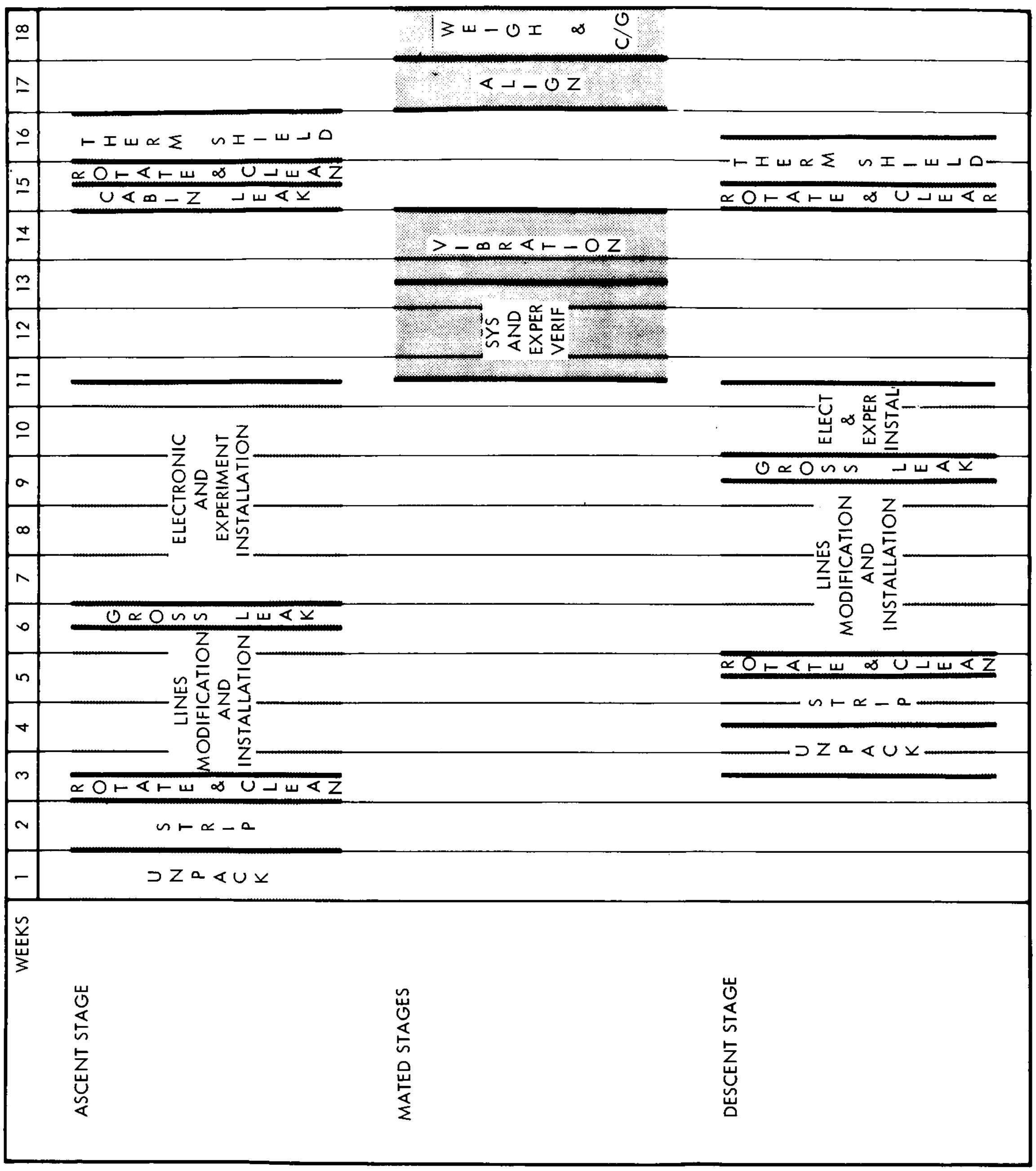


Figure 36. Phase I Laboratory Basic Modification Test

[redacted]

The baseline Phase I Lab pre-launch operations time line established by GAEC is presented in Figure 37. This schedule has been partially modified to accommodate interface requirements and phasing of CSM operations in the integrated flow schedules shown in Figures 28 and 29.

SPACE VEHICLE ASSEMBLY, CHECKOUT AND PRE-LAUNCH OPERATIONS

Launch complex assignment is dependant upon launch vehicle assignment. Saturn IB missions employ either or both Complex 34 and Complex 37. Saturn V missions employ the VAB and Launch Pads of Complex 39. The intent and sequence of operations is virtually the same for both cases. The CSM/LV and LAB/LV detailed operations on Saturn IB missions are disimilar due to interface differences, however, the overall requirements are the same.

Launch Complex 37 will be equipped to support an unmanned test of the LEM on the Apollo Program. Subject to final analysis of compatibility, it was therefore assumed reasonable to establish Complex 37 as the launch site for Lab vehicles and Complex 34 for CSM vehicles.

The mated spacecraft (be it CSM, Lab or CSM and Lab) is moved to the launch complex and mated to the launch vehicle. Following interface verification of SC-GSE and SC-LV connections the sequence of tests shown in Figures 22 and 23 are conducted to verify the spacecraft, launch vehicle, launch complex, and mission control. Experiment checkout will be integrated into the basic SC-LV checkout without schedule impact. However, experiment ground support equipment/facilities will be required. Perishable and consumable elements of experiments will be installed as late as possible in the launch countdown. The exact time of installation will be dependant on the location of the element and its characteristics.

Detailed planning factors associated with launch complex operations on AES missions could not be developed in the PDP study since this planning is dependant on experiment and design definition not available.

[redacted]

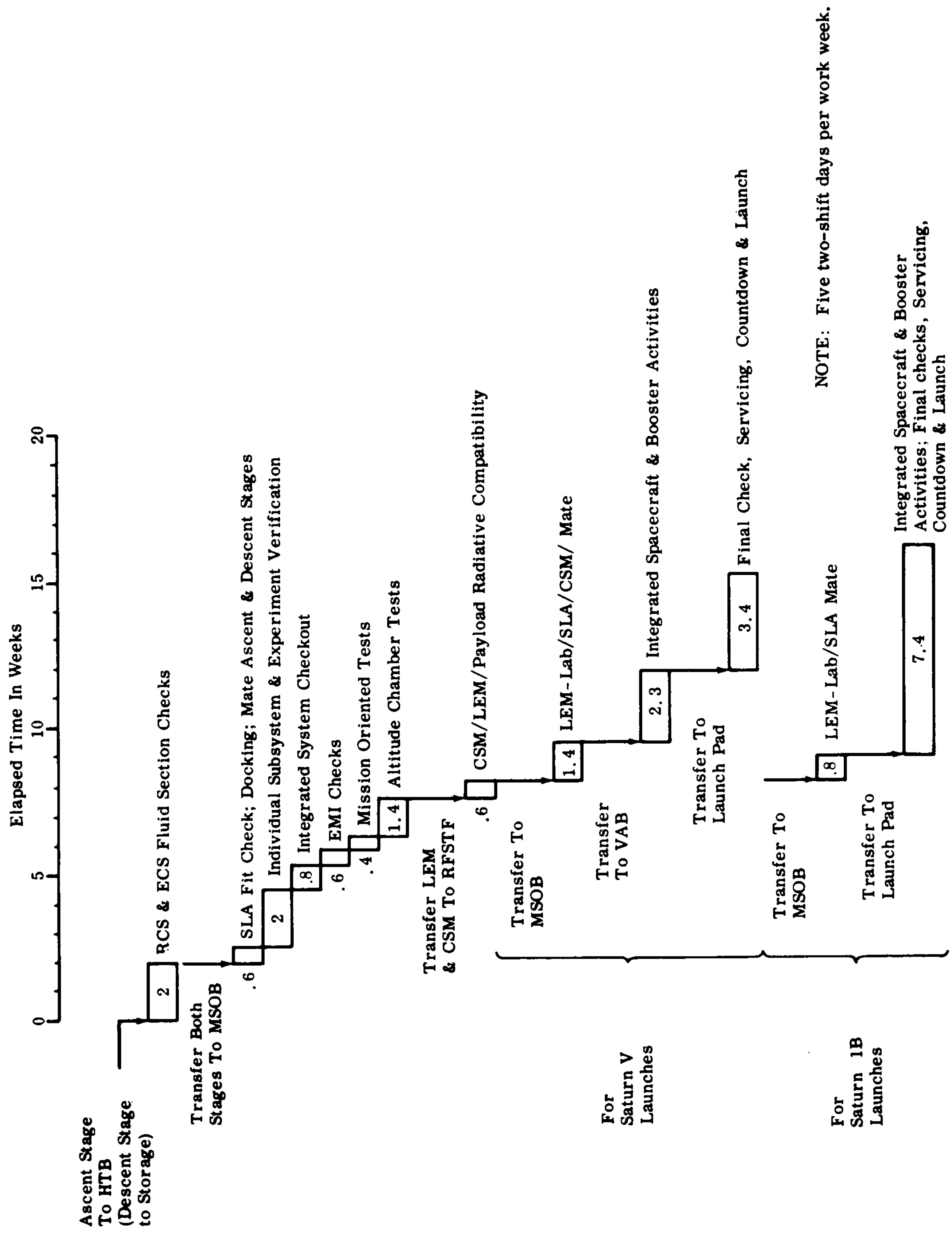


Figure 37. Phase I Laboratory/Payload Check-out

[redacted]

LOGISTICS

Existing Apollo Logistics Plans, such as the Apollo Support Plan, SID 62-702-1, Apollo Maintenance Plan, SID 62-702-2, Apollo Training Plan, SID 62-162, and AES Baseline Ground Operations Requirements Plan, SID 65-1151 were used as a baseline to help determine the delta support required for the AES Phase I experiments. However, unique requirements requisite for the Experimenter Contractor are defined to the extent that information and/or concepts were available. Responsibility for the definition of GFE hardware requirements will be the responsibility of the Experiment Contractor. The probable support impact of the AES Phase I missions is included to provide the NASA with a preliminary look at the Apollo Block II AES delta support effort for the anticipated experiment systems.

EXPERIMENTS PAYLOAD INTEGRATION SUPPORT

One of the Prime objectives of the AES Phase I Experiment Support is to minimize interference with CSM prelaunch operations and schedules. Experiment support will vary greatly depending on the size, weight, location, complexity or pecularity of the experiment equipment. Multiple experiments programmed for a specific mission will require a wide range of support requirements which must be integrated into the overall AES Phase I Support Program. Servicing and maintenance requirements must be defined early in the experiment definition phase to determine the gross impact on spacecraft assembly, checkout and prelaunch operations. The AES Phase I spacecraft's assembly in the prelaunch sequence will dictate experimental equipment accessibility with respect to GSE and facilities. Special equipment, skills, materials, environmental conditions, and access requirements for servicing and maintenance must be identified to ensure their timely availability.

The NAA AES Phase I Experiment Support Requirement Summary, Table 2, was developed from analysis of the individual experiments. The intent of this analysis was to depict the support considerations necessary for performing experiment operations which relate to program and spacecraft ground and in-mission requirements. The most critical ground support requirements for NAA-responsible experiments will be the SM Sector I area and pallet experiment equipment. This statement is predicated on the size and complexity of the type of experiments and equipment involved. The CM experiment equipments, such as sensors, regulators, cameras and other hand equipment, will be smaller, more accessible, and less complex. The SM experiment equipments will include telescoping booms, electronic recorders, and nuclear emulsion stacks, and will be more complex, larger, and non-accessible (during the last 10-20 hours before launch). Individual experiments, such as the biomedical-type, would not necessarily require specific support consideration, but when combined, they may impose a vital impact on the Apollo Block II/AES Phase I operation. For example,

[redacted]

training of the flight crew to perform individual experiments on a mission is considered to be a nominal task, but the critical training task will be the flight crew's ability to perform all of the experiments in conjunction with spacecraft's mission time and operations.

The support requirement considerations denoted for each experiment in Table 2, were based upon available experiment definition data and are subject to more specific revision as the detailed experiment data becomes available. The experiments are defined in SID 65-1537, "Experiment Identification Description."

Emphasis was directed towards the support for the CSM experiments in areas, such as supply support, maintainability, packaging, handling and transportation, modification, site activation, training, technical data and maintenance. All experiments and associated data contained herein apply only to those directed by the NASA as a NAA responsibility.

The following paragraphs describe the individual support considerations as determined during this study.

SUPPLY SUPPORT

Because of the variety of experiments, their equipment locations in the space vehicle, and relative importance to the mission, the specific support requirements for each experiment were considered. The following support considerations will apply generally to AES Phase I experiments and will be subject to individual experiment analysis to ensure that adequate and efficient support is provided on schedule. Experiment support includes the pre-launch and on-board equipment and supplies required to support the experiments in excess of the support requirements needed for the spacecraft operation and crew sustenance.

Scientific experiments will normally be NASA/Government Furnished Equipment (GFE), i.e., equipment purchased by the NASA and subsequently made available to the spacecraft contractors for integration into the spacecraft and ground support system. All experiment equipment having the same manufacturer's part number shall be physically and functionally interchangeable.

The Experimenter will provide spares to the following levels at the launch site and the Vehicle Contractor's facilities, as applicable:

a. Electrical and electronic spares will be provisioned to the replaceable package (black box) level.

b. Mechanical spares will be provisioned to the lowest replaceable unit level, consistent with minimizing delays in field and factory test due to maintenance activities.

[redacted]

EXPERIMENTS		EXPERIMENT FLIGHT NO. ASSIGNMENT						
NO.	TITLE	211	507	509	511	214	215	216
M-4	IN-FLIGHT PHONOCARDIOGRAM	X						
M-5	BIOASSAYS OF BODY FLUIDS	X	X	X	X		X	
M-7	CALCIUM BALANCE STUDY	X						
M-8	IN-FLIGHT SLEEP ANALYSIS	X	X	X	X			
M-11	CYTOGENETIC BLOOD STUDIES	X						
M-12	EXERCISE ERGOMETER	X						
M-17	THORACIC BLOOD FLOW	X						
M-18	VECTOR CARDIOGRAM	X	X					
M-19	METABOLIC RATE MEASUREMENT	X						
M-20	PULMONARY FUNCTION	X	X					
M-22	RED BLOOD CELL SURVIVAL	X						
M-23	LOWER BODY NEGATIVE PRESSURE	X	X					
0103	CIRCULATORY DYNAMICS		X		X			
0104	WORK CAPACITY		X		X			
0105	BLOOD VOLUME CHANGES		X		X			
0106	CAROTID BARORECEPTOR		X		X			
0107	VENOUS COMPLIANCE	X	X	X	X			
0108	CIRCULATORY REFLEX CHANGES							
0109	ASSESS PULMONARY FUNCTION	X		X	X			
0110	VENTILATORY GAS EXCHANGE	X		X	X			
0111	MUSCLE MASS & STRENGTH		X		X			
0112	MINERAL METABOLISM		X		X			
0113	NUTRITIONAL STATUS		X		X			
0114	GASTROINTESTINAL MOTILITY	X		X	X			
0115	THERMAL REGULATION			X	X			
0117	ENDOCRINE FUNCTION		X	X	X			
0118	HEMIC CELL		X	X	X		X	
0119	HEMATOLOGICAL DEFENSES		X	X	X		X	
0120	HEMOSTASIS		X	X	X		X	
0201	SENSORY & PERCEPTUAL PROCESS		X	X	X			
0202	PSYCHOMOTOR FUNCTIONING		X		X			
0203	HIGHER MENTAL PROCESSES		X	X	X		X	
N/N	SYNOPTIC WEATHER PHOTOGRAPHY		X					
N/N	UV STELLAR PHOTOGRAPHY		X					
N/N	ASTRONOMICAL EXPERIMENTS ORIENTATION SYSTEM			X				
MSF-1	LUNAR MAPPING AND SURVEY PHOTOGRAPHY		X		X			
	SM PALLET EXPERIMENTS 1. RADAR SCATTERING CROSS-SECTION MEASUREMENTS OF TERRAIN 2. TEMPERATURE SOUNDING OF THE ATMOSPHERE 3. ULTRAVIOLET MAPPING OF CELESTIAL SPHERE IN THE 1230 A TO 1700 A BAND 4. X-RAY ASTRONOMY 5. SPARK CHAMBER FOR GALACTIC GAMMA-RAY 6. NUCLEAR EMULSION 7. MEASUREMENT OF ATMOSPHERIC IODINE FROM ORBIT 8. ZERO-GRAVITY STUDIES OF PHYSICAL PROPERTIES 9. FROG OTOLITH FUNCTIONS DURING ZERO-GRAVITY	X						

Table 2. NAA AES Phase I Experiment Support Requirements (Summary)

217	SUPPORT REQUIREMENT CONSIDERATIONS: MAINTENANCE	SPARES	CHECKOUT	MODIFICATION	TRAINING	TECHNICAL DOCUMENTATION	SITE ACTIVATION	GSE/SPECIAL TOOLS	TRANSPORTATION	HANDLING	PACKAGING	STORAGE	POST-FLIGHT (RECOVERY)
	N	U	N	R	N	P	N	P	N	U	U	N	N
X	N	N	N	R	N	R	N	N	N	R	R	R	P
	N	U	N	R	N	R	N	N	N	R	R	R	R
X	N	U	N	R	N	N	N	P	N	N	N	N	N
	N	N	N	N	N	N	N	N	N	N	N	N	N
	N	P	N	N	N	N	N	P	N	N	N	N	N
	N	U	N	R	P	P	N	P	N	N	N	N	N
	N	U	N	R	N	N	N	P	N	N	N	N	N
	N	U	N	R	P	N	N	P	N	N	N	N	N
	N	U	N	R	N	N	N	P	N	N	N	N	N
	N	N	N	N	N	N	N	N	N	N	N	N	N
	N	N	N	N	N	N	N	P	N	N	N	N	N
X	N	U	N	R	P	P	N	P	N	P	P	P	N
X	N	U	N	R	P	P	N	P	N	N	P	P	N
X	P	P	P	R	P	P	P	P	P	P	N	P	N
X	N	U	P	P	P	P	N	P	N	P	P	P	N
	N	U	N	R	N	N	N	P	N	N	N	P	N
	N	U	N	R	P	P	N	P	N	P	P	P	N
	N	U	N	R	P	N	N	P	N	N	N	N	N
	N	U	N	R	P	N	N	P	N	N	N	N	N
X	N	U	N	P	P	N	N	P	N	N	P	N	N
X	N	U	N	P	P	N	N	P	N	N	P	N	N
X	N	U	N	P	P	N	N	P	N	N	P	N	N
	N	U	N	R	N	N	N	P	N	N	N	N	N
	N	U	N	N	N	N	N	P	N	N	N	N	N
X	N	U	N	N	P	N	N	P	N	N	P	N	N
X	N	U	N	N	P	N	N	P	N	N	P	N	N
X	N	U	N	N	P	N	N	P	N	N	P	N	N
X	N	U	N	N	P	N	N	P	N	N	P	N	N
X	N	U	N	R	P	N	N	P	N	P	P	P	N
X	N	U	N	R	P	N	N	P	N	P	P	P	N
X	N	U	N	R	P	N	N	P	N	P	P	P	N
	N	N	N	N	P	N	N	N	N	N	P	P	N
	N	N	R	R	R	P	P	N	N	N	P	P	P
	P	P	N	P	R	P	P	P	P	P	P	P	R
	R	R	R	N	R	P	R	R	P	P	P	P	P
	P	P	R	N	P	P	P	P	P	P	P	P	N

LEGEND:

N-NONE
P-POSSIBLE
R-REQUIREMENT
U-UNKNOWN
N/N-NO NUMBER ASSIGNED

c. Ground support equipment spares will be provisioned to the lowest replaceable unit level, consistent with approved capabilities at test sites, the Experimenter and Vehicle Contractor's facilities, and within cost restraints established by the NASA.

Critical long lead-time experiment items must be identified as soon as possible. Approximately two years may be required for design and development of the complex experiment equipment and their spares prior to their installation/integration with the CSM.

The KSC and Experiment Contractor will make warehousing facilities available, as necessary, at each applicable site, to perform the normal functions of storage, handling and issuing of experiments and associated equipment and their spares.

a. Experiment material and parts will be stored in a manner that will prevent commingling, damage, corrosion, or contamination.

b. Preserved experiment items and age controlled materials will be isued from stock on a first in, first out, basis.

c. Critical experiment items and calibrated components will be stored in a bonded and environmentally controlled area, as required.

d. Identification and traceability controls of experiment equipments will be maintained.

e. A preventive maintenance program, and periodic inspection of stored experiment articles will be in effect, and will support applicable specifications.

Unique Ground Support Equipment and associated equipments applicable to experiment checkout, auxiliary, service and handling requirements will be the responsibility of the Experiment Contractors and furnished as part of the equipment package.

EXPERIMENT MAINTAINABILITY

Due to the time element involved in Phase I missions (Spacecraft 106, Flight SA 211) assembly is scheduled to begin around August, 1966, the close relationship between Apollo and AES hardware, and the AES constraints imposed by utilizing an Apollo Block II spacecraft, the installation of experiments will place the burden of accommodation upon the experiments rather than the Apollo hardware. Experiment equipment maintainability requirements must be developed and integrated in design early in the AES Design Phase to provide adequate supportability of the equipment items during ground and inflight operations. Consideration must be given to AES modification requirements with respect to the Apollo lunar spacecraft configuration to eliminate interfacing problems caused by utilizing the basic vehicle, (Block II), for two different programs.

[redacted]

Experiments must be designed to ensure that maintenance and other support actions can be performed within the time-critical limitations established by prelaunch operational requirements. During all stages of design and operation, vehicle accessibility must be considered for experiment servicing, testing, inspection and replacing items, and requirements for calibration, and special tools or handling devices.

Experiment equipment, assembly, inspection and testing requirements should be simplified to minimize the demands on prelaunch time, equipment and personnel. Test points and procedures will be required to isolate a failure to the lowest field replaceable component of the experiment. Requirements for maintenance or servicing during KSC prelaunch operations must be carefully coordinated with launch operations. If experiment maintenance is required, each backup component must be physically and functionally interchangeable, including inertial properties, with the item it is to replace. The maintenance requirements of the experiment equipment must adhere to the Apollo-based maintenance level concept as described in the experiment maintenance portion of this section of the report.

The experimental pallet concept will permit installation and testing of experiments at locations separate from the spacecraft assembly area while minimizing interference with ground vehicle testing operations. This concept is ideally suited for experiments which require the support of specialized skills, tools and techniques, possibly in special areas, which are not normally associated with spacecraft operations. Installation and testing can proceed without interruptions caused by spacecraft operations.

EXPERIMENT PACKAGING AND HANDLING

Experiments must be packaged to provide adequate protection and prevention of contamination, deterioration, corrosion. Ground handling and transportation will require that adequate structure and cushioning be employed to prevent damage from in-transit shock, vibration and externally applied loads. Whenever possible, equipment and packaging should be designed to be transported and handled by common carrier without special handling devices or environmental controls. The packaging of backup components must be compatible with storage specifications and servicing requirements of the items.

MODIFICATION

Major modification to the CSM to accommodate experiments is not anticipated at KSC; however, minor changes, i.e., wiring connections, umbilicals, mounting brackets, etc., will be necessary to accommodate the insertion of the experimental packages.

The Experimenter will normally be the responsible agency for the modification of scientific experiment equipment. When equipment is manufactured by a sub-tier contractor, the experimenter will retain a primary responsibility and function accordingly.

[redacted]

All modification required for experiment installation/integration will be accomplished at NAA during the in-line cycle, unless the required modification becomes necessary after receipt of the CSM at KSC. Normally, CSM modification at KSC will be accomplished immediately after receiving inspection at the industrial area. If the modification involves a weight change, the modified experiment must be installed prior to the weight and balance checks of the CM and/or SM at the MSOB or VAB, prior to the mating of the two modules. Experiments installed at KSC will have fit check and equipment storage space verification.

Any experiment not installed in the SM or CM prior to their mating must be installed prior to four general checkout operations, if applicable to the experiment; polarity, altitude chamber, RF and ordnance. If an experiment is installed and then modified, and is affected by, or affects any of these checkout operations, that experiment must be subjected to the applicable checkout after the experiment reinsertion and/or reinstallation.

Modification kits required to incorporate experiments in the CSM will be furnished by S&ID in accordance with existing procedures which are described in the Apollo Support Plan, SID 62-702-1. This system contains the management controls necessary for authorizing the fabrication or procurement of modification kits to meet specific contractural requirements. S&ID's kit effort normally includes the provisioning, warehousing, accumulating for shipment, and installation of kits at S&ID or the customers' test and operational sites. When unique or special Experimenter (other than S&ID) equipment and/or techniques are required, S&ID will coordinate with the Experimenter and the NASA, as required, to facilitate the modification with the least amount of mission impact. An example concerning possible modification kits at KSC would be the Ultraviolet Stellar Photography experiment (reference, SID 65-1537, Experiment Identification Description). Modification Kits for this experiment may be required to: Mount the camera to the CM Adapter section; provide electrical cable connectors for power and camera timing; provide a mount assembly to permit installation and removal of the camera and also modification to permit launch storage for the experiment canister.

SITE ACTIVATION

The AES Phase I missions will utilize Launch Complexes 34 and 37 for checkout and launch of the Saturn IB's and Launch Complex 39 for checkout and launch of the Saturn V's. Consideration for experiment support for both complexes is required. Appropriate experiment facilities and GSE at all site locations, necessitate a joint effort between the Experimenter, the NASA, and the Vehicle Contractor to ensure their availability in accordance with the AES Phase I mission schedules.

Experimenters will be required to fully describe the experiment to the detail of installation and test site requirements, including facilities and GSE required for storage, installation, checkout, modification, and repair. From these requirements, the NASA/vehicle contractor shall:

[redacted]

1. Coordinate and establish interfaces between the facility and experiment/GSE to ensure interface compatibility.

2. Determine where existing or programmed Apollo activation design could be utilized to satisfy AES Phase I experiment requirements.

3. Establish new or modified facility/GSE requirements.

4. Provide scheduling and necessary milestone dates for the Experimenter, Vehicle Contractor, and the NASA facility/GSE site activation activities to ensure spacecraft/experiment installation and checkout requirements.

5. Integrate experiment activation activities into the vehicle site activation program and continue in accordance with established practices.

Some of the AES Phase I experiments will preclude installation of their respective payloads at the Experimenter's facility and will have to be inserted/installed at the KSC. Environment, storage time, handling, and lead time will be the most significant factors involved. However, investigation has concluded that NAA Building 290, located at Downey, California, offers the best overall advantages for preliminary installation and checkout of the majority of the AES Phase I experiments. This advantage would be predicated upon experiment availability within schedule constraints; however, fit check could be accomplished at Building 290 on some experiments with mockup components if their design dimensions are available. Building 290 offers the following advantages for most experiments:

1. Installation techniques, procedures, and technical personnel could be accomplished in the House Test Model.

2. Experiment items would be incorporated during normal subsystem installation imposing less schedule impact.

3. Ready availability of manufacturing personnel, skills and equipments.

4. Building 290 installation and checkout of experiments would leave major emphasis at KSC on actual payload integration (VAB or MSOB).

5. Maximum capability for rework or modification.

6. Availability of the House Test Model, and its support, for special tests and verification of experiment procedures.

EXPERIMENT TRAINING

The basic AES Phase I training objective will be to incorporate experiment requirements with other AES Phase I mission training requirements. Training of flight crew personnel involves careful planning and programming in order to achieve maximum crew proficiency within AES Phase I mission schedules. Training is also required for ground operations and support (mission planning and maintenance) personnel to enable them to participate effectively in the detailed technical planning of AES missions and also to monitor and analyze spacecraft data during and after flight. The flight crew personnel will have previously undergone extensive training; however, the following items which comprise training for a specific Phase I AES mission illustrate the magnitude of the additional training required:

1. Final refinement and practice of specific mission plans and procedures involving experiments.

2. Participation in preflight test and checkout of experiments, as required.

3. Specific mission training in scientific experiments and data gathering.

4. Participation of the crew in specific mission experiments using the Apollo Mission Simulator (AMS) or experiment trainer.

5. Practice and evaluation of possible specific mission experiment contingencies.

Experimenters will be required to provide assistance in the development of training materials and procedures and requirements for new and modified simulation-stimulation devices.

The nature of the experiments will dictate the need for simulation-stimulation devices. SID 65-1539, Ground Support and Logistics, defines the preliminary experiment trainer requirements for the AES Program. Complex experiments will require flight qualified or simulated experiments to be utilized in crew training. An experiment training system may be required. Additional functions will have to be added to the Apollo or LEM mission simulators or system trainers to incorporate the AES Phase I experiments. Experimenters will be required to furnish these devices or their requirements to NASA or a NASA designated contractor in addition to the experiment packages required for qualification tests, flight articles and contingency backup.

Examples of possible training necessary for the flight crew would be:

Experiment	Preflight Training
Circulatory Dynamics	Each crewman will be required to attain proficiency in the placement of sensors, attachment of instrumentation, and the use of the required measurement devices and techniques.
Gas Exchange	Each crewman will be required to attain proficiency in placement of the mouth piece and nose occluding device, control of salvation, operation of the gas meter-analyzer, method of handling the sample gas for analysis, attaching sensors, and assembling and positioning equipment to perform the experiment.
Nutritional Status	Each crewman will be required to attain proficiency in the use of the urine volume measurement system collecting samples and performing certain bio-chemical analytic procedures.
Gastrointestinal Motility	Subject crewman will be required to attain proficiency in the extended use of the endoradiosonde.

Present planning for preflight testing, maintenance and modification of spacecraft involves participation by the NASA and S&ID Agencies. As such, a requirement exists for training support for installation personnel, acceptance checkout equipment (ACE) personnel, bench maintenance equipment (BME), personnel, and integrated and combined systems checkout personnel.

EXPERIMENT TECHNICAL DATA

Technical data required to checkout, install, operate and maintain experiments and equipment must be provided. Experimenter's drawings and specifications will normally be required. Additional Experimenter's requirements may include special instructions and such items as training, test tapes and microfilm. The method, depth and format for providing these data are likely to vary for different experiments and missions. Matters for consideration include the degree of support to be provided by Experimenters in terms of special skills and knowledge, the degree of similarity between the experiment and the spacecraft operations for which flight and ground crews are presently skilled, and locations and times when the data must be available.

EXPERIMENT MAINTENANCE

Maintenance, both scheduled and corrective, will be predicated upon the designed maintainability of an experiment subsystem and the availability of certified parts, equipment and trained personnel. Experiments will be examined upon receipt at KSC. If damaged, the experiment and/or damaged portion will be subjected to corrective maintenance. Three levels of maintenance (A, B, and C) have been established on the Apollo Program and thereby dictate maintenance constraint on experiment subsystems or elements within the subsystem. These levels of maintenance are defined in SID 62-702-2, Apollo Maintenance Plan.

Repair of scientific equipment at the launch site or Vehicle Contractors facility will consist of Bench Test Equipment to be used for malfunction verification of packages (envelopes) removed because of suspected failure. Malfunctioned packages shall be returned to the applicable supplier. Spares certification will also require utilization of available Bench Test Equipment.

Maintenance functions, preventative or corrective, to be performed inflight are to be determined for each experiment and mission. Certain operations such as inflight checkout and adjustment are likely to be acceptable maintenance actions, whereas the repair or replacement of a failed component will normally be beyond the scope of inflight maintenance. If no inflight maintenance capability can be provided, consideration should be given to available alternatives to performing the planned experiment in the event of inflight experiment malfunction or equipment failure.

Some of the AES Phase I experiments will involve components and techniques which are peculiar to the individual experiment. Special tools and equipment required for assembly, checkout, installation, adjustment, fault isolation, etc., must be identified. Special tools and equipment utilized in conjunction with individual experimental packages will be furnished by the Experimenter. Equipment required for integration testing will normally be provided by the NASA/Vehicle Contractor. Common tools will be made available to Experimenter or Vehicle Contractor personnel through Government Supply Authorization (GSA), if required. Existing Government Furnished Equipment (GFE) will be utilized whenever possible.

Accessibility to experiments inserted into Sector I of the SM will require removal of the Sector panel. The Sector panel can be removed at the VAB or MSOB at KSC. Removal at the pad of the Sector I cover is not anticipated as it will not be accessible unless the cover is redesigned. This design feature is being investigated.

Maintenance operations on experiment or spacecraft equipment inside the Sector I must be performed inside a portable contamination shield. Time will have to be allowed for the shield erection.

All access to the SM will be lost when the Service Structure moves away from the pad (S-IB flights at T-5 hours and S-V flights at T-10 hours). The SM Sector panel cannot be removed after the hypergolics are loaded. This is scheduled at T-10 days. The VAB and MSOB will require a controlled environment shelter to provide high level clean air, such as 100,000 level, when the Sector I is open.

GSE requirements common to maintenance (spacecraft and experiments) should be available for fault isolation at the MSOB and VAB. The launch pad will not have the required GSE available. GSE, other than ACE-SC, is required for fault isolation, adjustment and alignment of some of the experiments and for verification of the maintenance activity. This will be the same GSE that is used for payload installation, except unique experiments where the experiment contractor will be responsible for the maintenance requirements such as; special tools, test equipments, and GSE.

[redacted]

FACILITIES

The results of the Mission Payload Integration analysis of facilities requirements is predicated on the basis that all CSM and LEM modification, support subsystem installation, experiment or pallet form-fit-function checks, experiment PIA, installation, functional and integrated tests will be performed at KSC.

IMPACTS AND REQUIREMENTS

S&ID - Fabrication and test of modification kits for KSC installation requires no additional facilities at S&ID.

KSC - Modifications and additions to the Manned Spacecraft Operations Building (MSOB) facilities will be necessary to accommodate CSM and LEM modifications, experiment build-up of assemblies, checkout, maintenance, and storage.

<u>CSM Facilities Utilization</u>

The integrated Block II program CSM field operations flow was analyzed in respect to the KSC checkout resources capability. This study was based on the schedules of Figures 27 through 29. Also, there is no significant decrease in loading on the checkout facilities if the CSM were ready for the AES mission at delivery. If the prelaunch checkout is performed at the latest time which will meet the assigned mission launch date (launch per ML 65-1), facility utilization problems develop. This can be seen in Figures 38 and 39, which reflect the program flow for MDS11-1 and MDS 11-2, respectively, where the operations are scheduled in respect to launch date requirement only without regard for delivery or resources capability. These schedules, evidence overload on checkout facilities such as the service propulsion static firing facility (Launch Complex #16), Cryogenic and Fuel Cell Test Facility, and integrated test station. Figures 40 and 41 were developed to determine the minimum flow loading to the facilities by taking advantage of the delivery oversupport. Since MDS 11-2 is the baseline schedule used for this study, a utilization plot of all test stations is shown in Figure 41. It was determined that slack time was available on most of the test stations until late in the Block II program. The propulsion, Hypergolic fuel cell system, integrated system and polarity and altitude test stations were determined to be the constraining elements.

Trade-off study of alternate flow plans resulted in the program schedule shown in Figures 42 and 43. This plan affords a reasonable degree of lunar mission coverage and supports the desired AES Phase I mission launch dates. Slack times are noted on some spacecraft where a segment of test must be completed early in order to clear the MSOB checkout stations for downstream spacecraft. In this plan, each Lunar Landing

[redacted]

[redacted]

Mission CSM is started through prelaunch checkout shortly after delivery to provide maximum backup to the previous Lunar Landing mission spacecraft. It would be held in the integrated and polarity test station (Stokes Stand Number 2) in the MSOB until operations had to be resumed in order to meet the assigned launch schedule or release the polarity test station and altitude chamber for the next spacecraft. The need date for the next spacecraft is determined by the start of the station preparation.

The polarity station was selected as the hold point as it affords the capability of re-running integrated systems tests. However, the time from start of the CSM interface test to launch may exceed existing calibration periods on such items as the G&N system. Final definition study must include consideration for equipment operating times.

This program schedule assumes use of the RF Systems Test Facility for the CSM RF tests, but use of the MSOB for CSM-LAB electrical interface tests. It was determined late in the PDP, that on the rendezvous mission, there was a requirement for a complete EMC test between the CSM and LAB to be performed at the RFSTF. If the RF and CSM-LAB interface tests are combined and performed at the RFSTF it will relieve loading on the polarity test station (Stokes Number 2). This would have a slight affect on the overall flow plan, but was determined to late for incorporation in this study.

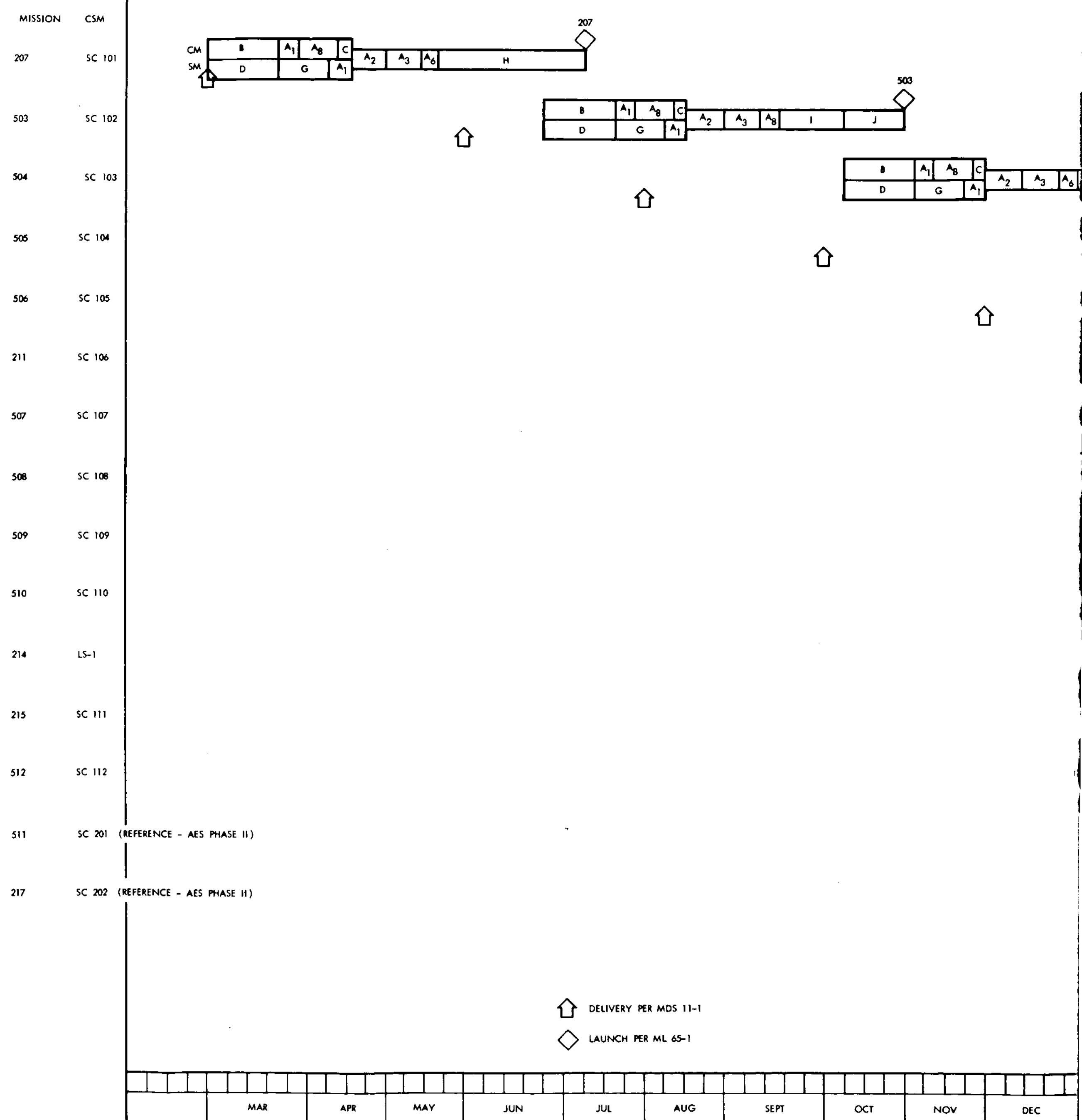
Figures 42 and 43 show that the desired launch schedule can be generally supported. However, launch dates defined by the CSM requirements do not exactly match the launch dates of ML 65-1 or the LEM master schedules. In order to optimize the integrated schedules, some adjustment to the launch dates, within launch window constraints, appears desirable. A mutually negotiated master schedule should be established upon final definition of individual CSM, LEM and LV requirements.

These studies also disclosed, but did not resolve, facility problems in phasing from the Block II AES Phase II program. These are specifically highlighted in Figure 41. The allowed time for site activation to convert the checkout stations is inadequate. The polarity test station and altitude chamber are the critical areas. An additional integrated test station in the MSOB was recommended in the AES PDP final report SID 65-1539, Ground Support and Logistics. This will relieve, but not eliminate entirely, the interference between Block II and AES Phase II. Phase II schedule adjustment may be required.

Phase I Lab Utilization

Integration of the AES Phase I and Apollo Lunar missions changes the facility requirements at KSC. The facilities loading is shown in Figures 44 and 45.

[redacted]



MISSION
CSM
207
SC 101
503
SC 102
504
SC 103
505
SC 104
506
SC 105
211
SC 106
507
SC 107
508
SC 108
509
SC 109
510
SC 110
214
LS-1
215
SC 111
512
SC 112
511
SC 201 (REFERENCE - AES PHASE II)
217
SC 202 (REFERENCE - AES PHASE II)
CM
SM
B
A1
A8
C
A2
A3
A6
H
D
G
I
J
207
503
DELIVERY PER MDS 11-1
LAUNCH PER ML 65-1
MAR
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV
DEC

GROUND RULES:

1. MDS II-1 PROGRAM
2. ALL MODIFICATIONS FOR EXPERIMENT INSTALLATION PERFORMED IN FIELD
3. BASIC STRUCTURE AND WIRE HARNESSES COMPATIBLE WITH PRACTICAL FIELD MODIFICATION
4. BASED ON 5-DAY WORK WEEK, 2 SHIFTS PER DAY

CODE	FACILITY	STATION	PERTINENT FUNCTIONS: COMMAND MODULE (CM) OR CSM	PERTINENT FUNCTIONS: SERVICE MODULE (SM)
A	MANNED SPACECRAFT OPERATIONS BUILDING (MSOB)			
A_1	MSOB	ASSEMBLY AND TEST AREA	8.1.11 AND 8.1.16	8.1.12, 8.1.19, 8.1.49, AND 8.1.50
A_2	MSOB	INTEGRATED AND POLARITY TEST	8.1.21, 8.1.20 AND 8.1.26	
A_3	MSOB	ALTITUDE CHAMBER	8.1.25	
A_4	MSOB	CSM RF TEST (COULD BE RF SYSTEMS TEST FACILITY)	8.1.23	
A_5	MSOB	CSM-LAB FUNCTIONAL INTERFACE TEST (COULD BE A_2 OR A_6)	8.1.32 (INTERFACE TESTS ON AES)	
A_6	MSOB	SPACECRAFT FINAL STACKING	8.1.32 (INCLUDES INTERFACE TEST ON BLOCK II)	
A_7	MSOB (OR ALTERNATE ASSEMBLY AREA)	CSM MODIFICATION	8.1.53 AND 8.1.36 (LATTER ON AES ONLY)	8.1.54 AND 8.1.37 (LATTER ON AES ONLY)
A_8	MSOB (OR ALTERNATE ASSEMBLY AREA)	CM BUILDUP	8.1.45	
B	HYPERGOLIC TEST NO. 2	CELL NO. 1 (CM) AND CELL NO. 2 (SM QUADS)	8.1.9 AND 8.1.36 (LATTER ON BLOCK II ONLY)	8.1.5 (SMQ'S)
C	PYROTECHNIC INSTALLATION BUILDING		8.1.18	
D	LAUNCH COMPLEX NO. 16			8.1.6 AND 8.1.37 (LATTER ON BLOCK II)
E	LAUNCH COMPLEX NO. 37		LEM SHROUD PAD OPERATIONS	
F	ORDNANCE STORAGE		NOT APPLICABLE	
G	CRYOGENIC TEST			8.1.10
H	LAUNCH COMPLEX NO. 34		7.0 COMPLETE	
I	VERTICAL ASSEMBLY BUILDING		7.1 THROUGH 7.11	
J	LAUNCH PAD-COMPLEX NO. 39		7.12 THROUGH 7.36	

PERTINENT FUNCTION DESCRIPTION (REFERENCE SID 65-1157)

7.0	SPACE VEHICLE ASSEMBLY, CHECK-OUT, AND PRELAUNCH OPERATIONS
8.1.5	PERFORM LEAK AND FUNCTIONAL TEST OF SM RCS QUADS
8.1.6	PERFORM SPS STATIC FIRING
8.1.9	PERFORM CM RCS LEAK AND FUNCTIONAL TESTS
8.1.10	PERFORM SM CRYOGENIC AND FUEL CELL SYSTEM TESTS
8.1.11	PERFORM CM-LEM DOCKING OPERATIONS
8.1.12	PERFORM SM-UPPER SLA FIT CHECK
8.1.16	CLEAN CM
8.1.18	PERFORM CM/LES WEIGHT AND BALANCE OPERATIONS
8.1.19	CLEAN SM
8.1.20	MATE CM AND SM
8.1.21	PERFORM CSM INTERFACE TESTS
8.1.23	PERFORM CSM RF TESTS
8.1.25	PERFORM CSM ALTITUDE TESTS
8.1.26	PERFORM CSM POLARITY AND INTEGRATED SYSTEMS TESTS
8.1.32	STACK CSM AND SLA (INCLUDES CSM-LEM INTERFACE TESTS)
8.1.36	RECEIVE AND INSPECT CM
8.1.37	RECEIVE AND INSPECT SM
8.1.45	BUILD UP CM FORWARD DECK AND INSTALL FHS AND CM EXPERIMENTS
8.1.49	INSTALL SM EXPERIMENTS
8.1.50	INSTALL SMQ'S
8.1.53	MODIFY CM FOR EXPERIMENTS
8.1.54	MODIFY SM FOR EXPERIMENTS

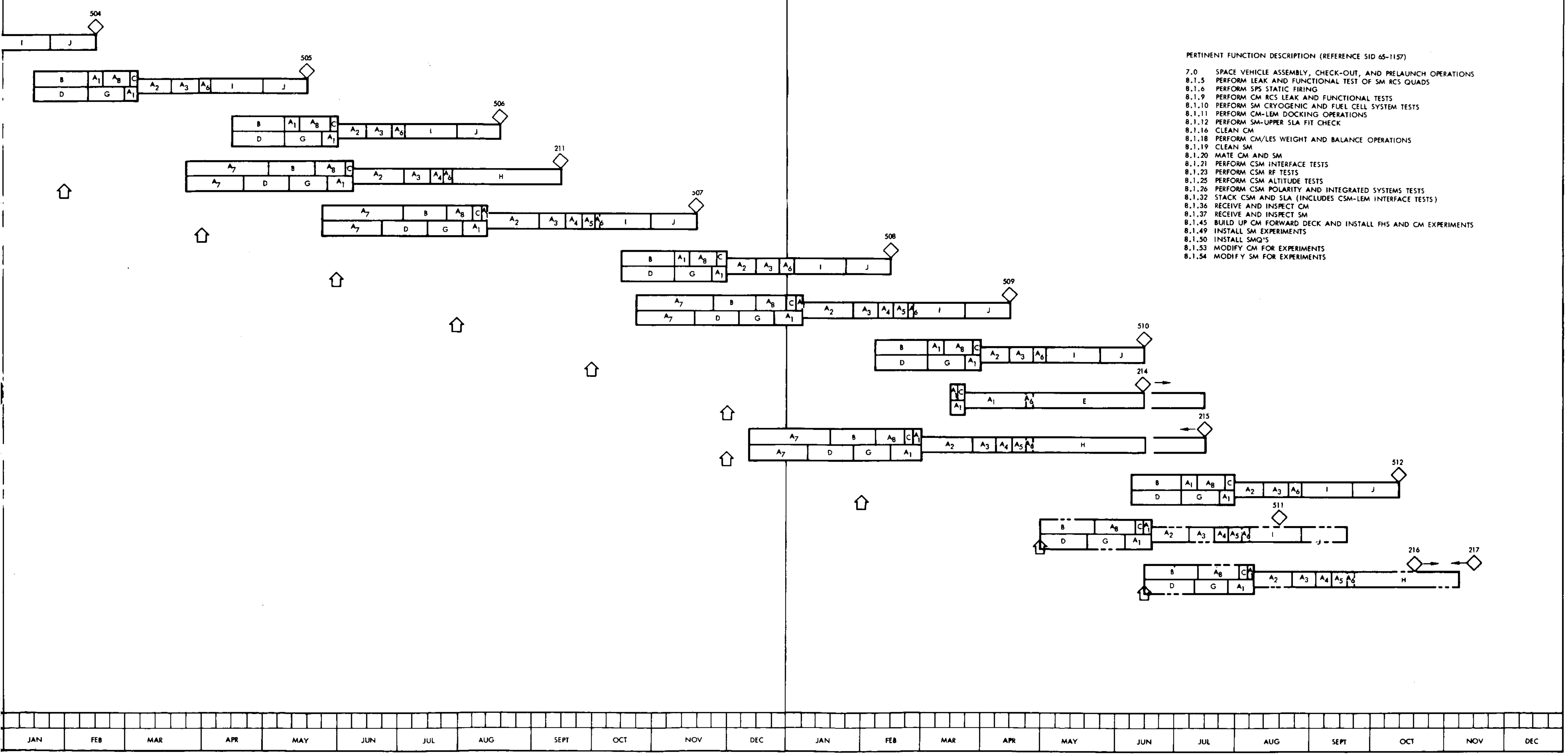


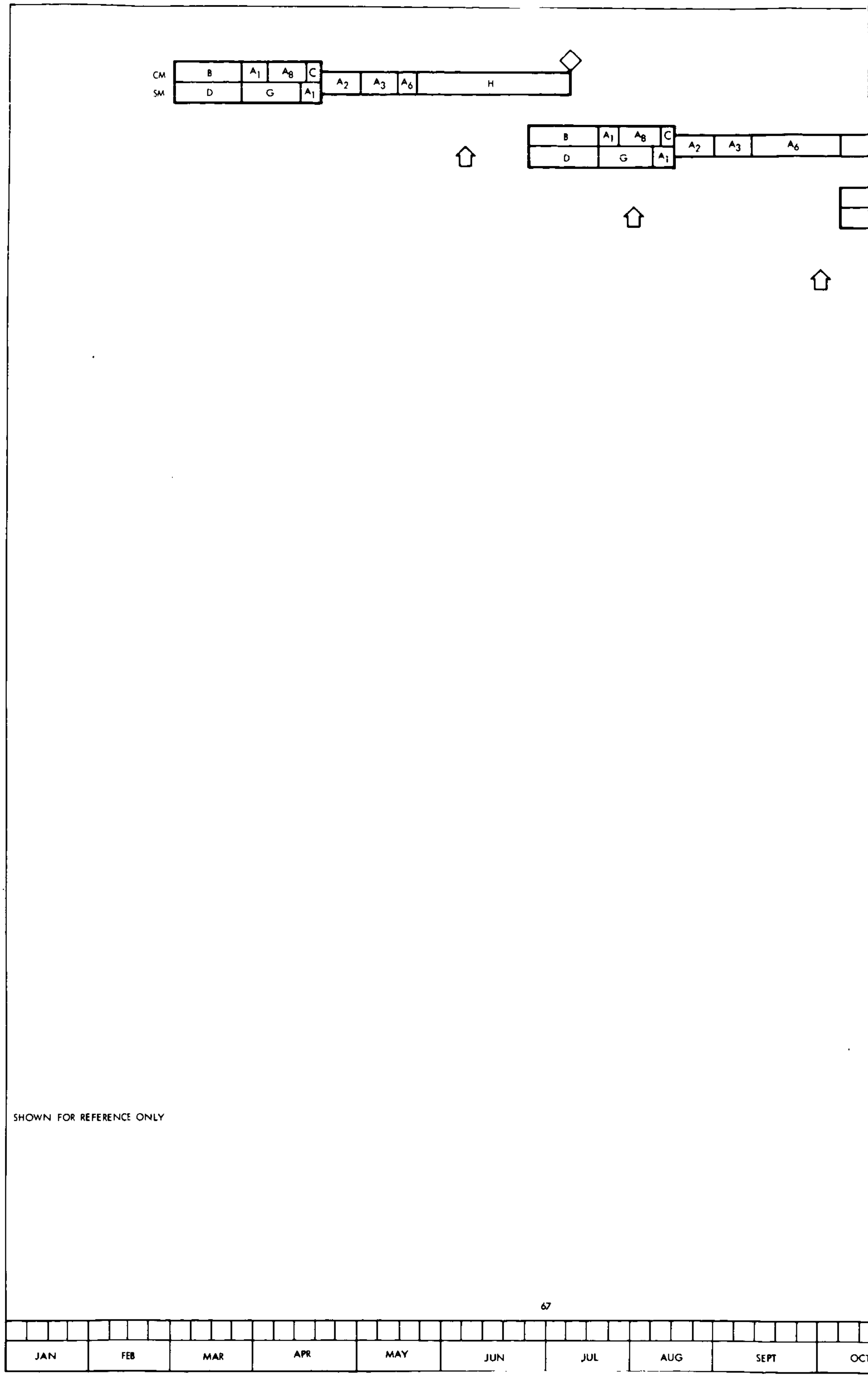
Figure 38. Preliminary CSM Baseline Block II - AES Phase I Integrated KSC Operations Loading Per Launch Schedule MDS 11-1

[redacted]

[redacted]

MISSION	CSM
207	SC 101
503	SC 102
504	SC 103
505	SC 104
506	SC 105
211	SC 106
507	SC 107
508	SC 108
509	SC 109
510	SC 110
214	LS-1
215	SC 111
511	SC 112
512	SC 113
216	LS-2
217	SC 114
513	SC 201
514	SC 202

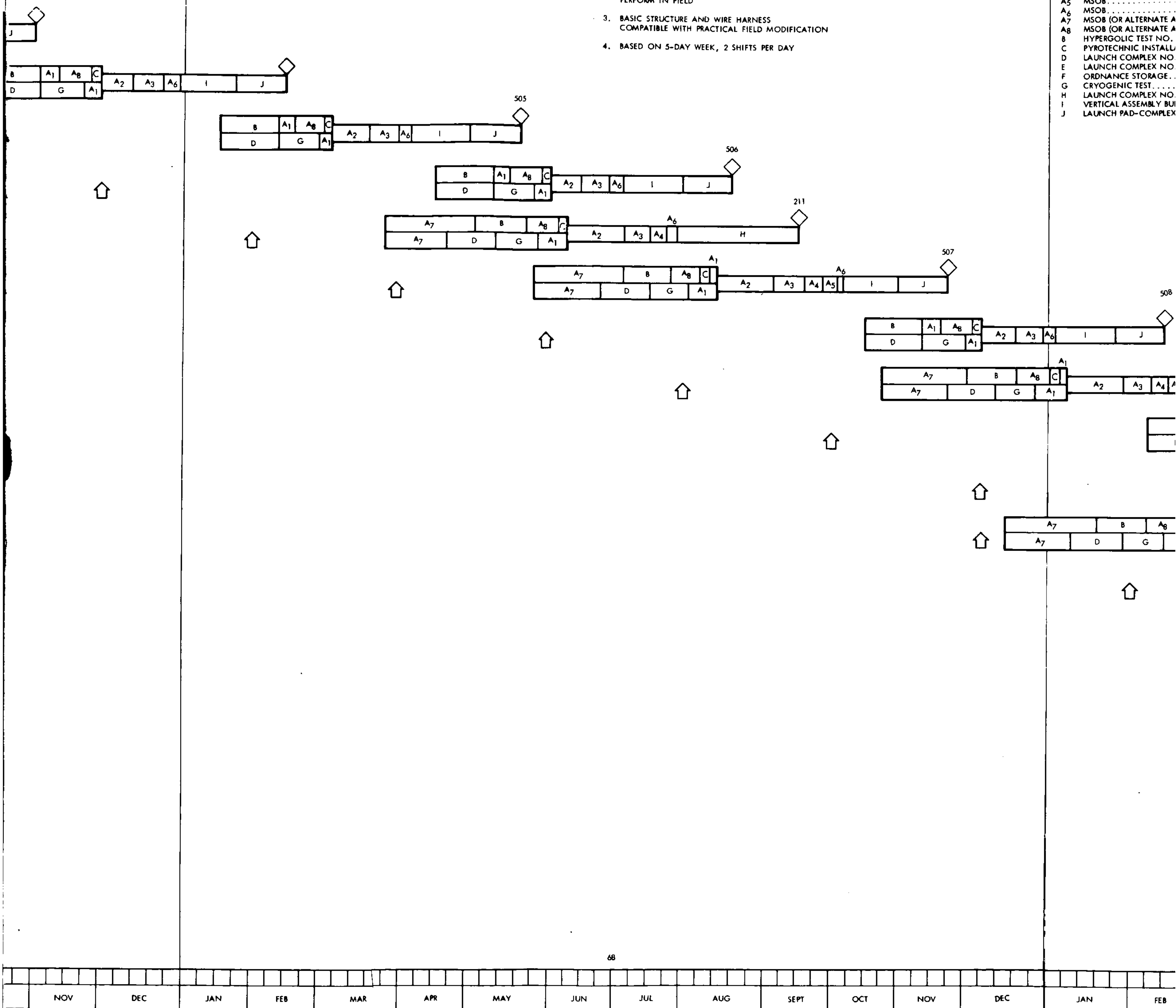
SHOWN FOR REFERENCE ONLY



GROUND RULES

1. MDS 11-2 PROGRAM
2. ALL MODIFICATION FOR EXPERIMENT INSTALLATION PERFORM IN FIELD
3. BASIC STRUCTURE AND WIRE HARNESS COMPATIBLE WITH PRACTICAL FIELD MODIFICATION
4. BASED ON 5-DAY WEEK, 2 SHIFTS PER DAY

A	MANNED SPACECRAFT (
A_1	MSOB . . . .
A_2	MSOB . . . . . .
A_3	MSOB . . . .
A_4	MSOB . . . .
A_5	MSOB . . . .
A_6	MSOB . . . .
A_7	MSOB (OR ALTERNATE A
A_8	MSOB (OR ALTERNATE A
B	HYPERGOLIC TEST NO.
C	PYROTECHNIC INSTALL
D	LAUNCH COMPLEX NO.
E	LAUNCH COMPLEX NO.
F	ORDNANCE STORAGE. .
G	CRYOGENIC TEST. . . . .
H	LAUNCH COMPLEX NO.
I	VERTICAL ASSEMBLY BU
J	LAUNCH PAD-COMPLEX



2

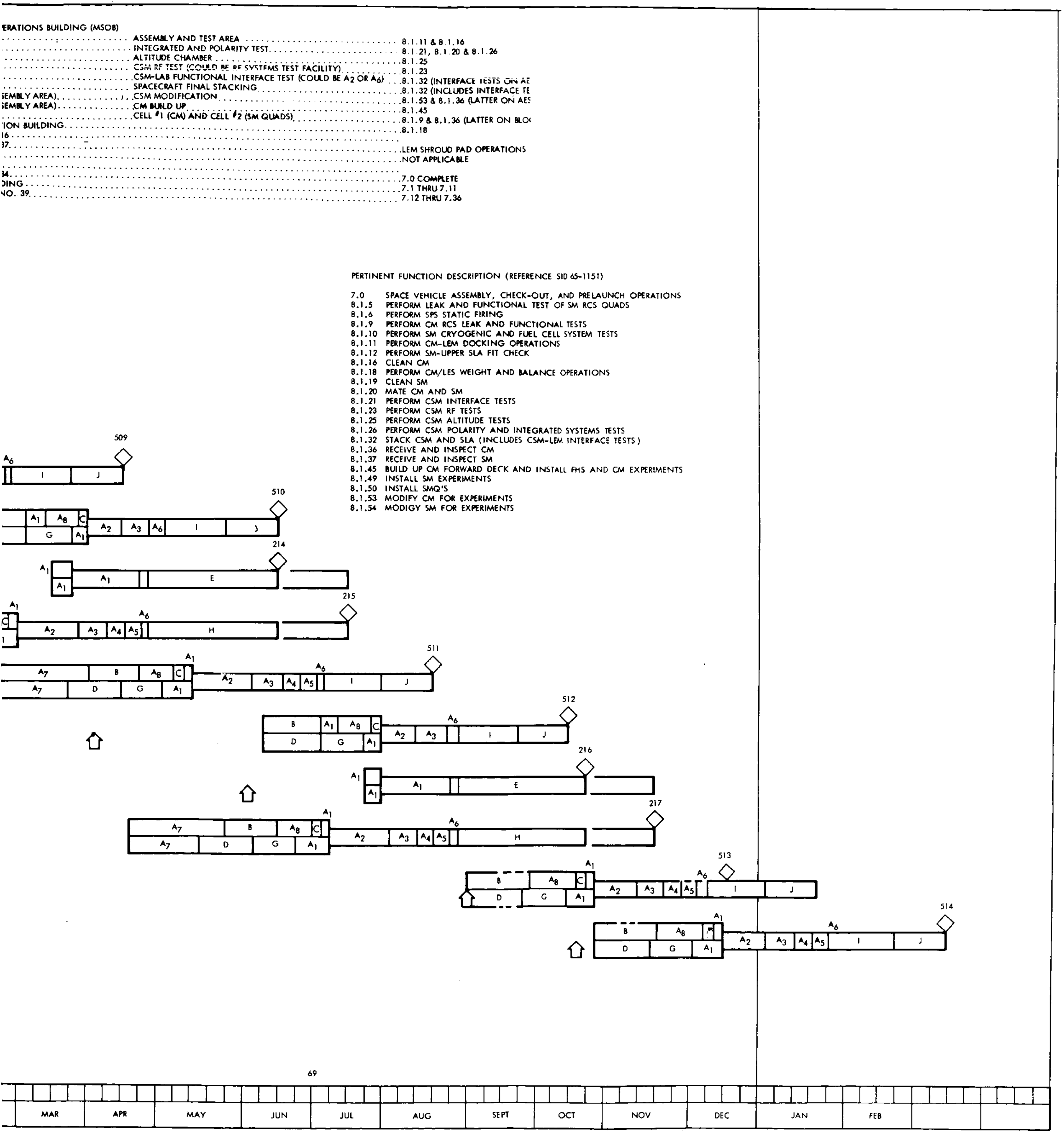
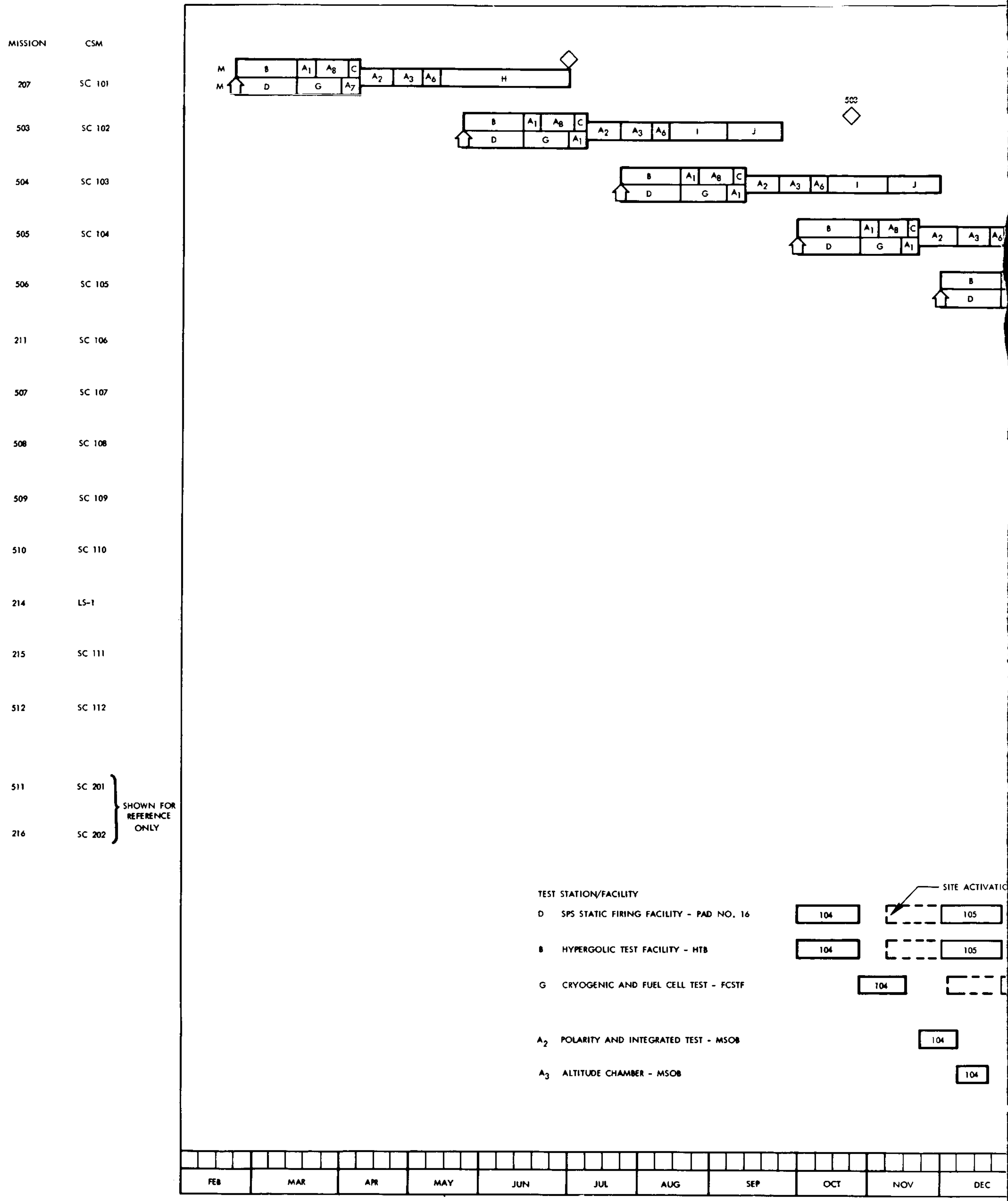


Figure 39. Preliminary CSM Baseline Block II - AES Phase I Integrated KSC Operations Loading Per Launch Schedule MDS 11-2

3

[redacted]

[redacted]



MISSION
CSM
207
SC 101
503
SC 102
504
SC 103
505
SC 104
506
SC 105
211
SC 106
507
SC 107
508
SC 108
509
SC 109
510
SC 110
214
LS-1
215
SC 111
512
SC 112
511
SC 201
216
SC 202
SHOWN FOR REFERENCE ONLY
M
B
D
G
C
H
I
J
503
TEST STATION/FACILITY
D SPS STATIC FIRING FACILITY - PAD NO. 16
B HYPERGOLIC TEST FACILITY - HTB
G CRYOGENIC AND FUEL CELL TEST - FCSTF
A2 POLARITY AND INTEGRATED TEST - MSOB
A3 ALTITUDE CHAMBER - MSOB
SITE ACTIVATIO
104
105
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

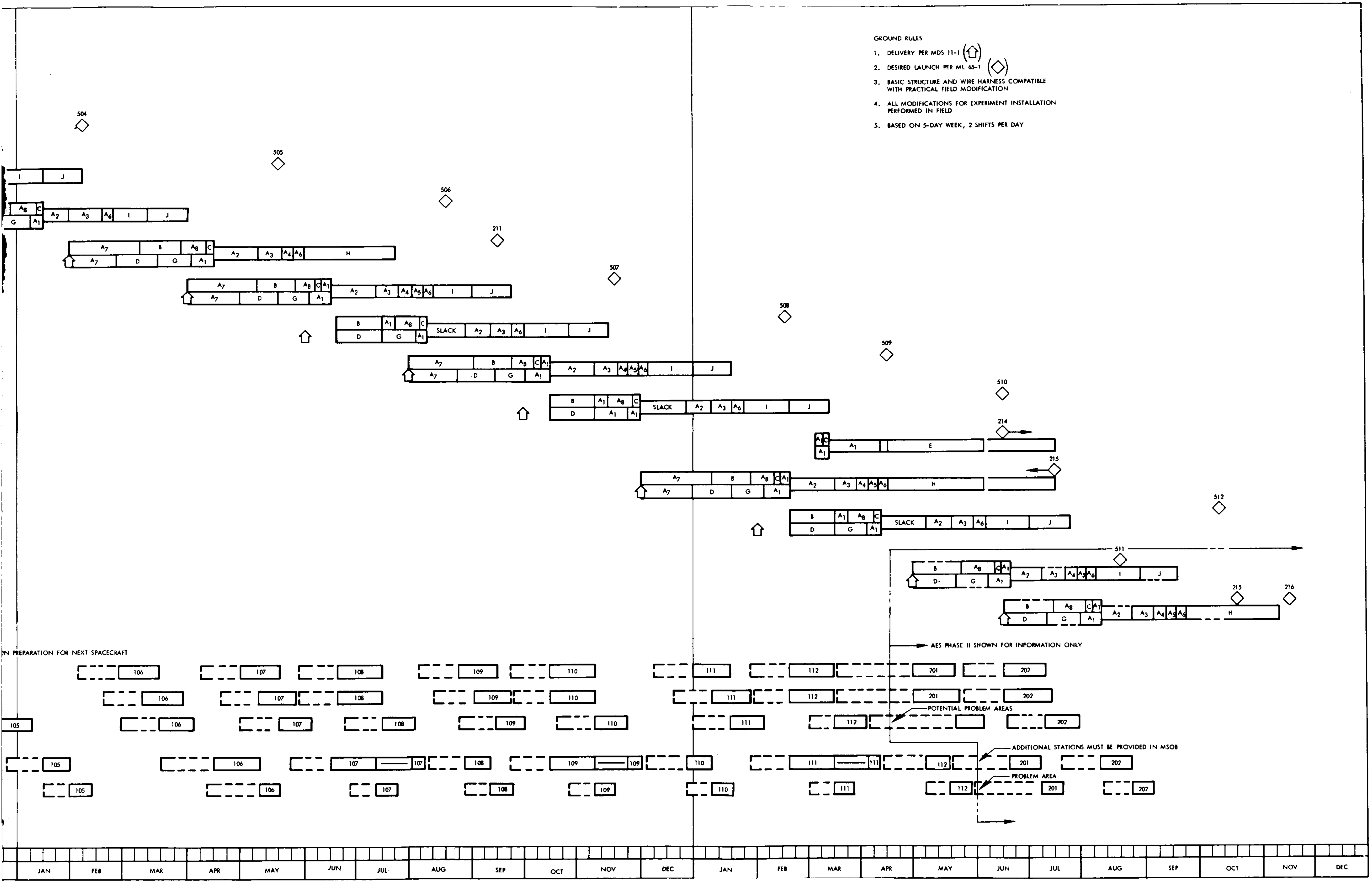


Figure 40. Preliminary CSM Block II - AES Phase I KSC Integrated Operations For Minimum Facilities Per Delivery Schedule MDS 11-1

[redacted]

[redacted]

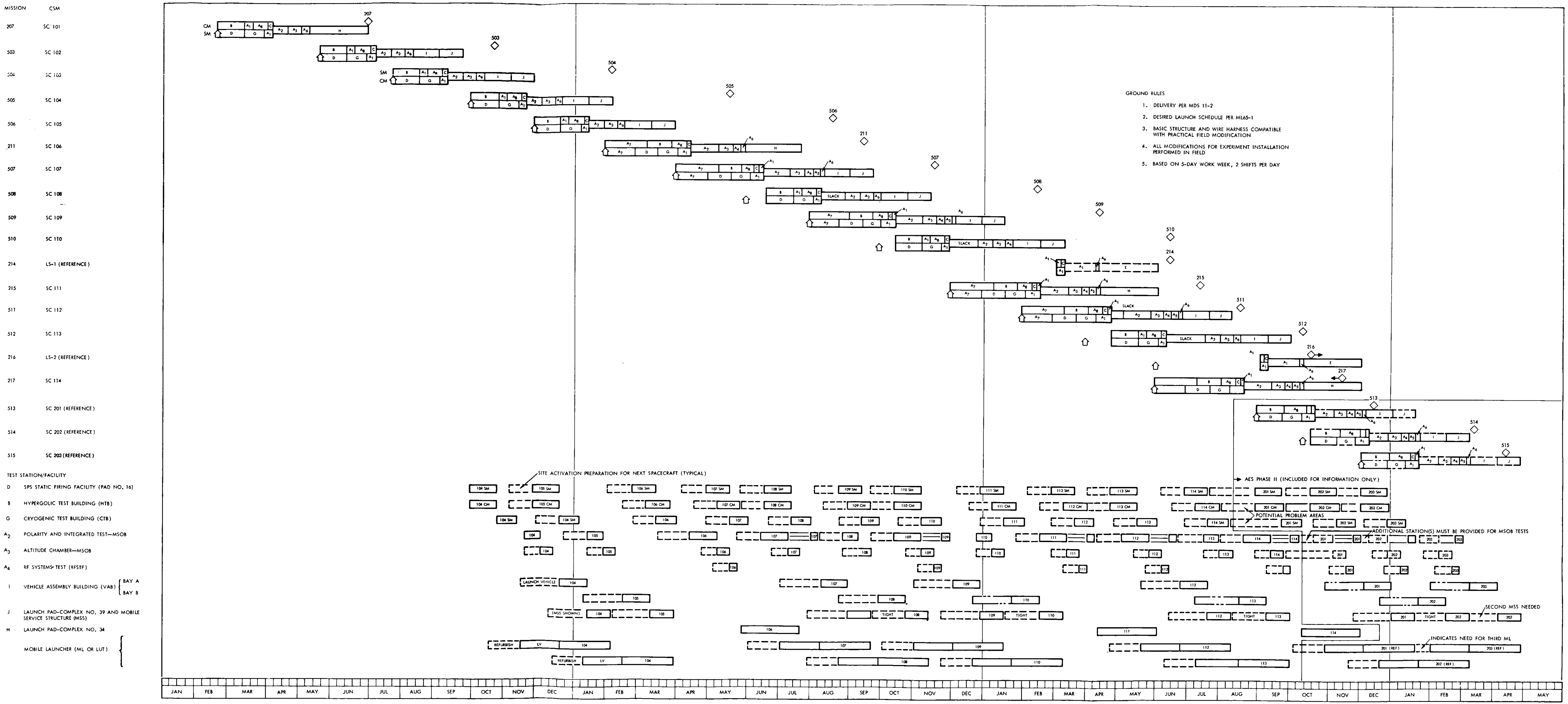


Figure 41. Preliminary CSM Block II - AES Phase I KSC Integrated Operations For Minimum Facilities Per Delivery Schedule MDS 11-2

[redacted]

MISSION	CSM
207	SC 101
503	SC 102
504	SC 103
505	SC 104
506	SC 105
211	SC 106
507	SC 107
508	SC 108
509	SC 109
510	SC 110
214	LS-1
215	SC 111
512	SC 112
511	SC 201
217	SC 202
513	SC 203

SC 201, SC 202, SC 203: SHOWN FOR REFERENCE ONLY

TEST STATION FACILITY

- D SPS STATIC FIRING - PAD NO. 16
- B HYPERGOLIC TEST - HTB
- G CRYOGENIC AND FUEL CELL TEST - FSTF
- A_2 POLARITY AND INTEGRATED - MSOB
- A_3 ALTITUDE CHAMBER - MSOB
- A_1 ASSEMBLY AND TEST AREA - MSOB
- A_4 RF TEST - MSOB OR RF SYSTEMS TEST FACILITY
- A_5 CSM-LAB FUNCTIONAL INTERFACE IN A_2 PLUS A_6 - MSOB
- A_6 CSM-SLA-LAB MATE - MSOB
- A_7 CSM MODIFICATION AREA - MSOB OR ALTERNATE
- A_8 CM BUILDUP (MSOB OR ALTERNATE)
- C WEIGHT AND BALANCE - PYROTECHNIC INSTALLATION BUILDING
- E LAUNCH COMPLEX NO. 37
- H LAUNCH COMPLEX NO. 34
- I VEHICLE ASSEMBLY BUILDING - COMPLEX NO. 39
- J LAUNCH PAD - COMPLEX NO. 39

A_1 through J: UTILIZATION NOT CRITICAL

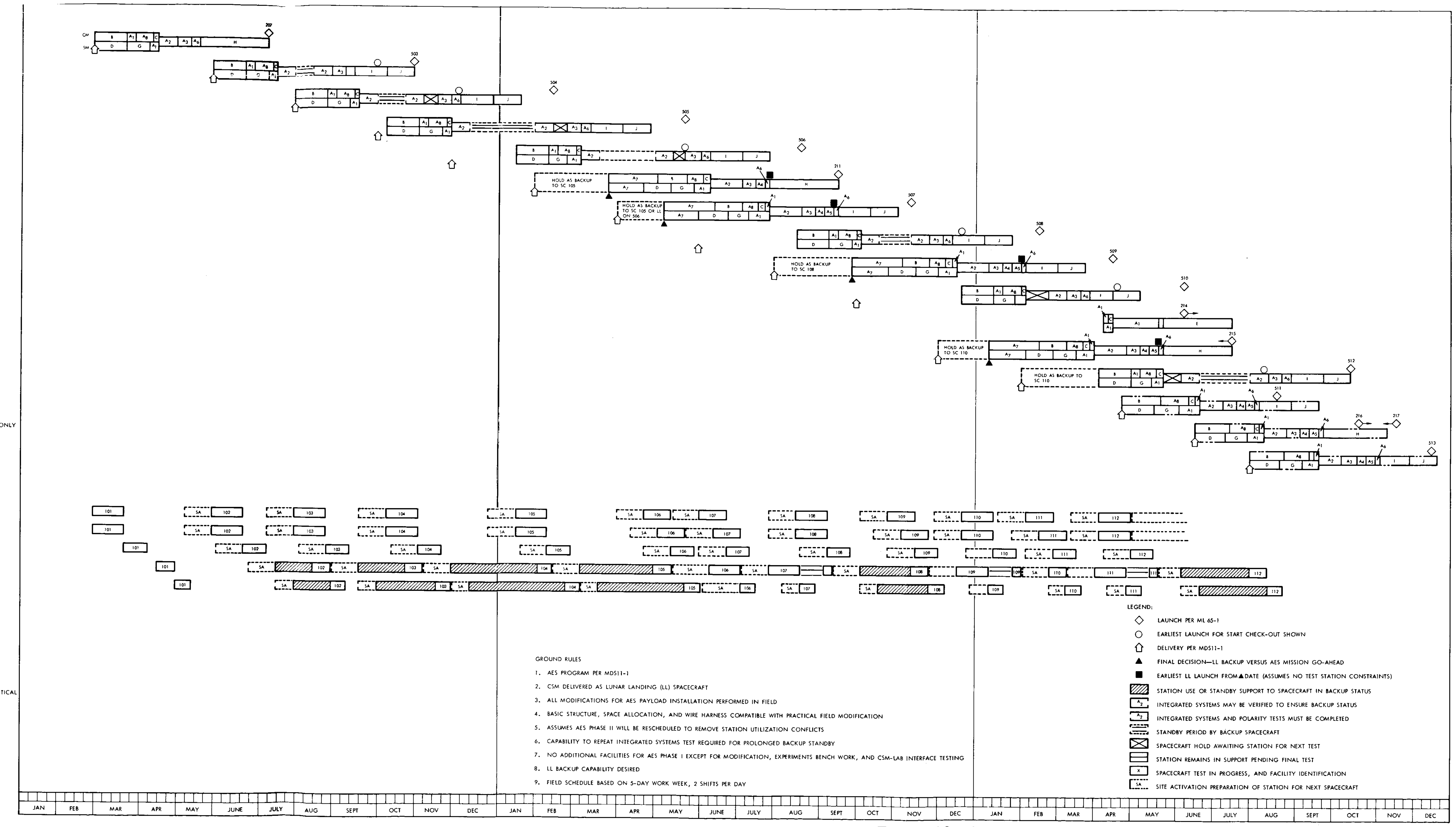


Figure 42. Preliminary CSM Block II - AES Phase I KSC Integrated Operations For Optimum Facilities Per Delivery Schedule MDS 11-1

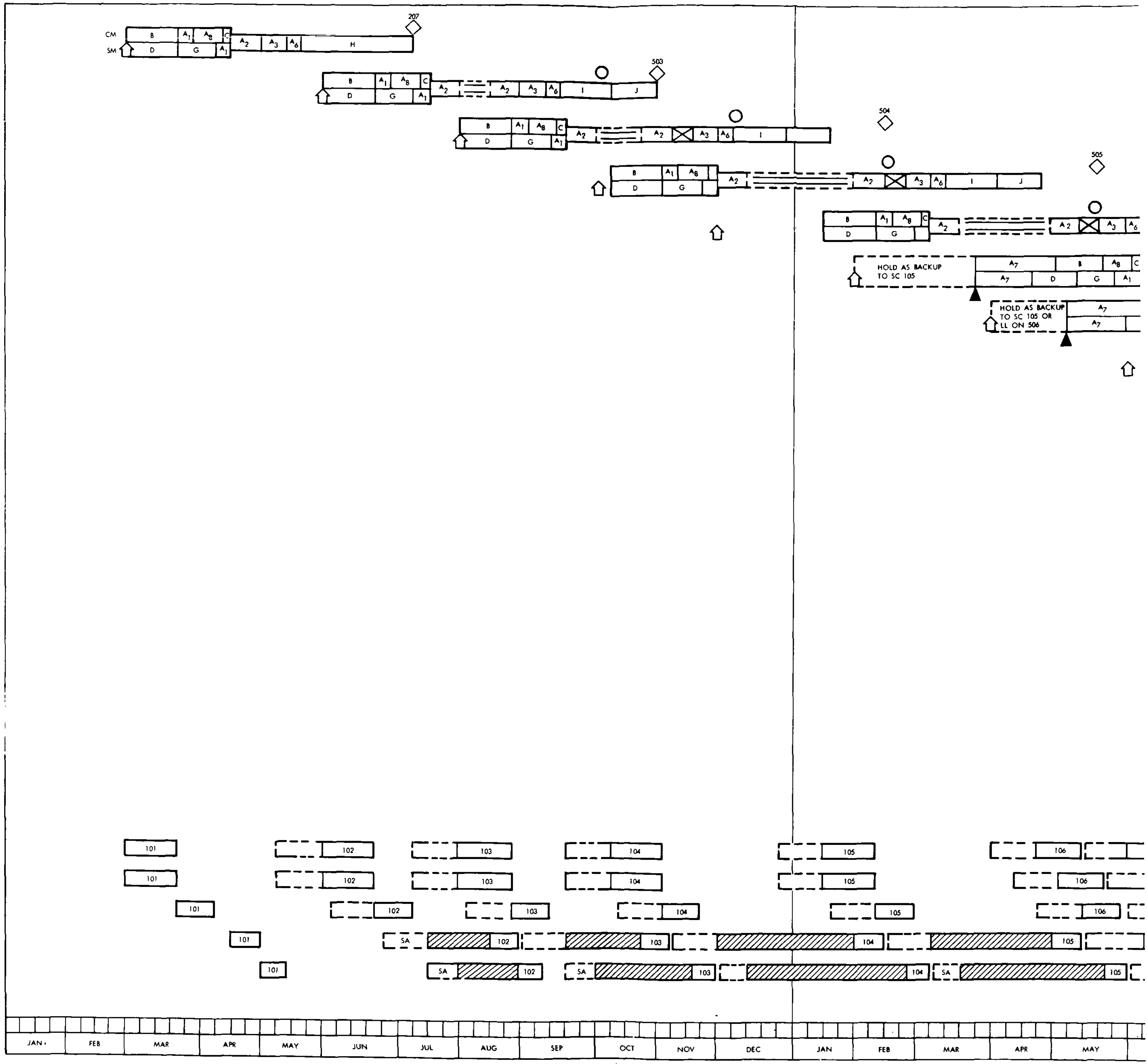
[redacted]

MISSION	CSM
207	SC 101
503	SC 102
504	SC 103
505	SC 104
506	SC 105
211	SC 106
507	SC 107
508	SC 108
509	SC 109
510	SC 110
214	LS-1
215	SC 111
511	SC 112
512	SC 113
216	LS-2
216	SC114
513	SC 201
514	SC 202

SC 201 and SC 202: SHOWN FOR REFERENCE ONLY

TEST STATION/FACILITY

- D SPS STATIC FIRING (PAD NO. 16)
- B HYPERGOLIC TEST - HTB
- G CRYOGENIC AND FUEL CELL TEST - FSTF
- A_2 POLARITY AND INTEGRATED - MSOB
- A_3 ALTITUDE CHAMBER - MSOB



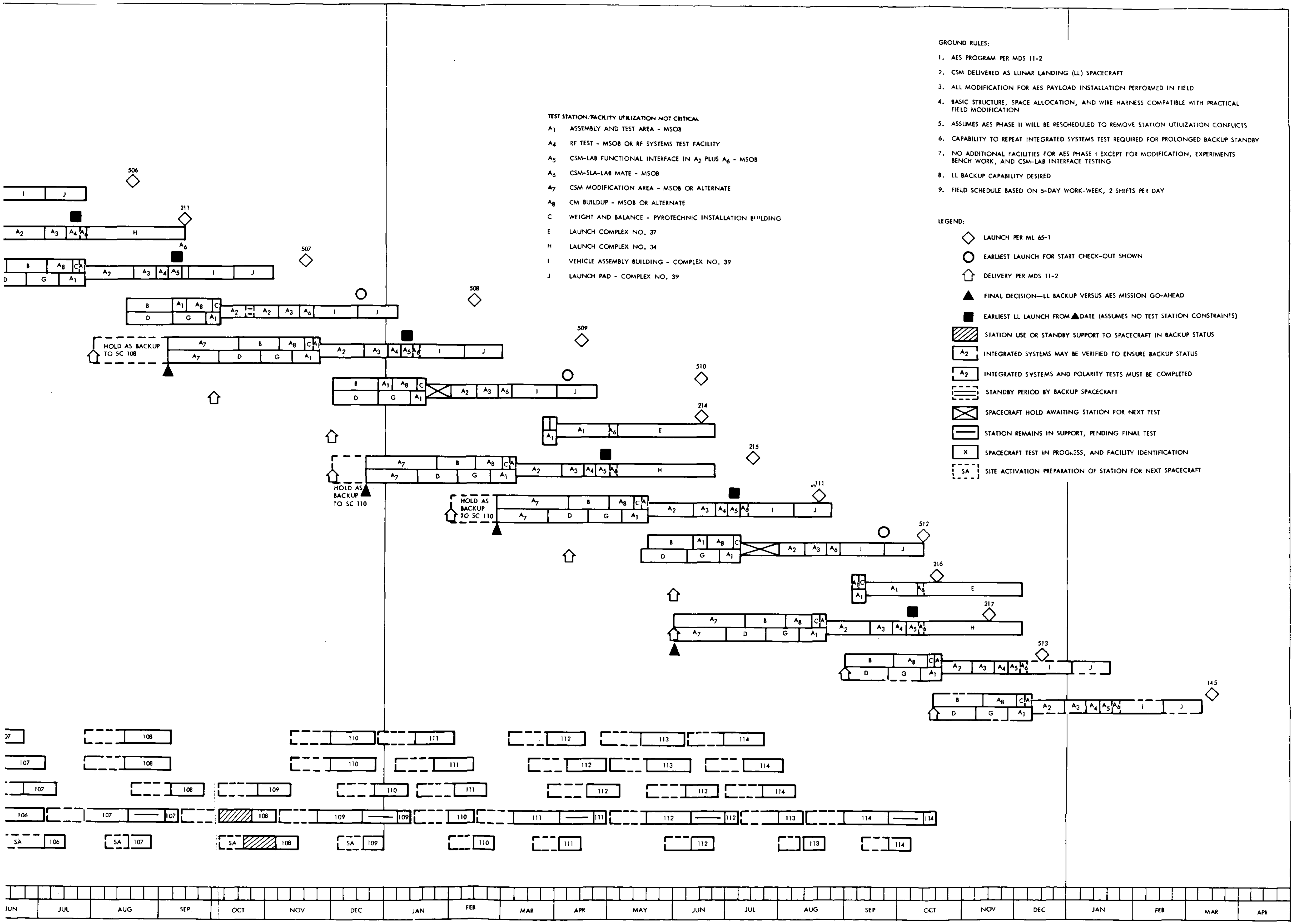


Figure 43. Preliminary CSM Block II - AES Phase I KSC Integrated Operations For Optimum Facilities Per Delivery Schedule MDS 11-2

[redacted]

An AES Phase I Laboratory modification area will be required to be activated at KSC by February 1968, to support Mission 507. This facility will be used for disassembly, assembly and final assembly acceptance test on the LEM Laboratory vehicle for Mission 509. This facility must also provide the additional bench support area required for the AES Phase I Laboratory as compared to a basic LEM. The Apollo program LEM prelaunch facilities will support the Laboratory pre-launch checkout operations except as noted below.

1. The MSOB requires an addition of an EMC shielded chamber in order to support the Phase I Lab EMI test described in a previous section of this report. The shielded chamber is necessary to demonstrate the EMC characteristics of the Lab after KSC modification and integration of experiments. This requirement is based on:

   The relatively high and variable ambient EMI levels at the KSC testing facilities.

   Low Lab communication circuit margins under operating conditions.

   Detection and correction of EMC anomalies not determined in the development program because of malfunction differences.

   Verification of the absence of all EMC anomalies that were detected during the development program.

   Verification of the magnetometer experiment's operations in the spacecraft.

2. As stated under CSM operations above, there is a requirement for an integrated spacecraft test station for testing CSM/LAB functional interfaces. This station is currently defined as supporting, as a minimum, a simulated (cable connected) docked configuration combined systems test on all except the rendezvous missions. A facility is required for a physically docked EMC test on the rendezvous missions. It is recommended that this be provided at the RFSTF and be used for all missions.

[redacted]

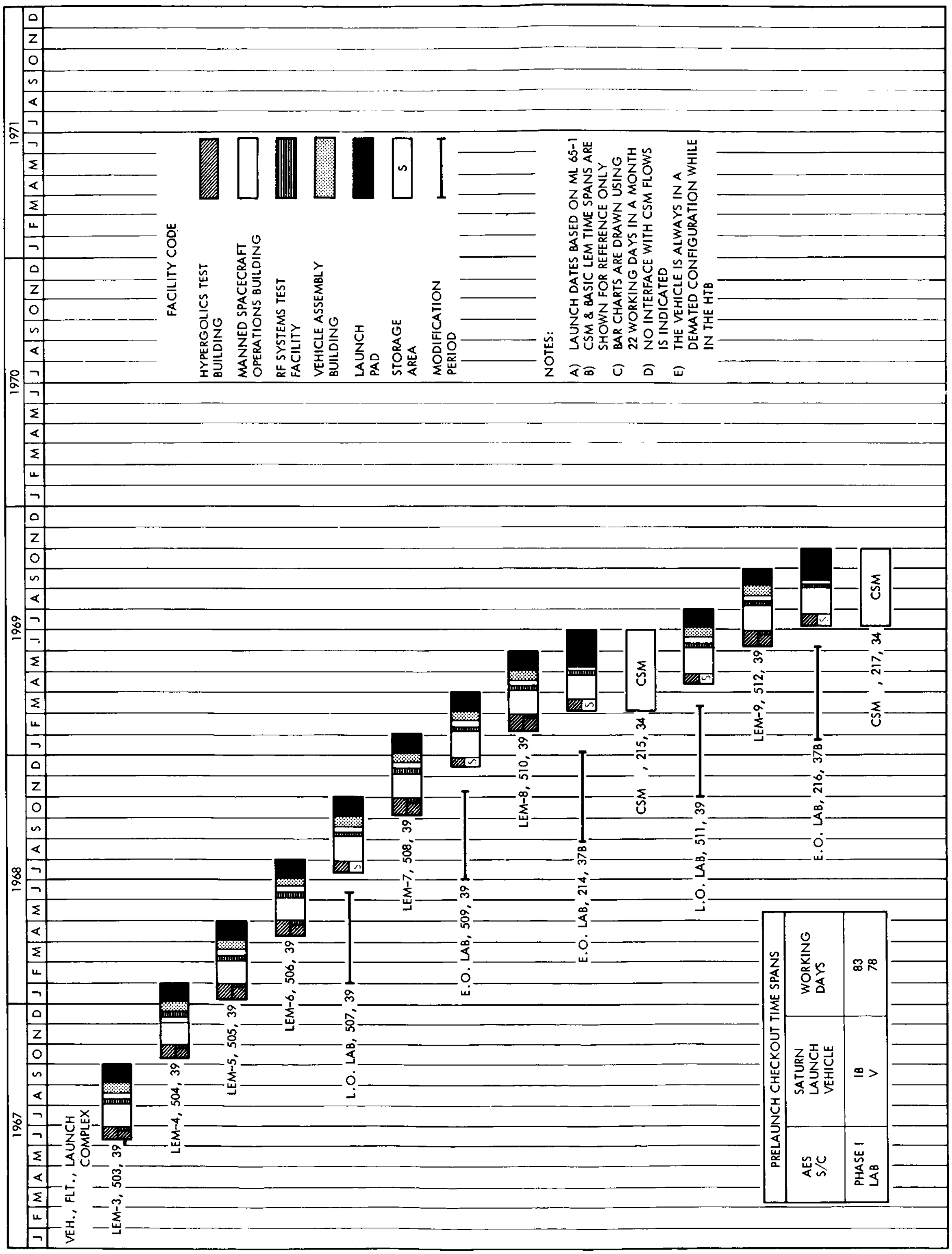
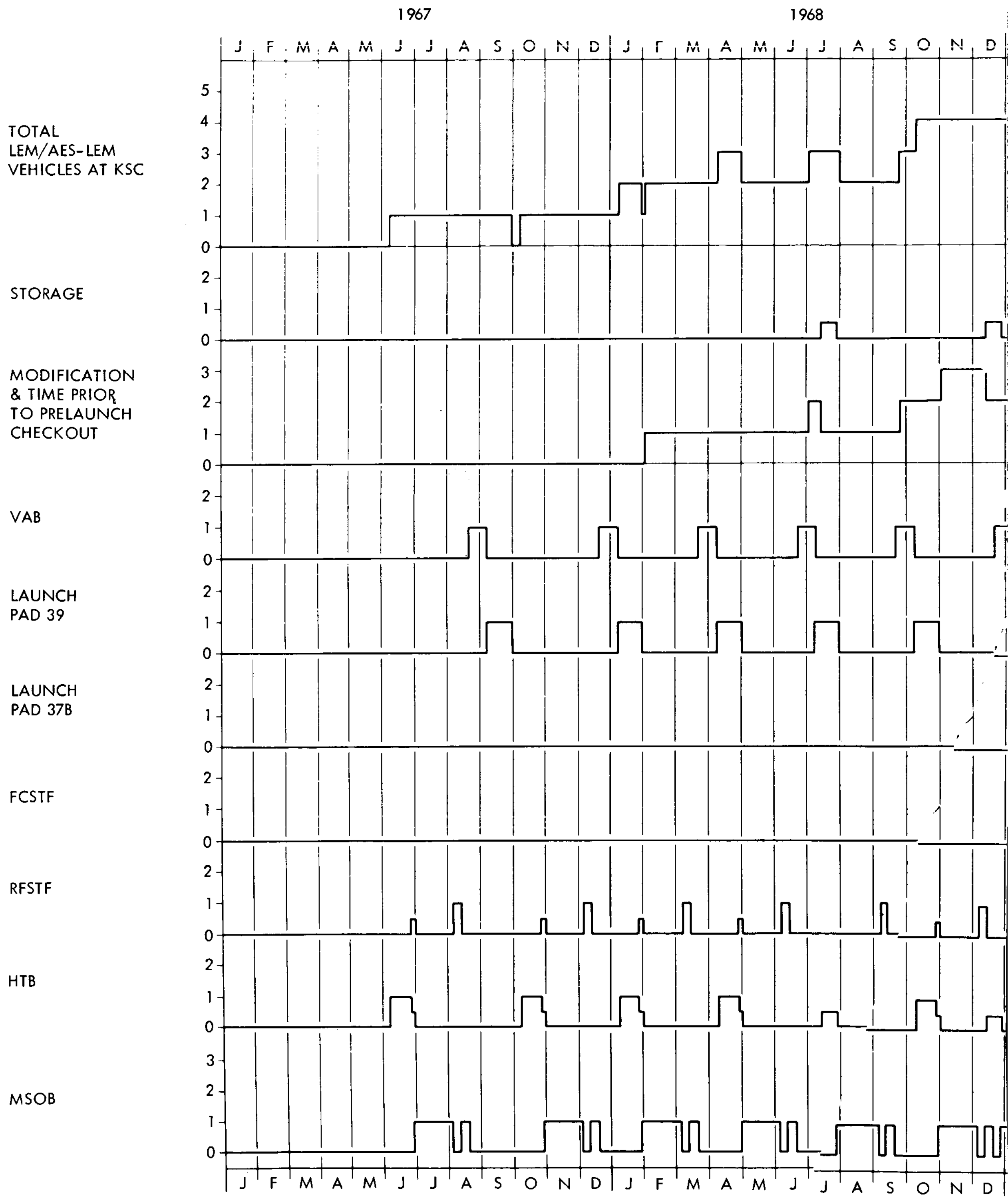


Figure 44. Phase I Prelaunch Operations Schedule

[redacted]AL

[redacted]



1967
1968
J F M A M J J A S O N D J F M A M J J A S O N D
TOTAL LEM/AES-LEM VEHICLES AT KSC
STORAGE
MODIFICATION & TIME PRIOR TO PRELAUNCH CHECKOUT
VAB
LAUNCH PAD 39
LAUNCH PAD 37B
FCSTF
RFSTF
HTB
MSOB

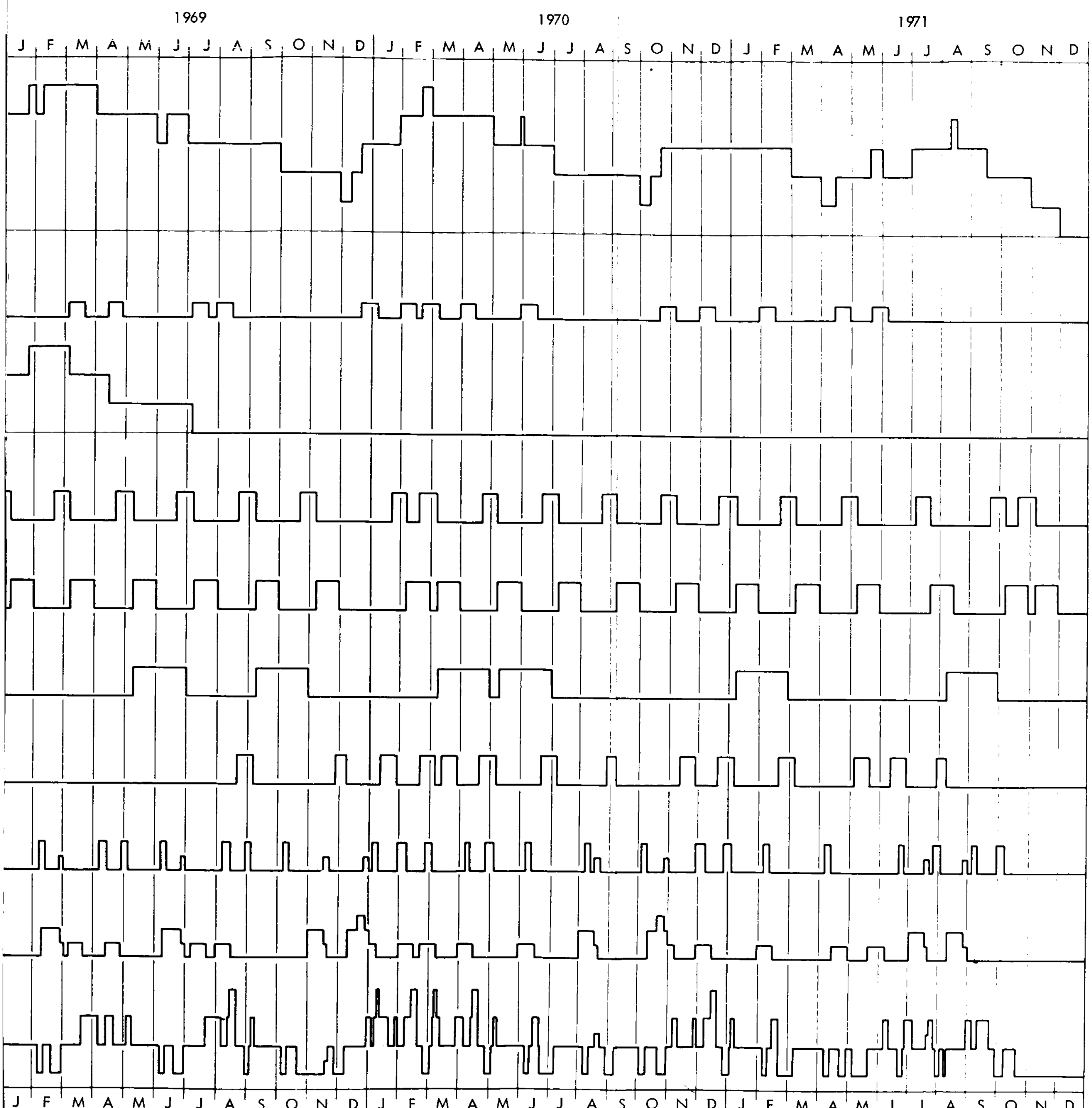


Figure 45. KSC Facility Loading Chart