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Part 2
Labcraft Payload
General Specification

Atmospheric, Magnetospheric and Plasmas in Space (AMPS) Spacelab Payload Definition Study

MARTIN MARIETTA

Bendix

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ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS) SPACELAB PAYLOAD DEFINITION STUDY

Prepared for

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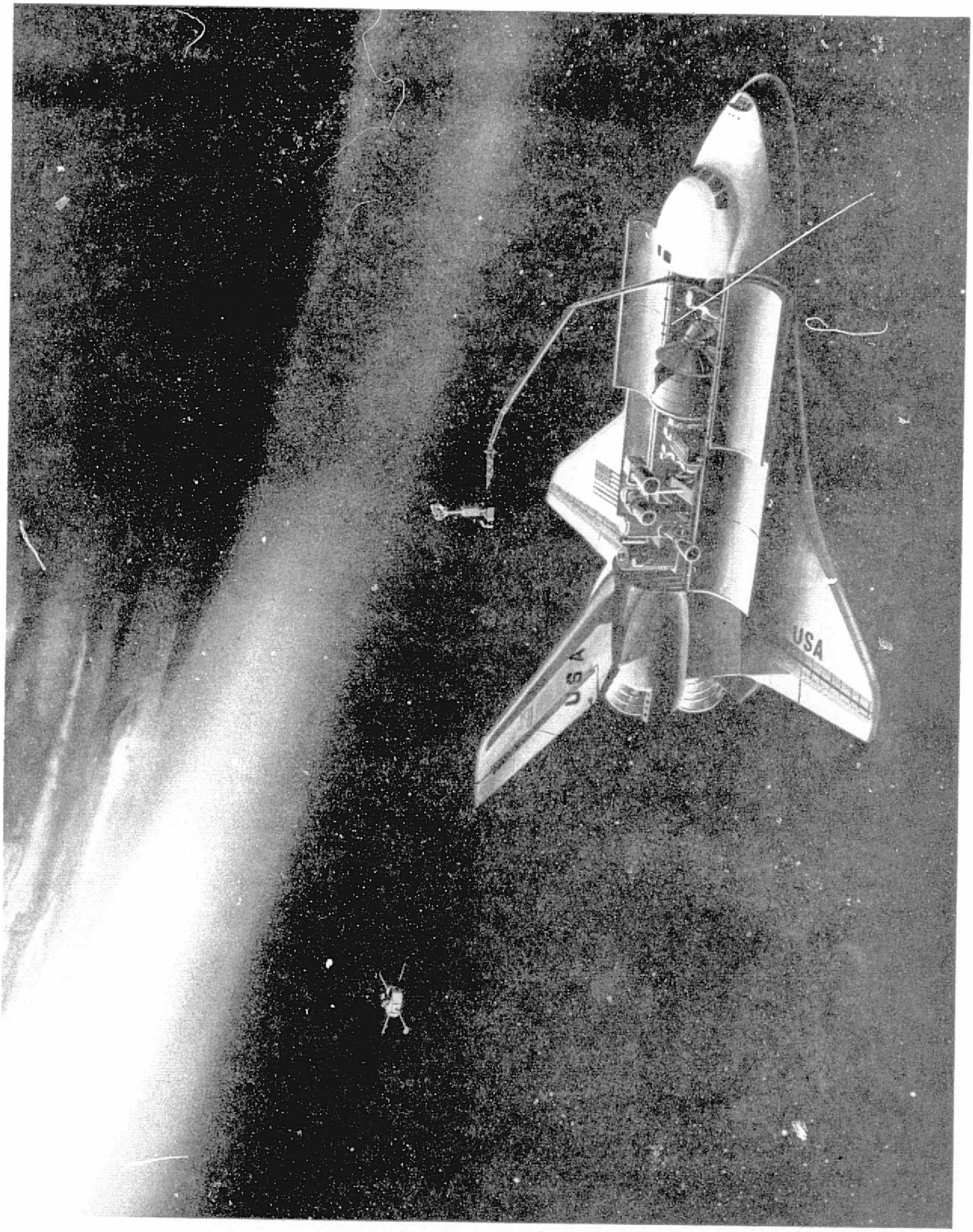

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FOREWORD

The AMPS final report is submitted by Martin Marietta in accordance with Data Procurement Document Number 486, Revision A, of Goddard Space Flight Center Contract NAS8-31689.

The AMPS final report consists of seven volumes. They are:

Volume 1	DR MA-05-A	Executive Summary Report
Volume 2	DR SE-01-A	Mission Support Requirements Document
Volume 3	DR SE-02-A	Interface Control Documents
	Part 1	AMPS Payload to Shuttle ICD
	Part 2	AMPS Payload to Spacelab ICD
	Part 3	AMPS Payload to Instruments ICD
Volume 4	DR SE-03-A	Specifications
	Part 1	AMPS Program Specification
	Part 2	Labcraft Payload General Specification
	Part 3	Labcraft Instrument Systems General Specification
Volume 5	DR SE-04-A	Deleted per Paragraph I, Attachment A, Request for Proposal under Changes Clause, dated 8/31/76
Volume 6	DR SE-05-A	Instruments Functional Requirements Document
Volume 7	DR MA-04-A	Program Analysis and Planning for Phase C/D Document
Volume 8	DR MF 003R-A	Program Study Cost Estimates Document

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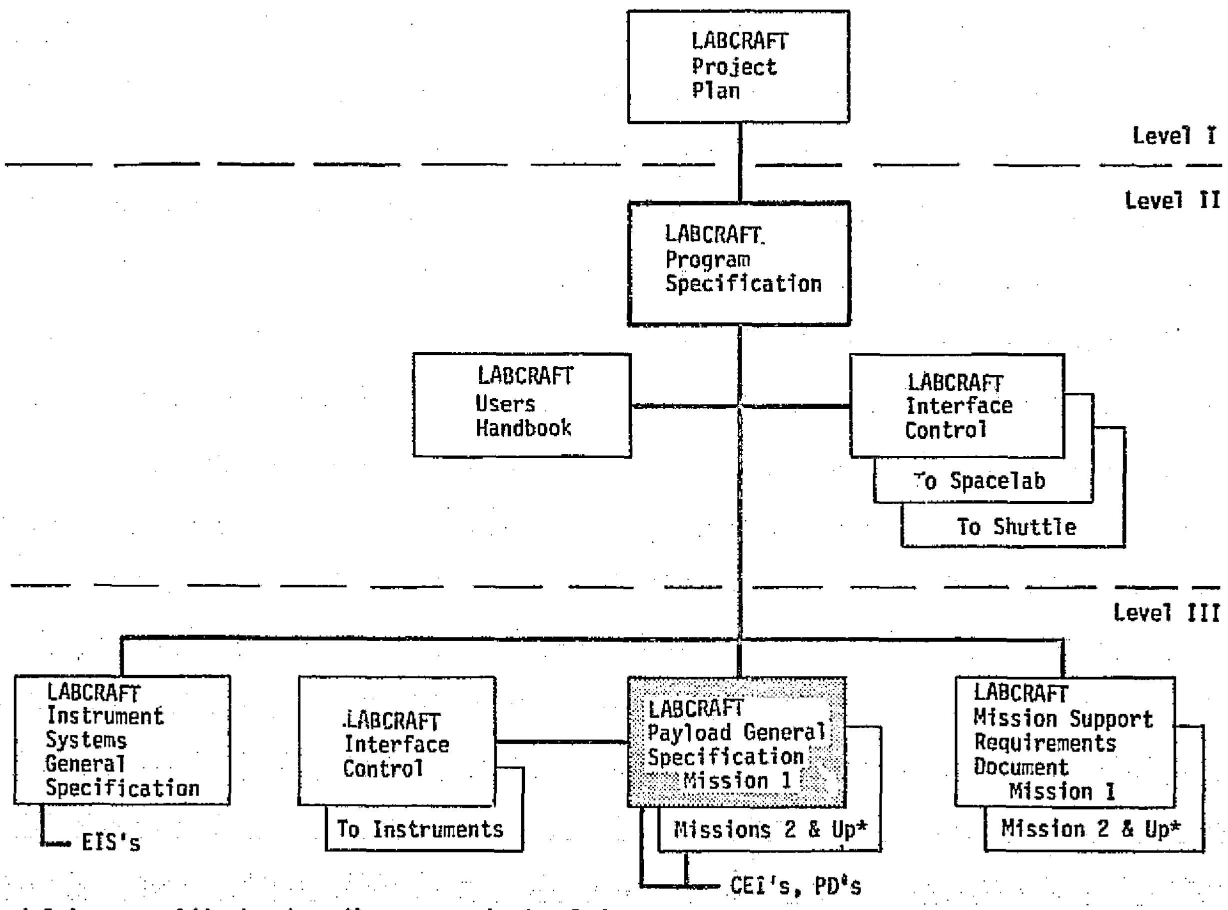
1.0 INTRODUCTION

The Labcraft Payload General Specification (LPGS) amplifies those general requirements in the Labcraft Program Specification (LPS) to ensure that all hardware, software and STS elements will successfully function as an integrated system to accomplish the objectives of the first Labcraft mission. Contract End Item Specifications (CEIS) and Procurement Drawings (PDs) will be prepared and implemented for all deliverable hardware and software elements. See Figure 1.0-1.



* Reissue or Addenda, depending on magnitude of change.

Figure 1.0-1 Labcraft Top Level Requirements Tree

The interfaces between Labcraft, Orbiter, Spacelab and instruments will be defined and controlled by Interface Control Documents (ICDs); experiment and instrument ground and mission operations requirements will be defined in the Labcraft Mission Support Requirements Document (LMSRD); and Labcraft instrument design will be controlled by the Labcraft Instrument Systems General Specification (LISGS) and individual instrument End Item Specifications (EISs). The relationship of these documents is also shown in Figure 1.0-1.

1.1 SCOPE

The LPGS is a systems oriented specification which defines the requirements for performance, design, integration, verification and operation of Labcraft Payload #1. These requirements shall be used as the basis for planning and performing the following Labcraft activities:

a. Definition of instrument and program payload requirements;

b. Conducting analyses (mission, ground, crew, compatibility, software, etc), studies and trades;

c. Allocating of performance and design requirements (instrument, STS, Spacelab or FSE);

d. Establishing and implementing mission assurance (safety, reliability, quality, etc);

e. Design, development, fabrication, integration and test of Labcraft flight support equipment, MGSE, EGSE and software;

f. Installation, assembly and checkout of instrument/FSE/ Spacelab systems;

g. Configuration, interface, design and performance, verification and operations documentation preparation and control;

h. Payload operations support; and

i. Post landing refurbishment and data evaluation.

The Labcraft payload performance and design requirements supporting these activities are defined in subsequent sections of this specification.

2.0 APPLICABLE DOCUMENTS

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

APPLICABLE DOCUMENT NUMBER	TITLE
Space Transportation Systems	
1.	Space Shuttle System Payload Accommodations, JSC 07700, Vol. XIV, Rev. D, Change 16
2.	KSC Launch Site Accommodations Handbook for STS P/Ls, K-STSM-14.1, June 1976
3.	Safety Policy and Requirements for Payloads Using the National Space Transportation System, NASA HQ, June 1976
4.	Safety, Reliability, Maintainability, and Quality Provisions for the Space Shuttle Program, NHB 5300.4 (1D-1), August 1974
5.	Space Transportation System Payload Safety Guidelines Handbook, JSC 11123, July 1976
6.	Space Shuttle System Pyrotechnic Specification, JSC 08060A, August 29, 1975
7.	Specification, Contamination Control Requirements for the Space Shuttle Program, SN-C-0005, JSC, March 1974
8.	Baseline Operations Plan, JSC (TBD)

APPLICABLE DOCUMENT NUMBER	TITLE
Spacelab	
9.	Spacelab Payload Accommodations Handbook, ESTEC SLP/2104, May 1976
10.	Spacelab GSE Allocation and Requirements Plan, MSFC 40A99005, June 25, 1976
11.	Spacelab GSE Items Description Document, MSFC 40A99006, June 25, 1976
Labcraft	
12.	Labcraft Mission Support Requirements Document (TBD)
13.	Labcraft Interface Control Documents (TBD)
14.	Labcraft Program Specification (TBD)
15.	Labcraft Instrument Systems General Specification (TBD)
NASA	
16.	Requirements for Soldered Electrical Connections, NHB 5300.4 (3A)
17.	GSFC, Aerospace Data Systems Standards, X-560-63-2
18.	Contamination Control Handbook, NASA SP-5076, Office of Technology Utilization, NASA, Washington, D.C., 1969
19.	General Specification for Protective Finishes for Space Vehicle Structures and Associated Flight Equipment, MSFC-SPEC-250, 2/26/64
20.	Standard Man/System Design Criteria for Manned Orbital Payloads, MSFC-STD-512

APPLICABLE DOCUMENT NUMBER	TITLE
21.	MSFC-STD-136, Parts Mounting Design Requirements for Soldered Printed Wiring Board Assemblies, June 1971
22.	MSFC-STD-154A, Standard For Design, Documentation and Fabrication of Printed Wiring Boards (Copper Clad)
23.	NHB 8060.1A, Flammability, Odor and Offgassing Requirements and Test Procedures for Materials in Environments That Support Combustion
24.	Requirements for Packaging, Handling and Transportation for Aeronautical and Space Systems Equipment and Associated Components, NHB 6000.1 (1B)
25.	SE-R-0006, NASA/JSC Requirements for Materials and Processes
26.	Revision D, Multi-Use Mission Support Equipment Catalog (NAS10-8902)
Military	
27.	Cables; RF, Coaxial, Dual Coaxial, Turn Conductors, and Twin Lead, MIL-C-17E
28.	Wire, Electric Fluoropolymer-Insulated, Copper or Copper Alloy, MIL-W-22759D
29.	Wire, Electric, Polymide-Insulated, Copper or Copper Alloy, MIL-W-81381A
30.	General Specification for Connectors; Electrical, Miniature, High Density, Quick Disconnect, Environment Resistant, Removable Crimp Contacts, MIL-C-38899F

APPLICABLE DOCUMENT NUMBER	TITLE
31.	Bonding, Electrical and Lightning Protection for Aerospace Systems, MIL-B-5087B(2)
32.	Brazing of Steel, Copper, Copper Alloys and Nickel Alloys, MIL-B-7883B
33.	General Requirements, Design, Installation, Test, and Data Requirements for Hydraulic Systems; Aircraft Types 1 and 2, MIL-H-5440F
34.	Engineering Drawing Practices, MIL-STD-100B
35.	Identification Marking of U.S. Military Property, MIL-STD-130D, July 30, 1971
36.	Order of Precedence for the Selection of Standards and Specifications, MIL-STD-143B, Nov 12, 1969
37.	Military Standard, Human Engineering Design Criteria for Military Systems, Equipment and Facilities, MIL-STD-1472B
38.	MIL-STD-810B, Material Standards for Environmental Test Methods
39.	MIL-STD-454C, Standard General Requirements for Electronic Equipment
40.	MIL-HDBK-5B, Metallic Materials and Elements for Flight Vehicle Structures, Sept 1, 1971

APPLICABLE DOCUMENT NUMBER	TITLE
Other	
41.	Specification, ARINC-404A, Air Transport Equipment Cases and Racking, 15 March 1974
42.	Clean Room and Work Station Requirements; Controlled Environment, FED-STD-209B, Apr 24, 1973

3.0 PERFORMANCE AND DESIGN REQUIREMENTS

3.1 INSTRUMENT COMPLEMENT

The instrument complement to be accommodated on Labcraft Mission #1 is shown in Table 3.1-1.

Table 3.1-1 Labcraft #1 Instrument Complement

Gas Release Module
OBIPS (L^3 TV)
Electron Accelerator
Gas Plume Release System
OBIPS (L^3 TV on RMS) Vector Fluxgate Magnetometer Faraday Cup, Electrostatic Analyzer, Plasma Potential Probe
Laser Sounder Cryo-Cooled Far-IR Radiometer Near-IR Spectrometer Cryo-Cooled Interferometer/Spectrometer
E-Field Power Spectral Density Analyzer B-Field Antenna and Receiver Langmuir Probe Ion Mass Spectrometer Vector Magnetometer Planar RPA Neutral Mass Spectrometer
IECM Mass Spectrometer Optical Effects Monitor Camera Photometer
Array of Spectrophotometers (300 to 3500 Å)

The design and interface requirements for these instruments are contained in the individual instrument End Item Specifications and Interface Control Documents, respectively. The operational usage requirements for the instruments during the performance of experiments is contained in the appendices of the Labcraft Mission Support Requirements Document.

3.2 SPACE TRANSPORTATION SYSTEM (STS) ELEMENTS

The payload shall be designed for launch and return by the NASA Space Transportation System and shall be designed to make maximum use of the existing systems and hardware capability of the Orbiter, Spacelab and other capabilities such as the TDRSS, STDN, existing GSE, facilities, MMSE, etc.

3.3 GENERAL CONFIGURATION

The Orbiter/Spacelab configuration for the first Labcraft mission is shown in Figure 3.3-1. The configuration utilizes the Orbiter and its Single Remote Manipulator System; the Spacelab tunnel, EVA hatch, pressurized module, three pallets and associated subsystems, etc. The instruments locations shown are typical. Actual locations will be determined from instrument/experiment requirements.

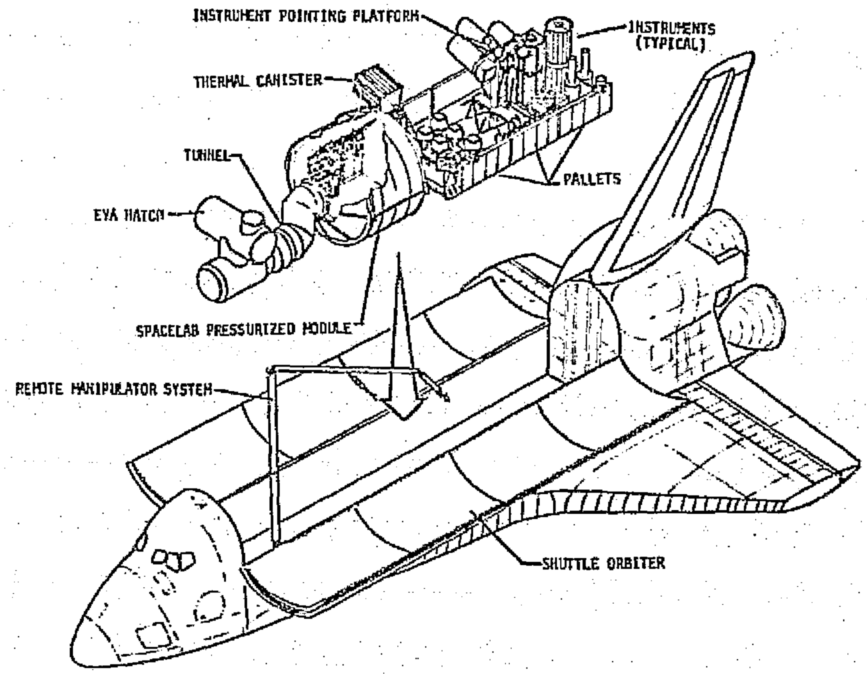


Figure 3.3-1 Labcraft Configuration

3.4 MISSION DESCRIPTION

Labcraft Mission #1 will be launched at 1200 hours on July 15, 1980, from Kennedy Space Center and inserted into a 200 to 210 kilometer circular orbit with an inclination of 57 degrees. The mission will be seven days in duration and will be performed using a crew complement of six including the basic Shuttle crew.

The major scientific objectives of this mission will be to:

a. Study the source mechanism, propagation characteristics and other properties of naturally occurring gravity waves in the earth's atmosphere by generating artificial gravity waves;

b. Study the nature of energetic electron beam interactions with the neutral and ionized atmosphere in the vicinity of the Shuttle; and

c. Study the role of trace constituents in the chemistry and dynamics of the atmosphere by remote excitation and sensing and provide diagnostic measurements for plasma/atmosphere interaction experiments.

The experiments which will be carried out to address these objectives are:

a. Acoustic Gravity Wave Generation;

b. Atmospheric Minor Constituent Profiles;

c. Electron Beam Studies;

d. EMI and Orbiter Wake Mapping;

e. Particulate and Gas Effluence Contaminate Studies; and

f. Solar Flux Monitoring Calibration.

3.5 SYSTEMS DESIGN AND INTEGRATION REQUIREMENTS

The Labcraft design and integration requirements shall be as specified in the following paragraphs.

3.5.1 GENERAL

A. The Labcraft payload shall be designed to allow for evolution and combination of payload buildup for downstream missions.

B. The Labcraft payload shall be designed to make maximum use of the existing Shuttle, Spacelab TDRSS/T, DOMSAT, MMSE, capabilities and facilities (POCC and MCC).

C. The Labcraft payload shall be designed to make maximum use of Shuttle GSE, Spacelab GSE and Multi-Use Mission Support Equipment GSE.

D. The Labcraft payload shall be designed for ease of turnaround to allow up to six (6) flights per year.

E. All hardware design shall be controlled by End-Item Specifications, ICDs and PDs.

F. The Labcraft payload shall be designed such that venting of payload elements combined with payload bay purge will not cause an overpressure in the payload bay during pre-launch, launch, and ascent.

3.5.2 SAFETY

A. The Labcraft payload shall be designed fail safe such that no credible single failure can result in a hazard to flight or ground personnel or prevent safe termination of the mission.

B. All Labcraft pyrotechnics shall use the NASA Standard Initiator (NSI) and the Pyrotechnic Initiator Controller (PIC) and shall meet the requirements of the Space Shuttle System Pyrotechnic Specification, JSC 08060A.

C. All pressure vessels used in the Labcraft payload shall meet the requirements specified in the NASA Headquarters "Safety Policy and Requirements for Payloads Using the Space Transportation System."

D. Where it is not possible to preclude the existence, or occurence of a known hazard, devices shall be included in the Labcraft payload design for the timely detection of the condition and the generation of an adequate warning signal coupled with automatic or manual contingency procedures designed to ensure that the hazard cannot become uncontrolled.

E. Hazardous or corrosive materials from payloads shall not be released in the payload bay.

F. Labcraft payload containing or using radioactive materials or that generate ionizing radiation shall be identified and approval obtained for their use.

G. All Labcraft payload elements shall be designed with attachment fittings that will retain the elements under crash landing loads as defined in the Space Shuttle Payload Accommodations Handbook, JSC 07700, Vol XIV.

H. All Labcraft payload deployable instruments and appendages which could prevent closure of the payload bay doors shall be designed with redundant retraction mechanisms and/or jettison capability.

3.5.3 ENVIRONMENTS

The Labcraft hardware shall be designed to be compatible with the defined environments of the STS. In addition all payload elements must be compatible with one another per GSFC Labcraft Mission #1 Environmental Specification TBD.

3.5.4 CONTAMINATION

The Labcraft hardware shall be designed to operate at the levels of contamination defined for manufacturing, assembly, transportation, test and operations as specified in the Labcraft Contamination Control Plan TBD.

3.5.5 SOFTWARE

A. The Labcraft payload shall use existing STS software to the maximum extent possible.

B. The Labcraft software developed for the payload shall provide maximum commonality of use for GSE/Test, mission simulation, flight, post flight and data evaluation.

C. Labcraft software shall be of modular design such that, for successive missions, modules may be added or removed depending upon specific experiment/mission requirements.

D. Software shall be written in a higher-order language, either HAL-S, GOAL, or FORTRAN.

E. Primary airborne computer will be the Spacelab Experiment Computer and utilization of the Orbiter On-Board Computer will be minimized.

F. The software development shall be defined, documented, and controlled using methods similar to, and consistent with hardware development activities and in accordance with the Labcraft Software Plan TBD.

3.5.6 MASS PROPERTIES

The total Labcraft payload weight and distribution shall be compatible with the requirements defined in Spacelab Payload Accommodations Handbook.

3.5.7 LOGISTICS

A. The Labcraft payload hardware shall be designed for routine maintenance and refurbishment operations to be performed at the launch site.

B. The Labcraft payload and GSE shall be designed for transport as specified in the Labcraft Transportation Plan (TBD).

C. The Labcraft payload hardware shall be capable of being stored in a controlled environment for extended periods up to TBD without degradation.

3.5.8 RELIABILITY/MAINTAINABILITY

A. No single failure point shall exist on Labcraft that can result in loss of life or serious personnel injury, mission termination, or major degradation causing loss of more than 50% of the instrument/experiment data.

B. Where redundancy is employed the Labcraft design shall include:

- the capability to check out redundant elements as a part of the normal ground checkout sequence;
- provisions to minimize the probability that all redundant elements can be lost by single credible cause or event;
- the capability to detect failures of redundant elements during operation.

C. The Labcraft payload shall be designed for accessibility for "black box level" maintenance on the ground with the payload not installed in the payload bay.

D. There will be no planned on-orbit maintenance of the Labcraft equipment.

3.5.9 GROUND OPERATIONS

A. The Labcraft hardware will be designed for either horizontal or vertical removal of the payload from the STS Orbiter.

B. The hardware will be designed for horizontal payload installation only.

C. Cryogenically cooled systems shall be designed for servicing on the launch pad with the Orbiter in the vertical orientation.

D. Ground Support Equipment required to interface the payload shall be subject to the same ground environments as the Flight Support Equipment and instruments.

3.5.10 CREW SYSTEMS

Labcraft hardware to be operated and maintained by man shall be designed in accordance with the requirements of Human Engineering Design Criteria for Military Systems, Equipment and Facilities, MIL-STD 1472B and Standard Man/System Design Criteria for Manned Orbital Payload, MSFC-STD-512.

3.5.11 INTERFACES

Labcraft hardware interfaces shall be defined and controlled by the Interface Control Documents (ICDs) listed in Table 3.5.11-1.

Table 3.5.11-1 Labcraft ICDs

Title	Control Number
Labcraft (FSE) to Instruments ICDs	
o Electron Accelerator	TBD
o OBIPS	TBD
o IECM	TBD
o Laser Sounder	TBD
Etc.	TBD
Labcraft to Spacelab	TBD
Labcraft to Shuttle	TBD

3.6 SUPPORTING SYSTEMS ANALYSIS

Supporting analyses shall be conducted to definitize and optimize systems design and integration requirements. These analyses shall be conducted for the instrument complement and mission description defined in Section 3.1 and based on the system requirements of Section 3.2.

As a minimum, supporting analysis shall be provided for the systems listed below and any other necessary to translate this specification into Labcraft operational equipment.

- Safety
- Environments
  - Natural
  - Induced (EMI, Spacecraft charging, etc)
  - Payload
- Contamination
- Mass Properties
- Software
- Logistics
- Reliability/Maintainability
- Ground Operations
- Mission Operations
- Interfaces (Instrument, Spacelab, Orbiter, etc)
- Crew Systems
- Compatibility

3.7 SUBSYSTEM PERFORMANCE AND DESIGN REQUIREMENTS

The Labcraft subsystems shall be designed to be compatible with the provided capability of the Orbiter/Spacelab as defined in Space Shuttle System Payload Accommodations (JSC 07700, Vol XIV) and the Spacelab Payload Accommodations Handbook. They shall also be developed within the design and construction standards as defined in Paragraph 3.4. Performance and design requirements are defined to include pre-launch, launch, ascent, orbital operations, reentry, landing, maintenance and refurbishment phases of a Labcraft flight.

3.7.1 STRUCTURAL/MECHANICAL SUBSYSTEM

The Labcraft Structural/Mechanical Subsystem shall provide the necessary equipment for the payload to install the instrument equipment on the Spacelab pallets or in the pressurized module, to install unique program flight support equipment on Spacelab pallets or modules, or to provide specialized mechanical support such as deployment, ejection, capture/release or other required functions to meet instrument/experiment requirements or STS constraints.

The performance and design requirements to be specified for this subsystem shall be oriented toward a specific Labcraft payload to be defined later and will include design limits for the following:

a. Payload envelope, weight, moment-of-inertia and center-of-gravity;

b. Instrument field-of-view and orientation;

c. Design criteria for intermediate support trusses and brackets for fastening instruments or other FSE to the Spacelab pallets or module structure. Both static and dynamic structural performance criteria of these subsystems will be specified.

d. Functional requirements for mechanisms, such as capture, release, deployment mechanisms for deployed packages;

e. Functional requirements and criteria for mounting of thermal components, such as curtains, environmental canisters, etc.

f. Structural characteristics and packaging criteria for deployed packages.

3.7.2 THERMAL CONTROL SUBSYSTEM (TCS)

The Labcraft TCS will provide the necessary equipment to control the temperature of the payload and unique flight support equipment within the limits required for equipment operation. The performance and design requirements to be specified for this subsystem shall include design limits for the following:

a. Instrument and FSE operating and non-operating temperatures;

b. Natural and induced environmental conditions imposed on payload and FSE;

c. Specific design requirements for GFP supplied canisters, cold plates, etc;

d. Deployed instrument and FSE temperatures (operating and non-operating);

e. Deployed package thermal control design criteria;

f. Overall design criteria governing the use of thermal curtains, heaters, multilayer insulation, coatings, etc.

3.7.3 ELECTRICAL POWER AND DISTRIBUTION SUBSYSTEM (EPDS)

The Labcraft EPDS shall provide the necessary equipment to support distribution of the Orbiter/Spacelab provided electrical power to the payload and to condition this power to meet unique voltages and currents not supplied by the Spacelab/Orbiter. The performance and design requirements to be specified for this subsystem shall include design limits for the following:

a. Power and energy requirements for instruments and FSE (DC and AC);

b. Functional requirements and design criteria for power conditioning equipment such as high voltage power supplies and peaking batteries;

c. Functional requirements and design criteria for intrapallet power distribution equipment;

d. Design criteria for interconnecting harnesses (i.e., wire type, sizing, cable spacing, shielding, etc);

e. Functional requirements for primary source power to support deployed or ejected instruments.

3.7.4 ATTITUDE, POINTING AND CONTROL SUBSYSTEM (APCS)

The Labcraft APCS shall provide the necessary equipment to assure that the payload instruments can be oriented properly and pointed/stabilized within the required accuracy as specified for the payload. Capability over and above that supplied by the Orbiter system shall be selected from the available standard GFE pointing platforms. The performance and design requirements to be specified for this subsystem shall include the design limits for the following:

a. Pointing accuracy for instruments including co-alignment;

b. Pointing stability for instruments;

c. Mission orientation profile and target data;

d. Scan requirements and rates;

e. Time duration for experimentation;

f. Field-of-view limitations and requirements;

g. Orbital and vehicle geometric constraints.

3.7.5 DATA MANAGEMENT SUBSYSTEM (DMS)

The DMS shall provide the necessary equipment to route, format, process and store the data generated by the payload as scientific data as well as instrument status data. It shall also provide the interfacing of the payload with the Spacelab control and display capability. The performance and design requirements to be specified for this subsystem shall include the design limits for the following:

a. Data rates and types for instruments;

b. Program format requirements;

c. Near real time and real time display and control requirements (on-board and on the ground);

d. Recording requirements (digital/analog/video);

e. Deployed instrument data processing requirements (data types, rates, formats, etc).

3.7.6 CONTROLS AND DISPLAYS

The Labcraft Controls and Displays subsystem shall be designed to be compatible with the STS systems as defined in the Space Shuttle System Payload Accommodations (Vol XIV) and the Spacelab Payload Accommodations Handbook. This subsystem will enable the crew to interact with Labcraft instruments and flight support equipment to perform experimentation and monitor hardware status. Additionally, this subsystem will interface with Shuttle and Spacelab Systems for support. Design criteria of the Labcraft controls and displays will be established for the following:

a. Determining circuit breaker reset and display requirements;

b. Defining panel lighting, including items such as console floodlighting, intensity control of numeric displays, and lamp test requirements;

c. Establishing the thermal loads and ducting requirements for cooling the consoles,

d. Determining the requirements for automatic versus manual functions, and for manually overriding automatic functions;

e. Determining requirements for the control of pyrotechnic circuitry;

f. Establishing the functional interactions with Labcraft instruments and FSE to define hardware, software and voice requirements;

g. Developing the fidelity requirements for onboard displays;

h. Developing the requirements for transfer of ground up-link commands.

3.7.7 COMMUNICATION SUBSYSTEM

The Labcraft and STS Communication Subsystem shall provide the necessary equipment to transmit data and commands between the spacecraft and the ground terminal and between the spacecraft and remotely operating satellites. Ground communication will be supplied entirely by Orbiter/TDRSS and subsystem design will limit data to be transmitted within the provided capabilities. The performance and design requirements to be specified for this subsystem shall include the design limits for the following:

a. Deployed instrument specification data such as relative position, type of data, data rates, etc;

b. Link margin requirements;

c. Tracking requirements for deployed instrument packages;

d. Overall data quantity profile.

3.7.8 CAUTION AND WARNING

Labcraft caution and warning design shall be established to interface with the Spacelab/Shuttle caution and warning systems.

3.7.8.1 CLASSIFICATION OF CAUTION AND WARNING LEVELS

A. Emergency is classified as a crew hazard which require immediate instinctive attention.

B. Warning is classified as an actual or impending anomalous hazardous condition requiring immediate crew attention.

C. Caution is defined as an actual or impending anomalous condition which in combination with other failures constitutes a system configuration that could be hazardous to the vehicle or crew and requires action or procedural changes for corrective measures.

3.7.8.2 CAUTION AND WARNING SENSORS

The Labcraft payload shall provide sensors and possibly signal conditioners to interface with Spacelab RAUs or the Orbiter MDM. Design interface characteristics shall include sensor and load parameters (RAU, MDM) such as line length, voltages--analog, digital discretes, ripple and noise, rise/fall times, etc. Five direct inputs to the Caution and Warning Electronics Assembly from Spacelab are possible. Details and availability are TBD.

3.7.9 GROUND SUPPORT EQUIPMENT

The Mechanical and Electrical Ground Support Equipment (MGSE, EGSE) shall provide the ground support to assure attainment of the Labcraft mission objectives by providing the necessary support functions and capabilities during prelaunch, launch and post launch operations. Performance and design criteria for the Labcraft GSE shall be established for the following:

a. Ground Handling Equipment (GSE) to move, hoist, handle, assemble, access and transport the integrated payload and payload elements;

b. Mechanical Servicing Equipment (MSE) to service, purge, pressurize and leak test the systems;

c. Electrical Support Equipment (ESE) to supply power and to support verification of the integrated payload and payload elements.

3.8 DESIGN AND CONSTRUCTION STANDARDS

Labcraft Design and Construction standards will adhere to current aerospace technology state-of-the-art and will make as much use of proven technology as possible. Design standards will be in accordance with requirements defined in the Shuttle/Spacelab Accommodations Documents, whenever applicable. Specifications and standards shall be selected, using MIL-STD-143B, Order of Precedence for Selection of Military Standards and Specifications as a guide. Design drawings shall be in accordance with MIL-STD-100B, Engineering Design Drawings.

3.8.1 MECHANICAL/STRUCTURAL

3.8.1.1 FACTORS OF SAFETY

Table 3.8-1 lists values of the factor-of-safety to be applied to limit loads, pressures, or stresses to obtain the ultimate or yield design loads, pressures, or stresses for the Labcraft.

Table 3.8-1 Factors of Safety

Spacelab Module (Internal) - General Structure
Yield Factor of Safety - TBD
Ultimate Factor of Safety - TBD
Pallets - General Structure
Yield Factor of Safety - TBD
Ultimate Factor of Safety - TBD
Hydraulic or Pneumatic Systems
Proof Pressure - TBD Times Limit Pressure
Burst Pressure - TBD Times Limit Pressure

3.8.1.2 STRENGTH

Structures shall be designed to the factors of safety defined in Paragraph 3.8.1.1 and shall have sufficient strength to withstand the calculated loads while subjected to the environments defined in Paragraph 3.5.3 without experiencing plastic deformation. The contractor shall design for sufficient strength to the requirements of MIL-HDBK-5, Metallic Materials and Elements for Flight Vehicle Structures, so fracture doesn't occur under crash load conditions. Structure shall be designed to withstand simultaneously the ultimate loads and other accompanying environmental phenomena without failure.

3.8.1.3 DEFORMATION

Structures shall be designed so that no permanent yielding occurs during normal Labcraft operations (except crash loads).

3.8.1.4 FATIGUE/FRACTURE MECHANICS

The effects of repeated loads and pressure cycles shall be considered in the design of the structural elements of the Labcraft. Equipment shall be designed to withstand the vibration requirements defined in the individual instrument ICDs and individual Support Equipment End Item Specification.

3.8.1.5 FASTENERS

Fasteners, e.g., for capture/release mechanisms, shall be designed in accordance with either MIL-HDBK-5 or NASA approved contractor-furnished test data.

3.8.1.6 DECOMPRESSION

Containers shall be designed structurally to be capable of withstanding the rapid decompression and repressurization experienced during ascent and reentry, respectively. These pressure environments are defined in Paragraph 3.5.3

3.8.1.7 TEMPERATURE

The effects of temperature extremes specified in Table (TBD) shall be considered in the design of the structural elements of the Labcraft. Thermal effects on the structure, including heating rates, temperatures, thermal stresses and deformations, and mechanical and physical property changes, shall be on a critical three sigma heating environment.

3.8.1.8 STRESS CORROSION

Metals susceptible to stress corrosion cracking in the environmental or service conditions defined in this specification shall not be used unless test data are furnished which indicate material suitability.

3.8.1.9 STRESS CONCENTRATION

Appropriate stress concentration factors shall be applied in stress analysis.

3.8.1.10 MISALIGNMENT AND TOLERANCES

The effects of allowable structural misalignments, control misalignments, and other permissible and expected dimensional tolerances shall be considered in the analysis of all loads, load distributions, and structural adequacy. For establishing allowable stresses and critical design stresses, the most critical combination of design tolerances shall be used.

3.8.1.11 MATERIALS PROPERTIES AND STRENGTH ALLOWABLES

Allowable material strengths used in design shall reflect the effects of load, temperature, and time and cycles associated with the design environment. Allowable yield and ultimate properties are the "A" values listed in MIL-HDBK-5.

3.8.1.12 WELDING/BRAZING

Welding/brazing shall be in accordance with SE-R-0006, NASA/JSC Requirements for Materials and Processes.

3.8.1.13 CASTINGS

Castings shall be designed in accordance with MIL-C-6021. Use of castings should be avoided when feasible.

3.8.1.14 LOADING CONDITIONS

Labcraft structures shall be designed to meet the loading conditions specified in the Space Shuttle System Payload Accommodations (Vol XIV) for prelaunch, launch, ascent, orbital operation, re-entry, landing, and during maintenance and refurbishment activities.

Additional loading caused by the release of deployed packages is TBD.

3.8.2 ELECTRICAL/ELECTRONIC

3.8.2.1 GROUNDING, ISOLATION AND BONDING

Circuit grounding, power and signal isolation and equipment case bonding are defined in the Spacelab Payload Accommodations Handbook.

3.8.2.2 WIRE BUNDLE AND HARNESS PROTECTION

All wire bundles and harnesses shall be designed to withstand anticipated handling, including disconnection and reconnection, and operating deformations without damage to the wires, insulation, or electrical connections. Wire smaller than 22 guage shall not be used in wire bundles. Routing and installation of all wire bundles and harnesses shall be specified on the drawings. Special precautions shall be taken to prevent damage as a result of extreme temperature conditions, chafing or any other conditions that may result in damage.

The insulation resistance between each conductor and shield, and between each conductor and connector shall be at least 100 megohms at 500 VDC potential.

3.8.2.3 WIRE/INSULATION

Wire used in cables shall be in accordance with MIL-W-22759D--Copper or Copper Alloy Wire, Electric Fluoropolymer-Insulation, MIL-W-81381A--Copper or Copper Alloy Wire, Electric, Polymide-Insulation, and MIL-C-17E--Cables; RF, Coaxial, Dual Coaxial, Turn Conductors and Twin Lead.

3.8.2.4 CONNECTORS

Connectors shall be in accordance with MIL-C-38999F, General Specifications for Connectors. When redundant paths are provided in the cabling, they shall be routed through separate connectors.

3.8.2.5 SOLDERING

Soldering shall be in accordance with NHB 5300.4 (3A).

3.8.2.6 CONFORMAL COATING

TBD

3.8.2.7 PRINTED CIRCUITS

Soldered printed wireboard assemblies shall be designed in accordance with MSFC-STD-154 and shall be mounted in accordance with MSFC-STD-136.

3.8.2.8 PROTECTION OF EXPOSED ELECTRICAL CIRCUITS

Electrical circuits of flight hardware which are to be disconnected in the normal course of mission events shall be protected against short circuiting or compromising of other circuits during the remaining phases of the mission.

3.8.2.9 PROTECTION OF ELECTRICAL AND ELECTRONIC DEVICES

Electrical and electronic devices shall incorporate protection against reverse polarity or other improper electrical inputs during qualification, acceptance, and other tests, if such inputs could damage the devices in a way that would not be immediately and unmistakably apparent. If it is impractical to incorporate adequate protection as a part of the device, protection shall be provided externally by ground-based equipment at the interface between the device and the ground test equipment.

3.8.2.10 MOISTURE PROTECTION OF ELECTRICAL AND ELECTRONIC DEVICES

Electrical connectors, wiring junctions and all electrical and electronic devices used in Flight Hardware shall be hermetically sealed or otherwise positively protected against moisture.

3.8.2.11 CORONA SUPPRESSION

Electrical and electronic systems and components of Experiment Hardware shall be designed so that proper functioning will not be impaired by corona discharge under any of the required operating conditions.

Where adverse corona effects are avoided by pressurizing or evacuating a component, the seals used shall be capable of maintaining the required internal pressure throughout the useful life of the hardware. Where adverse corona effects are avoided in unsealed components by restricting operation to space vacuum conditions, the ability of the equipment to reach the required vacuum level of 10^{-5} Torr in 10 hours or less of time on orbit shall be demonstrated.

3.8.2.12 NEW ELECTRICAL COMPONENTS

New component designs shall use conservative derating factors of no less than 30% for component parts, especially for power semiconductors, switching and fault isolation devices and capacitors.

3.8.2.13 POWER MANAGEMENT

Capability of power system evaluation and power management from the Mission Control Center as well as by the crew shall be provided.

3.8.2.14 BATTERIES

Peaking batteries are required to support the Labcraft high voltage supply and batteries are required for the deployed packages. Design standards are TBD.

3.8.3 FLUID DESIGN SYSTEM

The design, installation and test requirements of fluid systems shall be in accordance with MIL-H-5440F, Design, Installation and Data Requirements for Hydraulic Systems: Aircraft Types 1 and 2.

Routing and installation of all fluid lines for flight hardware, including pressure-sensor lines, shall be specified on the drawings. Special precautions shall be taken to prevent the installation of such lines where they would be exposed to extreme temperature conditions. A design analysis shall be made for each such line installations to show that the temperature extremes to which the line will be subjected are within limits acceptable for the fluid involved.

3.8.4 DATA MANAGEMENT/COMMUNICATIONS

The design of the Data Management/Communication Subsystems shall be in accordance with guidelines of X-560-63-2.

3.8.5 HUMAN ENGINEERING

Labcraft support equipment and instruments shall be designed in accordance with human engineering criteria of MIL-STD-1472B. Touch temperature limits of internal surfaces shall be within 55° to $105^{\circ}F$ during all operational phases of the Labcraft flights.

3.8.6 CLEANLINESS/CONTAMINATION

For ground operations activities the Labcraft shall be maintained in a class 100K environment per FED-STD-209. Design standards for minimizing contamination shall be in accordance with NASA-SP-5076 and SN-C-0005.

3.8.7 MATERIALS

Subsystem design for the Labcraft shall include, but not be limited to the material considerations, that follow.

3.8.7.1 FLAMMABILITY OF WIRING INSULATION, MATERIALS AND ACCESSORIES

Flammability and off gassing requirements of materials to be used in environments that support combustion shall be in accordance with NHB 8060.1.

3.8.7.2 ODOR REQUIREMENTS

Odor properties of materials to be used in environments that support combustion shall be in accordance with NHB 8060.1.

3.8.7.3 TOXICITY

Materials shall not be used in habitable areas of Labcraft or test facilities which, when operating at operational temperatures and pressures up to the maximum anticipated during the flight, will generate toxic or noxious fumes, or dust, in such concentration as to impair crew performance or safety.

3.8.7.4 CORROSION PREVENTION

Metals used shall be corrosion-resistant type or suitable treated to resist corrosive conditions likely to be met in manufacture, assembly, testing, servicing, storage or normal service use. Protective coatings shall not crack, chip, peel or scale with age when subjected to the environmental extremes specified. Unless suitable protected against electrolytic corrosion, dissimilar metals, as defined in MSFC-SPEC 250, shall not be used in direct physical contact. Any protection used shall offer a low impedance path to radio frequency currents. Hardware shall be designed so that no failures will occur due to stress corrosion resulting from exposure to specified natural and induced environments or from fluids used in or on the hardware or components of the hardware during fabrication, cleaning, flushing, inspection, testing, or operating.

3.8.7.5 FUNGUS RESISTANCE

Materials which are non-nutrient to the fungi defined in MIL-STD-810, Method 508 should be used. When fungus nutrient materials must be used, they should be hermetically sealed or treated to prevent fungus growth for the effective lifetime of the component. Materials not meeting this requirement shall be identified as a limited life component and shall identify any action required such as inspection, maintenance, or replacement periods. Fungus treatment should not adversely affect unit performance or service life. Materials so treated should be protected from moisture or other environments that would be sufficient to leach out the protective agent. Fungus inert materials are listed in MIL-STD-454 (Requirement No. 4).

3.8.8 STANDARD PARTS

NASA, Air Force-Navy (AN), Military Standards (MS) or joint Air Force-Navy (JAN) standard parts shall be used in flight hardware where applicable. Maximum economic standardization of parts and components shall be provided. Where identical or similar functions are performed in more than one application within the system, effort shall be made to use only one item design for all system applications.

3.8.9 IDENTIFICATION AND MARKING

Subsystems shall be marked for identification in accordance with MIL-STD-130.

3.8.10 INTERCHANGEABILITY AND REPLACEABILITY

Labcraft subsystems shall be designed for ease of manufacture, assembly, inspection, maintenance, and components with the same part number shall be physically and functionally interchangeable.

3.8.11 PYROTECHNIC DEVICES

Pyrotechnic devices required for support of Labcraft subsystems shall be designed in accordance with JSC-08060.

4.0 VERIFICATION

4.1 GENERAL

The Labcraft payload systems verification program shall demonstrate by test or other verification methods that the hardware and software will perform their intended functions. This program will include FSE/GSE development, qualification, and acceptance, as necessary; FSE/GSE system level tests; and complete payload integration and checkout (Level IV). The specific tests, test methods, and environmental test levels will be as defined in the Labcraft Payload Verification Plan (TBD).

4.2 FLIGHT CONFIGURED HARDWARE FAILURE REPORTING

Failures of FSE/GSE hardware during qualification, acceptance and payload integration testing shall require a complete analysis of each failure and corrective action documented by a non-conformance report. The contractor shall secure agreement from NASA/GSFC concerning the adequacy of the corrective action before tests can be resumed.

4.3 WAIVERS AND DEVIATIONS

TBD

5.0 PREPARATION FOR DELIVERY

The Labcraft payload and payload elements preservation and packaging shall be in accordance with the Transportation Plan (TBD).

6.0 ABBREVIATIONS AND ACRONYMS

Å	-	Angstrom
AC	-	Alternating Current
AN	-	Air Force - Navy
APCS	-	Attitude Pointing and Control Subsystem
B	-	Magnetic Field
C/D	-	Design and Development
CEIS	-	Contract End Item Specifications
CEIs	-	Contract End Items
C&W	-	Caution and Warning
DC	-	Direct Current
DMS	-	Data Management System
DOMSAT	-	Domestic Satellite
E	-	Electric Field
EGSE	-	Electrical Ground Support Equipment
EISs	-	End Item Specifications
EMI	-	Electromagnetic Interference
ESE	-	Electrical Support Equipment
EPDS	-	Electrical Power and Distribution System
EVA	-	Extra Vehicular Activities
°F	-	Degrees Fahrenheit
FSE	-	Flight Support Equipment
GFP	-	Government Furnished Procurement
GHE	-	Ground Handling Equipment
GSE	-	Ground Support Equipment
GSFC	-	Goddard Space Flight Center
Hq	-	Headquarters
ICD	-	Interface Control Document
IECM	-	Integrated Environmental Contamination Monitor
IR	-	Infrared
JAN	-	Joint Air Force - Navy
JSC	-	Johnson Space Center
k	-	Thousand (x 10^3)
LISGS	-	Labcraft Instrument Systems General Specification
L^3TV	-	Low Light Level Television
LMSRD	-	Labcraft Mission Support Requirements Document
LPGS	-	Labcraft Payload General Specification
LPS	-	Labcraft Program Specification
MDM	-	Multiplexer Demultipler
MGSE	-	Mechanical Ground Support Equipment
MMSE	-	Multiuse Mission Support Equipment
MS	-	Military Standards
MSE	-	Mechanical Servicing Equipment
MSFC	-	Marshall Space Flight Center
NASA	-	National Aeronautics and Space Administration
NSI	-	NASA Standard Initiator
OBIPS	-	Optical Band Imager and Photometer System

PDs	-	Procurement Drawings
PIC	-	Pyrotechnic Initiator Controller
P/Ls	-	Payloads
RAUs	-	Remote Acquisition Units
RF	-	Radio Frequency
RMS	-	Remote Manipulator System
RPA	-	Retarding Potential Analyzer
SLP	-	Spacelab Project
STDN	-	Spaceflight Tracking and Data Network
STS	-	Space Transportation System
TBD	-	To Be Determined
TCS	-	Thermal Control System
TDRSS	-	Tracking and Data Relay Satellite System
TDRSS/T	-	Tracking and Data Relay Satellite System Terminal
VDC	-	Voltage Direct Current
%	-	Percent