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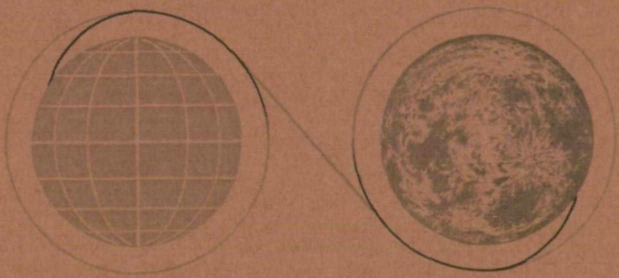

Apollo Extension Systems—Lunar Excursion Module
Phase B Final Report

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Apollo Extension Systems — Lunar Excursion Module
Phase B Final Report

to

National Aeronautics and Space Administration
Manned Spacecraft Center
Advanced Spacecraft Technology Division
Houston, Texas 77058

by

Grumman Aircraft Engineering Corporation
Bethpage, New York

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Vol. VIII Phase I Laboratory Master End Item Specification

"Available to U.S. Government Agencies and U.S. Government Contractors Only"

Contract No. NAS 9-4983
ASR 378B

8 December 1965

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Preface

This report presents the results of the Phase "B" Preliminary Definition Study (Contract NAS 9-4983) of the Lunar Excursion Module (LEM) and its modifications and additions, as necessary, for use in the Apollo Extension Systems (AES). This use includes a Laboratory for Earth and lunar orbital missions, and a Shelter, a Taxi and a Truck for extended-stay lunar surface missions. The overall objective of this study was to conduct sufficient analyses to provide a basis for selection by NASA of a single concept for each mission for final definition and development.

The study results are distributed in the volumes listed below in the following manner: Volume I contains a summary of the Preliminary Project Development Plan (PDP) with emphasis on estimates of the program costs and schedules. This volume was submitted on 30 October 1965, one month in advance of the remaining final documentation. Volume II is a brief summary of the overall study. Volumes III through XVI contain the design analyses, preliminary specifications, and operations analyses for each of the AES/LEM vehicle types. Volumes XVII through XXVI contain preliminary project planning data in the areas of management, manufacturing, development testing, and support.

It was necessary to base the preliminary project planning data, including estimated costs, on a single configuration for each of the AES/LEM vehicle types. Since these PDP data were required by the end of October, the configurations had to be selected at the mid-point of the study, before the configuration studies had been completed. These configurations have been called "baseline" configurations. The continuing design analyses in the second half of the study have resulted in recommended changes to the baseline configurations. Volumes III through VI describe the "recommended" configurations, the baseline configurations, and some additional alternates which were studied. It is anticipated that NASA will make a selection from these configurations, and that these selections will then be the new baseline configurations for the next phase of AES definition studies.

The scope of this study included integration of the experimental payloads with the Shelter and Taxi, but did not include study of the integration on individual LEM Laboratory flights. At approximately the mid-point of the study, an addendum was written with the objective of providing support to the NASA Mission Planning Task Force for study of the Phase I Laboratory flights. The schedule for the addendum calls for completion of these mission planning studies in January, 1966. Therefore, the addendum efforts are not described in this report.

The volumes which comprise this report are as follows:

I	*Phase B Preliminary Definition Plan (30 Oct 1965)*
II	*Preliminary Definition Studies Summary*
III	*Phase I Laboratory Design Analysis Summary*
IV	*Phase II Laboratory Design Analysis Summary*
V	*Shelter Design Analysis Summary*
VI	*Taxi Design Analysis Summary*
VII	*Truck Design Analysis Summary*
VIII	*Phase I Laboratory Master End Item Specification*
IX	*Phase II Laboratory Master End Item Specification*
X	*Shelter Master End Item Specification*
XI	*Taxi Master End Item Specification*
XII	*Phase I Laboratory Experimental Payload Performance & Interface Specification*
XIII	*Phase II Laboratory Experimental Payload Performance & Interface Specification*
XIV	*Shelter Experimental Payload Performance & Interface Specification*
XV	*Taxi Experimental Payload Performance & Interface Specification*
XVI	*Prelaunch & Mission Operations*
XVII	*Manufacturing Plan*
XVIII	*AES Modifications to LEM Quality Control Program Plan*
XIX	*Ground Development Test Plan*
XX	*Support Equipment Specification*
XXI	*Facilities Plan*
XXII	*Support Plan*
XXIII	*Transportation Plan*
XXIV	*Training Equipment Requirements*
XXV	*Support Equipment Requirements*
XXVI	*Management Plan*

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
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SPECIFICATION

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Specification No. ESP 11-0100

Revision No. ______

Release Date 12-1-65

MASTER END ITEM SPECIFICATION

PHASE I LABORATORY

APOLLO EXTENSION SYSTEMS - LUNAR EXCURSION MODULE

Approved by: [illegible]
Project Engineer

Approved by: ______
(NASA Office)

Date: 12/1/65

Approval Date ______

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Contract No. NAS 9-4983

Exhibit A; para. 6.1.7 Document Type Preliminary Line Item ______ Primary No. ______

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MASTER END ITEM SPECIFICATION

PHASE I LABORATORY

APOLLO EXTENSION SYSTEMS - LUNAR EXCURSION MODULE (U)

1 SCOPE

*1.1 Scope. - This specification establishes the requirements for the Baseline Phase I Laboratory of the Apollo Extension Systems - Lunar Excursion Module, hereinafter identified as Lab I. The Lab I shall be a Lunar Excursion Module modified to enable crewmen to perform scientific experiments and observations during earth and lunar orbital flights of up to 14 days duration. The Lab I shall permit the crew to survive in the orbital environment, transfer to and from the Command Module (CM) when docked, and transfer to and from space for extravehicular activities. Specific vehicle deviations from the Lab I configuration which are imposed by different mission requirements shall be defined by individual End Item Specifications, prepared as addenda to this Master End Item Specification.

*1.2 Objective. - The objective of this specification is to define the total requirements of the Lab I. The performance of the Lab I is contingent upon the performance of those LEM equipments which must be utilized in the Lab I without modification. Maximum utilization of LEM hardware is the primary constraint imposed upon the Lab I design. Section 6 of this specification itemizes the specific additions and deletions of equipments which are necessary for the conversion of a LEM into a Lab I.

*1.3 Baseline. - For the purpose of this specification, baseline represents the recommended configuration delineated in the Phase B Final Report.

*1.4 Identification of LEM to Lab I Modifications. - An asterisk (*) preceding a paragraph number of this specification indicates that the requirements defined in the paragraph represent a modification to existing LEM requirements. Each paragraph is identified separately, e.g., (*3.4.2.1) does not necessarily imply that 3.4.2.1.1 requirements represent a change to the LEM unless a separate asterisk (*3.4.2.1.1) precedes that subparagraph.

2 APPLICABLE DOCUMENTS

2.1 Document Precedence. - The following documents, of exact issue shown, form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced here and other detail content of Sections 3, 4, 5 and 10, the detail requirements of Sections 3, 4, 5 and 10 shall be considered a superseding requirement.

2.1.1 Specifications. -

Number	Title	Date
NASA		
MSC-ASPO-S-5B	Manned Spacecraft Center (MSC) Apollo Spacecraft Project Office (ASPO) Soldering Specification; and Supplement dated 5-18-65	2-10-64
MSFC-PROC-158A	Soldering of Electrical Connections (High Reliability), Procedure for	4-12-62
Military		
MIL-E-6051C	Electrical-Electronic System Compatibility and Interference Control Requirements for Aeronautical Weapon Systems, Associated Subsystems and Aircraft	6-17-60
MIL-P-7788A	Plate, Plastic, Lighting	2-15-61
Grumman		
ESP 11-9110	Experimental Payload, Performance and Interface Specification, Phase I Laboratory Apollo Extension Systems - Lunar Excursion Module (Preliminary)	12-1-65
LSP-14-001	Identification Markings, General Specification for	12-1-63

2.1.1 (Continued)

Number	Title	Date
LSP-14-009 with Amendments 1 through 4	Preservation, Packaging and Packing, General Specification for	4-22-65
LSP-390-001	Bonding, Electrical, General Specification for	4-22-65
LSP-530-001 with Amendment 1	Electromagnetic Interference Control Requirements, General Specification for	9-16-63

North American Aviation

TBD	AES-CSM/Lab I Performance and Interface Specification - Block II	

2.1.2 Standards. -

Military

MIL-STD-704	Electrical Power Aircraft, Characteristics and Utilization of	10-5-59
MIL-STD-810	Environmental Test Methods for Aerospace and Ground Equipment	6-14-62

Inter-Range Instrumentation Group

IRIG-106-60	Inter-Range Instrumentation Group (IRIG) Standards	8-62

2.1.3 Drawings. -

NASA

MSFC Drawing 10M01071	Manned Space Flight Center Drawing

2.1.3 (Continued)

Number	Title	Date
Grumman		
AES- CP-1002	Lab I Inboard Profile	
TBD	Level I Functional Diagram	

2.1.4 Bulletins. -

Number	Title	Date
NASA		
EC-1	Manned Spacecraft Center (MSC) Engineering Criteria Bulletin	11-8-63
AFMTCP-80-2 Vol. 1	General Spacecraft Center (MSC) Engineering Criteria Bulletin	11-8-63

2.1.5 Other Publications. -

Number	Title	Date
NASA		
NPC 200-2	Quality Program Provisions for Space Systems Contractors	4-20-62
NPC 250-1	Reliability Program Provisions for Space Systems Contractors	7-63

2.2 Availability of Documents. -

2.2.1 NASA and Government Documents. - Copies of NASA and Government documents may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D.C., 20402.

2.2.2 Grumman Documents. - Copies of this specification and other applicable Grumman documents may be obtained from AES Program Data Management, Grumman Aircraft Engineering Corporation, Bethpage, Long Island, New York, 11714.

2.2.3 North American Aviation Corporation, Space and Information Systems Division Documents. - Copies of North American Aviation Corporation, Space and Information Systems documents may be obtained from NAA, SID, Downey, California, Attention: Mr. R. Berry, Mgr. Assoc. Cont. Admin.

3 REQUIREMENTS

3.1 Performance Requirements. -

3.1.1 Operational Requirements. -

*3.1.1.1 Mission Related Requirements. - The Lab I shall be capable of performing earth orbital and lunar orbital missions of up to 14 days. The Lab I shall provide for normal operation under the maximum levels of natural and induced environmental and load conditions independent of the illumination environment. Temperature control of the spacecraft shall impose no constraint upon the Lab I attitude. The Lab I shall accommodate a two man crew, and shall provide the extravehicular life support equipment and rechargeable consumables for TBD manhours of separation from the Lab. The Lab I shall satisfy its performance requirements when docked to the CSM or when separated from the CSM. The Lab I shall provide for communications with the CSM, the EVA and earth-based communications facilities. The Lab I shall be capable of being attitude oriented to a known attitude coordinate frame of reference, maintained at that attitude orientation, and changed from that orientation to another in a controlled manner, without loss of reference to the original orientation. Lab I attitude control capability shall be provided for both automatic and manual operation. The Lab I shall incorporate provisions for electrical energy, mounting and data handling for the experimental payload.

3.1.1.2 Vehicle Performance Requirements. -

*3.1.1.2.1 Guidance, Navigation and Control Requirements. - The Lab I shall have the capability, while docked to the CSM, to:

3.1.1.2.1 (Continued)

(a) Establish vehicle attitude with respect to an inertial geocentric or selenocentric triad within 12.0 arc minutes maximum per axis. The vehicle attitude reference drift shall be less than or equal to 1.1 degree per hour per axis over a 30 day period without restriction on duty cycle.

(b) Maintain vehicle attitude with respect to the extablished reference plus drift within deadbands of 0.3 degree nominal for TBD hours and within 5.0 degrees nominal for TBD hours.

(c) Change vehicle attitude, with respect to the vehicle attitude reference at the start of the attitude change maneuver, within 0.0005 degree per net degree of vehicle rotation about any axis for vehicle rates up to and including TBD degree per second.

(d) Attain angular accelerations about the vehicle x, y and z axes, singularly or in combination, of TBD radians per second per second maximum for vehicle moments of inertia of TBD slug feet squared.

(e) Change vehicle attitude by either automatic or manual control at vehicle body rates up to TBD degrees per second for a total of TBD times about all axes.

(f) Provide display information to enable the crew to perform manual vehicle control functions.

*3.1.1.2.2 Electrical Power Requirements. - The Lab I shall supply:

(a) 274 kilowatt hours (kwh) of electrical energy for the Lab I systems and experimental payload (EP). 91.1 kwh of the 274 kwh of electrical energy shall be allocated for the EP.

(b) Electrical power in the form of 28 volts d-c nominal and 115 volts rms a-c single phase, 400 cps nominal.

*3.1.1.2.3 Environmental Control Requirements. - The Lab I cabin atmosphere will be controlled by the CM environmental control system during normal pressurized operations. The Lab I shall provide the capability for:

(a) Storing and delivering oxygen as required to make up losses associated with Lab I and Lab I/CSM interface leakage and with cabin repressurization after EVA periods. The following shall be accommodated:

(1) Cabin leakage: 0.20 pounds per hour.

(2) Interface leakage: 0.18 pounds per hour.

(3) Cabin repressurizations: 18.

(b) Depressurizing the Lab I cabin within TBD minutes, TBD minutes for emergencies, and repressurization to 3.7 psia within TBD minutes.

(c) Maintaining space suit environmental control during unpressurized operations including oxygen supply, temperature control, ventilation, removal of odors and noxious gasses, removal of foreign objects which might cause ECS malfunction or impairment of crew performance, removal of moisture, and control of the carbon dioxide level in the suit atmosphere.

(d) Cooling or heating the suit circuit by TBD to TBD degrees F.

(e) Cooling or heating the cabin atmosphere from TBD to TBD degrees F.

(f) Active thermal control for Lab I and experimental payload equipment which is not passively cooled.

(g) Rejecting the Lab I waste heat.

(h) Exchanging conditioned oxygen between the CSM and Lab I.

(i) Preventing overpressurization of the cabin pressure shell.

*3.1.1.2.3 (Continued)

(j) Refilling Portable Life Support System (PLSS) expendables for TBD EVA manhours, including:

(1) Storage and refill of O_2 system at TBD pounds per manhour.

(2) Storage and refill of water for cooling system at TBD pounds per manhour.

(3) Storage of LiOH cartridges of TBD weight and volume

(4) Storage of PLSS spares of TBD weight and volume.

(k) Storage capacity for all cooling water required aboard Lab I at launch.

*3.1.1.2.4 Telecommunications Requirements. - The Lab I shall provide for:

(a) Communications with the Manned Space Flight Net (MSFN) to 220,000 nm slant range minimum, including:

(1) Two-way voice

(2) Telemetry (including biomed)

(3) Emergency key

(4) Tracking and ranging aids

(b) Communications with the CSM while docked and to 550 nm slant range minimum when separated, including:

(1) Two-way voice (hardline when docked)

(2) TV-hardline only

(3) Telemetry to CSM (when separated only)

*3.1.1.2.4 (Continued)

(c) Communications with EVA to 3 nm slant range minimum, including:

(1) Two-way voice

(2) EVA Biomed data relay to MSFN.

(d) Intercommunication between the two crew stations.

(e) Operational instrumentation to acquire and process data determining spacecraft and crew status; route data for transmission for ground monitoring and to the crewmen for caution and warning display.

(f) Experimental instrumentation to acquire, process, record and playback preconditioned experimental data as specified in the Grumman P & I Specification ESP 11-9110.

(g) Timing frequencies and reference for equipment and experiment synchronization.

*3.1.1.2.5 Structural Requirements. -

(a) Thermal control - The Lab I shall be protected thermally from the environmental extremes which occur during translunar coast and earth and lunar orbits.

(b) Meteoroid protection - Meteoroid protection shall be provided to prevent critical damage of equipment or expendables and possible loss of crew and shall be identical in all respects with the meteoroid protection provided by the LEM.

(c) Crew visibility - Exterior visibility provisions for the Lab I crew shall be the same as for the Apollo Lunar Excursion Module (LEM). Interior visibility shall not be blocked by projecting structure.

(d) Ingress/Egress - Means shall be provided to get the crew from and to the CM while the vehicles are joined and to and from free space.

*3.1.1.2.5 (Continued)

(e) Pressurized cabin - The cabin, which houses the crew, shall be capable of holding oxygen at 5.2 psia pressure. The cabin shall also be capable of experiencing multiple repressurization cycles.

(f) Support for equipment (subsystems and experiments) - The primary structure and secondary equipment supporting structure shall sustain without failure the loads imposed by accelerations and vibrations resulting from the launch vehicle and SM engine thrustings during the mission phases and the loads produced during docking. When required, the structure shall provide an interface with the equipment that minimizes shock and vibration inputs, and holds the required alignments between dependent pieces of equipment and between equipment and body axes.

(g) Lab I/CSM docking interface - The docking interface with the CSM shall permit a structural tie between the vehicles to allow intra-vehicular transfer of crew and equipment and provide means for required umbilical connections. This interface with the CSM should be at the Lab I upper tunnel and in a plane perpendicular to the X axis.

*3.1.1.2.6 Crew Provisions Requirements. - Provisions shall be made for the following:

(a) Space Suit Assembly and Portable Life Support System - Capability for crew members to don spacesuit assemblies unaided within TBD minutes, and to perform required tasks while suited up and on the suit loop of the ECS. Capability to don PLSS and maneuver for EVA ingress/egress.

(b) Support and Restraint (mobility) - Protection of the crew members from physical injury, protection of equipment from damage due to inadvertent contact force. Support and mobility to crew members as required for comfort and performance of their duties.

*3.1.1.2.6 (Continued)

(c) Lighting - All illumination on the Lab I necessary to task performance under any external ambient lighting conditions.

(d) Living Necessities - Food, (no crew system water to be carried in Lab) TBD pounds.

(e) Inboard configuration control - Selection, allocation and arrangement of space for stored or installed items and expendables for crew utilization within the pressurized cabin area. The arrangement and accessibility of controls, displays, and equipment shall allow the crew to efficiently accomplish necessary tasks, including ingress/egress.

*3.1.1.3 Mission Technique. - The relationship between the mission phases delineated in 3.1.2.8 and the detailed mission profile shall be defined in the individual End Item specifications written as addenda to this specification for each flight.

3.1.2 Operability Requirements. -

3.1.2.1 Reliability. - The mission success reliability objectives for the Lab I shall be based on the operating times and environmental conditions incurred during each Lab I flight.

*3.1.2.1.1 Reliability Objectives. - The reliability objectives for the Lab I exclusive of the experimental payload shall be:

(a) Mission Success - TBD

(b) Crew Safety - TBD

The reliability objectives shall be exclusive of radiation and meteoroid impact consideration.

3.1.2.1.2 Crew Safety Reliability Objective. - The crew safety reliability objective shall be to minimize the probability of injury or loss of a crew member, due to a failure, or combination of failures, of Lab I equipment.

3.1.2.2 Maintainability. - Where feasible, the Lab I shall be designed to provide accessibility, replaceability and serviceability consistent with efficient servicing, checkout and maintenance operations. As a design consideration Lab I equipment shall be designed for rapid repair or replacement of malfunctioned equipment consistent with launch window requirements. Where practical, maintenance of Lab I equipment shall not require the use of special tools.

*3.1.2.2.1 Vehicle Maintenance Concept. - There shall be no in-flight maintenance requirement for Lab I subsystems except for certain items which will be identified by Grumman and approved by NASA. The Lab I subsystems shall be designed for field maintenance as follows:

(a) For electrical or electronic equipment or both (either installed or on the bench), checkout and replacement shall be at the integral package (black box) level. A "black box" is defined as a combination of factory replaceable units which are contained within a physical package, and which is removable from the Lab I as an integral unit.

(b) For non-electrical or non-electronic equipment or both (either installed or on the bench) checkout and replacement shall be at the lowest replaceable serialized unit level, which includes only those parts which are removable as integral units from the Lab I.

3.1.2.2.1.1 Test Points. - Test points and test ports shall be provided and identified to permit rapid fault isolation to the replaceable assembly or component, as applicable.

3.1.2.3 Useful Life. - The Lab I subsystems equipment shall be designed for an operating life and shelf life consistent with the operational and reliability requirements. Storage of explosive materials is a special case covered in the explosive device subsystem.

3.1.2.4 Natural Environment. - The Lab I shall be designed to meet its operational requirements during and after exposure to the following natural environments:

3.1.2.4.1 Transporation, Ground Handling and Storage of Non-Operating Lab I Equipment. - The following environments will be encountered by non-operating Lab I equipment during transportation, ground handling and storage. Lab I equipment shall be protected by suitable packaging for transportation and storage if these environmental extremes exceed the equipment design requirements.

3.1.2.4.1.1 Temperature. -

(a) Air Transporation - -45 to 140 degrees F for 8 hours.

(b) Ground Transportation -

(1) Packaged: -65 to +160 degrees F for two weeks.

(2) Unpackaged: -20 to +110 degrees F air temperature plus 360 BTU/sq.ft./hr. up to six hours per day.

3.1.2.4.1.2 Sand and Dust. - As simulated by Standard MIL-STD-810, Method 510, Procedure I. Modify exposure temperature to +90 ± 20 degrees F instead of +160 degrees F.

3.1.2.4.1.3 Fungi. - Exposure as defined in Standard MIL-STD-810, Method 508, Procedure I.

3.1.2.4.1.4 Ozone. - Three years exposure at 0.05 PPM concentration.

3.1.2.4.1.5 Salt Spray. - As simulated by Method 509 of Standard MIL-STD-810, Procedure I. (No direct impingement on flight hardware).

3.1.2.4.1.6 Humidity. - Exposure as defined in Standard MIL-STD-810, Method 507, Procedure I. Modify maximum temperature portion of cycle from +160 degrees F to +110 degrees F.

3.1.2.4.1.7 Rain. - Exposure as defined in Standard MIL-STD-810, Method 506. (No direct impingement on flight hardware).

3.1.2.4.1.8 Pressure. -

(a) Air Transporation - Minimum of 3.45 psia for 8 hours (35,000 feet altitude).

(b) Ground Transporation and Storage - Minimum of 11.78 psia.

3.1.2.4.2 Earth Ascent, Earth Orbit, Translunar Injection, Lunar Orbit Insertion and Lunar Orbit. -

3.1.2.4.2.1 Pressure. - Atmospheric pressure at sea level to less than 10^{-13} mm Hg.

3.1.2.4.2.2 Thermal Radiation. - The source of radiation presented below impinges on the exterior of the Lab I in logical combination:

(a)	Solar Flux	442 BTU/sq. ft./hr.
(b)	Earth Emission	73 BTU/sq. ft./hr.
(c)	Lunar Emission (sub-solar point)	419 BTU/sq. ft./hr.
(d)	Lunar Emission (dark side)	2.2 BTU/sq. ft./hr.
(e)	Earth Albedo (over entire solar spectrum)	0.35
(f)	Earth Albedo (over visible spectrum)	0.40
(g)	Lunar Normal Albedo (over entire solar spectrum)	0.047
(h)	Lunar Normal Albedo (over visible spectrum)	0.098
(i)	Lunar Spherical Albedo (over visible spectrum)	0.073
(j)	Space Sink Temperature	4 degrees K

NOTES: 1. Thermal emitted energy distribution to be interpreted according to cosine law.

2. Electromagnetic radiation from the sun is shown in Figure 1.

3.1.2.4.2.3 Meteoroid Environment. - The meteoroid environment is defined in MSC Engineering Criteria Bulletin, EC-1, for sporadic and shower meteoroids.

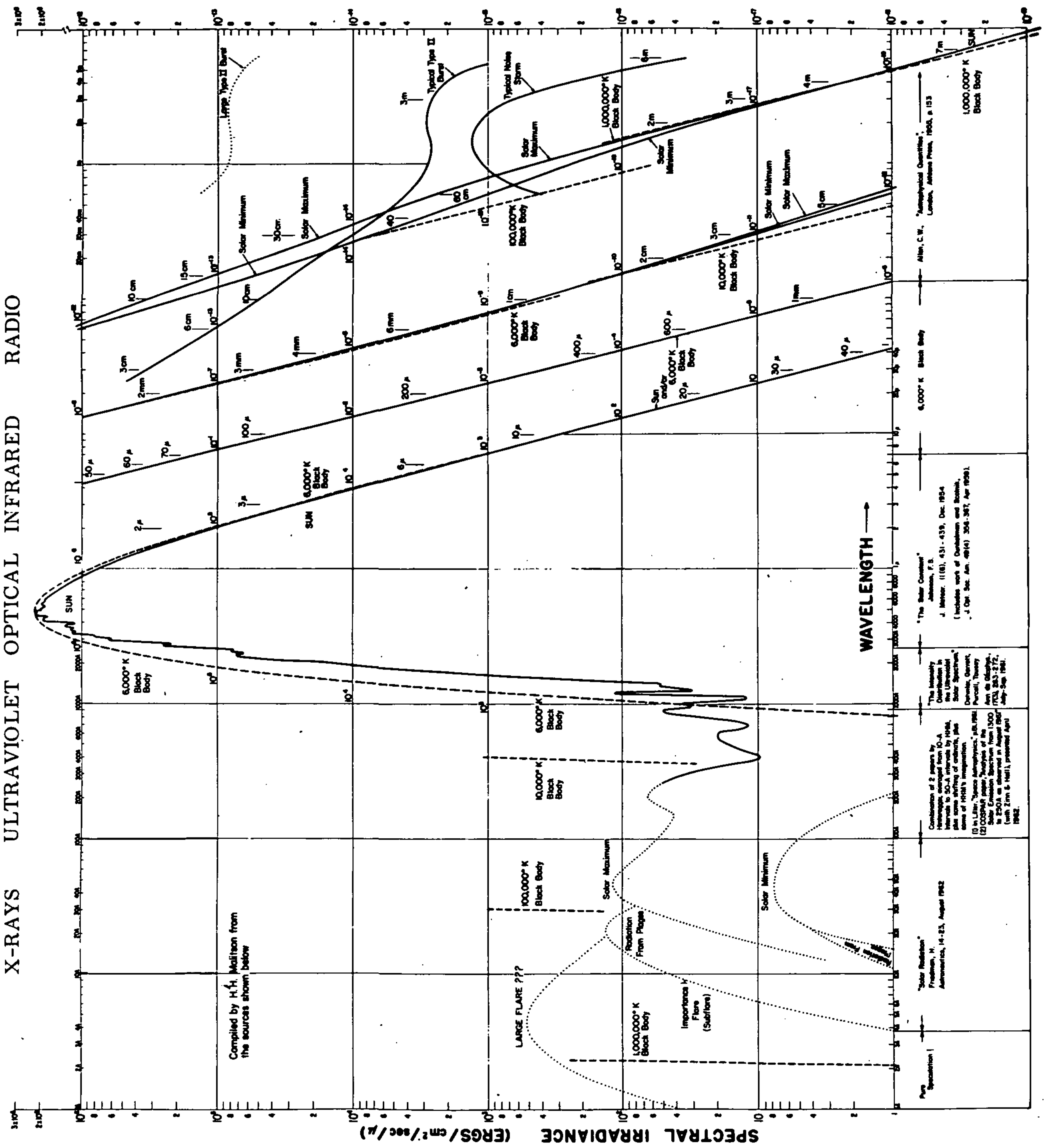


Fig. 1 The Solar Spectrum

3.1.2.4.2.4 Nuclear Radiation. - The nuclear radiation environments for near-earth, cislunar and near-lunar space will be as presented below:

(a) Trapped Radiation - Radiation levels due to the Van Allen and artificial belts will use protons and electron fluxes obtained from the Goddard Orbital Flux Code.

(b) Galactic Cosmic Rays - Galactic cosmic ray doses range from 0.1 radiation absorbed dosage (RAD) per week for solar activity maximum to 0.3 RAD per week for solar activity minimum.

(c) Solar Particle Events - The solar particle events described below are rigidities above the cut-off rigidity for solar particle events in the earth's magnetic field. The cut-off rigidity is defined by:

$$N = \frac{2.49 \times 10^9}{(6371 + h)^2} \left[\frac{2 + \cos^3\lambda \quad -2\,(1 + \cos^3\lambda)^{1/2}}{\cos^2\lambda} \right]$$

where:

N = Particles's cut-off rigidity, BV.

h = Altitude, KM

λ= Geomagnetic latitude.

NOTE: Solar particle events will be considered to contain solar produced alphas and protons with equal rigidity spectra.

(1) Time-Integrated Spectra - The time-integrated spectrum for alphas and protons with rigidities greater than 137 MV (10 Mev) will be considered to be of the form:

3.1.2.4.2.4 (Continued)

(c) (1) (Continued)

$N(>P) - N_o \text{ EXP } \left[-P/P_o\right]$ where P = 137MV

where:

$N(>P)$ = time integrated flux with rigidities greater than P, particles/cm^2.

N_o = total intensity of event, particles/cm^2.

P = particle rigidity, million volts.

P_o = characteristics rigidity, million volts:

The rigidity of a particle is given by:

$$P = \frac{-1}{Z_e} (T^2 + 2TM_oC^2)^{1/2}$$

where:

Z_e = particle's charge in units of electron charge e, i.e., $Z_e = -1$ (for protons) and $Z_e = -2$ (for alphas).

T = particle kinetic energy, Mev.

M_oC^2 = particle's rest mass energy, Mev

M_oC^2 = 938.2 Mev for protons;

M_oC^2 = 3727.1 for alphas.

P_o is evaluated in the energy ranges:

10 Mev $\leq T \leq$ 30 Mev $\leq T \leq$ 100 Mev.

3.1.2.4.2.4 (Continued)

(c) (1) (Continued)

Below 10 Mev the spectrum is defined by:

$$N(> T) = N_o T^{-n}$$

A model spectrum is described by the following expressions:

$$T < 10 \text{ Mev:} \quad N(> T) = 22.3\ N(> 239 \text{ MV})\ T^{-1.2}$$

$$137 \text{ MV} \leq P < 239 \text{ MV:} \quad N(> P) = 35.3\ N(> 239 \text{ MV})\ e^{-P/67}$$

$$P \geq 239 \text{ MV:} \quad N(> P) = 10.9\ N(> 239 \text{ MV})\ e^{-P/100}$$

where: $N(>239 \text{ MV})$ is the number of particles/cm^2 with rigidities greater than 239 MV (30 Mev) encountered during the mission. Figure 2 shows the probability of encountering greater than $N(> 239 \text{ MV})$ particles/cm^2 during the mission plotted against $N(> 239 \text{ MV})$. The values obtained for N_o shall be considered to hold for both alphas and protons.

(2) Time Dependent Spectrum - The model time dependent integral spectrum is shown in Figure 3 for several rigidities. The spectrum will be considered to hold for both alphas and protons. Note that the spectrum is normalized to one particle/cm^2 with rigidities greater than 0.239 BV for the entire event.

3.1.2.4.3 Lunar Surface Environment. -

3.1.2.4.3.1 Lunar Thermal Model. - The following paragraphs are included as a basis for thermal analyses of lunar orbital missions.

3.1.2.4.3.1.1 Surface Temperatures. - The variation of the surface temperature of a point on the lunar equator during a complete lunation (29.53 days) is shown by a solid line in Figure 4. During the lunar day, the temperatures of local surface areas may be up to 30 degrees centigrade

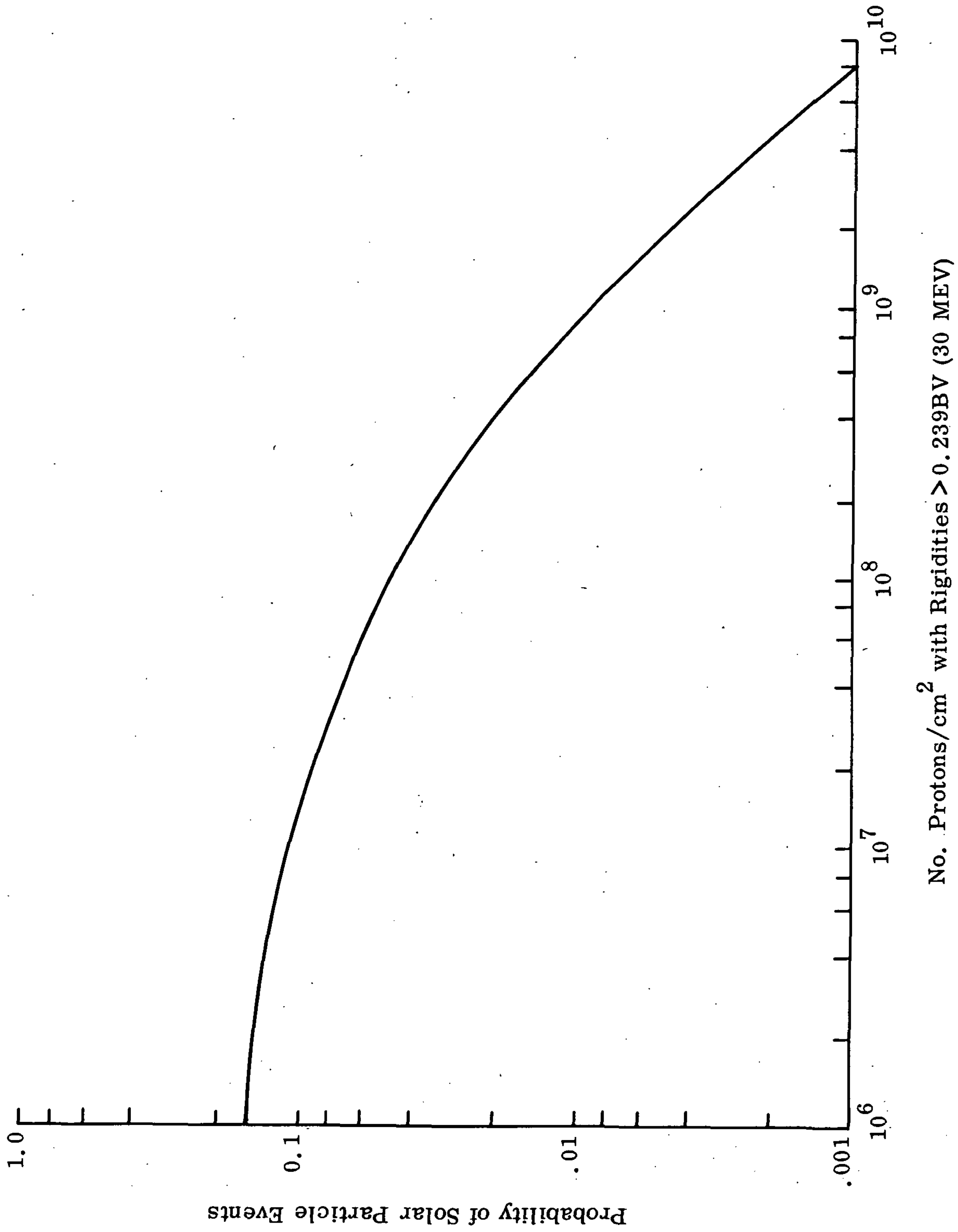


Fig. 2 Probability of Solar Particle Events

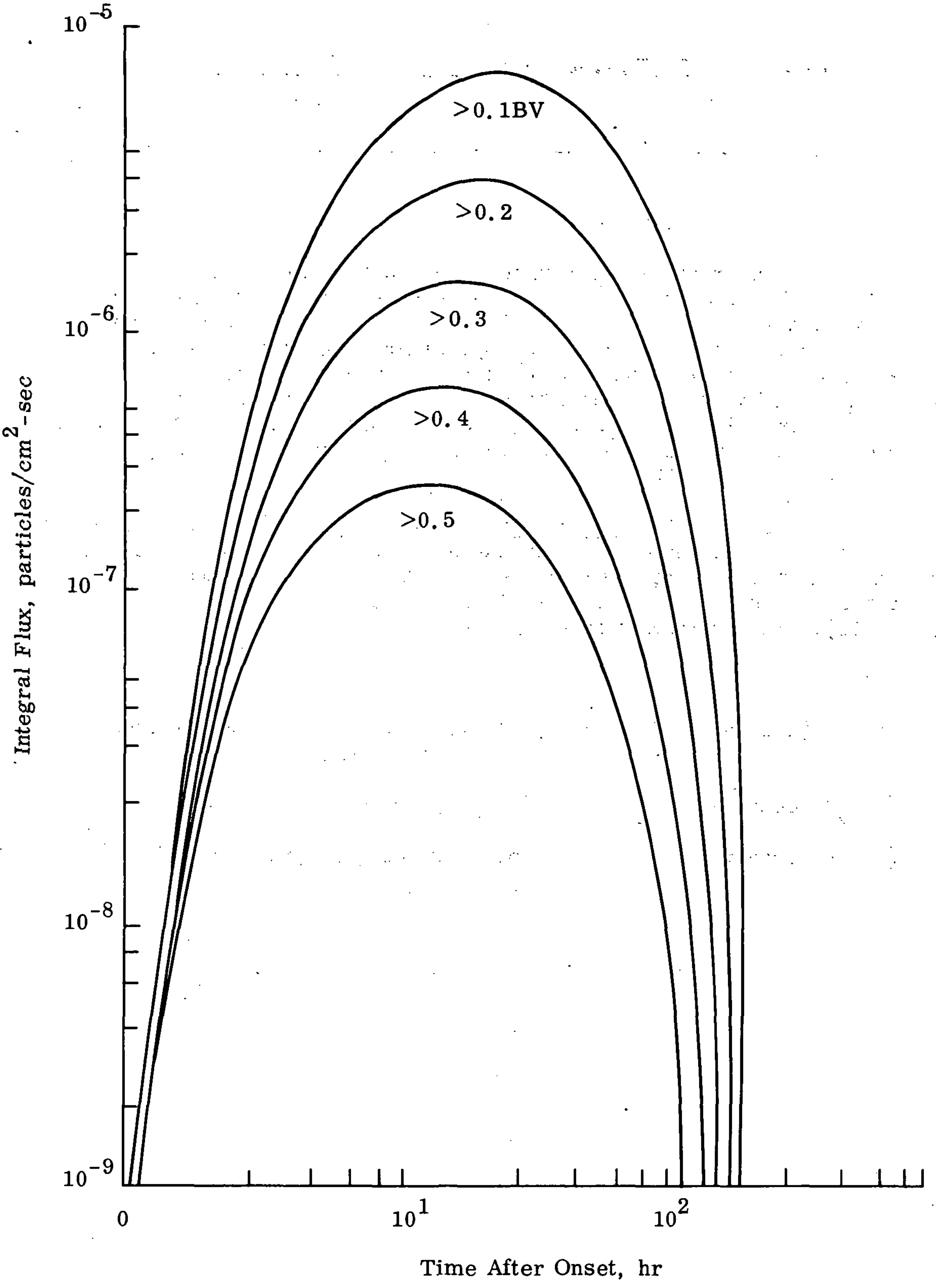


Fig. 3 Normalized Time-Dependent Integral Spectrum

3.1.2.4.3.1.1 (Continued)

higher than the averaged temperatures shown on this plot. This effect is due to local variations in albedo and topography, which cannot be taken into consideration on such a plot. For a point at some higher latitude, the temperature decreases approximately as the cosine of the latitude to the 1/4 power, as compared to the temperature of an equatorial point at the same brightness longitude. The calculated temperature variation for a lunar equatorial point having the thermal characteristics of a normal terrestrial rock is also shown in Figure 4 by a dash line, (γ = 30).

3.1.2.4.3.1.2 Thermal Properties (Average Model). - The variation of the lunar surface temperature during a lunar day is shown in Figure 4. The measured surface temperatures are best fit by a theoretical survey of temperature versus time based on a lunar surface thermal inertia $\gamma \approx 750$ (cgs units). The thermal inertia γ $(k \rho c)^{-1/2}$.

where:

(a) k (thermal conductivity) $\approx$ 1.0×10^{-5} cal/cm/sec/degrees centrigrade.

(b) ρ (density) $\approx$ 0.9 gm/cm^3.

(c) c (specific heat) $\approx$ 0.2 cal/gm/degrees centrigrade.

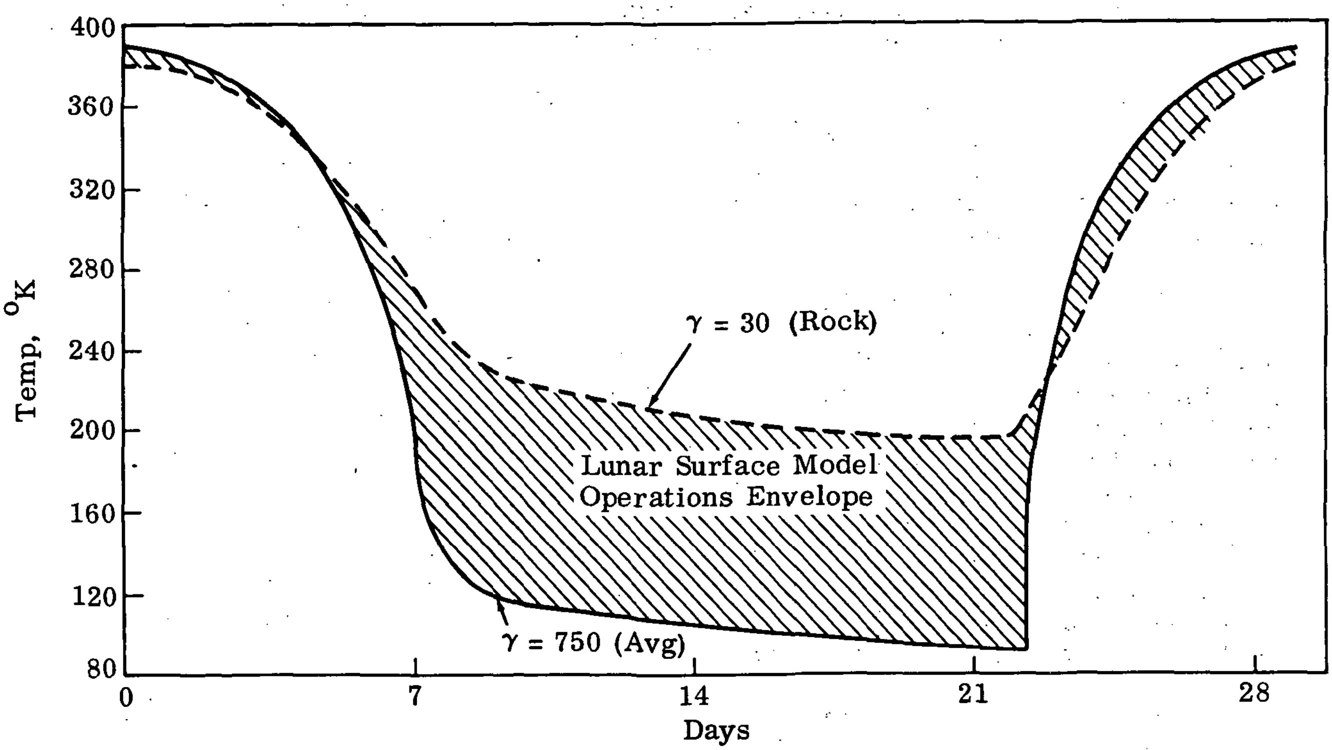


Fig. 4 Variation of Lunar Surface Temperature During a Complete Lunation

3.1.2.5 Transportability and Ground Handling. - Full design recognition shall be given to the durability requirements of Lab I equipment during transportation preparation. Wherever possible, equipment shall be designed to be transported by a common carrier. The use of protective materials and devices to insure no damage to the equipment shall be minimized. Special packaging and transportation methods shall be employed as required to prevent damage to the equipment.

3.1.2.6 Human Performance. - The vehicle design shall utilize the capability of the crew to perform efficiently throughout the mission. The design shall reflect human engineering principles. Provisions for preferred presentation arrangements, ease of maintenance, environmental and personnel safety shall be considered for ground and flight personnel.

3.1.2.6.1 Visibility. - The required external visibility will be achieved with a minimum amount of glass. Parallax, distortions, and unwanted reflection from glass (both window and instrument cover) and similar surfaces shall be kept to a minimum. Anti-reflection coatings on glass surfaces shall be used in order to reduce relection. Consideration shall be given to the use of variable density optical filters for windows in order to reduce light from sun shafting and earth and lunar reflections. When not in use, these filters shall be retractable from the window area. Internal lighting shall provide for control and display panel illumination. It shall be adjustable in intensity to compensate for varying ambient light conditions and also to insure retention of crew visual adaptation.

3.1.2.6.2 Atmospheric Environments. - The crew shall be provided a cabin atmosphere with the following characteristics for nominal operations:

(a) Pressure: - 5.0 ± 0.2 psia

(b) Oxygen Partial Pressure: - 233 mm Hg

(c) Carbon Dioxide Partial Pressure: - 7.6 mm Hg

(d) Temperature: 75 ± 5 degrees Fahrenheit

(e) Relative Humidity: 40 percent to 70 percent

3.1.2.6.2 (Continued)

For emergency conditions, the following limits apply:

(f) Pressure: 3.7 ± 0.2 psia

(g) Oxygen Partial Pressure: 160 mm Hg absolute

(h) Carbon Dioxide Partial Pressure - See Figure 5

(i) Temperature: 120 degrees Fahrenheit for four hours maximum

Nominal limits are defined as the limits within which the crew s environment shall be maintained during extended and normal operations. Emergency limits are defined as the environmental limits beyond which there is an increased probability of degraded performance or irreversible injury.

3.1.2.6.3 Noise Limits. - The noise non-stressed limits to the crew's ear canals shall not be greater than that shown in Figure 6, including an average at 55 db in the 600 cps to 4800 cps range to a reference level of 0.0002 dynes/cm^2. The stressed limit is that noise level where combinations of white noise duration and decibel level, measured at the entrance of the crewman's ear canal, shall not be greater than that defined by Figure 7. A limiting constraint shall be that the maximum noise level permissible is that which will permit communications with the ground and between crew members at all times, and which will not induce physiological disturbances. The emergency limit shall be considered that limit at which the crew finds the noise painful or tissue damage can occur. For design and test purposes, 127 db or higher peak value sustained for a period of no more than 2.5 seconds, in a pattern of equal periods of rest or low noise relief, is defined as the emergency limit. Pure tones generated in the cabin by operating equipment will be kep to a minimum intensity level.

3.1.2.6.4 Crew Vibration Limits. - The stress limits are those vibration loads which are uncomfortable to the crew, but tolerable, below the painful threshold, and shall not be greater than that defined in Figure 8. The emergency limit shall be considered that limit at which the crew finds the vibration painful or where tissue damage can occur. The emergency limit shall not be greater than that depicted in Figure 8 for less than one minute; one minute; and three minutes. For continuous exposure the continuous maximum tolerable curve shall be used. Crew performance degradation will occur immediately during emergency stress. Exposure to nominal stressed limits will result in performance degradation if sufficient recovery time is not provided between vibratory pulses. Minimum recovery time is equal to twice the exposure time period.

3.1.2.6.5 Metabolic Requirements. - Metabolic requirements and rates for various mission phase activities shall be as shown in Table I.

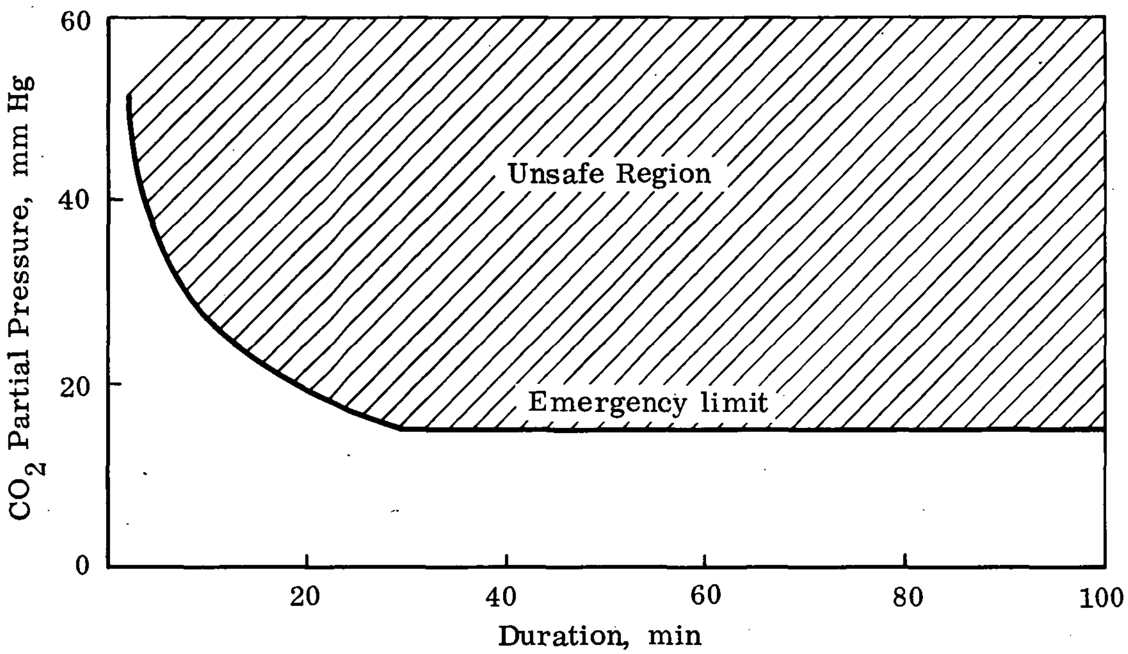


Fig. 5 Emergency Carbon Dioxide Limit

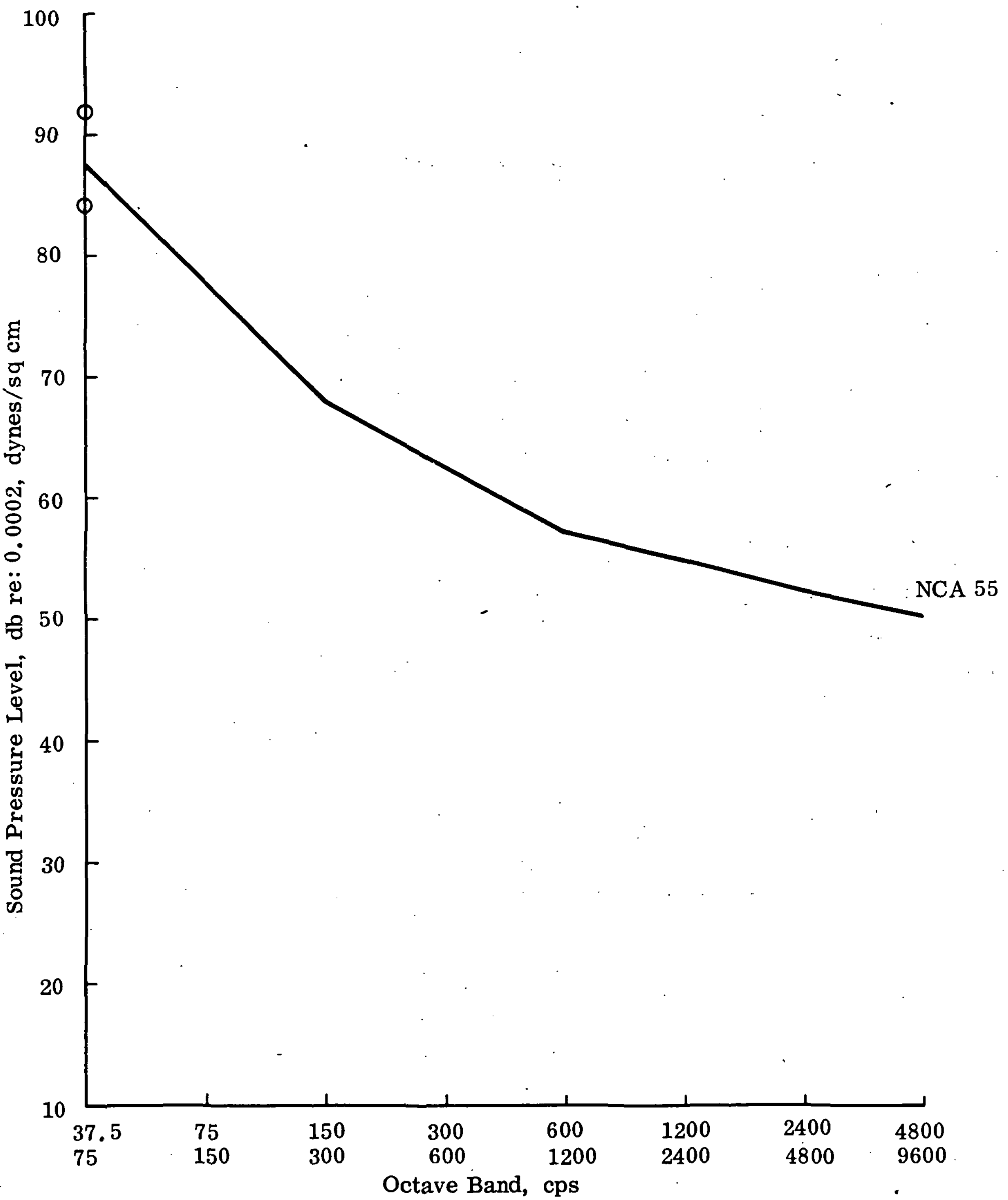
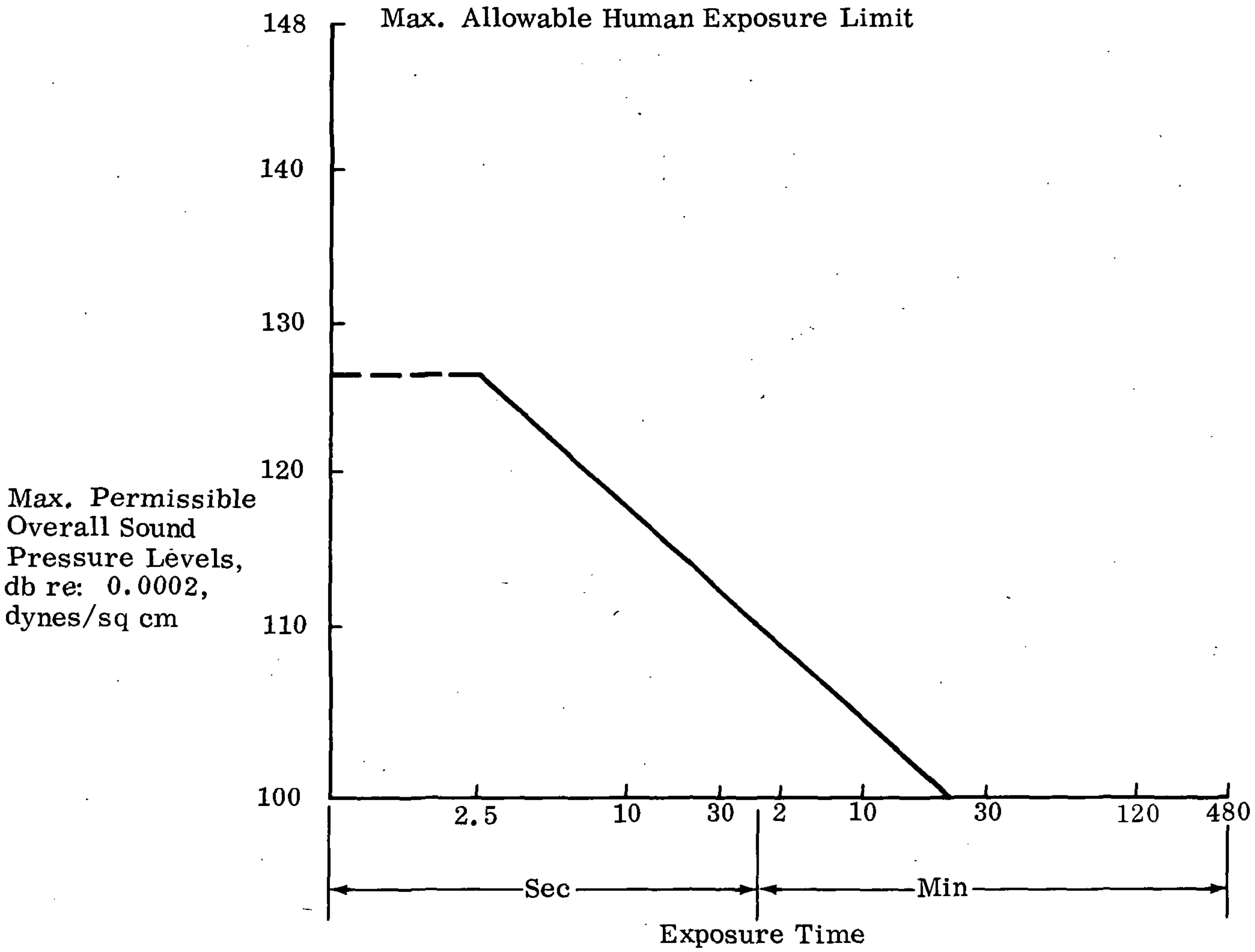


Fig. 6 Noise Limits



Unprotected Ear Noise Tolerance Limit

Fig. 7 Unprotected Ear Noise Tolerance Limit

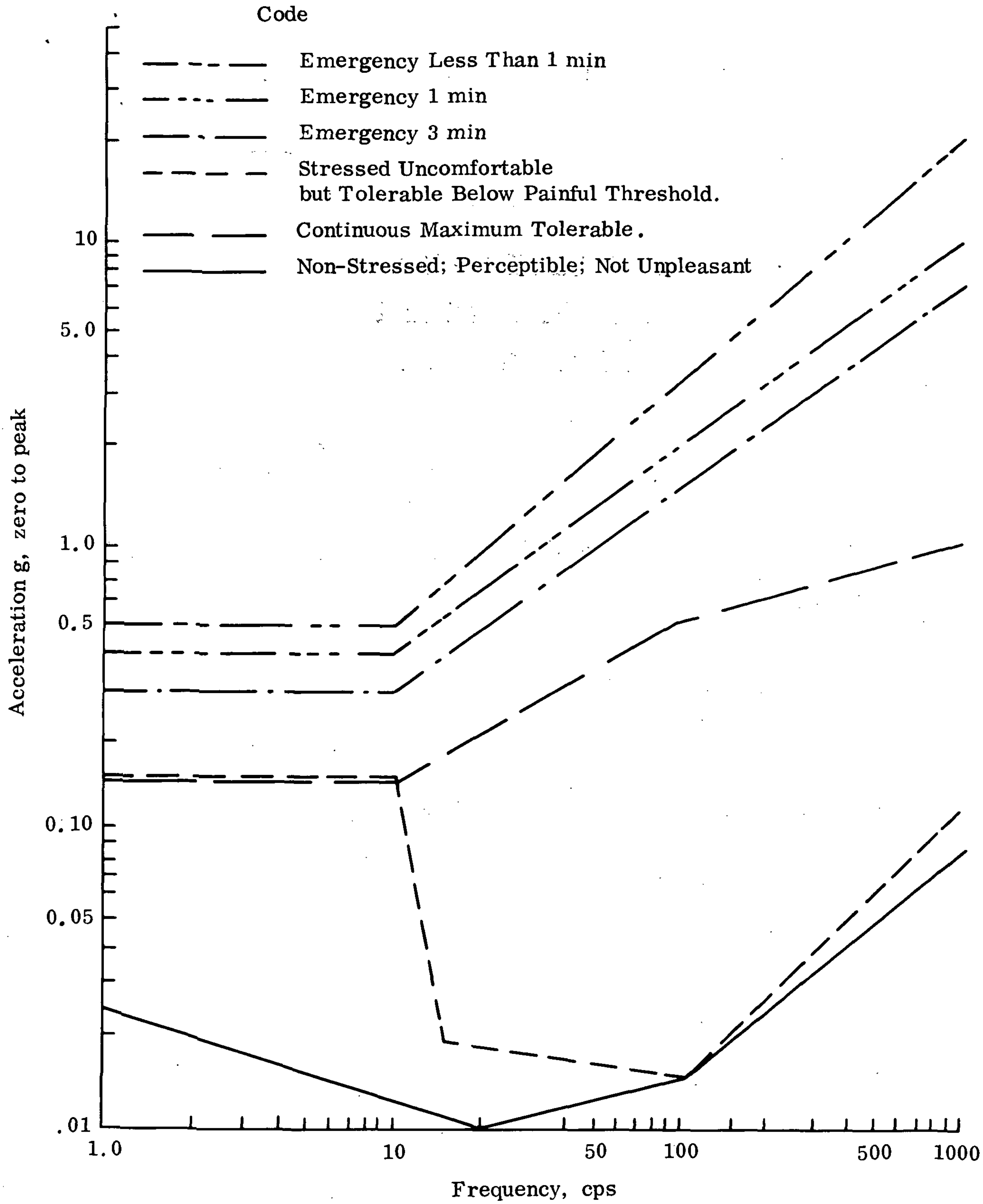


Fig. 8 Vibration Curve

TABLE I

ESTIMATES OF METABOLIC RATE, THERMAL BALANCE AND WATER REQUIREMENTS FOR CREW MEMBERS

	PER MAN	UNITS OF MEASURE	ROUTINE FLIGHT PER HOUR	ROUTINE FLIGHT PER DAY	EMERGENCY DECOMPRESSION PER HOUR	EXTRAVEHICULAR OPERATIONS PER HOUR
(a)	Heat Output	BTU				
(b)	Oxygen	lbs				
(c)	Carbon Dioxide	lbs				
(d)	Latent Heat (lungs)	BTU				
(e)	Latent Heat (sweat)	BTU		TBD		
(f)	Sensible Heat	BTU				
(g)	Urinary Loss	g				
(h)	Sweat Loss	g				
(i)	Lung Loss	g				
(j)	Total Water Requirement	g				
(k)	Total Water Requirement	lbs				
(l)	Food Consumption K	cal				

3.1.2.7 Safety. -

3.1.2.7.1 Hazard Proofing. - The design of the Lab I shall minimize the hazard of fire, explosion and toxicity to crew. Launch area personnel and facilities shall also be considered in designing for hazard proofing. Toxic, combustible and corrosive materials accumulated from leakages, and discharges from equipment sources or static potentials capable of ignition shall not occur.

3.1.2.7.2 Explosion Proofing. - Lab I components shall be either hermetically sealed or of explosion proof construction.

3.1.2.7.3 Fail Safe. - A failure in a subsystem or component shall not cause a failure in any other subsystem or component; that is, the design shall be "fail safe".

3.1.2.7.4 Lab I and Personnel Safety Requirements. - The design shall consider the following Lab I and personnel safety requirements:

(a) Toxicological control of outgas in Lab I atmosphere.

(b) Cabin control of aerosols, dust (such as LiOH from LiOH cartridges) and condensates.

(c) The Lab I interior and exterior shall be free of sharp objects, metal burrs or any abrasive surface which may puncture or otherwise damage the space suit or harm the crew.

(d) The cabin shall have adequate hand holds to facilitate controlled movement under zero "g" and interior design free of "traps" whereby crewman in a pressurized suit may become jammed or wedged and be incapable of escape.

(e) Eye protection from direct (unfiltered) sunlight.

(f) Bacteriological and fungus control.

(g) Provisions for securing items stowed or transferred into the Lab I cabin, to prevent their becoming a cabin hazard during vehicle operation.

3.1.2.7.4 (Continued)

(h) Protection from electrical shock hazard.

(i) Protection from cryogenic lines (freezing).

(j) Protection from static electrical hazard.

(k) Shielding from space thermal radiation hazard.

(l) Protection from excessive radiation heat loss.

(m) Protection from microwave and other RF radiation.

(n) Prevention of excessive load lifting (strain) and excessive fatigue.

(o) Protection for a suited crewman from damaging the suit by proper design and use of scientific instruments, stowage, packaging, and specimen containers.

(p) "Non Slip" Lab I walking surfacee.

(q) Fail safe and "jam proof" umbilical connections.

(r) Connectors keyed to preclude mismating.

3.1.2.7.4.1 Crew Safety Design Criteria. - The Lab I shall be designed such that no single failure shall cause the loss of all methods of implementing a function critical to crew safety. In those instances where redundant control and information paths are provided for crew safety, the redundant mechanical and electrical elements of these paths shall be separated from each other where practicable.

3.1.2.8 Induced Environment. - The Lab I shall be designed to meet its operational requirements during and after exposure to the induced environments listed in the following paragraphs.

3.1.2.8.1 Prelaunch. -

3.1.2.8.1.1 Prelaunch - Packaged. - Transportation and handling in the shipping container shall not produce critical design loads on the Lab I equipment and shall not increase the flight weight of the equipment. The equipment shall be protected by a suitable shipping container if the following externally induced environments caused by transportation and handling exceed the equipment design requirements.

(a) Acceleration: 2.67g vertical with 0.4g lateral applied simultaneously to the package. This condition also applies to the complete Lab I.

(b) Shock - In accordance with MIL-STD-810, Method 516, Procedure III.

(c) Vibration - Sinusoidal vibration shall be applied to the test package along the three mutually perpendicular axes (X, Y, and Z). The frequency shall be cycled three times between 5 cps and maximum cps and back to 5 cps at an applied double amplitude or accelerations as detailed by weights in (1), (2) or (3). The rate of change of frequency shall be logarithmic at 1/2 octave per minute.

(1) For 100 pounds or less:

cps	g or D.A.
5-7.2	0.5 in D.A.
7.2-26	± 1.3g
26-52	.036 in D.A.
52-500	± 5.0g

(2) For 100 pounds to 300 pounds: Use Figure 514.8, Method 514 of MIL-STD-810 for maximum frequency.

(3) For 300 pounds or more:

cps	g or D.A.
5-7.2	0.5 in D.A.
7.2-26	± 1.3g
26-52	.036 in D.A.

3.1.2.8.1.1 (Continued)

(d) Electromagnetic Interference - In accordance with 3.3.9.

3.1.2.8.1.2 Prelaunch - Unpackaged. - Ground handling shall not produce critical design loads on the Lab I equipment and shall not increase its flight weight. The unpackaged equipment shall meet its operational requirements after exposure to the following ground handling externally induced environments.

(a) Acceleration: 2.67g vertical with 0.4g lateral applied simultaneously. This condition also applies to the complete Lab I.

(b) Shock - In accordance with MIL-STD-810, Method 516, Procedure I except, modify shock pulse to a sawtooth 15g peak, having a 10 to 12 millisecond rise and a 0-2 millisecond decay.

(c) Pressure (Ambient Ground Level) - Hermetically sealed units installed in the crew compartment will be subjected to a maximum pressure of 20.5 psi absolute during preflight checkout.

(d) Hazardous Gases - Same as prelaunch - packaged.

(e) Electromagnetic Interference - In accordance with 3.3.9.

3.1.2.8.2 Launch and Boost. - (See NOTE 7)

(a) Acceleration (See NOTE 5):

	X		Y		Z	
	G	RAD/SEC^2	G	RAD/SEC^2	G	RAD/SEC^2
Lift Off Condition	+1.60	--	± .65	--	± .65	--
Max Q Condition	+2.07	--	± .30	--	± .30	--
End Boost Condition	+4.90	--	± .10	--	± .10	--
Cut Off Condition	-1.70	--	± .10	--	± .10	--
Engine Hardover	+2.15	--	± .40	--	0	--
Engine Hardover	+2.15	--	0	--	± .40	--
Earth Orbit	0	0	0	0	0	0

3.1.2.8.2 (Continued)

(b) Acoustics - As specified in North American Specification TBD.

(c) Vibration (See NOTE 6) - The mission vibration environment is represented by the following random and sinusoidal envelopes considered separately:

(1) Exterior Primary Structure -

a. Random -

10 to 23 cps	12 db/octave rise to
23 to 80 cps	$0.0148g^2$/cps
80 to 105 cps	12 db/octave rise to
105 to 950 cps	$0.0444g^2$/cps
950 to 1250 cps	12 db/octave decrease to
1250 to 2000 cps	$0.0148g^2$/cps

b. Sinusoidal -

5 to 18.5 cps	0.154 inches double amplitude
18.5 to 100 cps	2.69g peak

(2) Interior Primary Structure -

a. Random -

10 to 23 cps	12 db/octave rise to
23 to 80 cps	$0.0148g^2$/cps
80 to 100 cps	12 db/octave rise to
100 to 1000 cps	$0.0355g^2$/cps
1000 to 1200 cps	12 db/octave decrease to
1200 to 2000 cps	$0.0148g^2$/cps

3.1.2.8.2 (Continued)

(c) (2) (Continued)

b. Sinusoidal -

5 to 16 cps	0.154 inch double amplitude
16 to 100 cps	1.92g peak

Vibration levels may be lower at specific equipment locations due to the reaction of equipment on primary structure. Therefore, a rationally demonstrated reduction in these levels may be used for Lab I equipment design and test.

(d) Pressure - Atmospheric pressure at sea level to 1×10^{-8} mm Hg (N_2) as specified in North American Specification TBD.

(1) Controlled Cabin: 20.5 psia to 5.4 psia (O_2) with decay time of approximately 2 minutes.

(2) Uncontrolled Cabin - Decay to 1×10^{-4} mm Hg in approximately 17 minutes.

(e) Temperature - As specified in North American Specification TBD.

(f) Hazardous Gases - Same as prelaunch unpackaged.

(g) Electromagnetic Interference - Same as prelaunch unpackaged.

*3.1.2.8.3 Space Flight-Translunar. - To be determined.

*3.1.2.8.4 Space Flight - Earth Orbiting. - To be determined.

NOTES: 1. Factors of safety are not included in the levels specified in 3.1.2.8.1.1 through 3.1.2.8.4.

2. All accelerations are "earth g's".

3. Vibration spectra shown give straight lines on a log-log plot.

NOTES: (Continued)

4. Packaged and unpackaged - The word "packaged" refers to containers used for transportation, handling and storage.

5. Acceleration and shock levels are at the Lab I center of gravity.

6. For launch and boost vibrations, the primary structure which is directly excited by the acoustics transmitted through the Spacecraft LEM Adapter (SLA) is designated exterior primary structure. The primary structure which either does not face the adapter or is shielded from it by another piece of structure is designated interior primary structure.

7. The environments specified in 3.1.2.8.2 represent preliminary figures and will be modified after mass properties of the equipment installed on the vehicle are determined.

*3.2 Interface Requirements. - The Lab I shall be compatible with and shall satisfy the requirements of the following interfaces:

(a) Command Service Module, (CSM).

(b) Spacecraft LEM Adapter, (SLA).

(c) Acceptance Checkout Equipment (ACE).

(d) Manned Space Flight Net, (MSFN).

(e) NASA Crew Equipment.

(f) Experimental Payload, (EP).

*3.2 (Continued)

(g) Guidance, Navigation and Control, (GFE-GN&C).

(h) Mobile Launcher Tower (MLT)

(i) Mobile Service Structure (MSS)

*3.2.1 CSM Interface. - The Lab I shall be compatible with the CSM interface requirements as specified in North American Aviation Performance and Interface Specification TBD.

*3.2.2 SLA Interface. - The Lab I shall be compatible with the SLA interface requirements as specified in North American Aviation Performance and Interface Specification TBD.

*3.2.3 ACE Interface. - The Lab I shall be compatible with the ACE interface requirements which will be determined.

*3.2.4 MSFN Interface. - The Lab I shall be compatible with the MSFN interface requirements as specified in Grumman Specifications TBD.

*3.2.5 NASA Crew Equipment Interface. - The Lab I shall be compatible with the NASA crew equipment interface requirements as defined in Grumman P & I Specification TBD.

*3.2.6 EP Interface. - The Lab I shall be compatible with the EP interface requirements as specified in Grumman Specification ESP 11-9110.

*3.2.7 GN and C Interface. - The Lab I shall be compatible with the GFE section of the GN&C as defined by Grumman P & I specification TBD.

3.2.8 Launch Facilities Interface. -

*3.2.8.1 MLT Interface. - The Lab I shall be compatible with the MLT interface requirements as defined by Grumman P & I specification TBD.

*3.2.8.2 MSS Interface. - The Lab I shall be compatible with the MSS interface requirements as defined by Grumman P & I specification TBD.

SPECIFICATION NO. ESP 11-0100

3.3 Design and Construction. -

3.3.1 General Design Features. -

*3.3.1.1 Configuration. - The overall features and dimensions of the Lab I are shown in Figure 9. The detailed configuration of each vehicle will be defined in the individual vehicle end item specification.

*3.3.1.2 Weight. - The total weight of the vehicle including payload and expendables will be defined in the individual vehicle end item specifications.

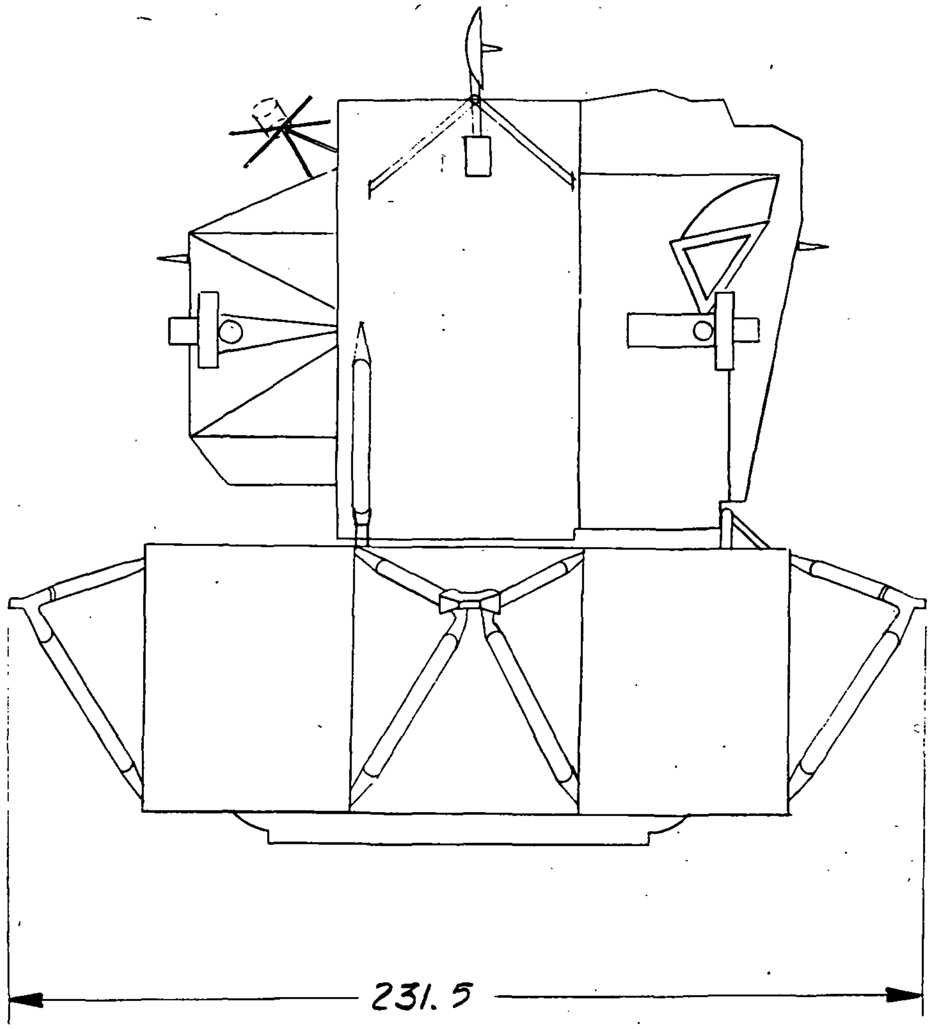
3.3.2 Selection of Specifications and Standards. - Specifications and standards shall be selected from released lists of NASA, federal, military, industry (trade associations) and Grumman specifications and standards in that order of preference. Requirements of specifications and standards selected shall not be less stringent than those imposed by the application and the reliability goal specified for the parts, material, or processes covered.

3.3.3 Materials, Parts and Processes. - Materials, parts and processes shall be selected to meet the requirements of the specifications and standards chosen in accordance with 3.3.2. Compliance with requirements of applicable specifications or standards shall be demonstrated by test data or analysis.

3.3.3.1 Soldering. - Soldering requirements shall conform to MSFC-PROC-158 as amended by MSC-ASPO-S-5B.

*3.3.3.2 Wiring. - The fabrication and installation of the vehicle cabling and wiring for the interconnection of electrical and electronic equipment shall be in accordance with Grumman Specification LSP-390-002 as modified for AES.

3.3.4 Standard and Commercial Parts. - Parts shall be selected on the basis of adequate data history with demonstrated reliability and knowledge that they are qualified for a given application selected from sources practicing proven reliability and quality control procedures in their manufacture. Parts qualified to the applicable MIL Specifications shall be selected when a need for such parts exists. IDEP files and other similar sources of information relating to the selection of parts and their application will be used wherever possible.



SIDE ELEVATION

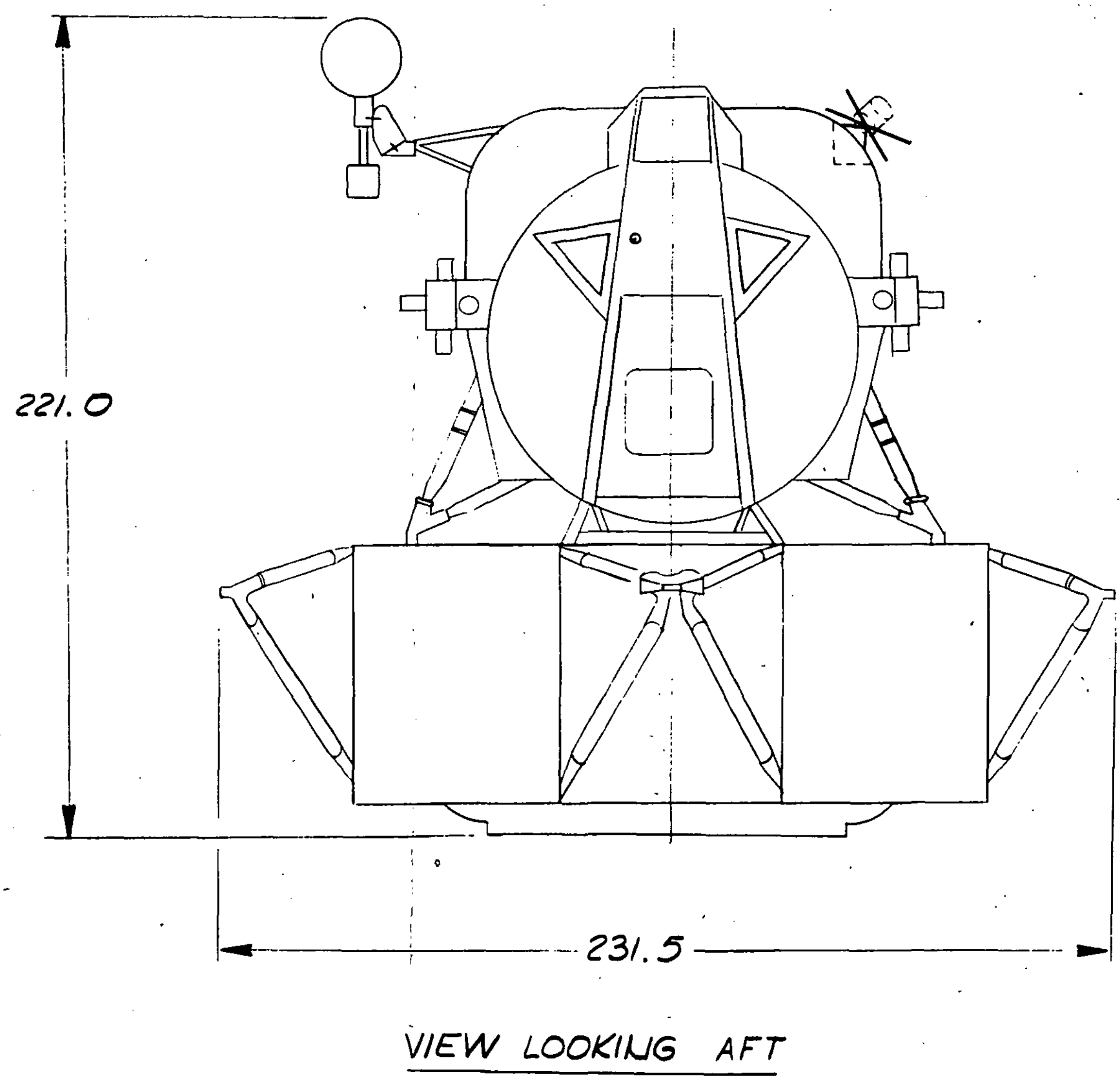


Fig. 9 Vehicle Design

3.3.5 Moisture and Fungus Resistance. - Materials which are nutrient to fungus shall only be permitted in hermetically sealed assemblies. In other applications, non-nutrient materials shall be used. However, if it is necessary to use nutrient material in an assembly which is not hermetically sealed, the material shall be treated such that it shall be capable of satisfactorily passing the fungus test specified in MIL-STD-810.

3.3.6 Corrosion of Metal Parts. - Metal parts shall be of corrosion resistant materials, or shall be processed to resist corrosion. Such corrosion resistant processes shall not prevent compliance with Grumman Specification LSP-390-001.

3.3.7 Interchangeability and Replaceability. - Mechanical and electrical interchangeability shall exist between like items having the same manufacturer's part number. Substitution of like assemblies and replaceable parts shall be easily effected without physical or electrical modification of any part of the equipment, including cabling and wiring.

3.3.8 Workmanship. - Workmanship shall be performed in a high grade manner in accordance with the applicable drawings, specifications, and standards. Processes and manufacturing methods, not covered by specifications, shall be suitable for the article, and workmanship shall be in accordance with high grade spacecraft practice. The quality or workmanship shall not degrade the reliability, performance, or life inherent in the design of the article. All surfaces shall be smooth and free from porosity, burrs, chips, dents, and other irregulatrities.

3.3.9 Electromagnetic Interference. -

3.3.9.1 Vehicle Interference Control. - The vehicle shall satisfy the requirements of MIL-E-6051C with the following exceptions:

(a) Delete "MIL-I-26600" and substitute Grumman Specification "LSP-530-001 as modified for AES" in all places.

(b) Delete "MIL-B-5087" and substitute Grumman Specification "LSP-390-001" in all places.

(c) Delete paragraph 3.1.1.

3.3.9.1 (Continued)

(d) Paragraph 4.3.1 - Delete reference to "first electrical-electronic weapon system" and "weapon system" and substitute: "appropriate AES Test Article" in two places.

(e) Paragraph 4.3.2 - Delete second sentence and substitute: "The specification compliance test shall be performed on the appropriate AES Test Article."

(f) Paragraph 4.3.5 - Add the following: "The 6 db level shall be a requirement where it has meaningful application as determined by Grumman and delineated in the approved test procedure."

*3.3.9.2 Vehicle Equipment Interference Control. - AES Vehicle equipment shall satisfy the requirements of Grumman Specification LSP-530-001, as modified for AES. The modifications to this specification are to be determined.

3.3.10 Identification and Marking. - Identification and marking shall be as specified in Grumman Specification LSP-14-001.

3.3.11 Storage. - The vehicle and its equipment shall be capable of withstanding a storage period of five years. The storage environments shall be as specified in 3.1.2.4.1 and 3.1.2.8.1.1 for the five year period except where shorter periods of time are specified for certain environments.

3.3.12 Structural Design Criteria. -

3.3.12.1 Margins of Safety. - The vehicle and its equipment shall possess a zero or positive margin of safety.

3.3.12.2 Limit Conditions. - The design limit load envelope shall be established by superposition of the rationally deduced critical loads which occur throughout the mission. The load envelopes shall recognize the cumulative effects of additive type loads. The vehicle shall be capable of performing as required at limit load conditions.

3.3.12.3 Primary Structure Design. - Primary structures shall not require pressure stabilization.

3.3.12.4 Pressure Vessel Design. - Pressure vessels shall be designed to withstand the design internal pressure continuously for a period equivalent to twice the mission duty cycle without permanent deformation.

3.3.12.4.1 Pressure Vessel Design Limit Load. - The pressure vessel design limit loads shall be derived from the combination of the critical loads imposed on it, and the applicable limit pressure. If the internal pressure of a vessel tends to reduce the effects of the critical loads, the resulting reduction in the pressure vessel design limit loads shall not be considered.

NOTE: Limit pressure is defined as the relief valve nominal pressure plus its tolerances, plus the hydrostatic head. For equipment which does not include a relief valve, the limit pressure is the maximum pressure which results from the highest temperature experienced after pressurization.

3.3.12.5 Effects of Transportation, Handling and Storage. -

(a) Provisions which are incorporated to withstand the effects of transportation, handling and storage shall not cause an increase in the weight of the vehicle or its equipment.

(b) Structural design shall be such that the environments of transportation, handling and storage shall not cause critical loads on the vehicle.

3.3.12.6 Vibration Design Requirements. - The vehicle and its equipment shall be designed to withstand the vibration levels specified in 3.1.2.8 multiplied by the appropriate factors presented in 3.3.12.7. The vibration levels shown in 3.1.2.8 are considered to be the maximum vibration response of the vehicle primary structure to the input excitation occuring during the mission. For the design of the equipment these vibration levels are the inputs from the vehicle primary structure. The modifying effects of the secondary or supporting structure shall be considered in determining vibration levels for both design analysis and test.

3.3.12.6.1 Vibration Amplification Factor. - The vibration motion amplification factor on any portion of the equipment shall be limited to 10, except in special cases which shall be identified by Grumman and approved by NASA.

3.3.12.7 Factors of Safety. - The factors of safety specified below will be applied to the limit loads to attain the proof, yield and ultimate loads.

3.3.12.7.1 Ultimate Factor of Safety. - The ultimate factor of safety for structural design shall be 1.5. This factor of 1.5 may be reduced to 1.35 for special cases subject to rational analysis and approval of NASA, MSC.

3.3.12.7.2 Proof Pressure Factor. - The proof pressure factor shall be 1.33 when pressure is applied as a singular load.

3.3.12.7.3 Vibration Factors. - For structural loads the following factors of safety shall be applied to the vibration amplitudes specified in 3.1.2.8.

3.3.12.7.3.1 Factors for Fatigue-Critical Structure. -

NOTE: These factors are used to determine the vibration qualification test levels for "equipment operating" modes.

(a) Prelaunch-packaged and unpackaged: Sinusoidal levels: 1.0 applied to acceleration or double amplitude.

(b) All Mission Phases after Launch -

(1) Sinusoidal levels: 1.3 applied to acceleration or double amplitude.

(2) Random levels: $(1.3)^2$ applied to acceleration spectral density (g^2/cps).

3.3.12.7.3.2 Factors for Strength-Critical Structure. -

NOTE: These factors are included in structural ultimate qualification test levels.

(a) Prelaunch - packaged and unpackaged: Sinusoidal Levels: 1.5 applied to acceleration or double amplitude.

3.3.12.7.3.2 (Continued)

(b) All Mission Phases after Launch -

(1) Sinusoidal levels - 1.5 applied to acceleration or double amplitude.

(2) Random levels: $(1.5)^2$ applied to acceleration spectral density (g^2/cps).

3.3.12.7.4 Environmental Factors. - The ultimate factor of safety shall be 1.0 for the following natural environments specified in 3.1.2.4:

(a) Rain

(b) Salt spray and fog

(c) Sand and dust

(d) Fungus

(e) Temperature

*3.3.13 Thermal Design Criteria. - To be determined.

3.3.14 Radiation Protection. - The level of radiation protection provided shall be that which is inherent in the vehicle structure.

3.3.15 Micrometeoroid Protection. - To be determined.

3.3.15.1 Penetration Mechanics. - To be determined.

3.3.16 Modification Criteria. - The design of the vehicle shall be such that modifications to the vehicle will not cause a perturbation of the interfaces with other modules of the AES Spacecraft.

3.4 Requirements of Sub-Areas. - The performance of the subsystem equipments delineated in this section is contingent upon those LEM subsystem equipments which are utilized without modification in the Lab I. Section 6 of this specification itemizes the specific additions and deletions of equipments which are necessary for the conversion of a LEM into a Lab I.

The functional interrelationship between subsystems of the Lab I and between major assemblies within subsystems shall be as shown in the Level I functional diagram (Figure 10).

3.4.1 Structural Design Subsystem (SDS). - The Structural Design Subsystem shall consist of the following major sections:

(a) Ascent Stage Section consisting of the Forward Cabin Structure, Aft Cabin Structure, External Equipment Bay Structure, Thermal and Micrometeoroid Shield, and Subsystems Support Structure.

(b) Descent Stage Section consisting of Descent Stage Primary Structure, Subsystems Support Structure, and Thermal and Micrometeoroid Shields.

3.4.1.1 Performance Requirements. -

3.4.1.1.1 The Ascent Stage Section. - The Ascent Stage Section shall perform the following:

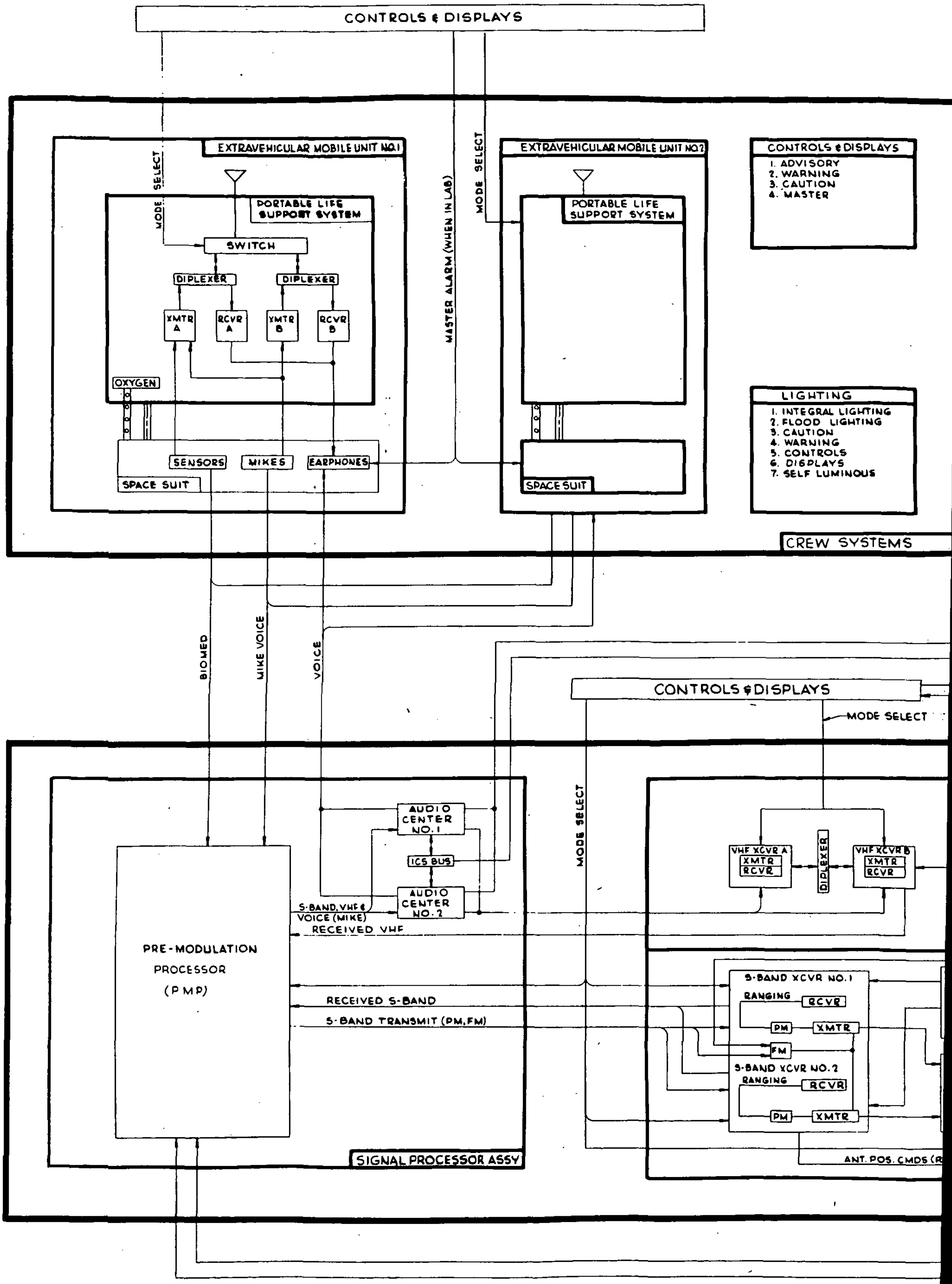
(a) Provide environmental protection for the crew during the earth orbital and lunar orbital phases of the Lab I mission.

(b) Provide support for all Ascent Stage equipment.

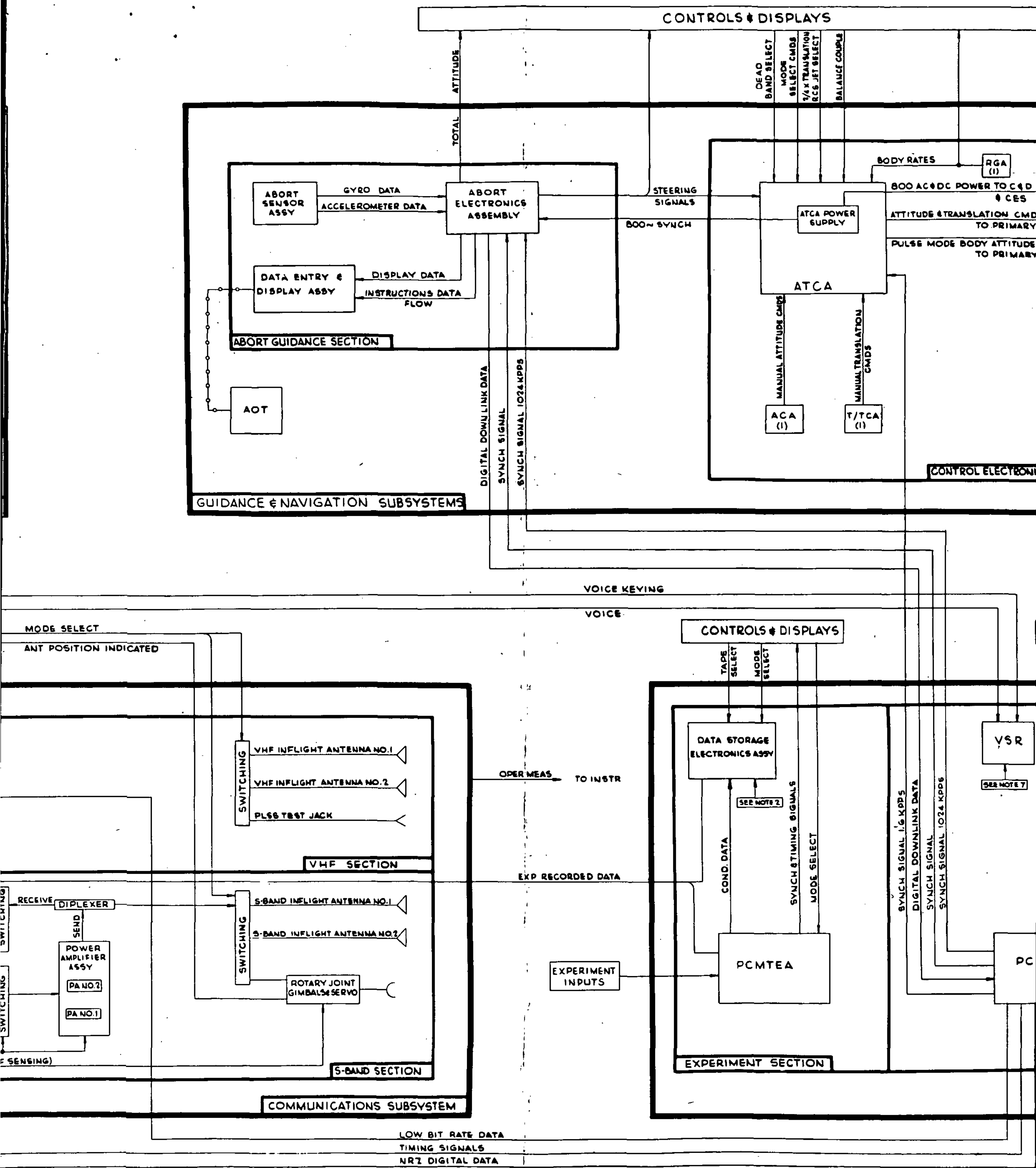
(c) Provide for the transfer of crew and equipment between the Lab I and the Command Service Module.

(d) Provide passive thermal control of the Ascent Stage subsystem environment.

(e) Provide protection of the Ascent Stage subsystems from the meteoroid environment.


CONTROLS & DISPLAYS
EXTRAVEHICULAR MOBILE UNIT NO.1
MODE SELECT
PORTABLE LIFE SUPPORT SYSTEM
SWITCH
DIPLEXER
DIPLEXER
XMTR A
RCVR A
XMTR B
RCVR B
OXYGEN
SENSORS
MIKES
EARPHONES
SPACE SUIT
MASTER ALARM (WHEN IN LAB)
EXTRAVEHICULAR MOBILE UNIT NO.2
MODE SELECT
PORTABLE LIFE SUPPORT SYSTEM
SPACE SUIT
CONTROLS & DISPLAYS
1. ADVISORY
2. WARNING
3. CAUTION
4. MASTER
LIGHTING
1. INTEGRAL LIGHTING
2. FLOOD LIGHTING
3. CAUTION
4. WARNING
5. CONTROLS
6. DISPLAYS
7. SELF LUMINOUS
CREW SYSTEMS
BIOMED
MIKE VOICE
VOICE
CONTROLS & DISPLAYS
MODE SELECT
MODE SELECT
AUDIO CENTER NO.1
ICS BUS
AUDIO CENTER NO.2
S-BAND, VHF & VOICE (MIKE)
RECEIVED VHF
PRE-MODULATION PROCESSOR (PMP)
RECEIVED S-BAND
S-BAND TRANSMIT (PM, FM)
VHF XCVR A
XMTR
RCVR
DIPLEXER
VHF XCVR B
XMTR
RCVR
S-BAND XCVR NO.1
RANGING
RCVR
PM
XMTR
FM
S-BAND XCVR NO.2
RANGING
RCVR
PM
XMTR
ANT. POS. CMDS (R
SIGNAL PROCESSOR ASSY

47 ①


CONTROLS & DISPLAYS
TOTAL ATTITUDE
DEAD BAND SELECT
MODE SELECT CMDS
BALANCE COUPLE
ABORT SENSOR ASSY
GYRO DATA
ACCELEROMETER DATA
ABORT ELECTRONICS ASSEMBLY
STEERING SIGNALS
800~ SYNCH
DATA ENTRY & DISPLAY ASSY
DISPLAY DATA
INSTRUCTIONS DATA FLOW
ABORT GUIDANCE SECTION
AOT
DIGITAL DOWN LINK DATA
SYNCH SIGNAL
SYNCH SIGNAL 1024 KPPS
GUIDANCE & NAVIGATION SUBSYSTEMS
BODY RATES
RGA (1)
800 AC & DC POWER TO C&D & CES
ATCA POWER SUPPLY
ATTITUDE & TRANSLATION CMD TO PRIMARY
PULSE MODE BODY ATTITUDE TO PRIMARY
ATCA
MANUAL ATTITUDE CMDS
MANUAL TRANSLATION CMDS
ACA (1)
T/TCA (1)
CONTROL ELECTRONI
VOICE KEYING
VOICE
MODE SELECT
ANT POSITION INDICATED
SWITCHING
VHF INFLIGHT ANTENNA NO.1
VHF INFLIGHT ANTENNA NO.2
PLSS TEST JACK
VHF SECTION
OPER MEAS
TO INSTR
EXP RECORDED DATA
RECEIVE
DIPLEXER
SEND
POWER AMPLIFIER ASSY
PA NO.2
PA NO.1
S-BAND INFLIGHT ANTENNA NO.1
S-BAND INFLIGHT ANTENNA NO.2
ROTARY JOINT GIMBALS & SERVO
S-BAND SECTION
COMMUNICATIONS SUBSYSTEM
SENSING)
CONTROLS & DISPLAYS
TAPE SELECT
MODE SELECT
DATA STORAGE ELECTRONICS ASSY
SEE NOTE 2
COND. DATA
SYNCH & TIMING SIGNALS
MODE SELECT
PCMTEA
EXPERIMENT INPUTS
EXPERIMENT SECTION
VSR
SEE NOTE 7
SYNCH SIGNAL 1.6 KPPS
DIGITAL DOWNLINK DATA
SYNCH SIGNAL
SYNCH SIGNAL 1024 KPPS
PC
LOW BIT RATE DATA
TIMING SIGNALS
NRZ DIGITAL DATA

47 (2)

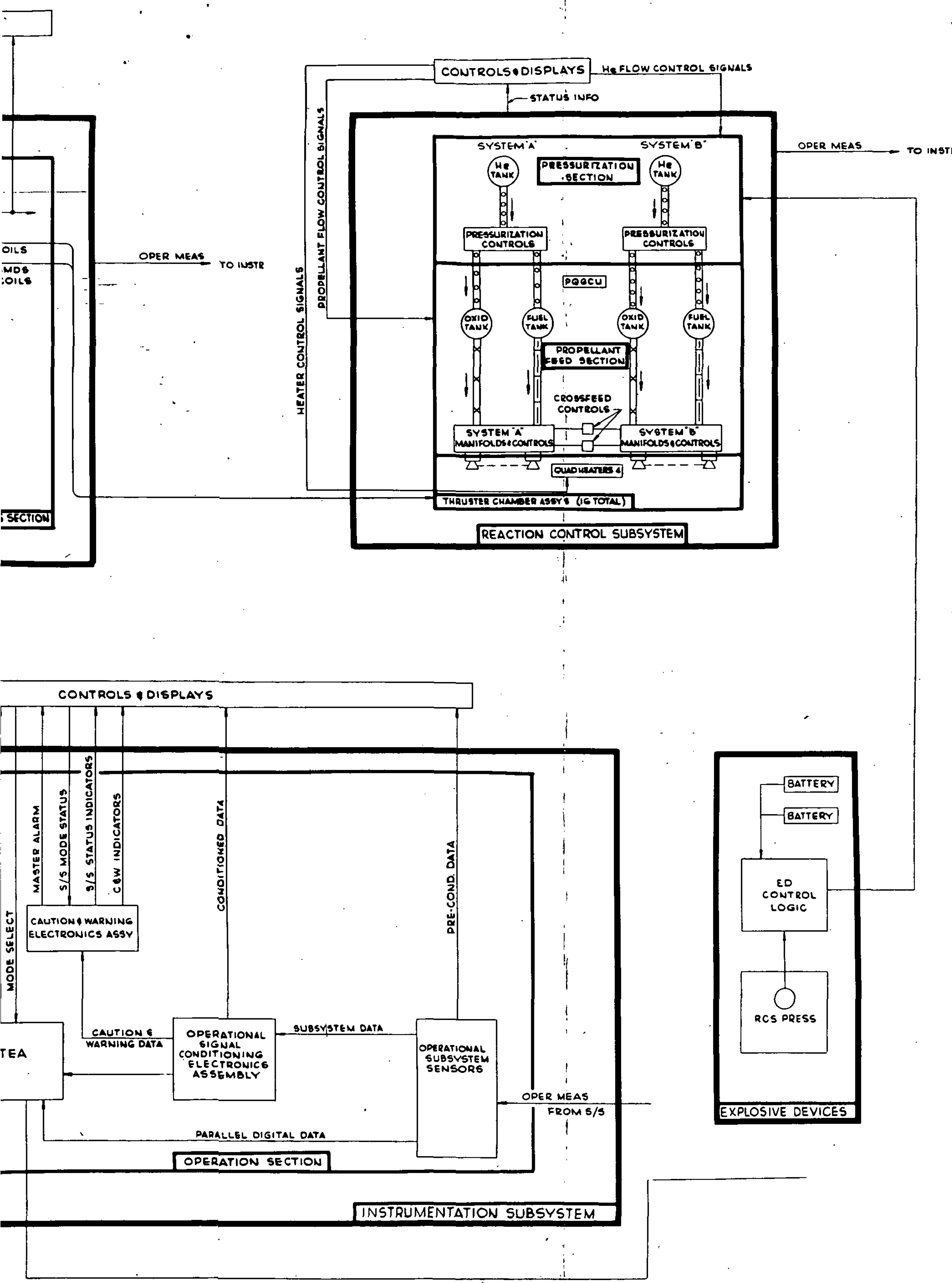
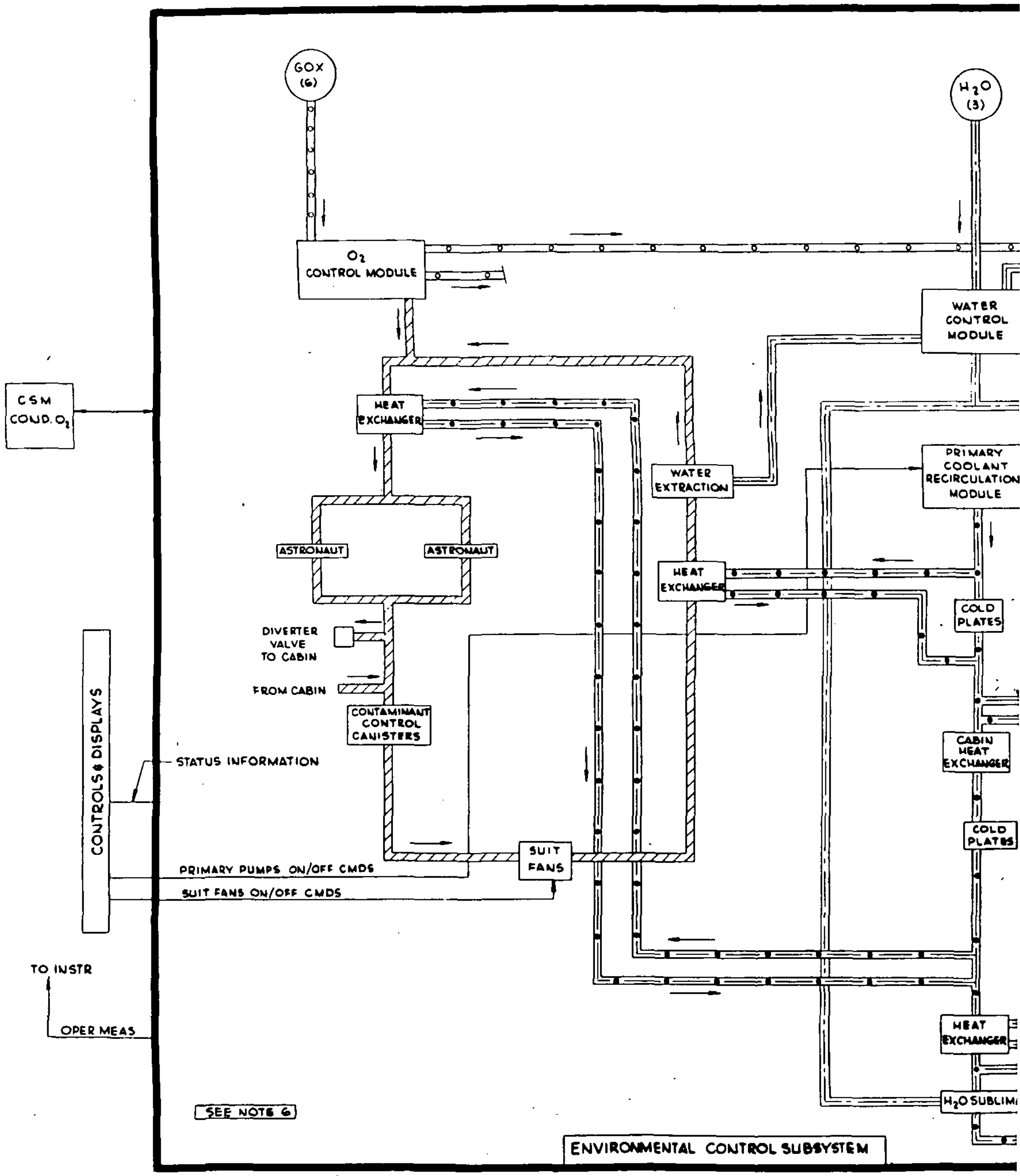
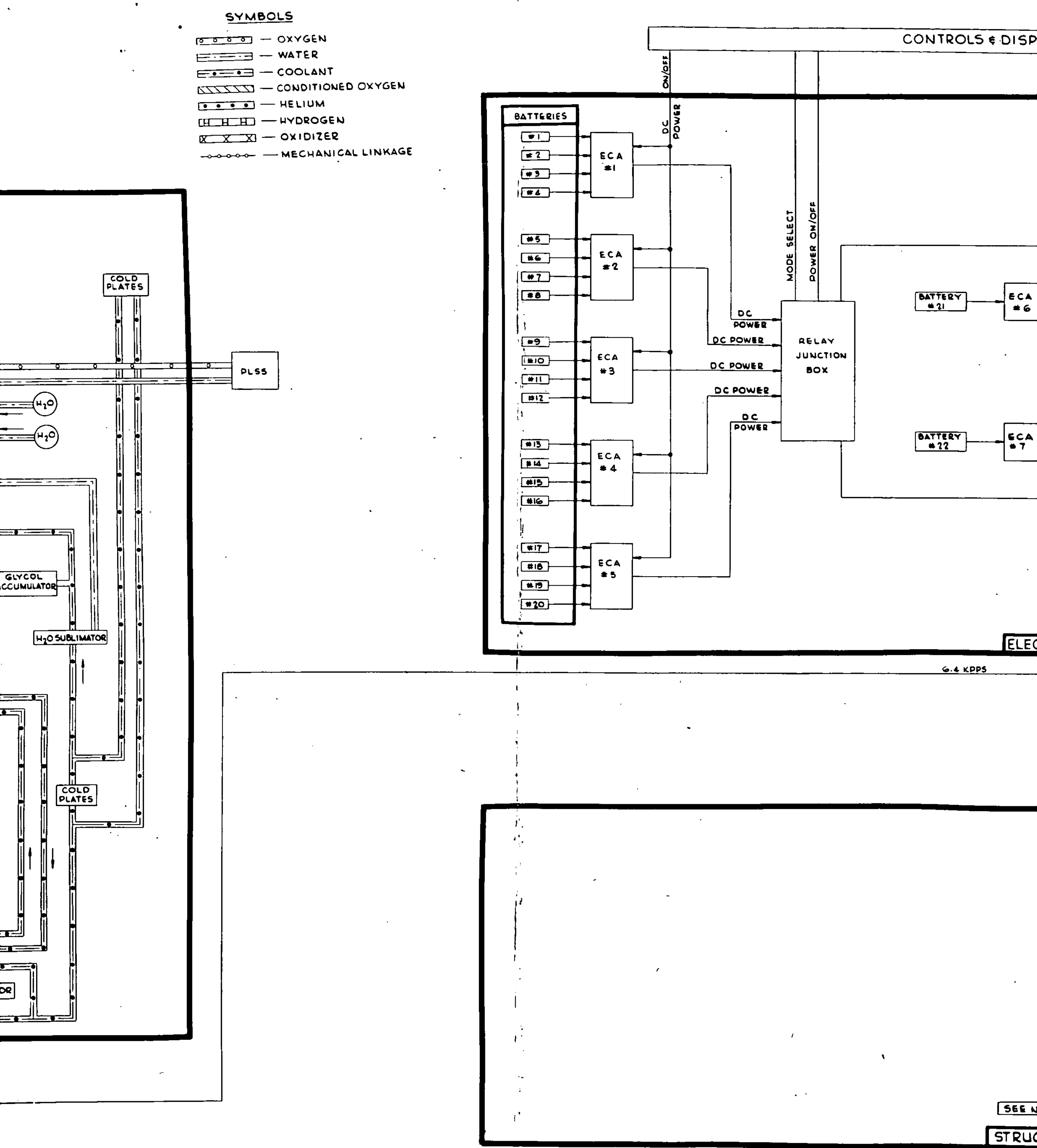


Fig. 10 Functional Diagram for Phase I Lab (Sheet 1 of 2)

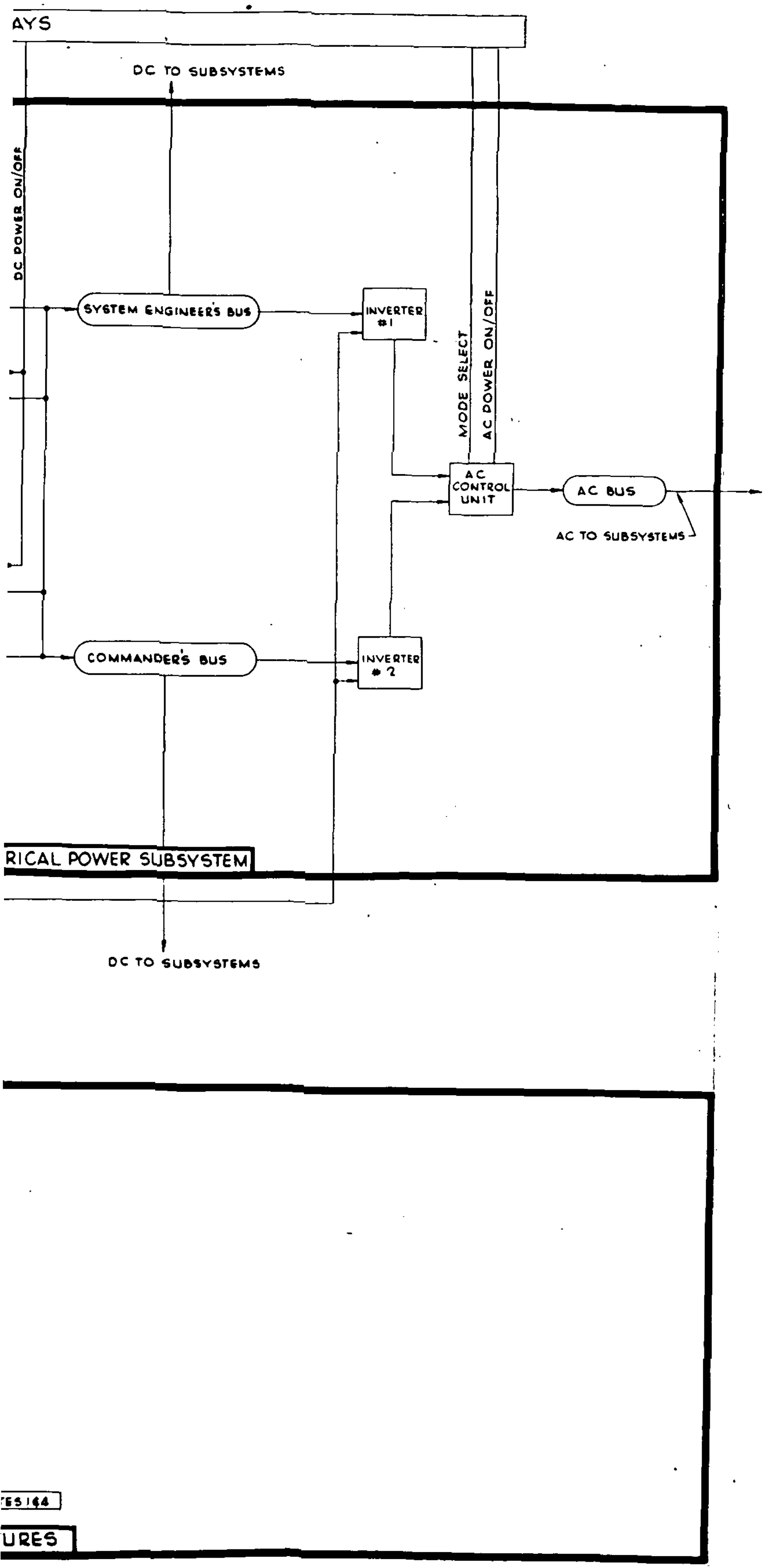


GOX (6)
H_2O (3)
O_2 CONTROL MODULE
WATER CONTROL MODULE
CSM COND. O_2
HEAT EXCHANGER
WATER EXTRACTION
PRIMARY COOLANT RECIRCULATION MODULE
ASTRONAUT
ASTRONAUT
HEAT EXCHANGER
COLD PLATES
DIVERTER VALVE TO CABIN
FROM CABIN
CONTAMINANT CONTROL CANISTERS
CABIN HEAT EXCHANGER
CONTROLS & DISPLAYS
STATUS INFORMATION
COLD PLATES
SUIT FANS
PRIMARY PUMPS ON/OFF CMDS
SUIT FANS ON/OFF CMDS
TO INSTR
OPER MEAS
HEAT EXCHANGER
SEE NOTE 6
ENVIRONMENTAL CONTROL SUBSYSTEM

48 (1)



SYMBOLS
— OXYGEN
— WATER
— COOLANT
— CONDITIONED OXYGEN
— HELIUM
— HYDROGEN
— OXIDIZER
— MECHANICAL LINKAGE
COLD PLATES
PLSS
H_2O
H_2O
GLYCOL ACCUMULATOR
H_2O SUBLIMATOR
COLD PLATES
OR
CONTROLS & DISP
ON/OFF
DC POWER
BATTERIES
#1
#2
#3
#4
#5
#6
#7
#8
#9
#10
#11
#12
#13
#14
#15
#16
#17
#18
#19
#20
ECA #1
ECA #2
ECA #3
ECA #4
ECA #5
MODE SELECT
POWER ON/OFF
DC POWER
DC POWER
DC POWER
DC POWER
DC POWER
RELAY JUNCTION BOX
BATTERY #21
BATTERY #22
ECA #6
ECA #7
ELEC
6.4 KPPS
SEE N
STRUC



NOTES

1. THIS IS A TENTATIVE FUNCTIONAL DIAGRAM OF THE AES PHASE I LAB.
2. THERE ARE (2) DATA STORAGE UNITS IN THE DSEA
3. THE AES PHASE I LAB MUST BE CAPABLE OF RETAINING THE FOLLOWING:
   STRUCTURES - BASE HEAT SHIELD, LOWER DECK INSULATION
   NAVIGATION & GUIDANCE - GDA, DECA, RENDEZVOUS RADAR, IMU, LGC, PTA, PSA, & CDU.
   DISPLAYS & CONTROLS - DSKY
4. LANDING GEAR IS COMPLETELY REMOVED.
5. ADDITIONS TO THE BASIC LEM CONFIGURATION FOR CREW PROVISIONS:
   (18) LIOH CARTRIDGES FOR BACKPACK, BATTERIES FOR (18) BACKPACK RECHARGES, FOOD FOR 13 DAYS, (26) CSM LIOH CARTRIDGES, EXTRA FLOOD LIGHTS, (21) CONSTANT WEAR GARMENTS, (2) WORK TOPS & WORK TOP LIGHTS, & (1) SEAT.
6. DELETIONS FROM THE BASIC LEM CONFIGURATION FOR CREW PROVISIONS:
   LUNAR SPECIMEN CONTAINERS, EVA LIFELINE, WATER PROBE & HOLSTER & (1) LIOH CANISTER.
7. CONTAINS (2) VSR'S (ONE SPARE).

ABBREVIATIONS

OPER - OPERATIONAL
MEAS - MEASUREMENTS
GOX - GASEOUS OXYGEN
SIMP - SIMPLEX
AOT - ALIGNMENT OPTICAL TELESCOPE
CMD(S) - COMMAND(S)
H_2O - WATER
O_2 - OXYGEN
C&D - CONTROLS & DISPLAYS
ATCA - ATTITUDE & TRANSLATION CONTROL ASSEMBLY
DECA - DESCENT ENGINE CONTROL ASSEMBLY
SYNCH - SYNCHRONIZATION
SIG - SIGNAL
VHF - VERY HIGH FREQUENCY
EXP - EXPERIMENT
ECA - ELECTRICAL CONTROL ASSEMBLY
DC - DIRECT CURRENT
AC - ALTERNATING CURRENT
CSM - COMMAND SERVICE MODULE
ANUN - ANNUNCIATOR
INFO - INFORMATION
VSR - VOICE STORAGE RECORDER
PLSS - PORTABLE LIFE SUPPORT SYSTEM
S/S - SUB-SYSTEM
He - HELIUM
IND - INDICATOR
C&W - CAUTION & WARNING
TCA - TRANSLATION CONTROL ASSEMBLY
ACA - ATTITUDE CONTROL ASSEMBLY
RGA - RATE GYRO ASSEMBLY
ASSY - ASSEMBLY
XMTR - TRANSMITTER
RCVR - RECEIVER
XCVR - TRANSCEIVER
PA - POWER AMPLIFIER
PM - PHASE MODULATION
FM - FREQUENCY MODULATION
ICS - INTERNAL COMMUNICATIONS SYSTEM
DSKY - DISPLAY KEYBOARD
INSTR - INSTRUMENTATION
CONT'S - CONTROLS
NRZ - NON RETURN TO ZERO
VOX - VOICE OPERATED SWITCH
CDU - COUPLING DATA UNIT
DUP - DUPLEX
EMU - EXTRA VEHICULAR MOBILE UNIT
PCM - PULSE CODE MODULATION
PSA - POWER SERVO ASSEMBLY

Fig. 10 Functional Diagram for Phase I Lab (Sheet 2 of 2)

3.4.1.1.1 (Continued)

(f) Provide adequate visibility for scientific observations during earth and lunar orbit.

(g) Provide functional continuity between descent stage and ascent stage subsystems by means of interstage umbilicals or solid connections.

3.4.1.1.2 The Descent Stage Section. - The Descent Stage Section shall perform the following:

(a) Serve as the support for the Lab I in the Spacecraft LEM Adapter (SLA).

(b) Provide support for all Descent Stage equipment.

(c) Provide support for the thermal and micrometeoroid shields.

(d) Provide passive thermal control of subsystems in the Descent Stage, except the Electrical Power Subsystem which shall be actively controlled.

(e) Provide protective shielding for critical Descent Stage subsystems from the meteoroid environment.

3.4.1.2 Design Requirements. -

3.4.1.2.1 Ascent Stage Structure Description. - The Ascent Stage Structure shall consist of a pressurized forward cabin, a pressurized aft cabin, and an external equipment bay. The Ascent Stage Structure shall be joined to the Descent Stage at four points. The Ascent Stage Structure shall withstand the environmental conditions encountered during all phases of the Lab I mission. The Ascent Stage structural design limit-load envelopes shall be established from the critical loads determined by the induced and natural environmental load conditions.

3.4.1.2.1.1 Forward Cabin Structure. - The Forward Cabin structural shell is cylindrical in shape and of semionocoque construction. It is a welded and mechanically fastened assembly of 2219 aluminum alloy sheet, chemilled to appropriate structural thickness, and machined longerons. The shell is supported by formed sheet metal rings of channel cross-section riveted to the structural skin. All mechanically fastened joints shall be sealed. The front face bulkhead is an assembly of integrally stiffened machined parts of 2219 aluminum alloy plate. Two near vertical beams support the bulkhead pressure loads and carry forward interstage loads. The front face bulkhead contains the forward hatch and the two crew windows. The forward windows are of dual pane construction. The inner pane is of structural glass and is designed to carry the cabin pressure loads imposed on it. The window is sealed with dual Roco seals, and is bolted to the structural window frame through an edge member bonded to the glass using sealing fasteners. Coatings are applied to reduce glare and reflections, and defogging provisions are incorporated. The outer pane is of glass, coated to limit thermal transmissions. The forward windows provide the visibility range from the design eye position. Anti-reflective coatings are used on the inner pane.

3.4.1.2.1.2 Aft Cabin Structure. - The structure of the Aft Cabin section consists of a ring stiffened semi-monocoque shell constructed similarly to the Forward Cabin. Integrally stiffened machined decks of 2219 aluminum alloy close off the Aft Cabin assembly at Lab stations +X294.643, and +Z233.500. The Aft Cabin shell is mechanically fastened to flanges on major structural bulkheads located at Lab stations +Z27 and -Z27. These bulkheads are integrally stiffened machined bulkheads of 2219 aluminum alloy plate. The Forward Cabin shell is mechanically fastened to the outboard flange of the +Z27 bulkhead to complete the assembly of the pressurized portion of the Ascent Stage structure. The upper deck (+294.643) provides structural support for the upper docking tunnel and contains the upper hatch. The -Z27 bulkhead contains provisions for the attachment of the tubular aft interstage structure.

3.4.1.2.1.3 External Equipment Bay Structure. - The external equipment bay is unpressurized and consists of the Electronic Replaceable Assembly Rack and its support structure. The rack consists of vertically oriented cold plates mounted in a structural frame. The frame is supported at its lower and upper edge by an arrangement of truss members supported on the -Z27 bulkhead.

3.4.1.2.1.4 Thermal and Micrometeoroid Shield. - The thermal and micrometeoroid shield shall be a composite of an outer sheet of aluminum and multiple layers of aluminized mylar mounted on low thermal conductance supports. The sheet of aluminum acts as a micrometeoroid bumper and will be varied in thickness to meet shielding requirements.

*3.4.1.2.1.5 Subsystem Support Structure. - The RCS propellant and helium pressurization tanks shall be modularized and mounted on each side of the aft cabin. The Alignment Optical Telescope (AOT) and the Navigation Base shall be located on the top center line of the cabin, outside of the pressure shell. The External Equipment Bay shall contain the cold plates for the mounting of the Electronic Replaceable Assemblies (ERA's), the Lab batteries and control assemblies, and the supports for the five ECS gaseous oxygen tanks. The four RCS thruster clusters are supported from the ascent stage primary structure.

3.4.1.2.1.6 Ascent Stage Hatch Mechanism. - The forward and upper hatches are hinged to the forward face bulkhead and upper aft cabin deck, respectively. Latches are provided to dog the hatches sufficiently to provide an initial seal. The final sealing force is supplied by the cabin pressure. The latches are operable from either side of the hatch. Both hatches contain a valve, operable from either side for de-pressurization of the cabin.

3.4.1.2.2 Descent Stage Structure Description. - The Descent Stage structure shall withstand the environmental conditions encountered during all phases of the Lab I mission. The Descent Stage structural design limit-load envelopes shall be established from the critical loads determined by the induced and natural environmentsl load conditions.

3.4.1.2.2.1 Descent Stage Structure. - The Descent Stage structure shall be of aluminum alloy and steel construction and shall consist of two pairs of parallel beams arranged in a cruciform shape with structural decks on upper and lower surfaces. The beam webs shall be located at ± Y27.00 and ± Z27.00. The upper deck shall be located at +X196.00. The lower deck shall be located at +X131.14. The ends of the beams shall be closed off by bulkheads at ± Z81.00 and ± Y81.00. At the ends of each pair of beams shall be a four legged truss to serve as support for the Lab I in the SLA. This truss shall be of aluminum alloy tubular construction. Aluminum alloy fittings shall be located on the -Z27.00 beam at ± Y65.00 to serve as the aft attachment points for the Ascent Stage. Aluminum alloy fittings shall be located on the ± Y27.00 beam at +Z65.906 to serve as the forward attachment points for the Ascent Stage.

3.4.1.2.2.2 Thermal and Micrometeoroid Shield. - The thermal shielding for the descent stage shall be a composite of outer micrometeoroid shield, thermal coatings, and multiple layers of aluminzed mylar mounted on low thermal conductance supports.

*3.4.1.2.2.3 Subsystem Support Structure. - The compartments formed by the Descent Stage structural arrangement shall house the equipment required by the subsystems.

3.4.1.2.2.3 (Continued)

The descent propellant tanks shall be located between the beams, the oxidizer tanks between the ± Y beams, and the fuel tanks between the ± Z beams. Three ECS water tanks shall be installed in the -Z, -Y quadrant (Quad II). The ECS gaseous oxygen tanks shall be installed in the -Z, +Y quadrant (Quad III). The Lab I batteries and the control assemblies shall be installed in the +Z, +Y quadrant (Quad IV) and on the end of bulkheads (4 places).

3.4.2 Electrical Power Subsystem (EPS). -

*3.4.2.1 Performance Requirements. - The Electrical Power Subsystem shall generate, distribute and control the total allowable electrical energy for the Lab I. The total available electrical energy shall be 274 kwh.

3.4.2.1.1 Electrical Power Characteristics. - Power characteristics sensed at the load shall be as follows:

(a) D-C Power - The d-c power shall be 28 vdc, two wire negative ground with the following characteristics:

(1) Steady-State Voltage Limits: 22 to 33 volts

(2) Transient Voltage Limits - (superimposed on 28 vdc)

a. Positive: 50 volts for ten microseconds at ten pps repetition rate for a period of five minutes.

b. Negative: 100 volts for ten microseconds at ten pps repetition for a period of five minutes.

(3) Ripple - As defined by Standard MIL-STD-704 except that the maximum sum of the peak a-c ripple and d-c voltage shall be 33.0 volts.

(b) A-C Power -

(1) Phases - Single phase

(2) Nominal Steady-State Voltage: 115 plus or minus two volts rms.

(3) A-C Voltage Transients - The a-c voltage shall recover to a minimum voltage of 144 volts peak or to a maximum voltage of 188 volts peak within 2.5 milliseconds, and return to steady-state conditions within 50 milliseconds, after experiencing an input line or load step change within the limits specified for line and load. Voltage spikes superimposed at any point to the sinusoidal waveshape shall not exceed ten volts peak. The maximum transient voltage at the output shall not exceed 225 volts peak.

3.4.2.1.1 (Continued)

(b) (Continued)

(4) Modulation: 2.5 volts single amplitude.

(5) Nominal Frequency Tolerance -

a. Normal: 400 plus or minus 4 cps (synchronized to master timing)

b. Free Running: 400 plus or minus 10 cps (loss of master timing)

(6) Waveshape - Sine wave

a. Maximum total distortion: 5 percent

b. Highest Harmonic: 4 percent

c. Crest Factor: 1.414 plus or minus 10 percent

*3.4.2.1.2 Power Profile. - The power profile shall be determined at a later date.

3.4.2.2 Design Requirements. - The EPS shall include the following major assemblies:

(a) Electrical control assembly

(b) Primary batteries

(c) Static inverters (general purpose)

(d) Power distribution equipment

*3.4.2.2.1 Electrical Control Assembly (ECA). - One ECA shall be provided for control of each ascent battery, and one ECA shall be provided for control of each set of four descent batteries. Each ECA

3.4.2.2.1 (Continued)

shall include the necessary electrical and electronic equipment for manual or automatic control of battery power output to the Lab I power distribution section. The ECA shall control battery "turn-on" or battery "turn-off". The ECA shall provide overcurrent and reverse current sensing and protection. The trip characteristics are to be determined.

*3.4.2.2.2 Batteries. - The primary source of electrical power shall be provided by 20 Descent Stage and two Ascent Stage silver-oxide-zinc batteries. Each Descent Battery shall supply 12.75 kwh and each Ascent Battery shall supply 9.5 kwh.

3.4.2.2.2.1 Battery Performance. - The Ascent and Descent Battery voltage shall be as follows:

(a) Maximum voltage: 32.5 volts, during all discharge.

(b) Nominal voltage: 30.0 volts

(c) Minimum voltage: 28.0 volts, during all discharge.

A low voltage tap will be used, if required, to enable the battery to achieve the above specified voltage requirements.

*3.4.2.2.2.1.1 Capacity. -

(a) Ascent Battery - The ascent battery shall have a capacity of not less than 425 ampere-hours when discharged at 2 amperes at 80° Fahrenheit. These requirements are based upon a minimum voltage of 28.0 volts.

(b) Descent Battery - The descent battery shall have a capacity of not less than 317 ampere-hours when discharged at 2 amperes at 80° Fahrenheit. These requirements are based upon a minimum voltage of 28.0 volts.

3.4.2.2.2.1.2 Parallel Operation. - The voltage requirements of 3.4.2.2.2.1 and 3.4.2.2.2.1.1 shall be satisfied when the Ascent and Descent Batteries are operated in parallel.

3.4.2.2.3 Static Inverters. - The two static inverters shall be solid state devices that convert 28 vdc (nominal) electrical power to 115 vac, single phase, 400 cps (nominal). Either inverter shall have the capability of supplying a-c power to its assigned loads with the other serving as a redundant standby unit.

3.4.2.2.3.1 Mounting. - The inverters shall be rigidly mounted.

3.4.2.2.3.2 Input Power. - Rated input voltage shall be 28 ± 4 vdc. The inverter shall operate but need not meet performance requirements when the input voltage falls below 20 vdc for five seconds or longer.

3.4.2.2.3.3 A-C Power Output Characteristics. -

(a) Voltage output: 117 volts rms, single phase, 400 cps.

(b) Steady-state voltage regulation: ± 1 percent at the a-c terminals of the mating connectors.

(c) Normal load requirements: 0 to 350 volt amps at power factors ranging from 0.65 lagging to 0.80 leading.

(d) Low power factor load requirements - Up to 120 volt amps at power factors ranging from 0.8 to 0.10 leading.

(e) A-C voltage transients - The a-c voltage shall recover to a minimum voltage of 144 volts peak or to a maximum voltage of 188 volts peak within 2.5 milliseconds, and return to steady-state conditions within 50 milliseconds, after experiencing an input line or load step change within the limits specified for line and load. Voltage spikes superimposed at any point of the sinusoidal waveshape shall not exceed ten volts peak. The maximum transient voltage at the output shall not exceed 225 volts peak.

(f) Frequency - Two modes of operation shall be provided:

(1) Externally synchronized mode - The frequency of the inverter shall be 400 ± 4 cps with an externally supplied synchronizing signal.

3.4.2.2.3.3 (Continued)

(f) (Continued)

(2) Free-running mode - In the absence of the external synchronizing signal the inverter shall maintain a free-running frequency of 400 ± 10 cps.

(e) Isolation - The a-c output shall be electrically isolated from the d-c input and from the case, except for the RFI feed-through capacitors which may be grounded to the case.

3.4.2.2.3.4 Overload. - The inverter shall provide up to 150 ± 5 percent of the maximum load requirements specified in 3.4.2.2.3.3 for a period of ten minutes. During the overload condition the inverter shall satisfy its performance requirements and shall incur no damage. The inverter shall automatically limit the output current to a maximum of 330 ± 10 percent of the maximum load requirements specified in 3.4.2.2.3.3 and shall be capable of withstanding this overcurrent condition for 20 seconds without damage and resuming normal operation when the overload is removed.

3.4.2.2.4 Power Distribution Equipment. - Power distribution shall be accomplished by a two wire grounded system for d-c loads and a single phase system for a-c loads. Wires and buses shall be employed as the return path for electrical currents, rather than the spacecraft structure. The system negative and neutral shall be grounded at one point only.

3.4.2.2.4.1 Load Grouping. - D-C electrical loads shall be connected to a common two section, electrically connected d-c bus. Provisions shall be made for disconnecting one section of the bus from the other in the event of a failure. Loads shall be grouped into two sections and in the event of a failure and subsequent disconnection of the busses, electrical power will continue to be supplied to the operating bus. A-C loads shall be supplied from a single a-c bus. The bus configuration shall be as shown in Figure 11.

3.4.2.2.4.2 Electrical Distribution Panels. - The distribution panels shall be adequately enclosed or otherwise protected to minimize hazards to the crew and provide maximum mechanical protection for the

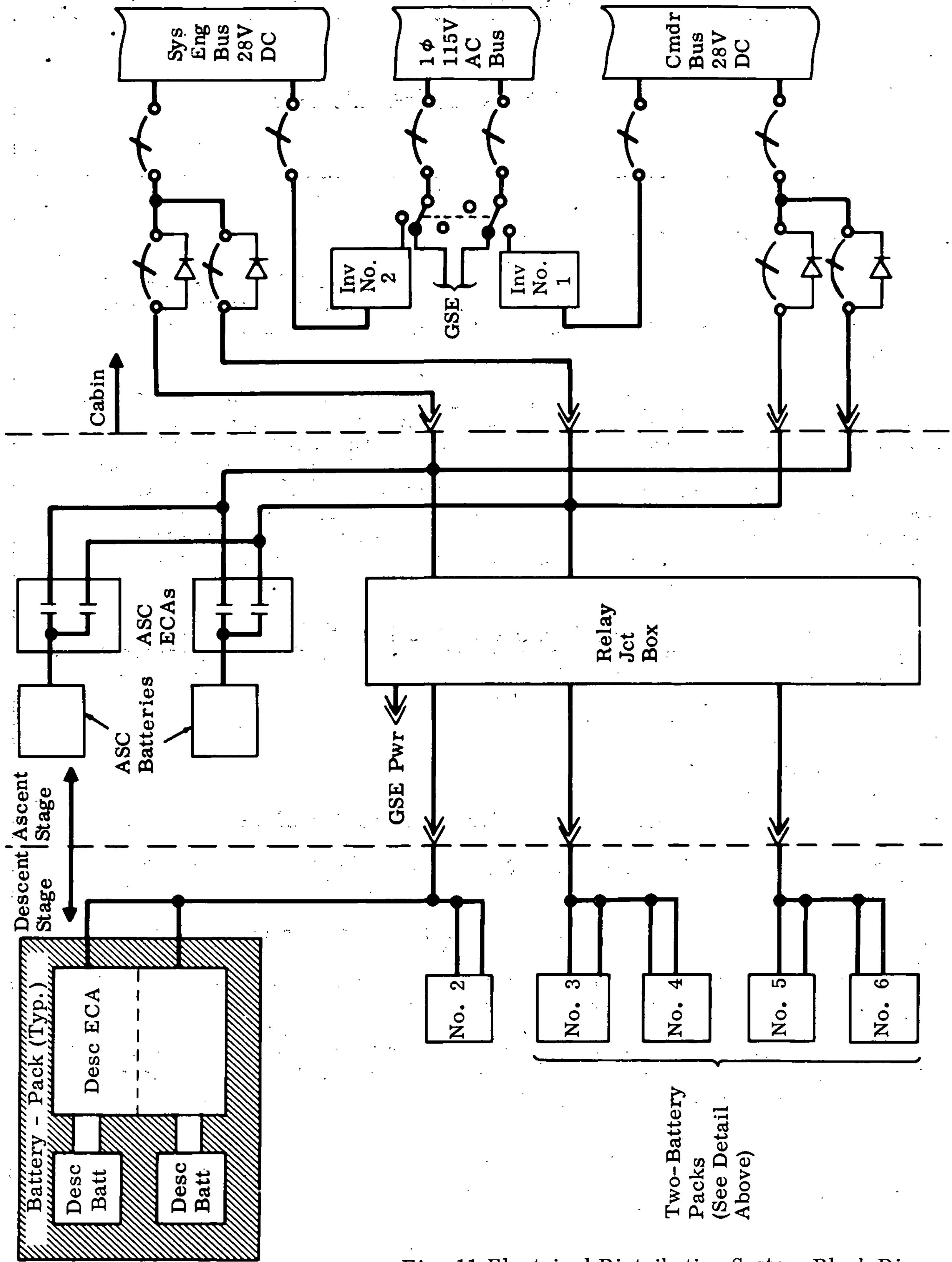


Fig. 11 Electrical Distribution System Block Diagram

3.4.2.2.4.2 (Continued)

electrical system and components. Switching and control shall be accomplished by manually operated circuit breakers or switches, except where use of a remotely controlled device will reduce weight or increase reliability.

3.4.2.2.4.3 Power Interruption Protection. - Buses and electrical loads shall be selectively protected such that individual load faults will not cause an interruption of power on the bus to which the load is connected. The bus shall be protected from a fault in a battery or its power feeder by the Electronic Control Assembly (ECA) and the tie-in control circuit. The bus ties connecting the divided busses shall be protected on either end by a circuit protective device. In the event of an interruption of power on the a-c bus, the loads shall be manually transferred to the standby inverter.

3.4.2.2.4.4 Power Distribution Equipment. - The power distribution equipment shall be capable of being energized by the following external power:

(a) DC: 27.5 to 32.5 volts

(b) AC: 115 volts nominal

3.4.3 Guidance, Navigation and Control Subsystem (GNCS). -

3.4.3.1 Subsystem Functions. - The GNCS shall provide the following functions:

*(a) Establish and update an inertially fixed reference triad.

*(b) Determine orientation of the vehicle body axis relative to an inertially fixed coordinate system.

(c) Maintain vehicle attitude within specified deadband limits about the vehicle roll, pitch and yaw axes. Deadband selection is not available on a per axis basis.

3.4.3.1 (Continued)

(d) Manual maneuvering capability about the vehicle roll, pitch and yaw axes either independently or in combination.

(e) Generate signals to the Reaction Control System (RCS) for implementation of stabilization and control.

3.4.3.2 Subsystem Operating Modes. - The GNCS shall be capable of providing two major modes of vehicle control:

(a) Automatic Mode.

(b) Attitude Hold Mode.

Three manual modes shall be available in each major mode:

(c) Two-Jet Direct Mode.

(d) Pulse Mode.

(e) Emergency Direct Mode.

An alignment mode shall be provided for updating the inertial reference.

*3.4.3.2.1 Automatic Mode. - This mode of operation shall automatically maintain the vehicle in an inertially fixed attitude once that attitude has been attained. Information shall be inserted into the GNCS indicating the desired orientation of the vehicle relative to the computational frame. The GNCS shall generate the appropriate signals to enable the RCS to effect appropriate attitude corrections. The GNCS shall automatically maintain the vehicle attitude within the specified deadband in the presence of attitude disturbances.

3.4.3.2.2 Attitude Hold Mode. - This mode of operation shall permit the vehicle to be maneuvered about the vehicle roll, pitch and yaw axes in response to manual inputs by means of an integrated hand controller. A vehicle rate proportional to hand controller displacement shall be commanded when the controller is moved out of the centered position, while attitude hold capability shall be provided when the

3.4.3.2.2 (Continued)

controller is centered. The command information from the hand controller shall be processed in the GNCS to generate the signals required by the RCS to effect the maneuver commanded. When the maneuver is completed and the hand controller is returned to its centered position, the GNCS shall maintain the final attitude attained. This attitude shall be maintained within the selected deadband limit.

3.4.3.2.3 Two-Jet Direct Mode. - The two-jet direct mode shall be a manual mode of both the automatic and attitude hold modes and shall be enabled on a per axis basis by the crew via a display and control panel. When in the two-jet direct mode, the automatic and attitude hold capability about the affected axis shall be disabled. Two-jet couples shall be activated by switches in the hand controller, which transmit signals directly to the RCS. These switches shall be activated when the controller is displaced by 2.5 degrees.

3.4.3.2.4 Pulse Mode. - The pulse mode shall be a manual mode of both the automatic and attitude hold modes and shall be enabled on a per axis basis by the crew via a display and control panel. When in the pulse mode, displacement of the hand controller 2.5 degrees from the detent position shall cause signals to be transmitted by the GNCS to the RCS. The automatic or attitude hold capability about the affected axis shall be disabled.

3.4.3.2.5 Emergency Direct Mode. - The emergency direct mode shall be a manual mode of both the automatic and attitude hold modes and shall provide a means for manual override of the automatic and attitude hold functions. It shall be available for each of the three vehicle axes by means of the hand controller. Moving the hand controller to the "hardover" position shall disengage the automatic or attitude hold functions about all three vehicle axes. Signals shall also be transmitted directly to the RCS to command the four jet couples.

3.4.3.2.6 Alignment Mode. - The alignment mode shall provide for initialization and updating of the GNCS.

3.4.3.3 Subsystem Performance. -

*3.4.3.3.1 Guidance and Navigation. - The guidance and navigation function of the Lab I baseline configuration shall be limited to the generation of the attitude reference required for the inertial attitude hold capability within the specified deadband. Included in this attitude hold function is the capability for holding the body axis attitudes existing at a selected time.

(a) The inertial reference coordinate system shall be TBD.

(b) The GNCS shall have the capability of aligning to the inertial reference system triad within 12.0 arc minutes maximum per axis.

(c) Deadbands of ± 0.3 and ± 5.0 degrees nominal shall be provided.

(d) The maximum vehicle rate which the GNCS shall sense shall be TBD degrees per second.

(e) The GNCS attitude reference drift rate shall be equal to or less than 1.1 degree per hour per axis over a 30 day period without restriction on duty cycle.

*3.4.3.3.2 Stabilization and Control. - The stabilization and control performance requirements are defined in terms of acceleration characteristics, limit cycle period, number of thruster operations and response requirements. These requirements are specified parametrically as follows:

(a) Vehicle angular acceleration performance as a function of its inertia shall be as indicated in Figure 12.

(b) Normal limit cycle period as a function of control system deadband shall be as indicated in Figure 13.

(c) Vehicle disturbed limit cycle period and thruster operations as a function of the disturbance torques shall be as indicated in Figure 14.

3.4.3.3.2 (Continued)

(d) Time to attain a commanded manuever rate as a function of vehicle inertia shall be as indicated in Figure 15.

(e) Time to attain zero rate as a function of vehicle inertia shall be as indicated in Figure 16.

NOTE: The performance specified above is based on the following RCS characteristics.

(1) Thruster minimum impulse shall be 0.75 pound seconds.

(2) Thruster minimum specific impulse shall be 130 pound seconds.

(3) Thruster maximum thrust level shall be 100 pounds.

(4) Roll and pitch axis moment arms shall be 5.5 feet.

(5) Yaw axis moment arm shall be 5.12 feet.

(6) Rotations shall be accomplished with 2 jet couples.

*3.4.3.4 GNCS Design. - The GNCS shall be composed of the following sections:

(a) Abort Guidance Section (AGS) - The AGS shall establish the inertial reference axis system and generate the attitude error signals required by the Control Electronics Section (CES).

(b) Control Electronics Section (CES) - The CES shall generate the signals required by the RCS to fire the jets for stabilization and control.

(c) Government Furnished Equipment (GFE) Section - The GFE section shall contain the alignment optical telescope (AOT) to provide the means for aligning the AGS to an inertial reference system, and the navigation base for equipment mounting to the vehicle.

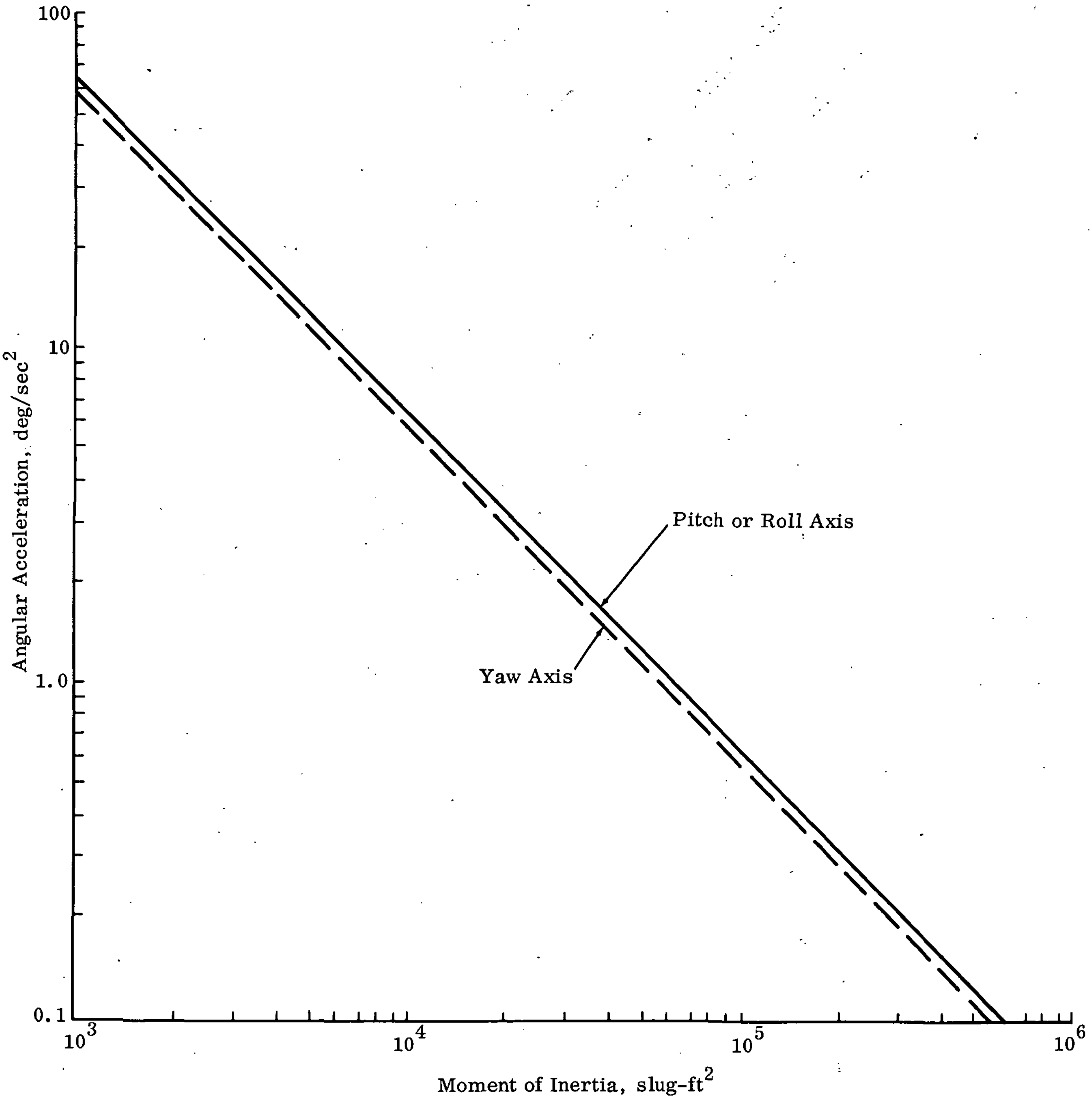


Fig. 12 Angular Acceleration Capability vs. Moment of Inertia

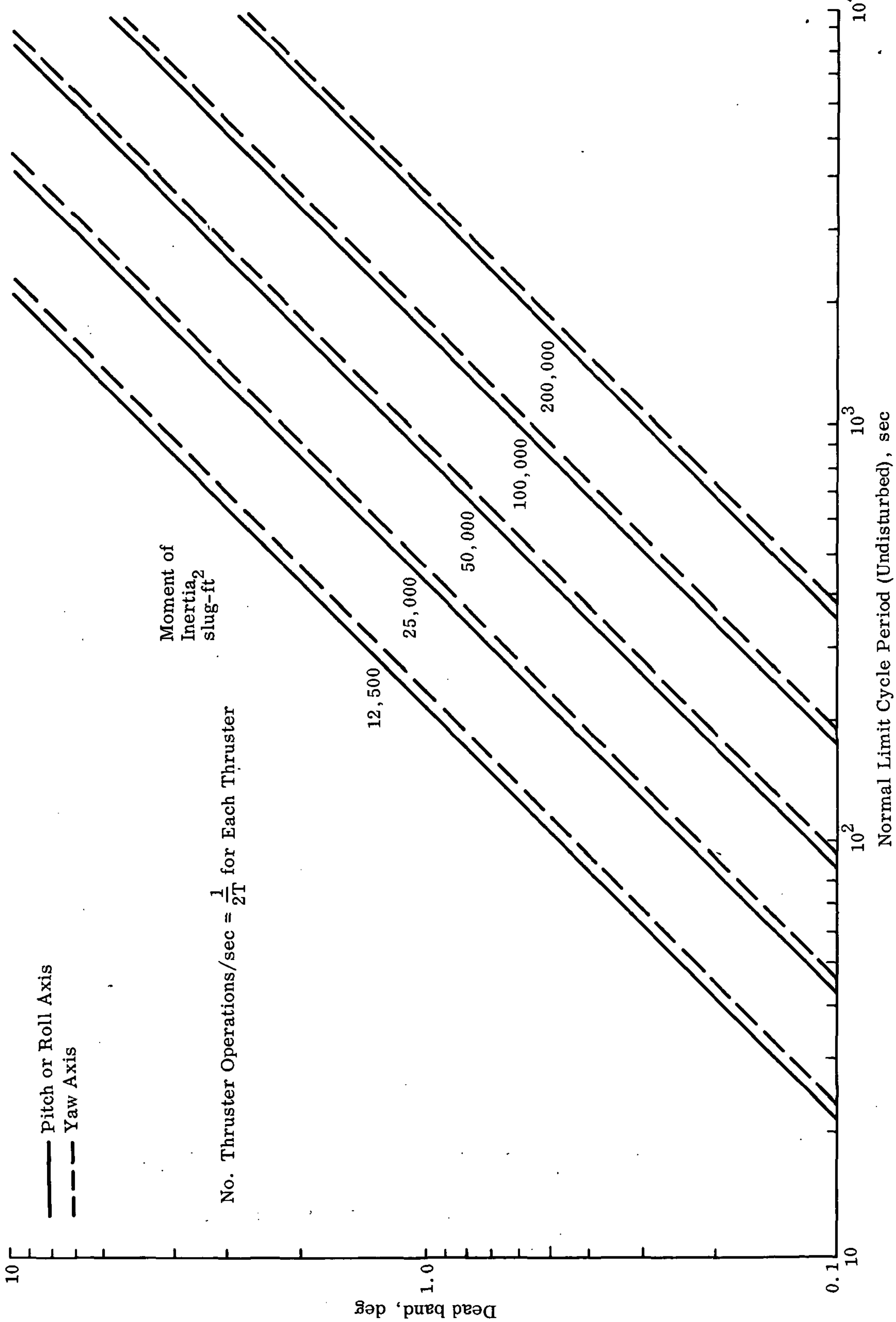


Fig. 13 Normal Limit Cycle Period vs. Control System Deadband

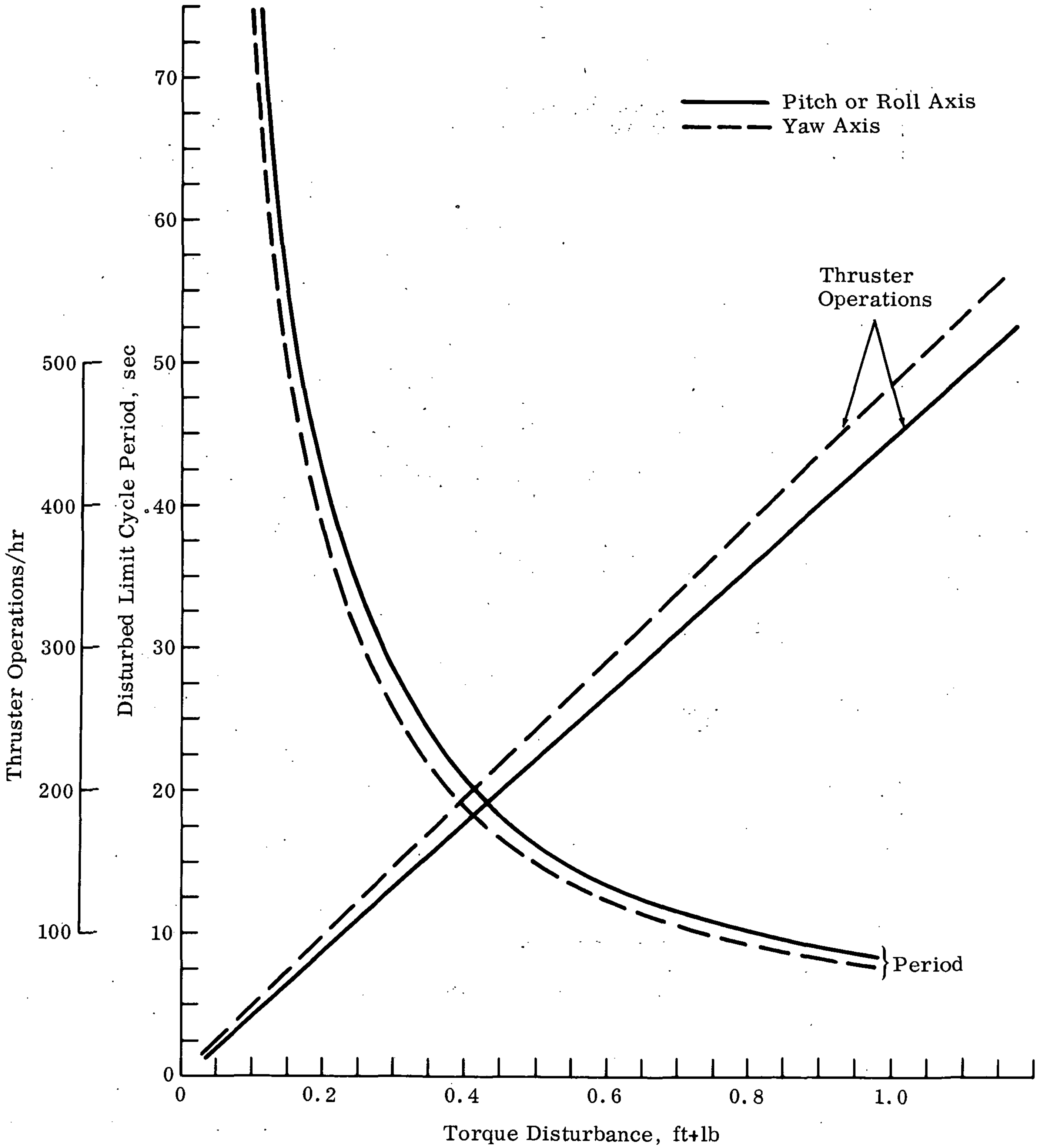


Fig. 14 Disturbed Limit Cycle Period vs. Disturbance Torque

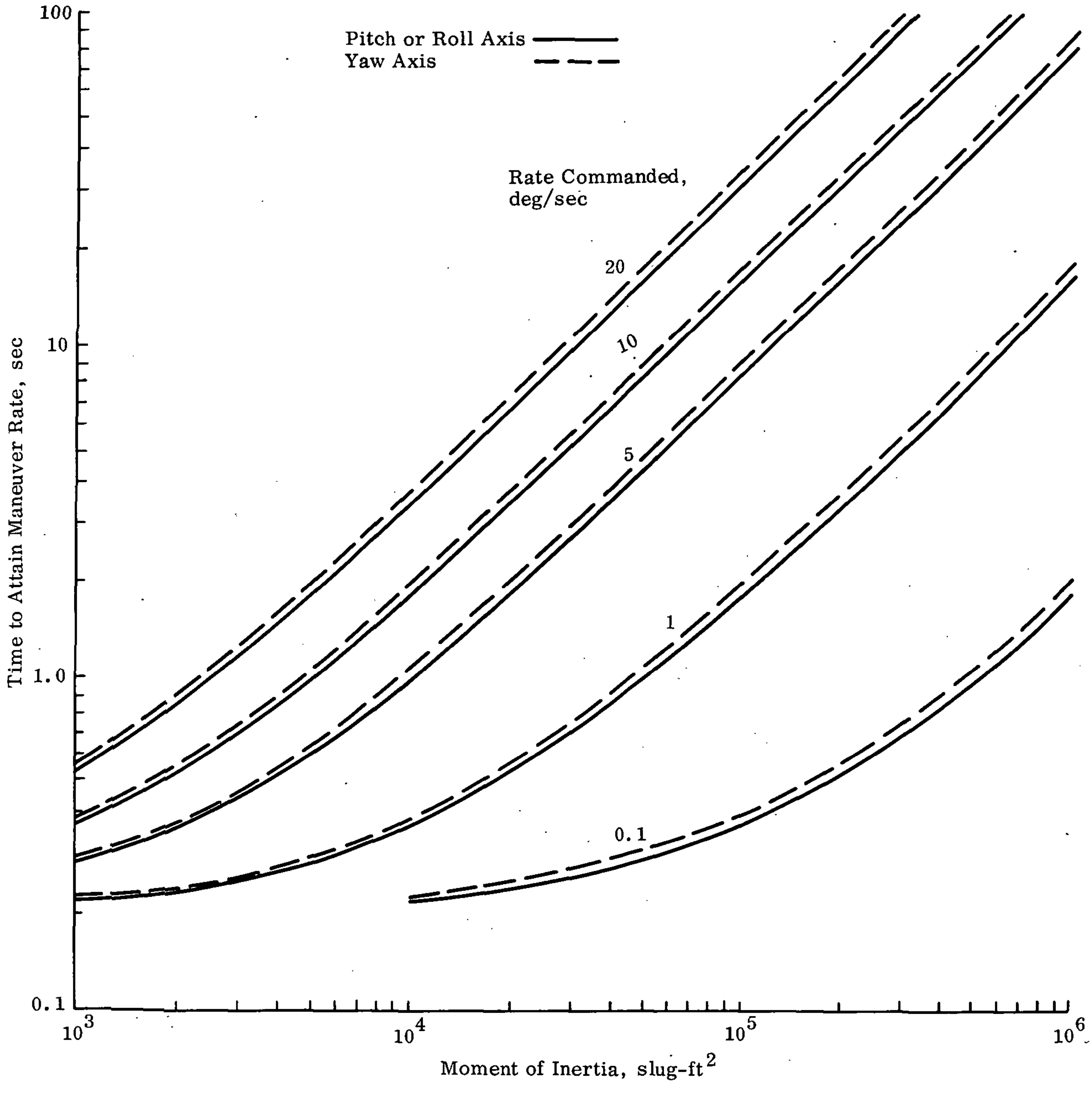


Fig. 15 Response Characteristics; Time to Attain Commanded Rate vs. Moment of Inertia

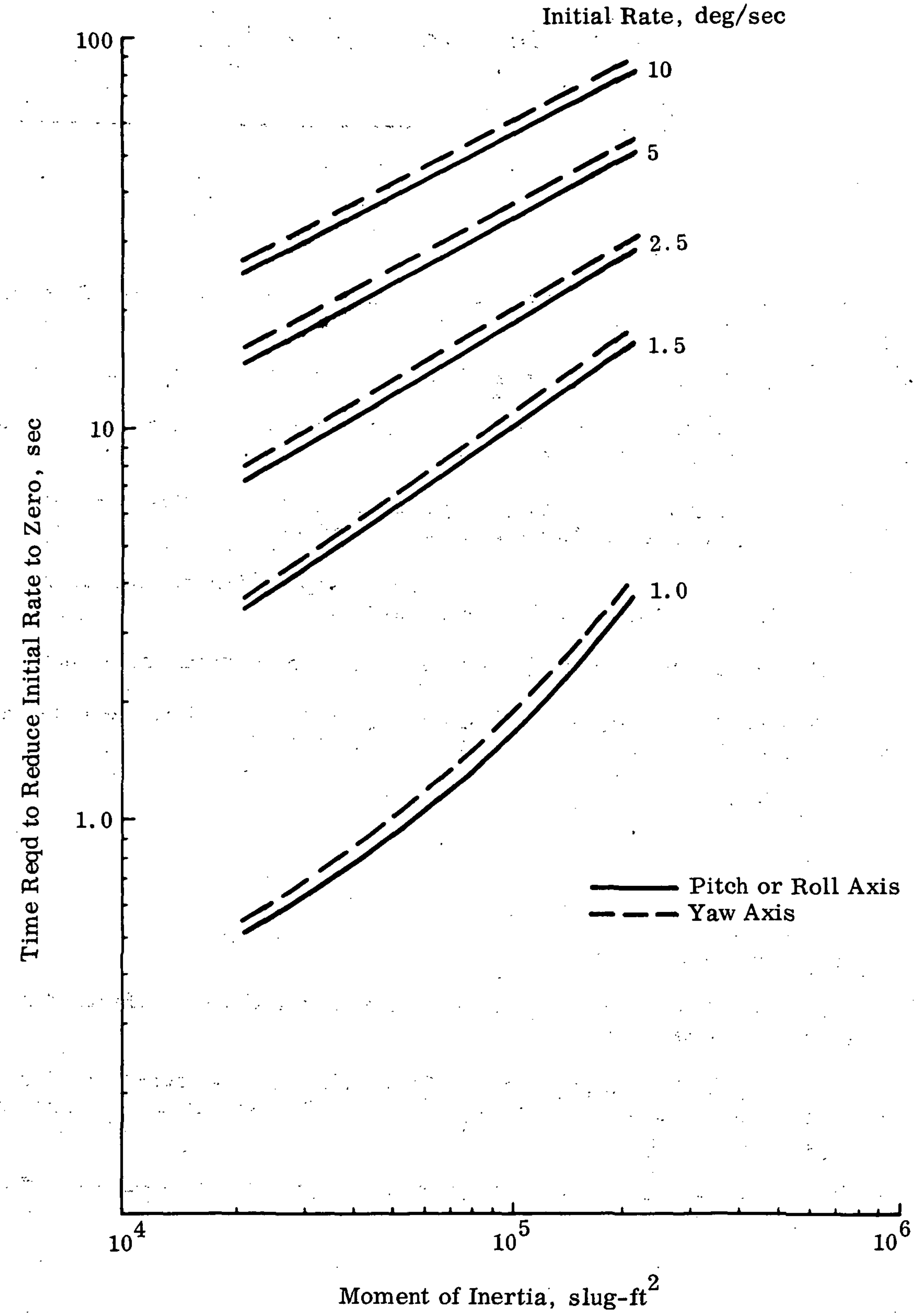


Fig. 16 Response Characteristics; Time to Reduce Initial Rate to Zero vs. Moment of Inertia

3.4.3.4.1 AGS. -

*3.4.3.4.1.1 AGS Functions. - The AGS shall be capable of performing the following functions:

(a) Establish and update a fixed inertial reference triad.

(b) Provide attitude steering signals to maintain a desired vehicle inertially fixed attitude.

(c) Provide attitude error signals to maintain a fixed vehicle attitude during non-maneuvering periods.

(d) Provide total attitude signals for operation of the Flight Director Attitude Indicator (FDAI).

(e) Accept input data for establishing the inertial reference.

3.4.3.4.1.2 AGS Modes of Operation. - The AGS shall be capable of performing in four major modes of operation as follows:

(a) Warm-Up

(b) Standby

(c) Alignment

(d) Inertial Reference

3.4.3.4.1.2.1 Warm-Up Mode. - This mode shall be available for warm-up of the AGS assemblies.

3.4.3.4.1.2.2 Standby Mode. - This mode shall be available for operation before the alignment or inertial reference modes are engaged. It shall be utilized to:

(a) Provide excitation and power for appropriate assemblies within the AGS.

3.4.3.4.1.2.2 (Continued)

(b) Allow "degraded operation" in the alignment or inertial reference modes after a 10 minute period. All of this period may be spent in the standby mode or 5 minutes of it may be spent in the warm-up mode.

(c) Provide the capability of entering the AGS alignment mode after a 35 minute period. If 25 minutes or more are spent in the warm-up mode, an additional 20 minutes shall be spent in the standby mode before the AGS alignment mode can be initiated.

*3.4.3.4.1.2.3 Alignment Mode. - The AGS shall be capable of providing two sub-modes of alignment:

(a) Stellar Alignment Sub-mode - This sub-mode shall be used when it is desired to establish and update a predetermined stellar reference. The AGS shall accept initial conditions and star data inserted via the Data Entry and Display Assembly (DEDA).

(b) Body Axes Alignment Sub-mode - This sub-mode shall be used when an arbitrary reference is required for vehicle stabilization. It shall enable the axes of the reference triad to be coincident with the vehicle body reference axes.

*3.4.3.4.1.2.4 Inertial Reference Mode. - The AGS shall be capable of operating in these sub-modes of the inertial reference mode. These sub-modes are as follows:

(a) Automatic - In the automatic sub-mode, the AGS shall provide error signals to the CES which cause the vehicle to hold a desired orientation with respect to a reference triad.

(b) Attitude Hold - In the attitude hold sub-mode, the AGS shall provide error signals to the CES which cause the vehicle to hold an existing attitude or the attitude resulting from a manually controlled maneuver.

(c) Follow-Up - In the follow-up sub-mode the AGS error signals to the CES shall be zero. This mode shall be activated by an out of detent signal from the Attitude Controller Assembly (ACA).

3.4.3.4.1.3 AGS Performance. - The AGS shall be capable of the following performance:

3.4.3.4.1.3.1 Operating Life. - A minimum operating life of 5000 hours with scheduled maintenance and a minimum shelf life of 5 years shall be provided.

3.4.3.4.1.3.2 Calibration Requirements. - AGS performance parameters which cannot be adjusted without hardware modification or removal of the AGS from the Lab I, shall maintain their specified values after calibration while accruing up to 1000 hours of operating time over a period of 120 days.

3.4.3.4.1.3.3 Loss of Reference. - The AGS shall not cause the accumulation of a permanent loss of reference greater than 0.0005 degree per net degree of vehicle rotation about any axis for vehicle rates up to and including TBD degrees per second.

3.4.3.4.1.4 AGS Assemblies. -

*3.4.3.4.1.4.1 Abort Sensor Assembly (ASA). - The ASA shall sense vehicle attitude changes about the pitch, roll and yaw axes.

(a) Sense minimum attitude changes of TBD degrees.

(b) Sense attitude changes at a maximum vehicle rate of TBD degrees per second.

*3.4.3.4.1.4.2 Abort Electronics Assembly (AEA). - The AEA shall consist of a 4096 word memory digital computer which shall perform the following functions:

(a) Establish an inertial reference coordinate system based on input star data.

(b) Generate attitude steering signals for both the automatic and attitude hold modes.

3.4.3.4.1.4.3 Data Entry and Display Assembly (DEDA). - The DEDA shall provide the following functions:

(a) Manual engagement of warm-up, standby, alignment or inertial reference modes of operation.

(b) Manual insertion of star information or coordinate data into the AEA.

(c) Permit the crew to command contents of a desired AEA memory word location to be displayed on the DEDA.

3.4.3.4.2 GFE Section. -

3.4.3.4.2.1 Alignment Optical Telescope (AOT). -

3.4.3.4.2.1.1 AOT Description. - The AOT shall be a unity power side field telescope with an adjustable reticle. It shall be capable of scanning a 60 degree field of view about the AOT center line. The AOT center line shall be inclined 45 degrees to the vehicle X axis and shall have the capability of being positioned in a center position or 60 degrees left or right of the center position.

3.4.3.4.2.1.2 AOT Functions. - The AOT shall provide line of sight information of target stars relative to the reference body axis system.

3.4.3.4.2.2 Navigation Base. - The navigation base shall be identical to the LEM-GFE navigation base and shall provide the mounting surface for the AOT and the ASA.

3.4.3.4.3 Control Electronics Section (CES). -

3.4.3.4.3.1 CES Functions. - The CES shall be capable of performing the following functions:

(a) Manual command of vehicle attitude changes.

(b) Generate pulse-ratio modulation signals for effecting proportional rate control.

3.4.3.4.3.1 (Continued)

(c) Provide the jet logic for selection of optimum jets for attitude control.

(d) Limiting the maximum rates about the vehicle roll, pitch and yaw axes in the automatic and attitude hold modes only.

(e) Accept input signals from the AGS to effect vehicle attitude maneuvering stability.

(f) Transmit signals to the RCS for vehicle stability and control.

(g) Sense vehicle rates about the roll, pitch and yaw axes.

(h) Generate vehicle rate information for the FDAI error needles.

3.4.3.4.3.2 <u>CES Operating Modes</u>. - The CES shall be capable of performing in two major modes of operation:

(a) Automatic Mode.

(b) Attitude Hold Mode.

Three manual modes shall be available in each major mode:

(c) Two-Jet Direct Mode.

(d) Pulse Mode.

(e) Emergency Direct Mode.

The above modes of operation are described in 3.4.3.2.

*3.4.3.4.3.3 <u>CES Performance</u>. -

(a) <u>Deadband Limits</u> - The CES shall generate signals to the RCS to control the vehicle within a deadband of $\pm$ 0.3 degrees or $\pm$ 5 degrees nominally.

(b) <u>Operating Life</u> - TBD.

*3.4.3.4.3.3.1 Attitude Controller Assembly (ACA). - The hand attitude controller shall contain the equipment necessary to accomplish the following functions:

(a) Transmit signals to the Attitude Translation Controller Assembly (ATCA) proportional to controller displacement for the attitude hold mode.

(b) Generate signals received by the ATCA to command pulse jet operation.

(c) Generate signals for two-jet direct operation after 2.5 degrees displacement.

(d) Generate signals for four-jet direct operation after TBD degrees displacement.

(e) Whenever the attitude hand controller is out of detent, the three axes information shall be used in the accomplishment of the follow-up mode.

3.4.3.4.3.3.2 Thrust and Translation Controller Assembly (TTCA). - The hand translation controller shall provide the signals required by the CES to command RCS operation for translation of the vehicle.

*3.4.3.4.3.3.3 ATCA. - The ATCA shall perform the following operations:

(a) Generate the signals required by the RCS to implement the vehicle stabilization and control requirements.

(b) Accept rate feedback signals from the Rate Gyro Assembly (RGA) for stabilization when in the automatic or attitude hold mode.

(c) Limit commanded attitude rates to a maximum of TBD degrees per second in the pitch axis and TBD degrees per second in the roll and yaw axes.

(d) Regulate RCS thruster commands such that the number of jet operations is minimized and the frequency of jet operations is less than TBD pulses per second in the undisturbed limit cycle.

(e) Accept attitude error signals from the AGS.

*3.4.3.4.3.3.4 RGA. - The RGA shall perform the following functions:

(a) Sense vehicle rates equal to or greater than TBD degrees per second about the pitch, roll and yaw axes.

(b) Sense a maximum rate of TBD degrees per second in the positive and negative directions in all axes.

(c) Generate signals which shall be used to rate damp the attitude control loop.

3.4.3.4.4 Display and Control Functions. - The displays and control panel shall provide the following capabilities:

(a) Means for engaging automatic or attitude hold modes.

(b) Means for selecting a 0.3 degree or a 5.0 degree limit cycle.

(c) Means for selecting two-jet or pulse operation about the roll, pitch and yaw axes on a per axis basis.

(d) Means for checking the operation of the RGA.

3.4.4 Reaction Control Subsystem (RCS). - The RCS shall consist of the following:

(a) Two independent helium pressurization sections.

(b) Two independent positive expulsion propellant supply and distribution sections with crossfeed capability.

(c) Sixteen reaction control rocket engines.

(d) A propellant quantity gaging section.

3.4.4.1 Performance Requirements. - The RCS shall provide the impulse for three axis rotational attitude hold control of the Lab I during all flight mission phases, and shall operate in a zero gravity environment.

3.4.4.1.1 Helium Pressurization Sections. - Helium at regulated pressure shall be distributed to the propellant tanks for positive expulsion of propellants through the assembly components and tubing.

3.4.4.1.2 Propellant Section. - The propellant shall be furnished to the engine for steady-state operation at a dynamic pressure of 170 ± 10 psia.

3.4.4.1.3 Rocket Engine. - The RCS engine shall have the following performance characteristics:

(a) Thrust - The rocket engine shall develop a continuous operating thrust of 100 ± 5 lb, in a vacuum.

(b) Thrust Transient Rate - The rocket engine shall demonstrate a thrust buildup and thrust decay as shown in Figure 17.

(c) Specific Impulse - For operating periods in excess of one second, the specific impulse shall be 294 seconds nominal. Specific impulse for pulse mode operation shall be as shown in Figure 18.

(d) Minimum Impulse - The engine shall provide a minimum impulse of 0.4 plus or minus 0.2 pound seconds during vacuum operation with an electrical input signal (pulse width) of 12.5 milliseconds.

(e) Reliable Operating Life - Following acceptance tests, the engine shall have a minimum reliable life of 1000 seconds operating life without deterioration. The engine shall be capable of continuous operation for a period of 500 seconds. The engine shall withstand a minimum of 10,000 operational cycles during the 1000 second operating life.

3.4.4.1.4 Propellant Quantity Gaging Section. - The propellant quantity gaging equipment shall determine the quantity of propellants in the positive expulsion tanks and shall be functional while the vehicle is exposed to a zero gravity environment.

3.4.4.2 Design Requirements. -

3.4.4.2.1 Propellant and Pressurant. - The propellant shall consist of nitrogen tetroxide (N_2O_4) oxidizer and a mixture of 50 percent hydrazine (N_2H_4) and 50 percent unsymmetrical dimethylhydrazine (UDMH) as fuel. Pressurant shall be helium (H_e)

3.4.4.2.2 Helium Pressurization Sections. - Each independent pressurization section shall consist of a high pressure helium supply, contained in one spherical titanium tank, and associated pressure regulation and distribution assembly.

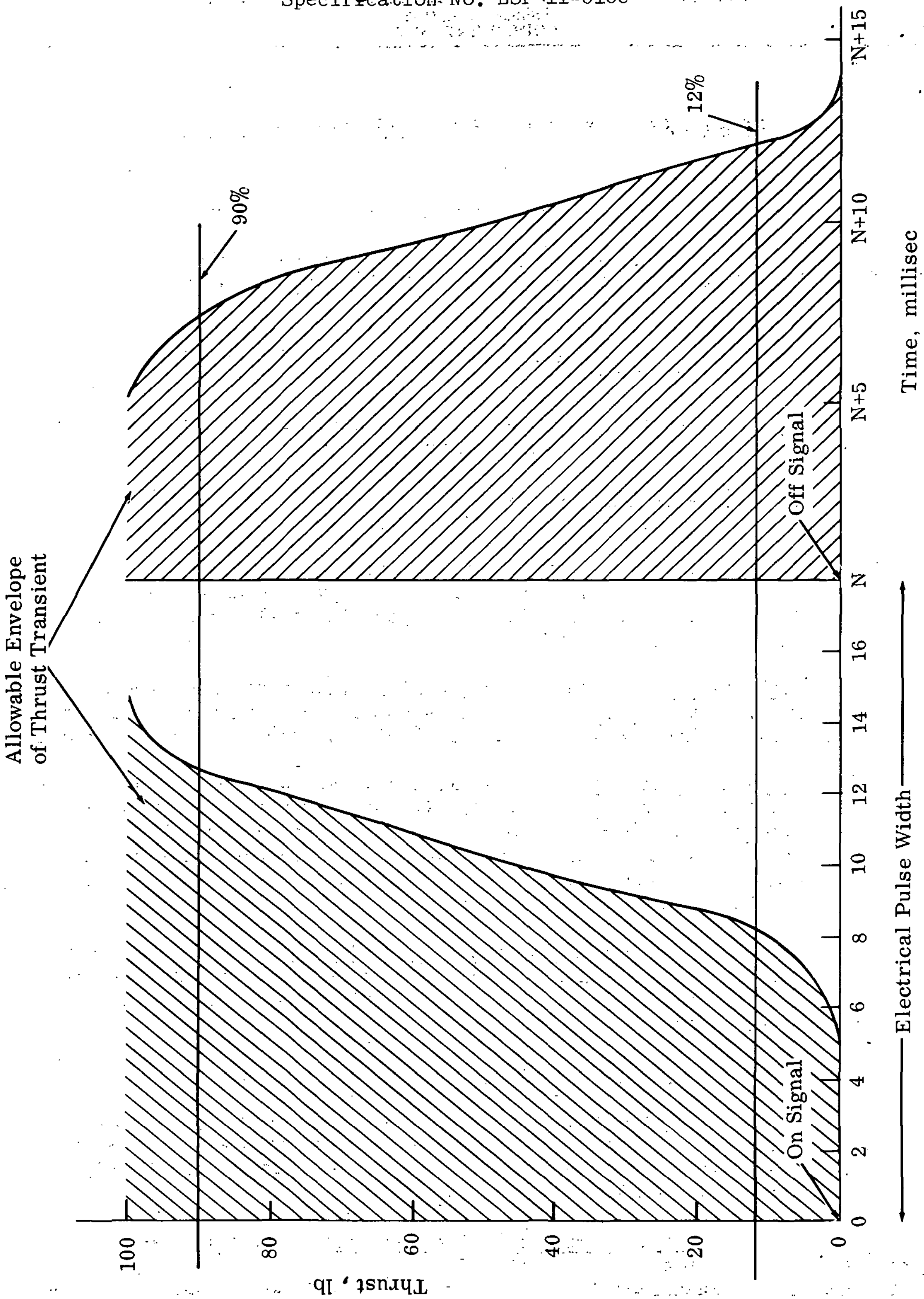


Fig. 17 Thrust vs. Time

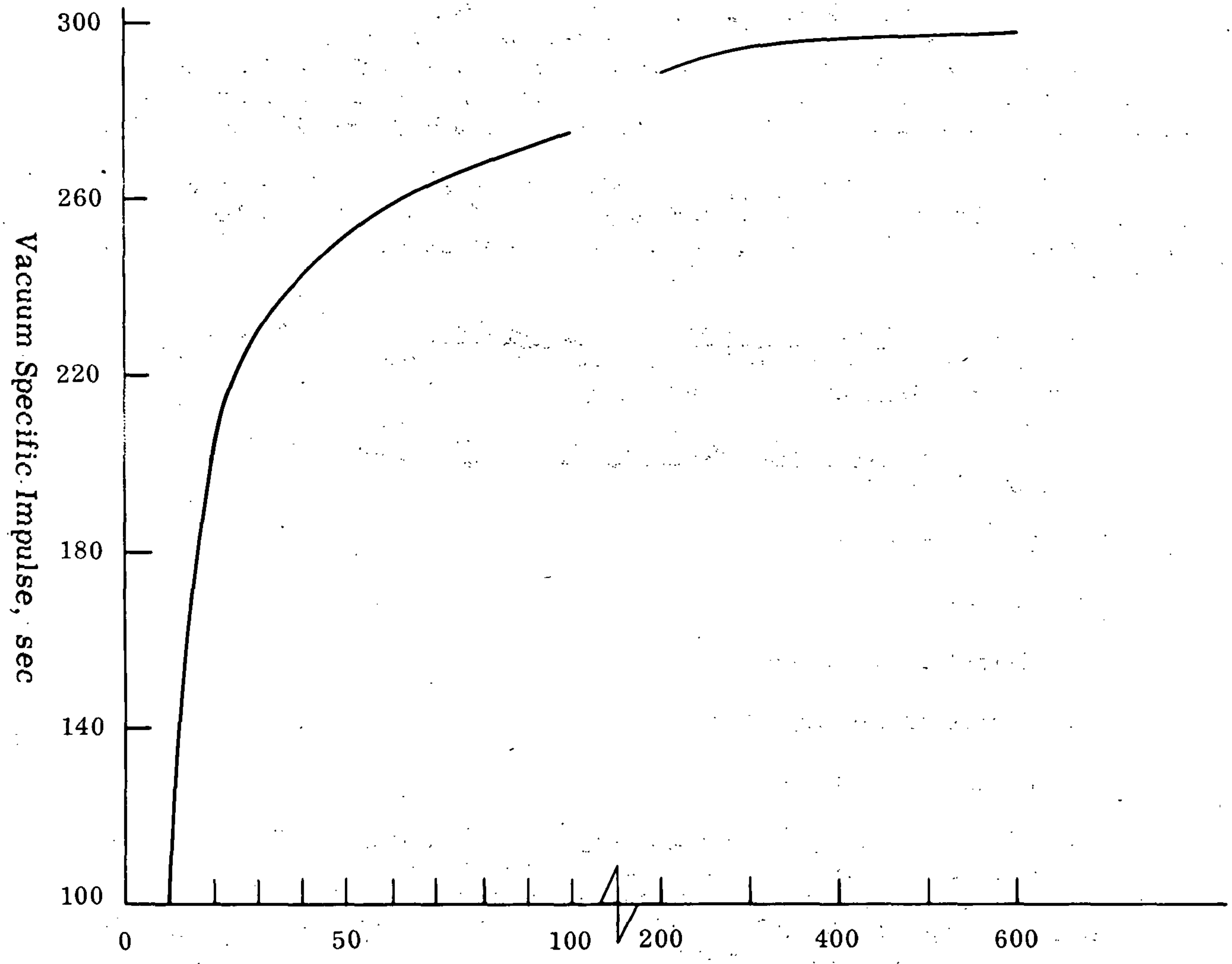


Fig. 18 Vacuum Specific Impulse vs. Electrical Pulse Width

3.4.4.2.3 Propellant Section. - Each independent propellant supply section shall consist of one oxidizer tank and one fuel tank. The tanks shall be fabricated of titanium alloy, and shall be similar except for volume, and shall be cylindrical with hemispherical ends. A teflon bladder shall be incorporated between the propellant and the helium.

3.4.4.2.4 Rocket Engine. - Each cluster shall include four engines (see Figure 19). The rocket engines shall be pulse modulated, pressure-fed, radiation cooled, and shall utilize earth-storable hypergolic propellants.

3.4.4.2.5 Propellant Quantity Gaging Section. - Continuous quantity gaging shall be furnished for each tank to provide data to the crew on the propellant quantity remaining.

*3.4.5 Communications Subsystem (CS). - The CS shall consist of the following sections:

(a) S-band section

(b) VHF section

(c) Television section

(d) Signal processing assembly

(e) Hardline intercom

3.4.5.1 Performance Requirements. - Communications capability shall be provided between the Lab I and the Manned Space Flight Net (MSFN), Command Service Module (CSM) and Extra Vehicular Astronaut (EVA). The communications equipment shall be compatible with the equipments with which it interfaces as shown in Figure 20.

3.4.5.1.1 Types of Communications. - The following types of communications shall be provided:

(a) Two way voice and voice conference

(b) Tracking and ranging aids

(c) Telemetry transmission

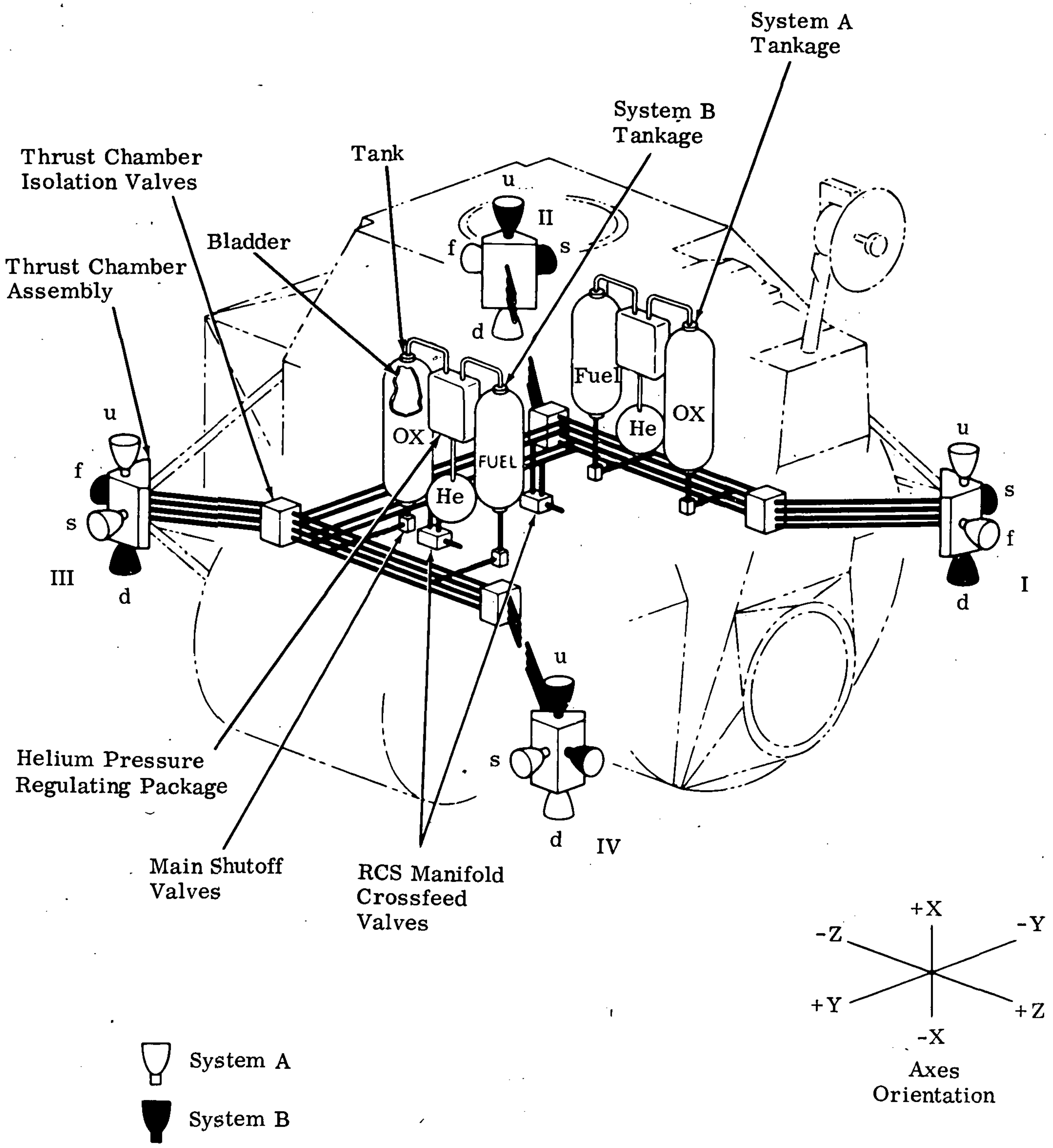
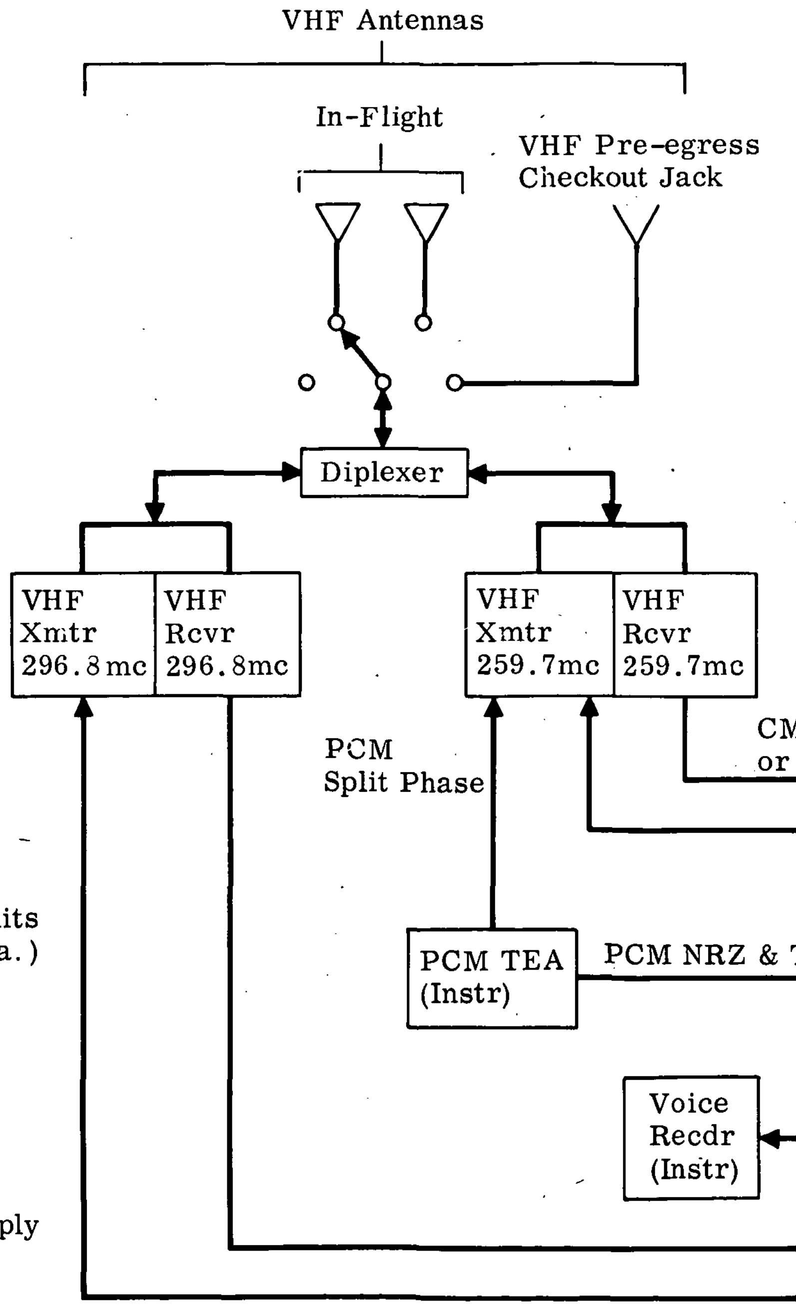


Fig. 19 RCS General Arrangement



Note: EMU (Extravehicular Mobility Unit Transmits both EVA voice & data.)

*Change from present LEM system.

Key

P ⟶ Power Supply

⟶ Signal

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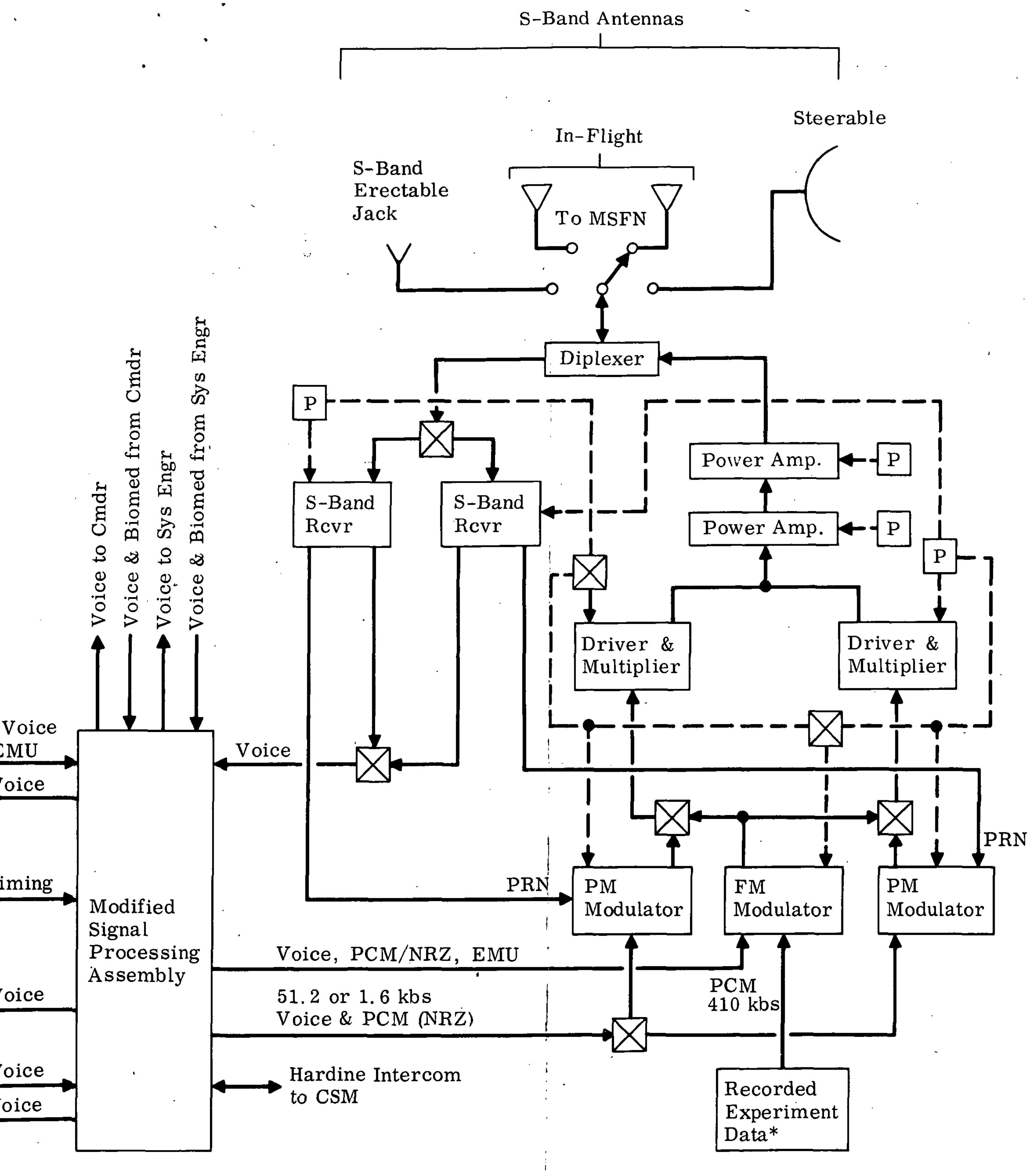

Fig. 20 Communications Subsystem Block Diagram

(2)

Grumman

3.4.5.1.1 (Continued)

(d) Key transmission

(e) Biomedical data transmission

Radio frequency utilization shall be as shown in Figure 21.

3.4.5.1.2 Two Way Voice and Voice Conference. - Two way voice and voice conference shall be available between the following:

(a) Lab I - MSFN - Duplex voice communications capability between the Lab I and the MSFN to a minimum slant range of 220,000 nautical miles shall be provided by an S-Band communications link. The voice channel shall be designed to provide two-way voice capability using the Lab I inflight omni antennas.

(b) Lab I/CMS/EVA Intercommunications - An intercommunications capability between Lab I/CSM/EVA shall be provided as indicated in Figure 21 with the CSM and Lab I docked. The hardline intercom provides a voice capability between the CSM and Lab I when docked. EVA is allowed two communication channels via the VHF link-one to the CSM and the other to the Lab I.

(c) Lab I - EVA - Duplex voice communications capability between the crew member inside the Lab I and an EVA within a three nautical mile radius of the Lab I shall be provided by a VHF/AM communications link. Duplex voice communications capability shall exist between the Lab I and an EVA as a backup.

(d) Lab I CSM - Simplex voice communications capability between the Lab I and the CSM shall be provided during all inflight line of sight phases of the lunar mission. Range capability inflight shall be 550 nautical miles minimum. Backup voice capability for terminal rendezvous shall be provided.

(e) MSFN/Lab I/CSM and MSFN/Lab I/EVA Voice Conferences - Voice conference capability between the MSFN, Lab I and CSM or EVA shall be provided by use of the Lab I to relay voice from the

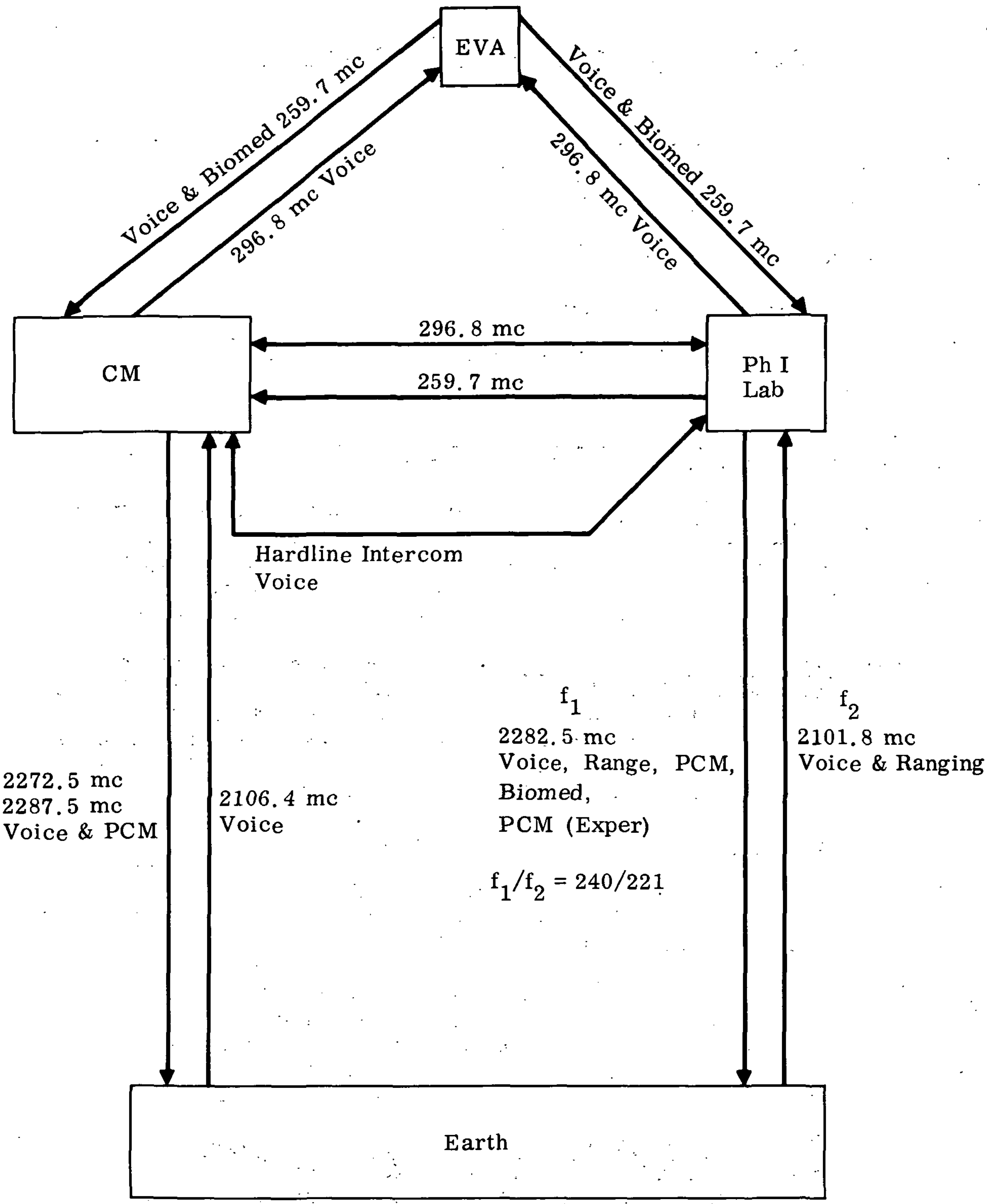

Fig. 21 Communications Links

3.4.5.1.2 (Continued)

(e) (Continued)

CSM or EVA to the MSFN via the Lab I - MSFN Duplex S-Band voice link, and to relay voice from the MSFN to the CSM or EVA via the CSM - Lab I Simplex VHF or Lab I - EVA Duplex VHF voice links, respectively. Simultaneous capability for these two modes is not required.

3.4.5.1.3 S-Band Tracking and Ranging. - The Lab I shall be equipped to permit the MSFN to track the Lab I at any time, to a minimum slant range of 220,000 nautical miles, during which the Lab I is in line of sight of a MSFN station. The S-Band communications equipment shall aid the MSFN in determining spacecraft velocity by receiving a phase modulated carrier from the MSFN, and retransmitting a carrier coherently related to a 240/221 ratio to the frequency of the received carrier. The Lab I shall aid the MSFN in determining accurately the spacecraft range through the reception, demodulation and retransmission of a Pseudo-Random-Noise Ranging (PRN) Signal generated by the MSFN. This ranging capability shall be possible at any time when the MSFN and Lab I are communicating via the S-Band link when in the Phase Modulation Mode.

3.4.5.1.4 Telemetry Transmission. - The Lab I shall be capable of transmitting telemetry as follows:

(a) Lab I to MSFN PCM Telemetry Transmission - The Lab I shall have the capability of providing Lab I data to the MSFN via a PCM telemeter and the S-Band link to a minimum slant range of 220,000 nautical miles. Three modes of telemetry capability shall be provided. A low bit rate output of 1600 bits/second, an intermediate bit rate output of 51,200 bits/second and a high bit rate output of 409,600 bits/second.

(b) Lab I to CSM PCM Telemetry Transmission - The inflight capability shall exist to transmit 1600 bits/second PCM data from the Lab I to the CSM via a VHF communications link to a minimum slant range of 300 nautical miles for recording onboard the CSM for subsequent playback to the MSFN.

3.4.5.1.4 (Continued)

(c) EVA Data Relay - During extravehicular operations, the capability shall exist for the Lab I to relay transmissions from the EVA to the MSFN via the S-Band communications link. The capability shall also exist to check out the EMU data system prior to the egressing of the crewman from the Lab I, by relaying the EMU Data System composite waveform to the MSFN for analysis via the S-Band Link.

3.4.5.1.5 Key Transmission. - An S-Band Transmission Mode shall exist that enables the transmission of manually encoded Morse code.

3.4.5.1.6 Biomedical Data Transmission. - Biomedical information shall be hardlined from each crewman within the Lab I and processed for transmission via the S-Band Transmitter. Biomedical data shall be processed and transmitted for only one crewman at a time.

3.4.5.2 Design Requirements. -

3.4.5.2.1 S-Band Section. - The S-Band section shall consist of the following equipment:

(a) Transceiver Assembly

(b) Power Amplifier Assembly

(c) Diplexer

(d) RF Switch

(e) In-Flight Antenna

(f) Steerable Antenna

(g) RF Cable Assemblies

3.4.5.2.1.1 Transceiver Assembly. - The transceiver assembly shall consist of the following:

(a) Two coherent transponders

(b) One FM modulator capable of using either transponder multiplier chain.

3.4.5.2.1.1.1 Coherent Transponders. - Each transponder shall consist of one phase locked receiver, one coherent phase modulator, a multiplier chain and power supply. The transponder shall permit ranging to the Lab I by the ground station as well as transmission of voice, telemetry, bio-medical and EMU information from Lab I to the ground station. Simultaneous operation of transponders shall be precluded. The receiver shall be capable of detecting a carrier at 2101.802 mc, a voice modulated subcarrier, and pseudo-random noise which is angle modulated by the ground transmitter. It shall also be capable of coherently translating and routing pseudo-random noise to the phase modulator (PM) in a coherent ranging mode. The transmitters shall be miniaturized, solid state devices capable of an RF output of 0.75 watts.

3.4.5.2.1.1.2 FM Modulator. - The FM modulator shall be provided for modes not requiring coherency. Simultaneous transmission of FM and PM shall be precluded.

3.4.5.2.1.2 Power Amplifier Assembly. - The power amplifier assembly shall consist of two amplifier tubes, one input isolator, one output isolator, and two power supplies mounted in a common enclosure. The power amplifier assembly shall be capable of operation with either multiplier chain. Simultaneous operation of the two amplifiers shall be precluded. The power amplifier equipment shall provide a 20 watt RF signal to the S-Band diplexer. The equipment shall provide power amplification at 2282.5 mc.

3.4.5.2.1.3 Diplexer. - The diplexer shall permit the transmitter and receiver to utilize one antenna at a time and shall be physically attached to the power amplifier assembly.

3.4.5.2.1.4 RF Switch. - The RF switch shall enable the crewman to select the desired S-Band antenna.

3.4.5.2.1.5 In-Flight Antenna. - The in-flight antenna assembly shall consist of radiating elements and matching devices.

3.4.5.2.1.6 S-Band Steerable Antenna. - The S-Band steerable antenna shall be used for communications between Lab I and earth. During most phases of the lunar mission, the RF sensor shall track an earth transmitting station and direct the steering components of the antenna in such a manner as to obtain continuous Lab I earth communications. Controls and displays shall be provided for antenna acquisition of an earth transmitting station from lunar distances, and for any required manual antenna steering.

3.4.5.2.1.7 RF Cable Assemblies. - The RF cable assemblies shall provide a means of interconnecting RF signals between the S-Band equipments.

3.4.5.2.2 VHF Section. - The VHF section shall consist of the following equipment:

(a) Two Transceivers (A and B)

(b) Diplexer

3.4.5.2.2 (Continued)

(c) RF Switch

(d) In-Flight Antenna

(e) RF Cable Assemblies

3.4.5.2.2.1 Transceivers. - Transceiver A shall be capable of simplex operation between Lab I and CM. The transmitter shall be a solid-state unit, modulated by infinitely clipped speech. The receiver shall contain automatic volume control (AVC) and squelch capabilities. Transceiver A shall operate at 296.8 mc. Transceiver B shall consist of a solid state unit capable of transmitting PCM data at 1.6 KB rate or, as in Transceiver A, infinitely clipped speech; it shall receive EMU information from the EVA or voice from the CM. The receiver shall also contain AVC and squelch capabilities. Transceiver B shall operate at 259.7 mc.

3.4.5.2.2.2 Lab I-EVA Communications. - The primary duplex link for Lab I EVA Communications shall utilize the Lab I 259.7 mc receiver for EVA voice data reception and the Lab I 296.8 mc transmitter for Lab I to EVA voice. In a backup situation the Lab I 259.7 mc transmitter would be used in conjunction with the Lab I 296.8 mc receiver for duplex, voice only, communications.

3.4.5.2.2.3 Diplexer. - The diplexer shall permit the VHF transceiver units to utilize the same antenna.

3.4.5.2.2.4 RF Switch. - The RF switch shall allow the crewman to select the desired antenna.

3.4.5.2.2.5 Inflight Antennas. - There shall be two circularly polarized antennas with matching devices.

3.4.5.2.2.6 RF Cable Assemblies. - The RF cable assemblies shall provide a means of interconnecting RF signals between the VHF equipments.

3.4.5.2.3 Television Section. - This section shall consist of a government furnished portable television camera and optics. The video information shall be hardlined (floating cable through open hatches) to the CSM and transmitted to earth via the CSM communication link.

*3.4.5.2.4 Signal Processing Assembly. - The signal processing assembly (SPA) shall provide the following functions:

(a) Voice, EMU and Biomedical Signals

(1) Voice information shall be hardlined to the SPA from each crewman. The SPA shall process the voice information for input to the Lab I ICS, S-Band modulator and/or VHF modulator as determined by mode selection.

(2) Biomedical information shall be hardlined to the SPA from each crewman within the Lab I and processed for transmission via the S-Band transmitter. Biomedical data will be processed and transmitted for only one crewman at a time.

(3) The SPA shall be capable of processing received VHF signals and of routing them to the ICS and the S-Band transmitter as determined by mode selection. The SPA shall also be capable of processing the EMU information received from the EVA for subsequent transmission to earth. EMU data shall be processed from only one EVA at a time.

(4) The SPA shall be capable of processing the S-Band received voice subcarrier and routing the audio to the crewman's headsets and/or the VHF transmitters.

(5) The SPA shall provide side tone for all VHF, S-Band and ICS voice paths.

(6) The SPA shall provide control of associated equipment with both push-to-talk and voice-operated relay methods.

(b) Other Signals - The SPA shall provide the interface between the pulse code modulation and timing equipment, voice recorder equipment, and the RF electronics, as related to the various modes of information transferal.

(c) The SPA shall accommodate the voice hardline intercom, between the CSM and Lab I. The SPA provides complete conference capability between Earth/CSM/EVA/Lab I.

*3.4.5.2.5 Hardline Intercom. - The hardline intercom shall interface between the CSM audio center and the Lab I SPA.

3.4.5.2.6 Associated Equipment. - The CS shall be capable of operation with the following associated equipments which are not a part of this subsystem:

(a) Pulse Code Modulation and Timing Electronics Assembly (PCMTEA)

(b) Voice Storage Recorder (VSR)

(c) Displays and Controls Subsystem

(d) Ascent and Descent Stage Structure

(e) EMU Communications System (GFE)

(f) Electrical Power Subsystem

(g) Command and Service Modules

(h) Ground Support Equipment

(i) Manned Space Flight Net (MSFN)

(j) Environmental Control Subsystem

(k) Experiment Recorded Data

3.4.6 Instrumentation Subsystem (IS). - The Instrumentation Subsystem shall consist of:

(a) Operational Instrumentation Section

(b) Experimental Instrumentation Section

3.4.6.1 Performance Requirements. -

3.4.6.1.1 Operational Instrumentation Section. - The Operational Instrumentation Section shall detect, measure, process, distribute and analyze various parameters encountered during a mission to:

3.4.6.1.1 (Continued)

(a) Acquire data to determine spacecraft status

(b) Generate a real-time reference

3.4.6.1.1.1 Data Acquisition. - The Operational Instrumentation Section shall acquire and present the status of spacecraft subsystems to the crew and ground stations by means of controls and displays for the purpose of:

(a) Aiding pre-flight assessment of spacecraft readiness for launch

(b) In-flight management of the spacecraft housekeeping functions

(c) Post-flight evaluation of performance

3.4.6.1.1.2 Real-Time Reference. - The Operational Instrumentation Section shall generate a "real-time" reference and provide synchronization signals to other Lab I equipment.

3.4.6.1.2 Experimental Instrumentation Section. - The Experimental Instrumentation Section shall acquire, process, record and distribute the preconditioned data provided by an experiment or group of experiments.

*3.4.6.1.2.1 Data Acquisition. - The Experimental Instrumentation Section shall combine groups of preconditioned signals supplied by an experiment or a group of experiments. The Section shall process the combined signals and produce coded digital signals suitable for data storage or telemetry transmission.

*3.4.6.1.2.2 Data Storage. - The Experimental Instrumentation Section shall provide storage for the coded digital signals produced by the Section.

3.4.6.2 Design Requirements. -

3.4.6.2.1 Operational Instrumentation Section. - The Operational Instrumentation Section shall consist of:

(a) Pulse Code Modulation and Timing Electronics Assembly (PCMTEA)

(b) Signal Conditioning Electronics Assembly (SCEA)

(c) Transducers

3.4.6.2.1 (Continued)

(d) Caution and Warning Electronics Assembly (CWEA)

(e) Voice Storage Recorder (VSR)

3.4.6.2.1.1 Pulse Code Modulation and Timing Electronics Assembly (PCMTEA).

3.4.6.2.1.1.1 Data Distribution. - The PCMTEA shall convert analog data, parallel-digital data, and serial-digital data into serial non-return-to-zero (NRZ), Type C, binary-coded signals for the signal processing assembly. It shall also provide serial return-to-zero (RZ), Type C, binary-coded signals for prelaunch checkout equipment. The PCMTEA shall supply output data at a high bit rate of 51.2 kilobits per second. The primary operational mode for the PCMTEA shall be at the high bit rate. A low bit rate of 1.6 kilobits per second shall be used when power conservation is necessary during a mission. In general, design of the PCMTEA shall be based upon requirements of Inter-Range Instrumentation Group (IRIG) Standard, IRIG-106-60.

3.4.6.2.1.1.2 Timing Data. - The PCMTEA shall supply timing frequencies to synchronize spacecraft equipment, and binary-coded, decimal Greenwich Mean Time for telemetering. The timing equipment shall accept 1.024 mcs input as its master timing signal. As a secondary mode of operation the unit shall generate an internal, highly stable 1.024 mcs signal for operation of the PCMTEA when the external input is absent.

3.4.6.2.1.2 Signal Conditioning Electronics Assembly (SCEA). - The SCEA shall act as a junction box for all analog signals pertaining to status and housekeeping functions of the Lab I subsystems. The SCEA shall accept raw analog signals from transducers, signal pickoff points and contact closures from the Lab I subsystems and condition these signals to the proper voltage and impedance levels. Those signals not requiring conditioning will be routed through the data distribution subassembly of the SCEA. All conditioned analog signals shall be made available for routing to any combination of PCMTEA, CWEA and Displays.

3.4.6.2.1.3 Transducers. - The transducers shall sense and convert physical phenomena from all the vehicle subsystems into a form compatible with the SCEA. The transducers shall be capable of accepting excitation power from either the SCEA or the onboard power supply.

3.4.6.2.1.4 Caution and Warning Electronics Assembly (CWEA). - The CWEA shall provide two basic functions:

(a) Caution function to advise the crew of an out-of-tolerance condition in a Lab I subsystem which does not require immediate attention, but could ultimately affect crew safety.

(b) Warning function to advise the crew of a malfunction which affects crew safety and requires immediate attention.

3.4.6.2.1.4.1 Caution Function. - The CWEA shall remain "on" during all manned phases of the Lab I mission. The CWEA shall accept signals from both the SCEA and the subsystems, and shall analyze these signals for out-of-tolerance conditions. The CWEA shall have reset capability. The Caution function shall activate a master alarm and onboard display whenever an out-of-tolerance condition exists.

3.4.6.2.1.4.2 Warning Function. - Inhibit gates contained in the CWEA shall be controlled by the subsystems to prevent false malfunction indications when a subsystem is intentionally made inoperative. The Warning function in the CWEA shall activate a master warning alarm and display onboard the Lab I, and shall advise the ground station of a malfunction by telemetry.

3.4.6.2.1.5 Voice Storage Recorder. - The VSR shall record voice and time correlation data. The VSR shall receive time correlation from the PCMTEA and voice inputs from the Communications Subsystem.

*3.4.6.2.2 Experimental Instrumentation Section. -

*3.4.6.2.2.1 Experimental Pulse Code Modulation and Timing Electronics Assembly (E/PCMTEA). - The E/PCMTEA shall convert experimental, preconditioned analog data and preconditioned, parallel-digital and serial-digital data into serial non-return to zero, coded digital form for the Communications Subsystem, or for the Experimental Data Storage Electronics Assembly as required.

*3.4.6.2.2.2 Experimental Data Storage Electronics Assembly (E/DSEA). - The E/DSEA shall record and replay the serial output of the E/PCMTEA and analog data at various tape speeds as required for optimum data handling efficiency.

*3.4.6.2.2.3 Experimental Instrumentation Control Panel. - The Experimental Instrumentation Control Panel shall control the operating mode and format of the E/PCMTEA, and the operating mode and speed of the E/DSEA, as required for experiments and optimum data handling efficiency. In addition, the Experimental Instrumentation Control Panel shall provide those displays necessary for the operation of the above control functions.

*3.4.6.2.2.4 Signal Conditioning. - The Experimental Instrumentation Section shall provide no signal conditioning capability. All signal inputs to the Experimental Instrumentation Section shall be preconditioned at the signal source.

3.4.7 Environmental Control Subsystem (ECS). - The ECS shall consist of:

(a) Oxygen Supply and Pressurization Control Section

(b) Atmosphere Revitalization Section

(c) Heat Transport Section

(d) Water Management Section

The ECS is shown schematically in Figure 22.

3.4.7.1 Performance Requirements. - The ECS shall provide pressurization, atmospheric conditioning, ventilation, active thermal control, water management and PLSS refilling.

*3.4.7.1.1 Oxygen Supply and Pressurization Control Performance. - This section shall store in gaseous form all oxygen required by the ECS and shall maintain cabin or suit pressurization by supplying oxygen in sufficient quantities to replenish losses due to crew metabolic consumption during suited, closed face plate operations and cabin and CSM interface leakage. This section shall also protect the cabin pressure shell against overpressurization and enable the crew to intentionally depressurize and repressurize the cabin. Capability shall be provided for 18 repressurizations of the cabin and 18 PLSS refills. The design of the Oxygen Supply and Pressurization Control Section shall be based on the following.

SPECIFICATION NO. ESP 11-0100

To be determined

ECS SCHEMATIC DIAGRAM

Figure 22

3.4.7.1.1.1 Cabin Criteria. -

(a) Free volume = 235 cu ft

(b) Total leakage at 5.0 psia and 75 degrees Fahrenheit = 0.2 lbs/hour (inclusive of leakage of both cabin pressure relief and dump valves)

(c) Repressurization time to a cabin pressure of 4.7 psia = TBD seconds maximum

3.4.7.1.1.2 Cabin Pressure Relief and Dump Valve Criteria. -

(a) Maximum leakage at 5.0 psia and 75 degrees Fahrenheit (both valves) = 0.01 lbs/hour

(b) Depressurization time (5.0 psia to 0.08 psia with no inflow):

One cabin pressure relief and dump valve open = 200 seconds maximum

Two cabin pressure relief and dump valves open = 100 seconds maximum

(c) Maximum cabin to ambient pressure differential = 5.8 psi

3.4.7.1.1.3 Oxygen Criteria. -

(a) PLSS refill = 0.91 lbs/refill at 850 psia

(b) Oxygen tank capacity = 45.17 lb useable fluid

3.4.7.1.1.4 Spacesuit Criteria. -

(a) Maximum leakage = 0.04 lbs/hour/suit at 3.7 psia and 70 degrees Fahrenheit

(b) Minimum purge flow = TBD

(c) Suit Pressure Increase Rate = TBD

3.4.7.1.2 Atmosphere Revitalization Section Performance. - This section shall provide ventilation and atmospheric conditioning for the cabin and suits. Atmospheric conditioning shall consist of the removal of carbon dioxide, odors, particulate matter, and excess water vapor during EVA experiments.

3.4.7.1.2.1 Suit Pressure Drop. - The pressure drop of each suit, including both halves of the suit umbilical hose disconnect shall be 5.0 inches of water at suit inlet conditions of 12 cfm at 3.5 psia and 50 degrees Fahrenheit.

3.4.7.1.2.2 Suit Inlet Temperature. - The range of suit inlet temperatures, for the conditions listed in Table II shall be as follows:

Suit Inlet Temperature	Conditions	
	Min Heat Load	Max Heat Load
Minimum	45°F	60°F
Maximum	60°F	80°F

3.4.7.1.2.3 Suit Ventilation Flow. - The minimum suit ventilation flow rate shall be as follows:

Unpressurized Cabin = 13.9 lb/hr

Pressurized Cabin = 18.0 lb/hr

3.4.7.1.2.4 Cabin Ventilation Flow. - The nominal cabin ventilation flow rates of the cabin recirculation assembly shall be 5 lbs/min with one cabin fan operating and 10 lbs/min with both cabin fans operating.

TABLE II

ECS THERMAL DESIGN CRITERIA

To be determined

3.4.7.1.3 Heat Transport Section Performance. - This section shall provide active thermal control of electrical and electronic equipment and cabin and suit ventilating gases.

3.4.7.1.3.1 Coolant. - The coolant shall be a corrosion-inhibited ethylene glycol (35.7 percent by weight) and water solution.

3.4.7.1.3.2 Coolant Temperature. - Coolant temperature limits during steady state operation shall be as follows:

(a) Minimum = 32 degrees Fahrenheit

(b) Maximum = 120 degrees Fahrenheit

3.4.7.1.3.3 Coolant Flow Rate. - The nominal coolant flow rate shall be as follows:

Coolant loop flow rate = 222 lbs/hr

3.4.7.1.3.4 Coolant Pressure Drop. - The maximum total pressure drop of the coolant loop shall be 30 psi.

*3.4.7.1.3.5 Thermal Loads. - The structural, electrical and electronic heat loads imposed upon the section shall be as shown in Table II. The cold plate thermal load characteristics shall be as shown in Table III.

3.4.7.1.4 Water Management Section Performance. - This section shall provide for storage and distribution of water used in the Lab I for PLSS refilling and evaporative cooling. In addition, this section shall provide for the utilization of the condensed water vapor removed by the Atmosphere Revitalization Section.

3.4.7.1.4.1 PLSS Water Refill. -

(a) Water quantity per refill: 6.8 lbs

(b) Minimum refill pressure: 0.5 psi above cabin pressure

3.4.7.1.4.2 Water Storage. - Useable water quantity.

(a) Descent tank: 322.0 lbs each

(b) Ascent tanks: 40.0 lbs each

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TABLE III

ELECTRONIC EQUIPMENT COLD PLATE CHARACTERISTICS

To be determined

3.4.7.2 Design Requirements. -

3.4.7.2.1 Oxygen Supply and Pressurization Control Section. - The Oxygen Supply and Pressurization Control Section shall consist of:

(a) Oxygen Supply Control Module

(b) High Pressure Oxygen Control Assembly

(c) Oxygen Hose Assembly

(d) Descent Stage GOX Tanks (5)

(e) Cabin Pressure Switch

(f) Cabin Pressure Relief and Dump Valve

3.4.7.2.1.1 Oxygen Supply Control Module. - The Oxygen Supply Control Module shall sense the suit loop ressure and replenish the suit loop oxygen from the GOX tanks to maintain the selected suit loop pressure in support of EVA experiments. The Module shall also contain a cabin repressurization emergency O_2 valve to dump oxygen into the cabin upon electrical signal from the cabin pressure switch, or by manual control. The Module shall contain provisions for manually selecting one of the five GOX tanks to be used, provisions for filtering oxygen before it enters the suit loop or the cabin, and a manual control valve for recharging the PLSS.

3.4.7.2.1.2 High Pressure Oxygen Control Assembly. - The High Pressure Oxygen Control Assembly shall reduce the GOX tank pressure, provide overpressure relief protection, and incorporate a quick disconnect for purging and filling the GOX tanks.

3.4.7.2.1.3 Oxygen Hose Assembly. - An Oxygen Hose Assembly shall be provided for refilling the PLSS.

3.4.7.2.1.4 GOX Tanks. - The GOX Tanks shall provide adequate oxygen supply for the Lab I for use during the manned phases of the Lab I mission.

3.4.7.2.1.5 Cabin Pressure Switch. - The cabin pressure switch shall sense the absolute pressure in the cabin. The switch shall provide a signal to activate or de-activate the cabin repressurization emergency O_2 valve. This valve shall maintain the cabin pressure at 4.7 psia. When the cabin repressurization emergency O_2 valve is activated, the cabin pressure switch shall provide a signal to close the suit diverter valve. When the cabin pressure is below 3.0 psia, the cabin pressure switch shall also provide another switch closure to energize the cabin fan control relay.

3.4.7.2.1.6 Cabin Pressure Relief and Dump Valve. - The cabin pressure relief and dump valve shall be a three position servo valve with manual overrides on the automatic actuation. When the valve handle is in "automatic" position the valve shall open to the ambient whenever the cabin pressure exceeds 5.3 psia. With the valve handle in "manual closed" position the valve shall remain closed irrespective of the cabin pressure. With the handle in the "manual open" position the valve shall open to the ambient and allow a rapid reduction of cabin pressure. There shall be one cabin pressure relief and dump valve on each Lab I hatch.

3.4.7.2.2 Atmosphere Revitalization Section Design Requirements. - The Atmosphere Revitalization Section shall consist of:

(a) Suit circuit

(b) Cabin recirculation assembly

(c) Steam flex duct

3.4.7.2.2.1 Suit Circuit. - The suit circuit shall consist of two umbilical hose assemblies, the suit circuit assembly, and the carbon dioxide partial pressure sensor. The suit circuit shall be used only to support crewmen wearing suits who are participating in EVA experiments.

3.4.7.2.2.1.1 Suit Umbilical Hose Assembly. - Two suit umbilical hose assemblies shall be provided to carry ventilating gas to and from the crewman's space suit and the suit circuit assembly. The suit umbilical hose assembly shall be sufficiently flexible to provide required crew mobility in both the pressurized and unpressurized modes of suit operation.

3.4.7.2.2.1.2 Suit Circuit Assembly. - The suit circuit assembly shall provide heat exchangers for rejection of all waste heat to the Heat Transport Section for cooling, and for transfer of heat from the Heat Transport Section to the suit circuit gas stream for warming. A water evaporator shall reject waste heat when the heat exchanger is inoperative.

3.4.7.2.2.1.2 (Continued)

Excess moisture condensed in the suit circuit shall be delivered by water separators to the Water Management Section. The carbon dioxide level in the suit circuit shall be maintained within limits by adsorption in lithium hydroxide, and odors shall be adsorbed in activated charcoal. Recirculation of gas through the suit circuit shall be provided by fans. The fans shall be capable of maintaining the pressure vessel integrity of the suit circuit in the event of any internal fan failure.

3.4.7.2.2.1.3 Carbon Dioxide Partial Pressure Sensor. - The carbon dioxide partial pressure sensor shall measure the partial pressure of carbon dioxide in the ventilating gas entering the suits. The sensor shall provide output signals to displays and telemetry which indicate the value of the partial pressure of carbon dioxide.

*3.4.7.2.2.2 Cabin Recirculation Assembly. - The cabin recirculation assembly shall provide for transfer of heat between the cabin gas and the Heat Transport Section, by means of the Cabin Heat Exchanger. The heat exchanger shall provide for storage of condensed moisture and for evaporation of water when the heat exchanger discharge gas is not saturated. The cabin fan(s) shall recirculate cabin gas from the CSM through the heat exchanger to maintain cabin gas temperature within limits and to provide cabin ventilation. The cabin fans shall be designed to permit operation at sea level for checkout purposes.

3.4.7.2.2.3 Steam Flex Duct. - A flexible duct shall be provided to carry the steam discharged from the suit circuit water evaporator.

3.4.7.2.3 Heat Transport Section Design Requirements. - The Heat Transport Section shall consist of the following:

(a) Coolant recirculation assembly

(b) Coolant regenerative heat exchanger

(c) Cabin temperature control valve

(d) Suit temperature control valve

(e) Coolant water evaporator

(f) Battery coolant water evaporator

(g) Coolant accumulator

3.4.7.2.3 (Continued)

(h) Cold Plate Assemblies

(i) GSE quick-disconnects

(j) Flex Lines

3.4.7.2.3.1 Coolant Recirculation Assembly. - The coolant recirculation assembly shall recirculate the coolant in the coolant loop, provide for removal of foreign particles in the coolant stream, incorporate provisions for isolating a failed pump, and limit the coolant pressure by providing for over pressure by-pass.

3.4.7.2.3.2 Coolant Regenerative Heat Exchanger. - The coolant regenerative heat exchanger shall provide for transfer of the heat rejected from the electronic equipment to the coolant entering the cabin heat exchanger for heating of the cabin gas.

3.4.7.2.3.3 Cabin Temperature Control Valve. - A cabin temperature control valve shall be provided to control the temperature of the coolant supplied to the cabin heat exchanger. The control valve shall sense the temperature of the coolant leaving the cabin heat exchanger. The valve shall respond mechanically to divert and modulate the flow of coolant through the coolant regenerative heat exchanger for temperature control of coolant entering the cabin heat exchanger. The valve shall include provisions for manual reset of the control temperature and provide for manual control in the event of sensor failure.

*3.4.7.2.3.4 Evaporator By-pass Control Valve. - The evaporator by-pass control valve shall be provided to control the temperature of the coolant downstream of the water evaporator. The valve shall sense the coolant temperature at this point and respond mechanically, diverting and modulating flow around the water evaporator. The valve shall include provisions for manual reset of the control temperature and provide for manual control in the event of sensor failure.

3.4.7.2.3.5 Suit Temperature Control Valve. - The suit temperature control valve shall permit the crew to manually control the temperature of the ventilating gas delivered to their spacesuits. The valve shall effect this control by controlling the flow of warm coolant through the suit circuit regenerative heat exchanger.

3.4.7.2.3.6 Main Coolant Water Evaporator. - A coolant water evaporator of porous plate design shall provide for rejection of waste heat from the Heat Transport Section coolant by evaporating water. Water evaporated shall be discharged to the Lab I ambient atmosphere

3.4.7.2.3.7 Battery Coolant Water Evaporator. - A coolant water evaporator of porous plate design shall provide for additional rejection of Lab I heat loads as a backup to the main coolant water evaporator. Water evaporated shall be discharged to the Lab I ambient atmosphere.

3.4.7.2.3.8 Coolant Accumulator. - The coolant accumulator shall maintain coolant pressure above the coolant vapor pressure at all points in the coolant loop and absorb normal volumetric changes of the coolant mass. Coolant pressure shall be maintained mechanically and the accumulator shall provide an electrical signal in the event of excessive reduction of the coolant volume within the loop.

3.4.7.2.3.9 Cold Plate Assemblies. - The Cold Plate Section shall consist of the following:

(a) Structural ("strip") cold plates

(b) Non-structural ("flat") cold plates

All cold plates shall be designed to permit removal of the equipment for which they provide thermal control without disconnecting the cold plates from the Heat Transport Section plumbing.

3.4.7.2.3.9.1 Strip Cold Plates. - Strip cold plates shall provide both active thermal control and structural support for those electrical and electronic equipments which utilize the Electronic Replaceable Assembly (ERA) packaging concept. The strip cold plates shall contain a single flow passage through which the Heat Transport Section coolant shall be circulated. This passage shall contain fins as required to provide adequate heat transfer surface area. Strip cold plates shall be provided for the electrical and electronic equipment as shown in Table III.

3.4.7.2.3.9.2 Flat Cold Plates. - Flat cold plates shall provide active thermal control for those electrical and electronic equipments which utilize packaging concepts other than the ERA concept. The flat cold plates shall contain a single flow passage through which Heat Transport Section coolant shall be circulated. Flat cold plates shall be provided for the electrical and electronic equipment as shown in Table III.

3.4.7.2.3.10 GSE Quick Disconnects. - Self-sealing quick disconnects shall be provided for the recirculation of coolant through the loop by the GSE during ground operation of the Heat Transport Section.

3.4.7.2.3.11 Flex Lines. - Flex lines shall be provided to accommodate relative motion between the interstage disconnect halves and the adjacent hard line coolant plumbing.

*3.4.7.2.4 Water Management Section Design Requirements. - The water management section shall consist of the following:

(a) Descent water tanks (3)

(b) Ascent water tanks (2)

(c) GSE connections

(d) Water control module

(e) Water squib valve

(f) Water hose assembly

*3.4.7.2.4.1 Descent Water Tanks. - The descent stage water tanks shall provide adequate useable storage for the water required for PLSS refill and evaporative cooling. The tanks shall be spherical and shall provide positive expulsion of water by use of a bladder and standpipe design. The tanks shall be pressurized with nitrogen prior to earth launch.

3.4.7.2.4.2 Ascent Water Tank. - Two ascent stage water tanks shall provide additional storage for the water required for PLSS refill and evaporative cooling subsequent to switchover from descent stage water supplies. The tanks shall be spherical and shall provide positive expulsion of water by use of a bladder and standpipe design. The tanks shall be pressurized with nitrogen prior to earth launch.

3.4.7.2.4.3 GSE Quick Disconnect. - Self-sealing quick disconnects shall be provided for the GSE to evacuate, fill and pressurize the water tanks.

3.4.7.2.4.4 Water Control Module. - The water control module shall consist of the following components plus all interconnecting plumbing and and couplings. This assembly shall also include all bracketry required to mount and support the components and to mount the assembly itself.

3.4.7.2.4.4.1 Water Check Valve. - Water check valves shall be provided for the following functions:

3.4.7.2.4.4.1 (Continued)

(a) Prevent water flow from the water control module to the water separators

(b) Prevent water flow from the water control module to the water tanks

(c) Prevent flow of water from the water separators to the water hose assembly

3.4.7.2.4.4.2 Water Shut-off Valves. - Manually operated water shut-off valves shall be provided for the following functions:

(a) Control the flow of water from the water control module to the water hose assembly

(b) Control the flow of water from the water control module to the suit circuit water evaporator

3.4.7.2.4.4.3 Water Tank Selector Valve. - A manually operated valve shall be provided for selection of the following modes of Water Management Section operation:

(a) In the "descent tank" position, the valve shall supply water from the descent water tanks.

(b) In the "ascent tank" position, the valve shall supply water from the ascent water tanks.

3.4.7.2.4.4.4 Water Pressure Regulators. - The water pressure regulators shall control the pressure of the water supplied from the water control module to a level which is compatible with the water pumping capability of the water separators. Two regulators in series shall control the pressure of water supplied to the water hose assembly and coolant water evaporator. A single regulator shall control the pressure of water supplied to the suit circuit water evaporator.

3.4.7.2.4.5 Water Squib Valve. - An explosively actuated valve shall be provided to initiate water flow from the water control module to the coolant water evaporator. The valve shall be normally closed. Once opened, the valve shall not be capable of closing.

3.4.7.2.4.6 Water Hose Assembly. - The water hose assembly shall provide for the transfer of water from the water control module to the water storage tanks of the PLSS. The water hose assembly shall consist of the following:

3.4.7.2.4.6.1 Water Hose. - A flexible water hose shall be provided of sufficient length and flexibility to permit refill of the PLSS water tank in both the PLSS tunnel stowing and the PLSS donning positions.

3.4.7.2.4.6.2 Water Disconnect. - A quick disconnect shall be provided for coupling the water hose to the PLSS for refilling the water storage tank of the latter. The disconnect shall be self-sealing and shall require no tools for engaging or disengaging the PLSS.

3.4.8 Crew Provisions Subsystem (CPS). - Crew Provisions Subsystem shall support the nominal and abort missions by providing the equipment or the volume for equipment (CFE and GFE) integrated into a coherent pressurized cabin arrangement. Crew aids, lighting and marking on the exterior of the vehicle shall be provided to the extent required. The cabin arrangement shall be designed to reflect task requirements for the crew.

3.4.8.1 Crew Equipment Performance Requirements. -

3.4.8.1.1 Extravehicular Mobility Unit (EMU). - A self donnable and doffable EMU (GFE) shall be provided for environmental protection and life support of the crew in or outside the cabin. The EMU, in conjunction with the vehicle ECS, shall provide a secondary environmental and life support protection, necessary in the event of a pressure failure within the vehicle. In a pressurized mode the EMU shall not reduce the capability of the crew to adequately perform the tasks essential to crew safety and mission success.

3.4.8.1.2 Crewman Umbilicals. - Umbilicals shall provide the environment necessary for the crew. The umbilicals shall be routed to provide necessary mobility for crew tasks within the cabin. The required ECS umbilicals, housing the communication, electrical and instrumentation cables shall be assembled into one primary umbilical assembly for each crewman for use in intravehicular operation.

3.4.8.1.3 Ingress and Egress. - Crew ingress and egress routes from free space for extravehicular activity and for crew and equipment transfer between the CM and the vehicle shall be free of protuberances and unprotected areas which would act as a snare or otherwise hamper crew transfer. Hand grips and foot holes shall be in accordance with human factors and cabin arrangement.

3.4.8.1.4 Stowable Government Furnished Equipment. - Additional GFE, installed, stowed or otherwise interfaced with the CPS shall be as specified, or as referenced within the applicable P&I specification but not limited to the following:

(a) Portable Life Support System (PLSS)

(b) PLSS Calibration Unit

3.4.8.1.4 (Continued)

(c) PLSS Spare Parts

(d) Pressure Garment Assembly

(e) Thermal Meteoroid Garment

(f) Extravehicular Boots

(g) Extravehicular/Intravehicular Gloves

(h) Extravehicular Mittens

(i) Suit Repair Kit

(j) External Visor Assembly

(k) PLSS Battery

(l) Radiation Survey Meter

(m) LiOH Cartridges

(n) First Aid Kit

(o) Water Probe

(p) Food Packages (including disinfectant)

(q) Emergency Oxygen System

(r) Umbilical Stowage Fitting

(s) Coupling Display Units

(t) Radiation Survey Meter

(u) Power and Servo Assembly

(v) Inflight Data Management Kit

3.4.8.1.4 (Continued)

(w) EMU - Radiation Dosimeter

(x) EMU - Bioinstrumentation

(y) Constant Wear Garments

(z) Liquid Cooled Garment

(aa) CSM Equipment

(bb) EMU Spare Parts

3.4.8.2 Cabin Arrangement Design Requirements. - The cabin arrangement shall provide for effective performance of the crew tasks by efficient storage of associated equipment and expendables, and the establishment of appropriate crew primary and secondary stations. The cabin shall consist of a 92 inch inside diameter cylindrical forward cabin and a 54 inch long cylindrical equipment tunnel with a total volume of approximately 250 cubic feet. The forward cabin, which accounts for about two-thirds of the total volume, shall contain the primary stations and most of the controls and displays. The cabin arrangement and crew station shall accommodate the required ranges of crew sizes (10-90 percentile men) with respect to reach, body clearance, visibility, mobility, "cubical" size and body position or attitude.

3.4.8.2.1 Primary Station. - A flight station shall be provided for a standing crewman. A design reference point (design eye) shall be established to orient flight station geometry for the required balance between external visibility, visual and physical access to controls and displays. Instrument panels, windows, glare shields, controllers and arm rests shall be oriented with respect to this design reference point. The flight station shall be provided with the necessary floor to overhead height, body clearance and arm rest adjustment to accept all crewmen in the 10-90 percentile anthropomorphic body size.

3.4.8.2.2 Secondary Station. - The secondary station is located in the center aisle between the individual flight stations for use of the alignment optical telescope (AOT). The crewman shall have a single step up adjustment for height in order to accommodate the range of percentile

3.4.8.2.2 (Continued)

men to the eye-piece and the AOT controls. The donning station shall also be in the center aisle but slightly aft of the optical alignment station. A removable height adjusting PLSS supporting harness shall permit donning and doffing of the PLSS backpack. A recharge station shall be in the rear of the left primary station and facing aft. This station will be accessible from the forward cabin.

3.4.8.2.3 Lighting. -

*3.4.8.2.3.1 Internal Lighting. - A primary and secondary means of control and display panel illumination shall be provided. These shall include integral and floodlighting by electroluminescent, incandescent or self-luminous methods as required. Lighting shall also be provided for crew use in illuminating remote or shadowed areas of crew cabin.

*3.4.8.2.3.2 External Lighting. - External lighting shall provide illumination for EVA.

3.4.8.2.4 Displays and Controls. - The displays and controls shall be mounted in panels and consoles consistent with the crew station and conforming to the human factor and geometry capability of the crewmen. The panel arrangement shall consist of tiered side panels, sloping to provide greater surface area, recessed protection of controls and displays, and to approximate normal inclination to the line of sight. A main panel shall be located between the forward windows which will permit visual and physical access by both crewmen in the primary station. Exposed areas of the panels or the displays shall not exceed a gloss level of 5 units as measured by ASTM Method D523 of Specification MIL-P-7788A. The panels and consoles shall be designed for efficient ground service maintainability.

*3.4.8.2.5 Support and Restraint. - An adjustable force harness system which will load the human body during zero or reduced "G" conditions in a manner simulating the earth gravitational load shall be used. The harness provides for the loading of the human body through the center of mass in a manner similar to the normal earth gravitational loading. This is accomplished with a spring and cable which is attached to the floor by means of a universal joint. The harness system shall provide for the following:

3.4.8.2.5 (Continued)

(a) Fixation for the crewman at a work station.

(b) Allowing for limited mobility to perform such tasks as the operation of controls, monitoring of instruments and maintenance activities.

(c) External loading to the human body to help prevent:

(1) Muscular atrophy

(2) Bone decalcification

(d) Possible alleviation of associated cardiovascular problems.

*3.4.8.2.6 Crew Aids. - Provisions for aids shall be included to permit safe transfer of crewmen and equipment in and out of the vehicle. Aids shall also be provided for crew resting during the performance of mission tasks.

(a) Interior and exterior aids shall be provided, as required, to promote and facilitate crew mobility. Hand holds, foot holes, alighting ladders, platforms and tether line attachments may be used for this purpose.

(b) An arm rest shall be provided for the crewman operating the left primary station controllers. For long periods of observation, one flat seat, capable of swiveling to primary areas of operation shall be provided. The seat shall be stowable when not required.

3.4.8.2.7 Marking and Identification. - Markings of interior and exterior areas by color for identification, including nomenclature, shall be provided as required to support the performance of tasks by flight and ground servicing personnel.

*3.4.8.2.8 Inboard Profile Drawing. - The inboard profile drawing, Figure 23, depicts the arrangement of the equipment to support the crew in the performance of their duties.

1. Fwd Panels & Consoles
2. Side Consoles & Breaker Panels
3. Attitude Controller Ass'y & Armrest
4. Translator Controller Ass'y & Armrest
5. Work Table
6. Fwd Hatch (Ingress /Egress)
7. PLSS (Back Pack)
8. Thermal Meteroid Garment
9. Constant Wear & Liquid Cooled Garments
10. Suit Servicing Kits
11. Adjustable Seat - (Working Position)
12. Adjustable Seat - (Stowed Position)
13. A. O. T.
14. Work Table Light
15. Flood Lights
16. PLSS LiOH
17. PLSS/Recharge Station
18. CSM LiOH
19. PLSS Batteries
20. Voice Storage Recorder
21. CSM Tape Recorder, Tapes & Cold Plate
22. Lunar Boots
23. ECS Package/Suit Loop
24. Cabin Blower
25. Flexible Duct From CSM
26. Docking Hatch (Open)
27. Dome Light
28. Storage Compartment
29. Food
30. Emergency Oxygen
31. Seat Mount Fitting

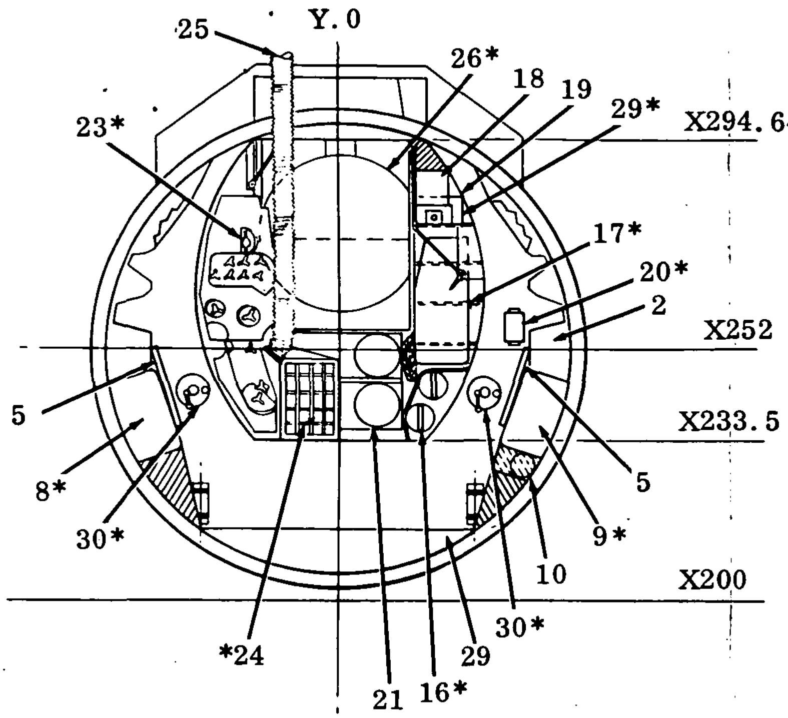
2

X294.64

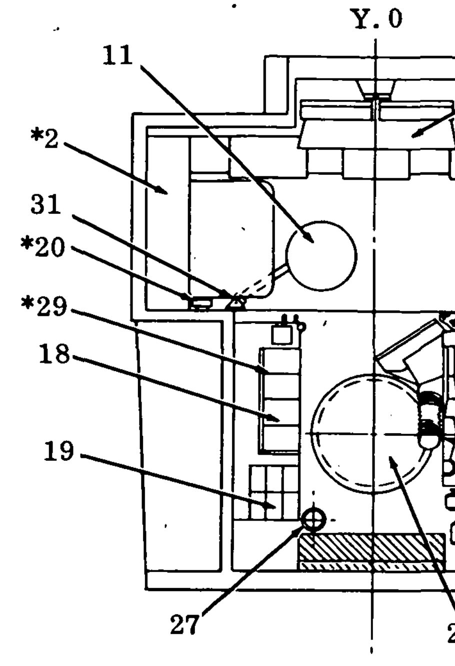
X233.5

NOTE:

1. Items Marked (*) Are Existing or Modified Equipment On The Present LEM Vehicle.
2. The Shaded Areas Indicate Available Experiment Storage Volume, Approximately 17.4 cu ft.

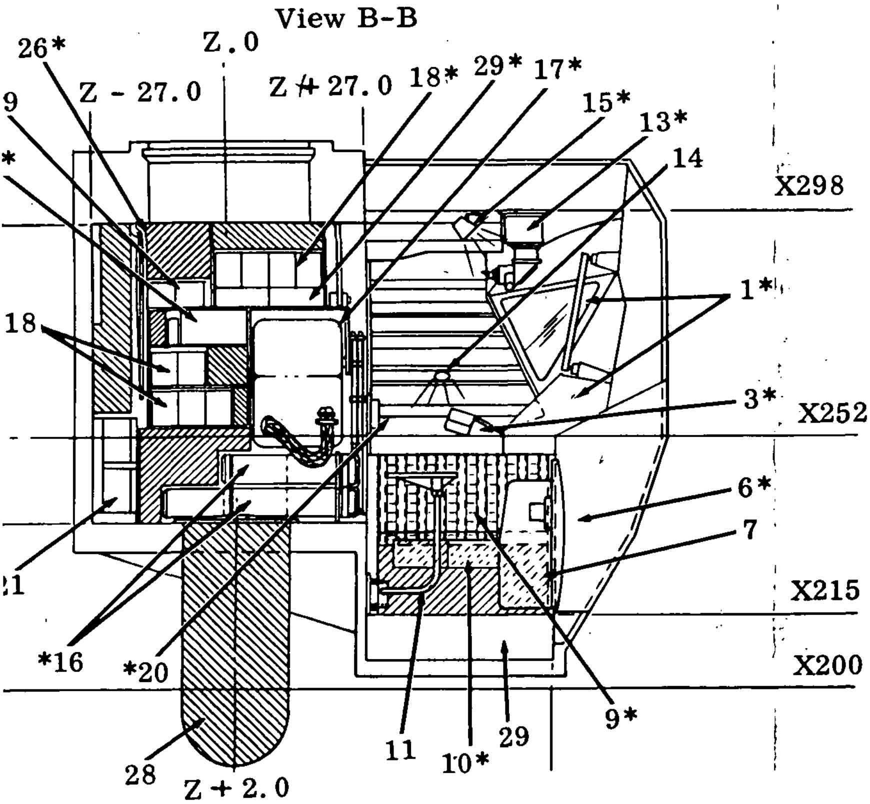


View Looking Aft + 27.0

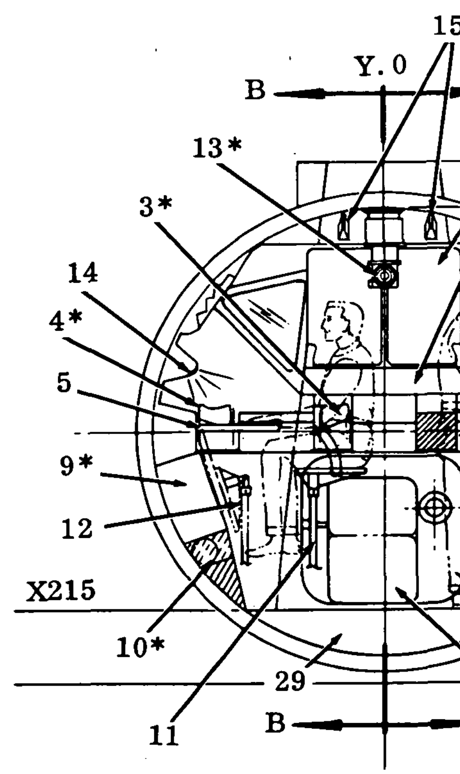


Plan View

View B-B



View Looking Outb'd
L. H. Side



View Looking

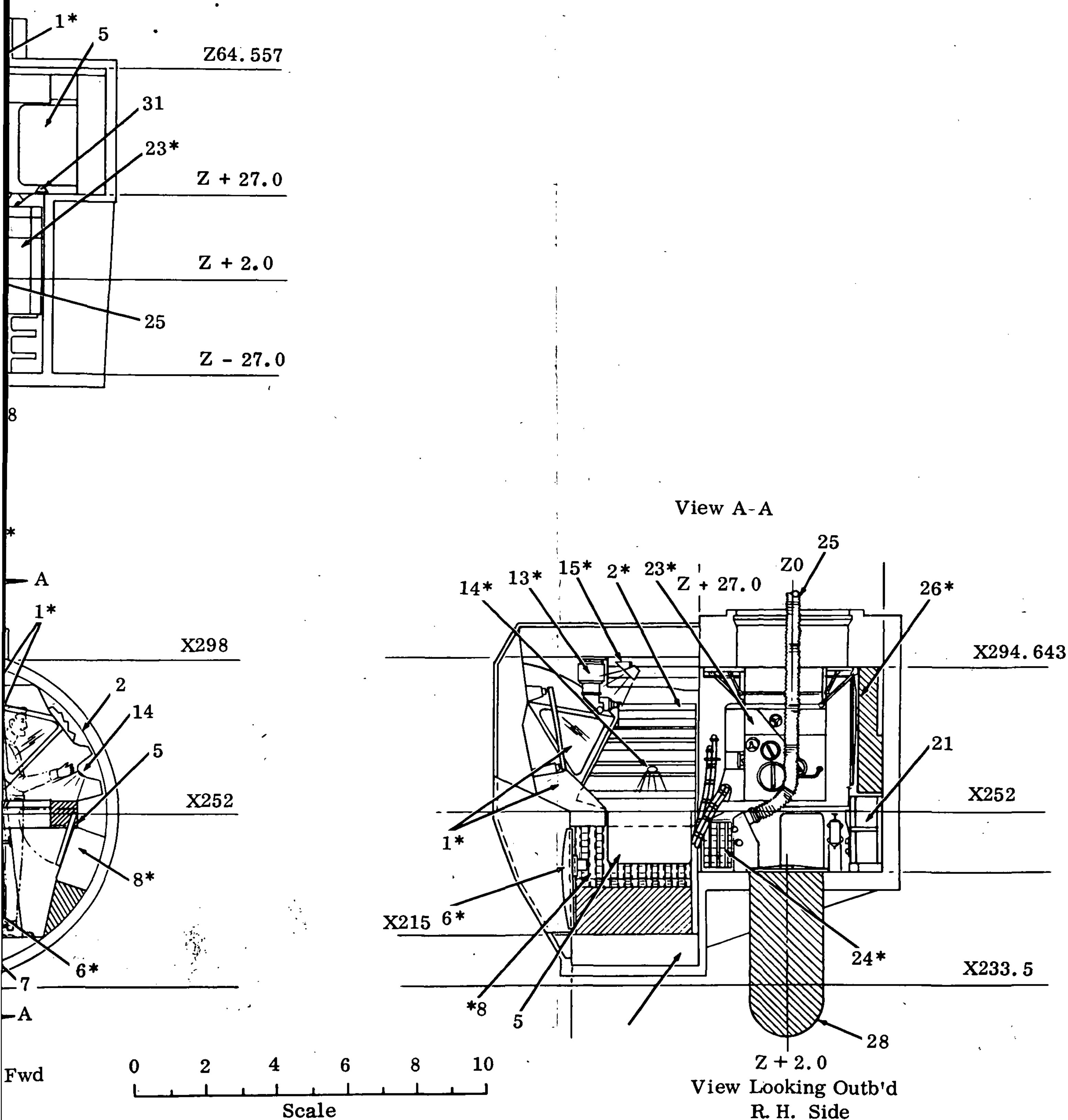


Fig. 22 Inboard Profile

Grumman

3.4.9 Displays and Controls Subsystem (D & C). - The D & C equipment shall present information to, and accommodate control action inputs from, the Lab I crew for the following purposes:

(a) Initiation, monitor and control of spacecraft maneuvers, maneuver sequences, and event sequences.

(b) Operation of Lab I subsystems and management of subsystem conditions.

(c) Management of Lab I stored propellants and energy sources.

(d) Alarm for hazardous conditions and Lab I subsystem malfunctions affecting the mission.

3.4.9.1 Performance Requirements. -

*3.4.9.1.1 Engine/Thrust Control. -

Control/Indicator	Function
Attitude Controller (CDR)	The 3-axis Attitude Controller shall provide attitude command signals to the vehicle.

3.4.9.1.2 Circuit Breakers. -

Control/Indicator	Function
CDR Panel and SE Panel	The circuit breakers within the vehicle shall provide electrical protection. Some circuit breakers shall serve as ON-OFF controls.

*3.4.9.1.3 Explosive Devices. -

Control/Indicator	Function
RCS Pressurization Switch	This switch shall activate all squib valves necessary to pressurize the Reaction Control Subsystem.

3.4.9.1.3 (Continued)

Control/Indicator	Function
Master Arm Switch	This switch shall arm all explosive devices.

3.4.9.1.4 Reaction Control Subsystem. -

Control/Indicator	Function
Propellant Quantity Monitor Select Switch	This switch shall select the mode for monitoring the fuel and oxidizer tank quantities.
Thruster Pair Switches	
System A System B	Each of eight switches shall actuate a TCA isolation valve controlling the fuel and oxidizer flow to the TCA.
Temperature/Pressure Monitor Switch	This switch shall select: (a) Helium, fuel and oxidizer tank pressure and temperature (b) Fuel and oxidizer tank pressure and temperature (c) Fuel and oxidizer manifold pressures on the pressure and temperature indicators.
RCS Crossfeed Switch	This switch shall control two valves which interconnect the propellant valves of systems A and B.

3.4.9.1.4 (Continued)

Control/Indicator	Function
Helium Regulator Switches	
System A System B	Each of four switches shall control solenoid operated shut off valve of systems A and B, upstream of the pressure regulators in each helium leg.
Test Switch	This switch shall be used to isolate a leaking thrust chamber assembly, or to test the gaging assembly (in conjunction with the Quantity Monitor Switch and the Propellant Quantity Indicators).
Main Shutoff Switch	
System A System B	Each of the two switches actuates latch type solenoid valves which control the flow of propellant downstream of the propellant tanks.
Pressure Indicator	
System A System B	These indicators shall display the pressures in the helium, fuel or oxidizer tanks or manifolds as selected by the monitor switch.
Temperature Indicator	
System A System B	This indicator shall display the temperatures in the helium, fuel or oxidizer tanks as selected by monitor switch.

3.4.9.1.4 (Continued)

Control/Indicator	Function
Oxidizer Quantity Indicator, Fuel Quantity Indicator	These digital indicators shall display oxidizer and fuel quantities left in system A or B.
Regulator #1 Status; System A	Each of four 2-position flags shall indicate the open or closed status of its respective solenoid valve.
Regulator #2 Status; System A	
Regulator #1 Status; System B	
Regulator #2 Status: System B	
Main Shutoff Status	
System A	Each of two 2-position flags shall indicate the open or closed status of its respective solenoid valves.
System B	
Thruster Pair Status	
Quad. #1, System A	Each of two 2-position flags shall indicate the open or closed status of its respective solenoid valves.
Quad. #2, System A	
Quad. #1, System B	
Quad. #2, System B	

3.4.9.1.4 (Continued)

Control/Indicator	Function
Thruster Pair Status	
Quad. #3, System A	Each of two 2-position flags shall indicate the open or closed status of its respective solenoid valves.
Quad. #4, System A	
Quad. #3, System B	
Quad. #4, System B	
Crossfeed Status	This 2-position flag shall indicate the open or closed status of the crossfeed solenoid valves.

*3.4.9.1.5 Flight Controls. -

Control/Indicator	Function
Attitude Monitor (Automatic Mode) (CDR)	This display enables monitoring of the FDAI vehicle attitude inputs and steering errors.
Flight Director Attitude Indicator (CDR)	The Attitude Indicator consists of a gimballed, servo-driven sphere which is free to rotate through 360 degrees in each of three mutually perpendicular axes. The yaw, pitch and roll attitude indications shall have a static accuracy of ± 0.5 degrees at zero degrees. The yaw and pitch indicators have a static accuracy of ± 1.0 degree at other points on the sphere. Vehicle

3.4.9.1.5 (Continued)

Control/Indicator	Function
	attitude inputs derived by either the AGS or PGNCS can be selected for display through the appropriate attitude monitor switch. Attitude rates shall be displayed from the rate gyros in the CES. The indicator lag in each axis shall not exceed 1 degree at an input rate of 10 degrees per second.
Elapsed Time Indicator	This indicator shall display Lab I mission elapsed time in hours, minutes and seconds.
Digital Event Timer	This indicator shall display time in minutes and seconds on a four digit display.
Elapsed Time Set Control	This control shall allow setting of the elapsed timer.
Timer Control Switch	This switch shall have momentary contacts for the start and stop positions.
Reset/Count Control Switch	This 3-position toggle switch shall determine the direction the digital event timer will count after it is manually started.
Slew Control Minutes Switch	This momentary toggle switch shall slew the minutes' digits of the digital event timer.

3.4.9.1.5 (Continued)

Control/Indicator	Function
Slew Control Seconds Switch	This momentary toggle switch shall slew the seconds digits of the digital event timer.

3.4.9.1.6 Guidance, Navigation and Control. -

Control/Indicator	Function
Gyro Test Select (Pitch, Roll, Yaw) Switch	This switch shall select a rate gyro for test.
Gyro Test Select (Positive Rate, Negative Rate) Switch	This switch shall torque the selected rate gyro positively.
Deadband Select Switch	This switch shall select either a large or narrow deadband amplitude limit cycle for vehicle attitude control.
Attitude Control Switch	
Pitch	Each of these switches shall select direct or pulse operation. These switches shall provide individual selection in each attitude axis.
Attitude Control Switch	
Roll	
Attitude Control Switch	
Yaw	
Attitude Control Mode Switch	This switch shall slect the mode of operation of the vehicle's attitude axis.

*3.4.9.1.7 Communications. -

Control/Indicator	Function
Modulator Select Switch	This switch shall select phase modulated or frequency modulated transmission mode of the S-Band transmitter.
Transmitter/Receiver Select Switch	This switch shall select either of two redundant transmitter/receiver subassemblies.
Power Amplifier Select Switch	This switch shall select either of two redundant S-Band power amplifiers.
Voice Function Select Switch	This switch shall select either normal voice or backup voice function of the S-Band transmitter.
PCM/Key Function Select Switch	This switch shall select either the telemetry or Morse Code keying function for transmission via the S-Band equipment.
Biomed Select Switch	This switch shall select bio-medical data to be telemetered.
PCM Rate Select Switch	This shall select the high or low bit rate to be transmitted.
VHF Transmitter/Receiver Select Switch	This switch shall select various combinations of VHF A and B transmitters and receivers.
VHF A Squelch Control VHF B Squelch Control	These controls shall permit the adjustment of the threshold of the VHF A or B receiver squelch circuit.

3.4.9.1.7 (Continued)

Control/Indicator	Function
Voice Recorder Switch	This switch shall be used in conjunction with the VOX circuit for controlling tape recording.
Record Status Indicator (Tape)	This display shall indicate whether the tape transport is moving and voice recording is taking place.
Biomed Jack & Hardline Jack	This control shall adjust the intercom audio level.
Hardline Volume Control	
Hardline CSM Switch	This switch shall select the Commander or the Systems Engineer.

*3.4.9.1.8 Instrumentation. -

Control/Indicator	Function
Recorder #1 Status Display	These displays shall indicate the number of feet of tape remaining.
Recorder #2 Status Display	
Electronic Control Switch	
Recorder #1	These switches shall select record or dump mode.
Electronic Control Switch	
Recorder #2	
Speed Control Switch	
Recorder #1	These switches shall select speeds for Hi, Lo or Normal bit rates.
Speed Control Switch	
Recorder #2	

3.4.9.1.8 (Continued)

Control/Indicator	Function
Direction Control Switch Recorder #1	These switches shall select forward, stop and reverse directions for the tape recorder.
Direction Control Switch Recorder #2	
Bypass Switch	This switch shall bypass the tape recorder for transmission on real time.

3.4.9.1.9 Audio Control Panel (2 Identical Panels). -

Control/Indicator	Function
S-Band Switch	This switch shall tie the respective audio center into the S-Band transmitter/receiver circuitry.
ICS Switch	This switch shall tie the audio into the intercom circuitry.
Relay Switch	This switch shall tie the VHF into the S-Band transmitter/receiver circuit to provide voice communications between the Lab I, Earth, EVA or CM.
VHF A Switch	These switches shall tie the respective audio center into the VHF A or B transmitter/receiver circuit.
VHF B Switch	

3.4.9.1.9 (Continued)

Control/Indicator	Function
VOX Switch	This switch shall provide either voice operated relay activation or push-to-talk keying of transmitters.
VOX Sensitivity	This control shall adjust the level of voice input required to activate the voice operated relay.
S-Band Volume Control	This control shall adjust the level of the S-Band audio input to the headphone.
ICS Volume Control	This control shall adjust the level of the intercom audio input to the headphone.
VHF A Volume Control VHF B Volume Control	These controls shall adjust the level of the VHF A or B audio input to the headphone.
Master Volume Control	This control shall simultaneously adjust the level of all audio inputs to the headset through the respective audio center.

3.4.9.1.10 Communications Antennas. -

Control/Indicator	Function
Pitch Antenna Control	This control shall drive the S-Band antenna in the pitch axis.
Yaw Antenna Control	This control shall dirve the S-Band antenna in the yaw axis.

3.4.9.1.10 (Continued)

Control/Indicator	Function
Track Mode Select	This switch shall select either the auto or manual mode of track of the S-Band antenna.
VHF Antenna Select	This switch shall select the VHF antennas as well as a test position to check out EMU information exchange.
Signal Strength Meter	This meter shall monitor the S-Band signals received from the earth.
Antenna Pitch Meter	This meter shall display the pitch angles of the S-Band steerable antenna.
Antenna Yaw Meter	This meter shall display the yaw angle of the S-Band steerable antenna.
"No Track" Light	This component caution light indicates that the S-Band steerable antenna has broken track with the RF signal trana-mitted from earth.

*3.4.9.1.11 Electrical Power Supplies. -

Control/Indicator	Function
Batteries #1 through #20 High Voltage Control Switches	Each 3-position toggle shall control the high voltage power output from one of 20 descent batteries.

3.4.9.1.11 (Continued)

Control/Indicator	Function
Batteries #1 through #20 Low Voltage Control Switches	Each 3-position toggle shall control the low voltage power output from one of 20 descent batteries.
Descent Batteries Switch	This 3-position, center return toggle shall provide power interruption of the descent batteries' feed path to the ascent stage.
Battery #21 - Normal Feed Battery #22 - Normal Feed	These 3-position toggles shall control Ascent battery #21 and Ascent battery #14 feed paths to both busses, respectively.
Battery #21 - Alternate Feed	This 3-position toggle shall control Ascent battery #21 power feed path to both busses.
Battery #22 - Alternate Feed	This 3-position toggle shall control Ascent battery #22 power feed path to both busses.
AC Power Control Toggle	This 3-position toggle shall control a-c power to the a-c bus.
Power/Temperature Monitor Select Switch	This 10-position rotary shall provide power and temperature monitoring on meters of the electrical power subsystem.
Ascent Power Auto Transfer Switch	This toggle shall control the automatic switch-over feature whereby the two ascent batteries energize the busses in the event of failure of two or more descent batteries.

3.4.9.1.11 (Continued)

Control/Indicator	Function
Battery Temperature Indicator	This meter shall indicate battery temperature in Fahrenheit.
Voltmeter	This meter shall indicate the voltage of any battery or bus in the EPS.
Ammeter	This meter shall indicate the current of the batteries.
Over Temperature Light	This light shall warn of battery overheating.
Reverse Current Light	
Descent Batteries #1 through #20 Status Flags	These flags shall indicate the battery is on the line when the gray position is in view. The battery is off the line when the "barber-pole" position is in view.
Ascent Battery #21 - Feed Status	This flag shall indicate that Battery #21 is powering the System Engineer's bus when the gray position is in view.
Ascent Battery #22 - Cdr Bus Feed Status	This flag shall indicate that Battery #22 is powering the Commander's bus when the gray position is in view.
Ascent Battery #21 - Cdr Bus B.U. Feed Status	This flag shall indicate that Battery #21 is powering the Commander's bus when the gray position is in view.

3.4.9.1.11 (Continued)

Control/Indicator	Function
Ascent Battery #22 - SE Bus B.U. Feed Status	This flag shall indicate that Battery #22 is powering the System Engineer's bus when the gray position is in view.

3.4.9.1.12 Environmental Control. -

Control/Indicator	Function
Suit Circuit Fan Select Switch	This switch shall select suit fans.
Coolant Pump Select Switch (3)	This switch shall select pump #1, 2 or 3 and shall enable an automatic shut off of a malfunctioning pump.
Water, O_2 Quantity Monitor Switch	This switch shall indicate the quantity of water or gaseous oxygen in percent.
CO_2 Partial Pressure Indicator	This indicator shall display carbon dioxide partial pressure of the Atmospheric Revitalization Section.
Cabin Pressure/Suit Pressure Indicator (Double Movement)	This indicator shall display cabin interior and EMU suit pressure.
Cabin Temperature/Suit Temperature Indicator (Double Movement)	This indicator shall display cabin and EMU suit circuit temperature.
Gaseous Oxygen Pressure/H_2O Indicator	This indicator shall display gaseous oxygen pressure and shall display total water in Ascent tanks (#1 or #2) and Descent tank.

3.4.9.1.12 (Continued)

Control/Indicator	Function
Glycol Pressure/Temperature Indicator	This indicator shall display the pressure and temperature of the glycol coolant in both the primary and secondary heat transport loops.
CO_2 Component Caution Light	This light shall indicate the CO_2 status of the primary LiOH canister.
Water Separator Component Caution Light	This light shall indicate the failure status of the operating water separator.
Suit Circuit Fan Component Caution Light	This light shall indicate the failure status of the selected suit fan.
Glycol Pump Component Caution Lights	Each of three lights shall indicate the failure status of its respective glycol pump.

3.4.9.1.13 Subsystem Lighting. -

Control/Indicator	Function
Annunciator Numeric Brightness Control	This control shall vary the brightness of all component caution lights, annunciator, and EL numeric displays.
Integral Lighting Control	This control shall vary the brightness of the low level integral lighting.
Flood Lighting Control	This control shall regulate the brightness of the floodlights.

3.4.9.1.13 (Continued)

Control/Indicator	Function
Side Panel Control (CDR) (SE)	This control shall make or break the circuits from the Integral Lighting Control and the Flood Lighting Control to provide lighting for the CDR and SE side panels.
Dome Light Control	This control shall regulate the brightness of the dome light.
Docking Light Control	This control shall turn the docking light ON or OFF.
Exterior Lighting Control	This switch shall control the docking and tracking lights on the vehicle.
Light/Tone Test Switch With 3 Override Toggle Switches (annunciator, numerics and integral)	This rotary switch is used to perform test functions.
Integral Override Switch	This switch supplies full voltage to the low level EL integrally illuminated markings and displays.
Annunciator Override Switch	This switch provides a full voltage bypass of the Caution/Warning and Component Caution light portion of the Annunciator/Numerics control.
Numerics Override Switch	This switch provides a full voltage bypass of the numeric portion of the Annunciator/Numerics control.

*3.4.9.1.14 Abort Guidance Section. -

Control/Indicator	Function
DEDA	Shall identify the program for communication with the computer. Shall enable the crew to communicate with the computer. Shall provide the capability of interrupting a continuously updated readout when activated.

3.4.9.1.15 Caution and Warning. -

Control/Indicator	Function
Caution and Warning Displays	These displays shall consist of two master alarm lights, an array of caution and warning indicators, and component caution lights.
Master Alarm Lights	Two aviation red Master Alarm lights.
Master Alarm Tone	Shall be an audible tone heard through the headphones in conjunction with the Master Alarm lights.
Warning Array	Shall be an array of no more than 20 aviation red-lighted legends, located near the top of panel I.
Caution Array	Shall be an array of no more than 20 aviation yellow-lighted legends, located near the top of panel II.

3.4.9.1.15 (Continued)

Control/Indicator	Function
Component Caution Lights	Shall be located on the control and display panels to aid in location of a particular malfunction. The face of these caution lights shall be circular and of the press-to-test type.
Caution & Warning Lights Test Switch	This switch shall provide a test for the bulbs in all the lights of Caution/Warning, Master Alarm, audible tone, and engine start and stop override pushbutton.

3.4.9.1.16 Heater Controls. -

Control/Indicator	Function
Battery Heaters	These heaters shall control heat of Ascent and Descent batteries.
RCS Quad #1 Heater Switch	These switches shall be used to control temperature of the four RCS quads.
RCS Quad #2 Heater Switch	
RCS Quad #3 Heater Switch	
RCS Quad #4 Heater Switch	
Temperature Monitor Select Switch	This 6-position rotary switch shall provide monitoring of the RCS quad. temperature.
Temperature Indicator	This indicator shall display the temperature, in degrees Fahrenheit, of the quad selected by switch 18-S-10.

3.4.9.1.16 (Continued)

Control/Indicator	Function
S-Band Heater Select Switch	This switch selects the range of temperature control desired to heat the S-Band Antennas.
S-Band Mode Switch	This switch selects one of three modes for the heaters. (Auto-Off-Manual).

*3.4.9.1.17 Biomedical. -

Control/Indicator	Function
Body Temperature Meter	Shall display body temperature in degrees Fahrenheit.
Respiration Rate Meter	Shall display respiration rate in breaths per minute.
Cardiotachometer/Rate Alarm	Shall display heart rate.

3.4.9.1.18 Radiation Protection. -

Control/Indicator	Function
Tissue Ionization Equivalent Chamber	Shall measure dangerous levels of radiation and display it on a rate meter.

3.4.9.2 Design Requirements. - The design of controls and displays shall conform to the following requirements:

(a) Display range and readout accuracy shall not exceed the needs of the flight crew to manage the vehicle. Scale markings shall not permit readout accuracies of a more precise nature than the accuracy of the input signal.

(b) All controls essential to crew safety shall permit satisfactory operation by a flight crew in pressurized space suits. Such considerations as appropriate location, spacing, size, and torque shall be included in this operation.

3.4.9.2 (Continued)

(c) Status indicators (flags or lights) shall be employed to indicate valve positions where such valves are actuated by inputs from momentary toggle switches.

(d) Time shared displays of parameters shall be employed when such parameters need not be monitored continuously or concurrently.

(e) Percentage readouts shall be employed where specific quantities are not required by the crew.

(f) Where feasible dual meters of the fixed scale, moving pointer type shall utilize a single scale, appropriate for both parameters displayed, centered between two pointers.

(g) Scale graduations shall progress by 1, 5 or 2 units, in that order of preference, or decimal multiples thereof only.

(h) All scale markings shall be equally spaced. The use of non-linear scales shall be avoided, if possible.

(i) Heights, widths, and spacing of all nomenclature shall be as close as feasible to the preferred dimenstions established by human engineering considerations. In no case shall these dimensions be smaller than the acceptable minimum established by these same considerations.

(j) Abstract symbols and abbreviations shall not be used unless they are easily understood by the crew. A minimum of two letters shall be required when any abbreviation is employed and shall be standard between modules.

(k) Interruption of power to any display shall be made immediately apparent to the crew.

(l) Maximum torque shall not exceed 10 inch-lbs. for crew operation of small valve control handles. A small valve control handle will not exceed 2 1/4" in diameter. This valve control is of the faucet type.

(m) Where 20-30 inch-lbs. control torques are required, control handles shall be not less than 3 inches in length.

(n) Controls or displays shall be designed to avoid blind actuation by the flight crew.

3.4.10 Explosive Devices Subsystem (EDS). - The EDS shall consist of explosive devices and related components necessary to initiate and control the functions specified in 3.4.10.1.

3.4.10.1 Performance Requirements. - The EDS shall initiate and control the following functions:

(a) Environmental Control Subsystem (ECS) water valve opening.

(b) Reaction Control Subsystem (RCS) pressurization.

3.4.10.2 Design Requirements. - Electrical wiring from the Lab I/CM interface to the Lab I/Spacecraft LEM Adapter (SLA) shall be provided through the Lab I to conduct the signal for SLA/Lab I separation.

3.4.10.2.1 Power Supplies. -

3.4.10.2.1.1 Logic Power. - Logic d-c power shall be supplied by the System Engineer bus and Commander bus in the ascent stage. Explosive device power shall be controlled by a manual switch.

3.4.10.2.1.2 Transient Power Characteristics. -

(a) The subsystem shall cause no transients under any condition as specified below:

  (1) Signal duration or signal interruption of greater than 10 microseconds and voltage variation greater than plus or minus 2 volts.

  (2) Signal duration sufficient to fire a standard pyrotechnic device.

(b) The subsystem shall operate satisfactorily when the logic bus voltage is maintained between 25 and 36.5 volts and with no logic bus voltage interruption greater than 500 microseconds during any 20 milliseconds period.

3.4.10.2.1.3 Explosive Devices Power. - The electrical power for the firing of explosive devices shall be supplied by two silver-oxide-zinc batteries in the descent stage.

(a) Battery Voltage - Open-circuit voltage shall be a maximum 37.8 volts. Nominal voltage shall be 23 volts while delivering 75 amperes. Final voltage shall be 20 volts when the battery is completely discharged after delivering 75 amperes.

(b) Battery Capacity - The battery shall be capable of delivering a current of 75 amperes for 36 seconds during the first six cycles of discharge down to a final voltage of 20 volts.

(c) Battery Service Life - The total number of complete cycles of discharge and recharge within the 60 to 100 degrees Fahrenheit temperature range shall be a minimum of six cycles.

3.4.10.2.2 Circuitry. -

(a) Circuit Protection. - Circuit protection for the EDS shall be provided by a system of high reliability circuit breakers and current limiting fuses.

(1) Circuit breakers shall be provided as follows:

a. To clear the logic busses of ground faults in the EDS.

b. To protect wiring from deterioration (including production of smoke or toxic fumes in the ascent stage cabin) caused by faults or overloads.

(2) Fused resistors shall be provided to limit current drain on the ED batteries due to vehicle wiring or ED firing circuit.

(b) Explosive Device Circuits - Explosive device circuits shall be the only electrical load to be connected to the explosive device power bus and shall not be powered from the logic bus.

3.4.10.2.1.3 (Continued)

(c) Isolation - Explosive device circuits and logic circuits shall be electrically and physically isolated from one another and their wiring shall be routed separately where possible.

(d) Grounds and Returns - The ED circuits shall not be grounded. The logic and instrumentation circuit ground returns shall be separate and shall in no way cause the ED circuit to become grounded.

(e) Shields - Firing circuit shields shall be electrically continuous with no physical discontinuities and grounding shall be consistent with the requirements of AFMTCP 80-2, General Range Safety Plan.

(f) Operational Assurance - To assure operation of all functions controlled by the EDS, the design shall be "fail safe" in all respects. The EDS shall consist of two independent circuits to provide redundancy. There shall be no electrical or mechanical crossovers except for the common mechanical actuation of control switches. A single failure shall not be cause for function failure or mission abort.

(g) Redundant Wiring - Redundant internal wiring shall be used where a loss of a single lead would cause premature initiation of a major function or loss of control of the function.

(h) Timing - Timing requirements shall be held within plus or minus 5 percent maximum under all conditions specified herein.

(i) Time Delays - Time delays shall be arranged to minimize the possibility of function initiation occurring before the termination of the specified time delay.

(j) Transients - See 3.4.10.2.1.2.

(k) Explosive Devices Shorting - The controller fire relay shall maintain a shunt across each explosive device circuit prior to firing. The firing circuit operation shall simultaneously remove this shunt and provide ED initiation. The shunt resistance shall be 2.5 ohms maximum.

3.4.10.2.2 (Continued)

(l) Manual Capability - Manual capability shall be provided for selected functions as specified herein.

3.4.10.2.3 Explosive Device Requirements. - The modular concept shall be used in the design of all explosive devices and assemblies. Explosive charge assemblies of all types shall be separate from higher assemblies and from structural elements. Devices containing an integral Apollo Standard Initiator (ASI) and which would by their own energy or by initiating a chain of events, cause injury to people or damage to property, shall be capable of installation on the launch pad. Explosive devices having unique applications shall be designed to preclude mis-installation. Threaded cartridges having different output characteristics shall have different thread sizes. All high explosive charges such as a mild detonating fuse (MDF), shall be mounted in suitable charge holders which are separable from structural elements. Charge holders shall be designed to protect the explosive trains, to minimize and/or direct backblast, and to permit ease of installation at the launch site. The explosive charge shall be sealed from exposure to atmospheric and mission environments. Explosive trains consisting of more than one integrally assembled component shall have boosted interfaces.

*3.4.10.2.4 Explosive Devices. - The following explosive devices separately or in various combinations shall accomplish the previously specified functions.

(a) Apollo Standard Initiator (ASI) - The ASI shall initiate all electrically actuated explosive functions required during the Lab I mission. This device is common usage with NAA.

(b) Apollo Standard Detonator (ASD) - The ASD shall be used to detonate all high explosive charges in the Lab I. This device is common usage with NAA.

(c) Mild Detonating Fuse (MDF) - The MDF shall be common usage with NAA.

(d) ECS Water Valve - The ECS water valve shall be actuated by one or both of the two ASI's installed.

3.4.10.2.4 (Continued)

(e) RCS Helium Pressurization - The RCS explosive valve shall be actuated by the single ASI installed.

(f) Circuit Interrupter - Circuit interrupters shall be provided to terminate all signal and power leads running between the ascent and descent stages which are live at time of separation or which could subsequently become live due to activation of a circuit. These devices shall be initiated explosively approximately 10 milliseconds after stage command is received. They shall be actuated by either of the two ASI's.

4 QUALITY ASSURANCE PROVISIONS

4.1 Quality Program. - A Grumman quality program shall be established in accordance with NASA Publication NPC 200-2. The quality program shall provide the general requirements necessary to ensure that the vehicle meets the quality requirements of the contract. These requirements shall include the establishment and maintenance of an effective quality program from the design conception to the delivery of a vehicle.

4.1.1 Identification and Traceability. - The quality program shall provide for identification and traceability control.

4.2 Reliability Program. - A Grumman reliability program shall be established in accordance with NASA Reliability Publication NPC 250-1.

4.3 Tests. -

4.3.1 Development. - The development tests shall be as specified in 4.3.1.1 and 4.3.1.2.

4.3.1.1 Design Feasibility Tests. - Design feasibility tests shall be conducted for all new equipment and to LEM equipment which has been redesigned or modified to the extent that performance or safety strength margins under selected environments are now in doubt. The tests shall be conducted to:

(a) Achieve component and part selection.

4.3.1.1 (Continued)

(b) Investigate the performance of breadboard models, components and subassemblies under selected environmental conditions.

(c) Substantiate safety/strength margins and analytical assumptions.

4.3.1.2 Design Verification Tests. - Design verification tests shall be conducted for all new equipment and to LEM equipment which has been redesigned or modified in order to verify the optimum design characteristics prior to qualification testing. These tests shall include all tests conducted to substantiate the correctness of the design for its intended mission under simulated ground and flight environments and off design conditions.

4.3.1.2.1 Required Tests. - As a culmination to design verification, the specified vehicle equipments shall be subjected to the critical environments of an operational cycle followed by an overstress test. These tests shall fulfill the following essentials:

(a) The tests shall be performed on production equipment.

(b) Successful completion of these tests except for overstress tests shall be a prerequisite to the start of qualification tests. Completion of overstress tests shall precede the completion of qualification tests.

(c) No failure, replacement of parts, maintenance or adjustments shall be permitted during the critical environments tests, except those adjustments which are included as part of the normal operation of the equipment under test.

4.3.1.2.1.1 Critical Environmental Tests. - The specified equipments shall be successfully subjected to the critical environments of an operational cycle. The critical environments shall be at mission levels. An operational cycle shall consist of all the environments and dynamic conditions to which the equipment will be exposed during the acceptance tests, handling, transportation and storage, prelaunch, launch, translunar, and lunar phases of the vehicle mission. Equipment subject to particular environments shall be subjected to applicable critical environmental tests.

4.3.1.2.1.2 Overstress Tests. - At the completion of the critical environmental tests, the equipment shall be tested to failure by systematically increasing dynamic and environmental stresses. Deviation of performance from the minimum acceptable operating mode shall constitute a failure. The equipment shall dwell long enough at each increment of overstress to stabilize conditions and complete an abbreviated operational test.

4.3.1.2.1.2.1 Selection of Stresses. - A failure mode prediction analysis shall provide the basis for the selection of critical stresses to be employed in the overstress tests. Only conditions from the launch and post-launch phase of the mission shall be used for the overstress tests. If the critical mission stresses are due to a combination of dynamic and environmental conditions, the tests shall be performed under that combination of environments. If the critical stresses are due to several dynamic and environmental conditions which are not in combination in the mission, the test increments shall be performed with each condition imposed separately. Each increment of the test conditions shall be increased in proportion to their values at mission levels.

4.3.1.2.1.3 Analysis of Results. - An engineering analysis of the data generated by the overstress tests, including a correlation with the failure mode prediction analysis, shall be performed.

*4.3.2 Qualification Tests. - Qualification tests shall be performed in compliance with the requirements of NASA Quality Publication NPC 200-2. Qualification tests of parts, components, subassemblies and higher levels of assembly shall be performed to demonstrate that the vehicle is capable of meeting the requirements specified in the applicable individual End Item specification. Qualification tests shall be performed on two production equipments. One equipment shall be used for design limit tests and the other equipment shall be used for endurance tests. A qualification endurance test shall be performed on a selective basis on only those equipments identified for endurance testing as the result of analysis.

4.3.2.1 Qualification Testing Requirements. -

4.3.2.1.1 Applicability. - The qualification tests shall start at the lower levels of assembly and proceed to levels of higher assembly. As a general rule, it is not economically practical or feasible to conduct

4.3.2.1.1 (Continued)

qualification tests on complete subsystems. Accordingly, most of the qualification tests shall be conducted on lower levels of assemblies to the degree necessary to provide confidence on a subsystem basis. This will be done by conducting tests at hardware levels such that when the total qualification program on a subsystem is completed all items of hardware and all operational modes will, as a minimum, be tested to an amount equivalent to a subsystem qualification test.

4.3.2.1.2 Purpose. - Qualification tests shall be designed to:

(a) Locate significant failure modes.

(b) Determine the effects of varied stress levels.

(c) Determine the effects of combinations of tolerances and drift of design parameters.

(d) Determine the effects of applicable combinations and sequences of environments and stress levels.

4.3.2.1.3 Environments. - Qualification testing shall include both natural and induced environments. Combined environments shall be used when applicable.

4.3.2.1.3.1 Qualification Criteria for Environments. -

4.3.2.1.3.1.1 Criteria for Imposing Environment. - The criteria for imposing environments during qualification testing shall be based on the concept that all vehicle equipment shall demonstrate their capability to withstand the worst case operational cycle environments, both natural and induced.

4.3.2.1.3.1.3 Natural Environments. - All natural environments shall be considered for inclusion such as: humidity, salt spray, rain, sand and dust, fungus, ozone, solar radiation, and pressure/vacuum.

4.3.2.1.3.1.3 Induced Environments. - All induced environments shall be considered for inclusion such as: acceleration, acoustics, shock, vibration, high temperature, low temperature, pressure/vacuum, oxygen, cabin contaminates (salt and humidity), and EMI/RFI.

4.3.2.1.3.1.4 Environmental Levels. - The environmental levels shall be derived from the most severe conditions that may be imposed during an operational cycle and shall be as defined in 3.1.2.4 and 3.1.2.8.

4.3.2.1.3.1.5 Testing. - Testing shall be performed on those equipments that have an inherent sensitivity to the particular environment. The sensitivity shall be based upon the item failure modes and the effects of the environment upon its endurance, strength, and operational characteristics.

4.3.2.1.3.1.6 Sensitivity. - If the sensitivity of the equipment to a particular environment cannot be positively determined, the equipment shall be subjected to testing to that environment.

4.3.2.1.3.1.7 Particular Environment. - Testing to a particular environment may be waived when analysis demonstrates that the environmental level is reduced through reliable protective measures to a point where it is insignificant. Testing may also be waived where the inherent strength or design characteristic of the equipment renders it insensitive to the specified environmental level.

4.3.2.1.3.1.8 Sequence. - The sequence in which the environments imposed during testing shall be as outlined below except that tests shall be planned to minimize the number of test set-ups, providing the test objectives are not severly compromised. Tests shall avoid facility and special test equipment overlap.

(a) For endurance qualification, environments shall be imposed in the same sequence that will be experienced during a normal operational cycle.

(b) For design limit qualification, the sequence shall be based upon its possibility of occurrence, the severity of the degradation effects and inter-reaction effects, where known. The most critical environments shall be imposed first.

4.3.2.1.4 Program Design. - In determining the number of equipments required for qualification, all prior development tests including integrated ground tests shall be considered. Portions of the

4.3.2.1.4 (Continued)

development tests may be used to reduce the qualification tests required provided all qualification test requirements are met, prior NASA approval is obtained. Where redundancy in design exists, the qualification tests shall assure that each redundant component and mode will be included in the test program. Qualification test procedures and criteria shall be specified for each equipment which will undergo qualification testing, and the qualification tests will fully encompass the design requirements specified for that equipment.

4.3.2.1.5 Schedule. - Qualification tests supporting a particular flight vehicle shall be completed prior to that vehicle being delivered by the contractor.

4.3.2.1.6 Qualification Basis. - The minimum qualification shall include one set of equipment subjected to sequential, singly applied environments at design limit conditions (Design Limit Test), and another set subjected to one operational cycle and one subsequent mission cycle at nominal mission conditions (Endurance Test).

4.3.2.1.6.1 Qualification by Similarity. - Qualification by similarity may be accepted provided the following criteria are satisfied:

(a) The equipment was qualified to environmental test requirements that meet or exceed those specified for Lab I.

(b) The equipment was fabricated by the same manufacturer with the same methods or processes and quality control.

(c) The equipment was designed to specifications that satisfy all the requirements set forth for that item in Lab I specifications.

4.3.2.1.6.2 Requalification. - Requalification shall be performed when:

(a) Design or manufacturing processes are changed to the extent that the original tests are invalidated.

4.3.2.1.6.2 (Continued)

(b) Inspection, test, or other data indicate that a more severe environment or operational condition exists than that to which the equipment was originally qualified.

(c) Manufacturing source is changed.

4.3.2.1.7 Procedures. -

(a) Acceptance test shall precede all qualification tests.

(b) Functional operation shall be required as applicable. During all qualification tests all interfaces shall be present or simulated.

(c) Adjustments shall be permitted during an operational cycle only if they are part of a normal procedure.

(d) Limited life items and single-shot devices may be replaced at the completion of satisfactory operation through their life requirement.

(e) Any failure shall be cause for positive corrective action. The degree of retest in event of failure shall be agreed upon between the NASA and the contractor after evaluation of the failure. In the event of failure, the contractor shall immediately notify NASA.

4.3.2.1.8 Additional Testing. - Subsequent to the completion of the qualification tests further tests shall be conducted at conditions more severe than design limit. The purpose of these tests shall be to determine failure modes and actual design margins.

4.3.2.2 Design Limit Tests. - (To be determined)

4.3.2.3 Endurance Tests. - The second equipment shall be successfully subjected to the conditions of a complete operational cycle plus the conditions of the flight simulation phase of an operational cycle at mission levels.

4.3.2.4 Post-Qualification Tests. - At the completion of the qualification tests, the test units shall be subjected to the tests specified in 4.3.2.4.1 and 4.3.2.4.2 in order to increase confidence in equipment design life and strength. These tests shall be run on qualified equipment.

4.3.2.4.1 Overstress Tests. - The post-qualification testing of the design limit test unit shall consist of overstress tests in the same mode or condition as selected for the design verification overstress test (4.3.1.2.1.2), unless results of previous testing indicates otherwise.

4.3.2.4.2 Flight Simulation. - The post qualification testing of the endurance test unit shall consist of two additional flight simulations.

4.3.3 Test at Higher Levels. - Grumman uses the terms "flight ready" and "flight release" rather than "qualified" and "qualification" to describe subsystems test and higher level test to avoid confusion with the generally accepted definition of qualification. Flight release does not connote demonstration of all Lab I development requirements but only those associated with a specific flight. The ground test program proceeds through a series of logical steps to verify, within constraints, that the Lab I will fulfill test requirements. These constraints are such that complete verification requires a test flight buildup before the mission is attempted. The successful completion of each ground or flight test (except the last) releases a constraint on a subsequent tests. At a point specified in the ground or flight plan, subsystems will be ranked as "flight ready" for a specific flight.

4.3.4 Acceptance Test. - Acceptance tests shall demonstrate that the equipment is representative of that equipment used in the qualification tests. Acceptance test conditions shall not be more severe than expected flight conditions and shall include factors of safety and margins of life. Contract end-item test is equivalent to an acceptance test.

4.3.4.1 Applicability. - Acceptance testing shall include all inspections and tests which are used as a basis for acceptance by the contractor. It may include tests on parts, components, or subsystems.

4.3.4.1 (Continued)

These requirements shall apply to the acceptance of hardware by the contractor from the subcontractors and to the acceptance of in-house produced hardware by the prime contractor.

4.3.4.2 Program Design. -

(a) Acceptance tests shall be performed on the equipment prior to delivery or upon completion of in-house manufacture.

(b) Acceptance tests of equipment are to be technically integrated with the manufacturing tests and the vehicle checkout so that the total program is designed to provide assurance that each contract end item is capable of fulfilling its required end-use.

(c) Acceptance testing shall include functional tests, environmental exposures as required, and inspection techniques designed to:

(1) Locate manufacturing defects.

(2) Locate handling damage.

(3) Provide assurance that no malfunction exists prior to shipping.

(4) Provide assurance that equipments conform to their performance specification and other approved performance criteria.

(d) Acceptance testing may include calibration or alignment or both.

(e) The degree, duration and number of tests and checks shall be sufficient to provide assurance that each equipment possesses the required quality and performance without degradation to the item.

4.3.4.3 Procedure. -

(a) Selection of the acceptance test and checkout procedures shall be based upon the performance requirements of the item.

(b) Where possible, without degradation or destruction of the equipment, all normal, alternate, redundant, and emergency operational modes shall be demonstrated.

(c) The functional tests shall simulate end-use to the highest degree practicable without degradation of the operational or life characteristics of the item. Sampling plans may be employed when the tests are destructive or when the classification, characteristics, records, or non-critical application of the item indicates that less testing is required.

(d) If calibration of the equipment is necessary, then calibration and alignment shall be performed on the equipment in order to detect and adjust any variation in its accuracy prior to test. No adjustments shall be made during the performance of the test unless it represents a normal operating procedure.

(e) Final inspection techniques shall include visual examination, measurements, non-destructive tests, and special procedures such as x-ray, infrared, ultrasonics, and optical alignment where required

4.3.4.4 Environments. -

(a) Each item shall be subjected to only those environmental tests necessary to reveal defects without overstressing or degradation.

(b) Selection of the environments and stress levels shall be based upon design specifications or end use requirements or both, and if available, the results of development and qualification tests. The performance trends versus stress as observed during development and qualification tests may be used to modify these environments or stress levels.

4.3.4.4 (Continued)

(c) Environmental exposure shall be limited to the acceptance testing following manufacturing. Exposure to environments in excess of those specified for acceptance testing shall be cause for rejection.

4.3.4.5 Acceptance Basis. -

(a) The acceptance of each item shall be determined by a comparison between the acceptance test results and the applicable specification requirements.

(b) After completion of tests and inspections, execution of any repairs, modifications, or replacements shall necessitate a reinspection and retest to assure the acceptability of the change and its effects on related equipment. The extent of retest shall be determined jointly by the contractor and NASA or their delegated representatives.

4.3.4.6 Test Equipment. - The contractor shall provide for the selection, evaluation, approval, maintenance, and control of all inspection standards, gages, measuring and test equipment necessary to determine conformance with specification, drawing, and contract requirements.

4.3.5 Formal Engineering Acceptance Test (FEAT). - A formal engineering acceptance test will be performed on the vehicle, using ACE and other associated equipment, to verify compliance of operational and performance parameters with design requirements.

4.3.6 Electromagnetic Interference Test. - A test program to verify compliance to requirements imposed by 3.3.9 shall be conducted at all levels through the entire test program.

5 PREPARATION FOR DELIVERY

5.1 Preservation and Packaging. - Individual deliverable items shall be preserved and packaged for the maximum anticipated storage life. Preservation and packaging, in accordance with Grumman Specification LSP-14-009, shall maintain the cleanliness level established.

5.2 Packing. - Individual deliverable items shall be packed to withstand the selected mode of transporation and handling.

6 NOTES

6.1 LEM to Lab I Deviations. - The following Table IV lists the LEM equipments that have been removed, modified or added to achieve the Lab I configuration:

TABLE IV

LEM TO LAB I DEVIATIONS

CHANGE / SUBSYSTEM	LAB I Baseline		
	REMOVED	MODIFIED	ADDED
Structural Design Sub-system (ref. 3.4.1)	Ascent Engine Cover Propellant Tank Sup-ports Water Tank Supports Ascent Gaseous Oxygen (GOX) Tank Supports Propellant Tank Shielding Base Heat Shield Landing Gear		Mid-Section Canister Gaseous Oxygen (GOX) Tank Supports Lower Deck Insulation Water Tank Supports Battery Supports (for 16 batteries)
Electrical Power Subsystem (ref. 3.4.2)	2 Descent Electrical Control Assemblies		16 Descent Batteries 5 Modified Descent Electrical Control Assemblies 1 Circuit Breaker Pan Panel 1 Bus Wiring

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TABLE IV (Continued)

CHANGE / SUBSYSTEM	LAB I Baseline		
	REMOVED	MODIFIED	ADDED
Guidance Navigation and Control Subsystem (ref. 3.4.3	Descent Engine Control Assembly Gimbal Drive Actuator Landing Radar Rendezvous Radar Inertial Measuring Unit Display and Keyboard LEM Guidance Computer Pulse Torquing Assembly Power and Servo Assembly Coupling Data Unit	Abort Electronics Assembly (Software to change to accommodate star catalog) Rate Gyro Assembly (modified to provide lower rate threshold) ATCA (changed rate gain to insure one pulse limit cycle)	
Reaction Control and Propulsion Subsystems (ref. 3.4.4)	Ascent Engine Ascent Propellant Tank Ascent Helium System Ascent Controls and Control Electronics Descent Engine Descent Helium Tank		
Communications Subsystem (ref. 3.4.5)	S-Band Erectable Antenna VHF Erectable Antenna	Signal Processing Assembly (modified to provide hardline intercom)	Hardline Intercom Data Channel to FM Modulator (409 kilobits per sec. bypass SPA)

SPECIFICATION NO. ESP 11-0100

TABLE IV (Continued)

CHANGE / SUBSYSTEM	LAB I Baseline		
	REMOVED	MODIFIED	ADDED
Instrumentation Subsystem (ref. 3.4.6)			One Pulse Code Modulator (PCM) Two modified CSM recorders providing 409 kilobits per second dump rate and single phase AC operation
Environmental Control Subsystem (ref. 3.4.7)	STD LEM Ascent GOX Tanks Secondary coolant loop Water Evaporator Accessible secondary coolant loop plumbing and valves	Drain and cap off secondary coolant loop Cabin fans (to provide for duct losses)	Abort Sensor Assembly Bypass CSM/Lab I Recirculation Duct 2 Descent Water Tanks 5 Descent Gaseous Oxygen (GOX) Tanks Cold Plates for: 16 Descent batteries 4 Descent Electrical Control Assemblies
Crew Provisions Subsystem (ref. 3.4.8)		Revised External Lighting	18 LiOH cartridges for backpack recharge Batteries for 18 backpack recharges

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TABLE IV (Continued)

CHANGE / SUBSYSTEM	LAB I Baseline		
	REMOVED	MODIFIED	ADDED
Crew Provisions Subsystem (Continued)			Food for 13 days 26 CSM LiOH cartridges Remove lunar specimen return containers Add extra flood lights Provide 21 constant wear garments Add 2 work tops and work top lights Add 1 seat Remove EVA life line Remove water probe and holster Remove 1 LiOH (LEM/ARS) canister Add 1 LEM voice recorder (Total 2)
Displays & Controls	ACA (1) TTCA (1) FDAI (1) DSKY Ascent Engine Controls Descent Engine Controls Radar Displays	DEDA G, N & C Display & Control Panel Audio Control Explosive Devices	Controls for additional batteries Water tanks and hardline intercom Crew safety displays Data handling controls and displays

10 APPENDIX (TBD)

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