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TECHNICAL REPORT

PAYLOAD SPECIALIST STATION STUDY

PART II
CEI SPECIFICATIONS (PART I)

Approved

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FOREWORD

This document was prepared by the Martin Marietta Corporation, Denver Division, for the National Aeronautics and Space Administration, Marshall Space Flight Center. This volume forms a part of the Final Study Report for Contract NAS8-31789, *Payload Specialist Station Study*, completed under the technical direction of Mr. William Lucero, Contracting Officer's Representative, MSFC.

The following documents form the complete Final Study Report:

Volume I	Executive Summary
Volume II	Technical Report
Part I	Preliminary Design Document
Part II	Contract End Item Specifications (Part I)
Part III	Program Analysis and Planning for Phase C/D
Volume III	Program Study Cost Estimates
Part I	Work Breakdown Structure
Part II	Cost Data

The following Part I CEI Specifications are included in this volume:

- Multifunction Display System (MFDS) Specification
- Multi-use Mission Support Equipment (MMSE) Specification
- Flight Software Specification
- Ground Test Software Specification
- Ground Support Equipment (GSE) Specification

Multi-Function Display System (MFDS) Specification

PRIME EQUIPMENT DETAIL SPECIFICATION

PART I

PERFORMANCE, DESIGN AND VERIFICATION REQUIREMENTS

MULTIFUNCTION DISPLAY SYSTEM

CEI NO. _____

FOR

PAYLOAD DEDICATED

CONTROLS & DISPLAYS

APPROVED BY _____

CODE IDENTIFICATION _____

DATE _____

APPROVED BY _____
NASA

DATE _____

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1.0 SCOPE

This part of this preliminary specification establishes the requirements of performance, design and verification of equipment identified as the MULTIFUNCTION DISPLAY SYSTEM (MFDS), Contract End Item (CEI) Number (TBD).

The Multifunction Display System provides the display units (with video, alphanumerics, and graphics capabilities), associated Electronics Unit(s), keyboards (KBs) in support of the payload dedicated controls and displays concept to be located at the Payload Station (PS) in the Shuttle Orbiter Aft Flight Deck (AFD).

2.0 APPLICABLE DOCUMENTS

The following documents, of the exact issue shown, form a part of this specification to the extent specified herein. In event of conflict between documents referenced here and other detail content of this specification, the detail requirements herein shall be considered superseding. Contractor specifications satisfying the intent of the below-listed documents may be used in lieu of the specifically listed documents after review and approval by MSFC. Reference to these documents contained herein shall be by basic number only.

2.1 Specifications

MSFC Specifications

		CEI Para.
MSFC-SPEC-250 Amendment 1 26 February 1964	Protective Finishes for Space Vehicles Structures and Associated Flight Equipment, General Specification.	3.3.9.2

2.2 Standards

MSFC Standards

MSFC-STD-512 12 August 1974	Standard Man/Systems Design Criteria for Manned Orbiting Payloads	3.3.15
MSFC-STD-486 Amendment 1 July 1970	Threaded Fasteners, Torque Limits For	3.3.6.2
MSFC-STD-509 October 1972	Lubricant Selection	3.3.2.4

Federal Standards

FED-STD-209B 24 April 1973	Clean Room and Work Station Req. Controlled Environment	3.3.10

Military Standards and Specifications

MIL-STD-143B 12 November 1969	Standards and Specifications, Order of Precedence for the Selection of	3.3.1
MIL-C-17E 12 July 1974	Cables, RF, Coaxial, Dual Coaxial, Twin Conductors and Twin Lead	3.3.5.1

Military Standards and Specifications		CEI Para.
MIL-STD-1472B 31 December 1974	Human Engineering Design Criteria for Military Systems, Equipment and Facilities	3.3.15
MIL-STD-130D 1 August 1973	Identification Marking of U.S. Military Property	3.3.13.2 3.3.13.4
MIL-STD-810(C) 10 March 1975	Environmental Test Methods	3.2.7.2.2 3.3.8
MIL-STD-470 21 March 1966	Maintainability Program Requirements	3.2.4
MIL-STD-889A 5 May 1972	Dissimilar Metals	3.3.9.1
MIL-B-5087B(2) 31 August 1970	Bonding, Electrical and Lightning Protection, for Aerospace Systems	3.3.5.7.3
MIL-S-7742B 15 March 1973	Screw Threads, Standard, Optimum Selected Serial, General Specification for	3.3.6.2.2
MIL-S-8879A(1) Notice 1 15 March 1973	Screw Threads, Controlled Radius Post With Increased Minor Diameter, General Specification for	3.3.6.2.2
MIL-STD-461A Amendment 4 June 1973	Notice 1, 2, 3 Electromagnetic Interference Characteristics, Req. for	3.3.5.7.1
MIL-STD-462(2) 1 May 1970	Notice 1, 2 - Electromagnetic Interference Characteristics, Measurement of	3.3.5.7.1
MIL-STD-189 Notice 2 14 March 1961	Racks, Electrical Equipment, 19-inch and Associated Panels	3.3.12 3.2.1.1.15
MIL-STD-12C(2) 1 February 1971	Abbreviations for Use on Drawings, Specifications, Standards and Technical Documents	3.3.13.4

2.3 Drawings

MSFC Drawings

		CEI Para.
MSFC-DWG-40M39582	Harnesses, Electrical Design	3.3.5.1
MSFC-DWG-40M51264(A)	Outgassing, Thermal Vacuum, Spec. for	3.3.2.3.1
MSFC-DWG-10M90221	Materials Management Plan for Contamination Control	3.3.2.3.1
MSFC-DWG-50M02442	ATM Material Control for Contamination due to Outgassing	3.3.2.3.2

2.4 Shuttle Program Publications

National Aeronautics and Space Administration

JSC-07700, Vol. XIV Revision D Change No. 17 27 July 1976	Space Shuttle System, Payload Accommodations; Program Definition and Requirements	3.2.4.1 3.2.6 3.2.7.1.1 3.2.7.1.2
JSC-07700, Vol. III Change No. 16 27 July 1976	Program Planning and Analysis	3.1.2
JSC-07700, Vol. I Change No. 8 5 July 1976	Program Description and Requirements Baseline; Level II Program Definition and Requirements	3.1.4
JSC-07700, Vol. IV Revision A Change No. 10 26 March 1975	Configuration Management Requirements	3.1.4
JSC-07700, Vol. I-014-PIV-01 Change No. 1 1 June 1976	Payload Interface Verification; Vol. I General Approach and Requirements	3.2.4.1

European Space Agency

SLP/2104 Spacelab, Preliminary May 1976	Spacelab Payload Accommodations Handbook	3.2.1.2
EQ-MA-0010, Issue 1 15 May 1976	Data Display System	3.2.1.2 3.2.1.3.1.1 3.2.1.3.1.2

European Space Agency		CEI Para.
EQ-MA-084, Issue 1 20 May 1976	Data Bus Interconnecting Station	3.2.1.2
EQ-MA-0002 Preliminary 14 May 1976	Input Output Unit	3.2.1.2
Contractor (RI)		
MJ070-0001-1B 15 January 1976	Orbiter Vehicle End Item Specification for the Space Shuttle System Part I; Performance and Design Requirements	3.2.7.1.1
MF0004-002A Amendment B-03 14 June 1974	Electrical Design Requirements for Electrical Equipment Utilized on the Space Shuttle Vehicle	3.2.1.1.13.1 3.2.1.1.13.2 3.2.1.1.13.4 3.2.1.1.13.7 3.2.1.1.13.8 3.2.1.2.9.1 3.2.1.2.9.2 3.2.1.2.9.4 3.2.1.2.9.8 3.2.1.3.1.5

2.5 Other Publications

NHB 5300.4(1D-1) August 1974	Safety, Reliability, Maintainability and Quality Provisions for the Space Shuttle Program	3.2.3 3.2.6
NHB 5300.4(3A) May 1968	Requirements for Soldered Electrical Connections	3.3.2.5
NHB 8060.1A November 1971	Flammability, Odor, and Offgassing Req. and Test Procedures for Materials in Environment that Support Combustion	3.3.2.2
SE-004-002-2H	Guidelines for Identifying Flammability Hazards in Air	3.3.2.2
NHB 1700.1(VI) July 1969	NASA Safety Manual	3.2.6

Other Publications		CEI Para.
JSC-07636 September 1973	Space Shuttle Lightning Protection Criteria Document	3.2.7.2.1
NPC200-4 August 1964	NASA Quality Publication	3.3.2.5
DOD Handbook H4-1 Latest Revision	Federal Supply Code of Manufacturers Name to Code	3.3.13.1
MA-06, Vol. III Part I	Work Breakdown Structure	3.1.5.2
EIA STD RS-170	Electrical Performance Standard Monochrome Television Studio Facilities, Electronic Industries Association	3.2.1.4.2

3.0 REQUIREMENTS

3.1 CEI Definition

3.1.1 General Description

The Multifunction Display System (MFDS) shall consist of two cathode ray tube (CRT) display units, associated electronics unit(s) (EU), keyboard(s) (KB), and required cables. The CRTs shall consist of one black and white unit with video capability including alphanumeric and graphic overlay features (located at Panel L-11, Payload Station, PS), and one tricolor unit (green/yellow/red, located at Panel L-10, PS).

3.1.2 Missions

The Shuttle Program scheduling, operations planning, flight hardware, ground system requirements, and costs shall be based on the Shuttle Program mission model described in JSC-07700, Volume III. The first use of the MFDS will be for the first operational flight utilizing the AFD core C&D capability, the Spacelab (SL) 2 mission.

3.1.3 Operational Concepts

The Multifunction Display System (MFDS) will be used by the Payload Specialist to perform various on-orbit tasks. Using the keyboard, the payload specialist will have the capability to operate various instruments within an experiment, display experiment status and data, point various instruments and select several video displays. He will have access to either the S/L computers or Orbiter computers.

3.1.4 Organizational and Management Relationship

MSFC has been designated as the development management center for the Aft Flight Deck core controls and display (C&D) program. The core C&D equipment will be located in the Orbiter AFD, and therefore, JSC will be required to ensure interface control documentation compatibility.

3.1.5 Systems Engineering Requirements

3.1.5.1 Systems Engineering and Integration

Systems engineering and integration will include performance of the analyses and studies necessary to define requirements for the Aft Flight Deck Payload Core C&D, interfaces, ground support equipment (GSE) and support test equipment (STE), and product assurance. Systems design and integration, operations requirements analyses, GSE and STE requirements, and systems test requirements are all a part of the Aft Flight Deck (AFD) Core C&D engineering and integration (SE&I) task. Also included are interface analyses and definition, PSS specification development and weight management. The objective of the SE&I analysis is to assure an integrated AFD core C&D design that provides a core capability for operating and controlling the many anticipated payloads for the Shuttle Orbiter, at the lowest life cycle cost to the Shuttle Program, compatible with the required level of capability and limitation information to prospective payload developers.

3.1.5.2 Work Breakdown Structure (WBS)

The WBS for the AFD core C&D will be in accordance with MA-06, reference Volume III, Part I.

3.1.6 Government Furnished Property List

a. Spacelab equipment: Display Unit (DU); Keyboard (KB); Data Display Unit (DDU); Remote Acquisition Unit (RAU); Power Distribution Box (PDB).

b. Phase II: One set of Ground Support Equipment (GSE).

3.1.7 Critical Components

3.1.7.1 Engineering Critical Components List

Not applicable.

3.1.7.2 Logistics Critical Components List

The failure mode and effects analysis (FMEA) will be performed and will be used to prepare the Critical Items List (CIL), which will be used to identify critical spares. This CIL shall include the Single Failure Point Summary and Critical Redundant Items. The corrective action required and/or rationale for retention shall be determined for each critical single failure point.

3.2 Characteristics

3.2.1 Performance

3.2.1.1 Display Units

Two Display Units (DUs) shall be provided; one shall have the capability of displaying only alphanumerics and graphics in tricolor, and one shall have the capability to display both video and overlay symbolic data (alphanumerics and graphics) in black and white (B&W). The black and white display monitor shall accept video signals from the Orbiter closed circuit television system (CCTV) video switching unit.

The majority of the requirements specified herein shall apply to both the B&W and tricolor type of DUs, and therefore are stated only once with no specific reference to either unit. Specific requirements pertaining to only one of the DUs are properly identified herein.

3.2.1.1.1 Brightness

The brightness of generated symbols shall not vary by more than plus or minus 20 percent when positioned anywhere within the useful screen area. The brightness level of the black and white Display Unit shall be a minimum of 46.5 foot lamberts at the maximum writing speed. The brightness level of the color Display Unit shall be a minimum of 60 foot lamberts at the maximum writing speed.

3.2.1.1.1.1 Manual Brightness Control

The Display Unit shall be provideo with a continuous manual brightness control, mounted on the front panel of the display unit.

3.2.1.1.1.2 Automatic Brightness Control

Readjustment of the brightness control shall not be required at any ambient light level above 100 foot lamberts when it has been set to a desired contrast ratio.

3.2.1.1.2 Contrast

The black and white Display Unit shall be able to provide a contrast ratio of 8:1 at 100 foot lamberts. The color Display Unit shall be able to provide a contrast ratio of 1:4 at 60 foot lamberts.

3.2.1.1.3 Resolution and Line Width

3.2.1.1.3.1 TV Scan Resolution

The B&W Display Unit shall provide 525 and 1000 horizontal scanning lines.

3.2.1.1.3.2 Line Width

The line width for all lines shall be plus or minus .012 inch maximum in the central 80 percent of the viewing area when measured at the 50 percent brightness amplitude points for both the horizontal and vertical resolutions. The line width growth shall vary no more than 30 percent over the remaining 20 percent viewing area. The line width requirements shall be met for the line(s) written at all writing speeds at the required refresh rate and contrast ratio requirements.

3.2.1.1.3.3 Resolution

The Display Unit shall exhibit horizontal and vertical resolution of not less than 42 line pairs per inch in the central 80 percent of the viewing area based on a 10 percent modulation index and a square wave video input. A line pair is defined as one line bright and one dark adjacent area.

3.2.1.1.3.4 Video Bandwidth

The bandwidth of the B&W video channel shall be flat plus or minus 3 dB from DC to a minimum of 10 MHz for output amplitudes consistent with the required contrast ratios. Transient response shall be such that overall rise and fall times shall be no greater than 35 ns each when measured between the 10 percent and 90 percent points with overshoots and undershoots less than 20 percent of the pulse amplitude. The bandwidth of the color channel shall be flat plus or minus 3 dB from DC to 32 MHz for output amplitude consistent with the required contrast ratios.

3.2.1.1.4 Linearity

The DU non-linearity shall not exceed plus or minus 2 percent of the length of any line at any point within the central 80 percent of viewing area and shall not exceed plus or minus 4 percent in the remaining area. In addition, there shall be no deviation greater than plus or minus 0.020 inch from a straight line in any 0.8 inch segment of a line. The maximum deviation shall not exceed plus or minus 0.060 inch at any point of a line of length up to 6 inches, defined by its end points.

3.2.1.1.5 Jitter

Displayed symbolization shall not jitter in excess of 0.003 inch under static conditions. Jitter phenomena frequencies range from 0.25 Hz to 60 Hz.

3.2.1.1.6 Position Stability

Short term position stability shall be within plus or minus 0.015 inch vertically and plus or minus 0.015 inch horizontally with a drift rate not to exceed .005 inches per minute. Long term position stability shall be within plus or minus 0.05 inches vertically and plus or minus 0.06 inches horizontally.

3.2.1.1.7 Positional Error

Positional error at any point on the CRT face shall not exceed 2.0 percent of its location relative to the center of the presentation.

3.2.1.1.8 Display Centering

Display formats shall be centered to plus or minus 0.05 inch within the viewable area.

3.2.1.1.9 Phosphor

The phosphor for the cathode ray tube (CRT) shall meet the requirements of this specification. It shall cause no flicker or apparent motion while the display is viewed under any ambient illumination.

3.2.1.1.10 Built-in Test Equipment (BITE)

The DU shall provide BITE and self-test capabilities in conjunction with a Keyboard Unit, Electronics Unit (EU), and the EU generated test patterns interpreted by an operator, shall detect and indicate single-solid failures in the MFDS to a probability of 0.96 or better upon operator command. The test pattern, on command from the keyboard shall be made available for the operator to check visual performance of the display unit.

3.2.1.1.11 Color

The display unit shall be capable of displaying tricolors of green, red, yellow.

3.2.1.1.12 Screen Area

The useful display areas should be at least 8 inches square, each; however, smaller displays will be considered if off-the-shelf status provides cost advantages for the system.

3.2.1.1.13 Power

3.2.1.1.13.1 Input Power

The DU shall meet all the specified performance requirements when energized by a prime source of 28 plus or minus 4 volts DC or 115 plus or minus 5 volts, 400 Hz AC having the characteristics defined by MF0004-002. In addition, the DU shall be capable of withstanding, without damage or data loss, the emergency transient characteristics defined in MF0004-002.

3.2.1.1.13.2 Grounding and Isolation

Provisions for equipment grounding; for isolation of circuitry from grounding, power returns, and shields; and for isolation of input power, normally and under failure conditions, shall conform to MF0004-002.

3.2.1.1.13.3 Power Dissipation

The DU shall be designed to dissipate the following amounts of power, under worst-case cooling conditions, without compromise to the temperature derating criteria established for components utilized therein. The derating criteria shall be compatible with the reliability objectives.

a. Operation (Normal TV Mode) - 130 watts maximum monochromatic
- 150 watts maximum color

b. Standby - 25 watts maximum

3.2.1.1.13.4 Power Conversion

The DU shall convert primary input power to internal operating voltages as required. Conversion equipment and characteristics shall conform to the requirements of MF0004-002.

3.2.1.1.13.5 Power-on Sequence

Application of input power to the unit shall be sensed and shall initiate an orderly startup, reset, and initialization sequence. No special power-on sequence shall be required.

3.2.1.1.13.6 Power-off Sequence

Removal of input power from the unit shall be sensed and shall initiate an orderly power shutdown sequence. No special power-off sequence shall be required.

3.2.1.1.13.7 Normal Power Transient

Input power transients within the limits defined in Specification MF0004-002, Figure 1, shall not cause unit malfunction or sync anomalies.

3.2.1.1.13.8 Abnormal Power Transients

Input power transients within the limits defined in MF0004-002, Figure 3, shall not cause equipment damage or spurious behavior. For under-voltage transients which exceed normal limits as defined in 3.2.1.1.13.7 above, execution of a shutdown/restart sequence is permissible.

3.2.1.1.13.9 Power Interruption

Loss of input power shall not cause any DU malfunction, transmission of erroneous signals nor create any operating anomalies.

3.2.1.1.14 Weight

The weight of the B&W Display Unit shall not exceed 35.0 pounds. The weight of the Color Display Unit shall not exceed 40 pounds.

3.2.1.1.15 Dimensions

The Display Unit shall be contained in an enclosure not exceeding 12.0 inch height x 11.0 inch width x 20.0 inch depth and mounted into a 19 inch panel/chassis in accordance with MIL-STD-189.

3.2.1.2 Electronics Unit

The EU shall interface with the Spacelab interconnecting stations (IS) and input and output (I/O) units for both the experiment and subsystem computers via the serial data buses. The EU shall allow keyboard commands to be sent to either the experiment or subsystem computers via the IS, I/O units and redundant data buses. A dedicated switch on the keyboard shall select the experiment or subsystem computer. The EU shall accept and store data from the Spacelab computers and cause the display on the display unit to be modified in accordance with the data (reference Spacelab Payload Accommodations Handbook, EQ-MA-0010, EQ-MA-084 and EQ-MA-0002).

Normally the multifunction display system shall interface with either the Spacelab experiment or subsystem computers. However, when the Spacelab computers are not flown, the MFDS shall be capable of interfacing with the Orbiter GPC via the Orbiter data bus and input output processor (IOP). The Orbiter GPC shall then perform the same functions as the Spacelab computers.

3.2.1.2.1 Symbol Arrays

The EU shall be capable of utilizing sequences of format control words such that a set of symbols can be uniquely specified and identified as if it were a single-symbol element.

3.2.1.2.2 Symbol Elements

The EU shall be capable of generating at least 128 symbols. The symbols repertoire shall be such that it can be changed and not affect the performance of the EU or require design changes.

3.2.1.2.3 Circles and Vectors

The EU shall be capable of generating the following patterns:

3.2.1.2.3.1 Circles

Circles of at least 512 radii centered at any point on the display.

3.2.1.2.3.2 Vectors

Vectors between any two points on the display field.

3.2.1.2.4 Features Related to Symbols

The EU shall provide the following features that can relate to individually displayed elements or sets of displayed elements.

3.2.1.2.4.1 Flash

Any symbol or set of symbols shall flash when so designated.

3.2.1.2.4.2 Dash

Any circle, vector, or set thereof shall be dashed when so designated.

3.2.1.2.4.3 Rotate

Any symbol or set of symbols shall be capable of being rotated about a center that may be any point on the face of the CRT. Rotation designations shall be able to specify the angle of rotation as either an absolute rotation from a fixed reference or as a rotation from a variable reference. A combination of rotation and translation of the same display element (or set of elements) shall be possible.

3.2.1.2.4.4 Translation

Any symbol or set of symbols shall be capable of being translated in cartesian coordinates when so designated. It shall be possible to specify the resulting location of a translation as either an absolute position or a position relative to the current location of the designated symbol.

3.2.1.2.4.5 Character Size

There shall be at least two sizes. Any combination of sizes shall be possible on the same display presentation.

3.2.1.2.4.6 Intensity

There shall be at least two levels of intensity that can be designated for any symbol. All levels (intermixed) shall be possible in any combination on the same display presentation. Brightness uniformity shall be maintained to within plus or minus 12 percent by linear compensation of intensity for various stroke writing speeds.

3.2.1.2.4.7 Blanking

There shall be a capability of blanking or unblanking any group of symbols.

3.2.1.2.4.8 Text Presentation

It shall be possible to designate a text presentation starting at any point on the CRT face such that character positioning, line positioning, and boundaries of the display field shall be referenced from that point automatically within the EU without need of further information.

3.2.1.2.4.9 Scratch Pad

It shall be possible to designate the last line of any presentation as a scratch pad. The scratch pad shall display symbols consistent with each KB signal sensed by the EU.

3.2.1.2.4.10 Computer Specified Symbols

The EU shall receive messages that will replace portions of the display presentation. These symbols shall be superimposed upon the part of the display presentation that is unalterable.

3.2.1.2.5 Presentation Criteria

All symbols as presented on the face of the CRT of the DU shall be as follows:

3.2.1.2.5.1 Text Data

At least 25 lines of 50 characters at minimum character size.

3.2.1.2.5.2 Character Relationships

Width = 0.67 to 0.75 of height
Character Spacing = 0.20 to 0.33 of height
Line Spacing = 0.30 to 0.50 of height

3.2.1.2.5.3 Character Size

Height 0.125 inches, minimum

3.2.1.2.5.4 Number of Intensity Levels

Two, minimum

3.2.1.2.5.5 Refresh Rate

50 Hz, minimum

3.2.1.2.5.6 Character Generation

Stroke

3.2.1.2.5.7 Position Matrix

1024 x 1024 (addressable locations)

3.2.1.2.5.8 Occlusion Zone

A software selectable occlusion zone shall exist at the bottom of any displayed presentation.

3.2.1.2.6 Display Information

The EU shall be capable of storing for a read-only mode of operation at least 512 16-bit words of information. It shall be able to process this information as a display message, and special symbol arrays.

3.2.1.2.7 Memory

The nonvolatile Read and Write (R/W) memory shall consist of at least 8196 16-bit words of information required to support refresh of the display unit for a given display presentation. The Read Only Memory (ROM) shall be large enough to contain all necessary display formats.

3.2.1.2.8 Built-in Test Equipment

The EU shall provide BITE and self-test and in conjunction with the DU and Keyboard Unit shall detect and indicate single-solid failures in the MFDS to a probability of 0.96 or better upon operator command. Failure detection and indication shall involve a test pattern, displayed on the DU, interpreted by an operator, Keyboard Unit inputs and a cooperative computer - Input/Output, I/O unit (i.e., to test the applicable data buses). Whenever a detected error occurs, the EU shall generate an error signal for output to the computer(s) and keyboard control panel.

3.2.1.2.9 Power

3.2.1.2.9.1 Input Power

The EU shall meet all the specified performance requirements when energized by a prime source of 28 plus or minus 4 volts DC or 115 plus or minus 5 volts, 400 Hz AC having the characteristics defined by MF0004-002. In addition, the EU shall be capable of withstanding, without damage or data loss, the emergency transient characteristics defined in MF0004-002.

3.2.1.2.9.2 Grounding and Isolation

Provisions for equipment grounding; for isolation of circuitry from grounding, power returns, and shields; and for isolation of input power, normally and under failure conditions, shall conform to MF0004-002.

3.2.1.2.9.3 Power Dissipation

The EU shall be designed to dissipate the following amounts of power, under worst-case cooling conditions, without compromise to the temperature derating criteria established for components utilized therein. The derating criteria shall be compatible with the reliability objectives.

a. Operation - 225 watts

b. Standby - 10 watts

3.2.1.2.9.4 Power Conversion

The EU shall convert primary input power to internal operating voltages as required. Conversion equipment and characteristics shall conform to the requirements of MF0004-002.

3.2.1.2.9.5 Power-on Sequence

Application of input power to the unit shall be sensed and shall initiate an orderly startup, reset, and initialization sequence. No special power-on sequence shall be required.

3.2.1.2.9.6 Power-off Sequence

Removal of input power from the unit shall be sensed and shall initiate an orderly power shutdown sequence. No special power-off sequence shall be required.

3.2.1.2.9.7 Normal Power Transient

Input power transients within the limits defined in Specification MF0004-002, Figure 1, shall not cause unit malfunction or sync anomalies.

3.2.1.2.9.8 Abnormal Power Transients

Input power transients within the limits defined in MF0004-002, Figure 3, shall not cause equipment damage or spurious behavior. For undervoltage transients which exceed normal limits as defined in 3.2.1.2.9.7 above, execution of a shutdown/restart sequence is permissible.

3.2.1.2.9.9 Power Interruption

Loss of input power shall not cause any EU malfunction transmission of erroneous signals nor create any operating anomalies.

3.2.1.2.10 Weight

The weight of the digital electronics unit shall not exceed 37 pounds. Weight excludes control and display (C&D) interfacing logic and circuits.

3.2.1.2.11 Dimensions

The Electronics Unit shall be contained in an enclosure not exceeding 7.62 inch height x 10.13 inch width x 19.62 inch depth.

3.2.1.3 Keyboards

Two keyboards shall be provided as specified herein.

3.2.1.3.1 General Keyboard

The general keyboard at Panel L-10 shall be the primary device issuing commands to the computer for experiment control and display and for IPS commands. The Aft Flight Deck panel designations are presented in Figure 3.2-1.

3.2.1.3.1.1 Key Functions

The functions performed by each key shall be identical to that of the Spacelab Keyboard specified in MATRA EQ-MA-0010.

3.2.1.3.1.2 Key Layout and Nomenclature

The key layout and nomenclature shall be identical to the Spacelab keyboard specified in MATRA EQ-MA-0010.

3.2.1.3.1.3 Control and Status

The keyboard shall contain the identical switches and indicators as the Spacelab keyboard.

3.2.1.3.1.4 Built-in Test Equipment BITE

Sufficient monitoring circuits shall be incorporated within the keyboard compatible with detecting 96 percent or better of the single-solid failures of the entire MFDS as stated in paragraphs 3.2.1.1.10 and 3.2.1.2.8.

3.2.1.3.1.5 Power

a. Input Power - The keyboard shall meet all the specified performance requirements when energized by a prime source of 28 plus or minus 4 volts DC or 115 plus or minus 5 volts, 400 Hz AC having the characteristics defined by MF0004-002. In addition, the keyboard shall be capable of withstanding, without damage or data loss, the emergency transient characteristics defined in MF0004-002.

b. Grounding and Isolation - Provisions for equipment grounding; for isolation of circuitry from grounding, power returns, and shields; and for isolation of input power, normally and under failure conditions, shall conform to MF0004-002.

c. Power Dissipation - The keyboard shall be designed to dissipate 10 watts maximum.

d. Normal Power Transient - Input power transients within the limits defined in Specification MF0004-002, Figure 1, shall not cause unit malfunction or sync anomalies.

e. Abnormal Power Transients - Input power transients within the limits defined in MF0004-002, Figure 3, shall not cause equipment damage or spurious behavior.

f. Power Interruption - Loss of input power shall not cause any keyboard malfunction transmission of erroneous signals nor create any operating anomalies.

3.2.1.3.1.6 Weight

The weight of the keyboard shall not exceed 15 pounds.

3.2.1.3.1.7 Dimensions

The keyboard shall be contained in an enclosure not exceeding 2.75 inch height x 16.63 inch width x 7.75 inch depth and mounted into a 19 inch panel/chassis per MIL-STD-189.

3.2.1.3.2 Secondary Keyboard

A 32 key keyboard may be considered for the performance of the following functions in support of the display unit, located at Panel L-11:

a. Select a video channel for display from the CCTV system.

b. Facilitate in manual pointing control operations such as selection of the applicable instrumentation pointing system.

c. Dedicated buttons such as "start reposition command" for crosshair pointing.

d. Other mission unique functions, including video overlay applications.

3.2.1.3.2.1 Power

The power requirements for the secondary keyboard shall be identical to those specified in paragraphs 3.2.1.3.1.5.a through 3.2.1.3.1.5.f.

3.2.1.4 Special Features

3.2.1.4.1 Crosshair Pointing

Crosshair pointing is an efficient method by which an instrument (mounted on an instrument pointing system, IPS) can be positioned to a particular area of scientific interest.

3.2.1.4.1.1 Position Crosshair

The EU shall accept two inputs which provide the horizontal and vertical positioning coordinates. The EU shall generate the crosshair and position it on the display at the position specified by the two inputs. The EU shall convert the two inputs to a digital signal and output this digital signal (representing the crosshair position) to the computer.

3.2.1.4.1.2 Reposition Command

The EU, upon command from the keyboard or momentary switch, shall send a start reposition command to the computer. This will cause the computer to initiate a repositioning sequence to the applicable instrumentation pointing system.

3.2.1.4.1.3 Crosshair Updating

The crosshairs shall track the IPS from the offset position to the center of the video presentation. The EU will be updated from the computer during the IPS translation.

3.2.1.4.1.4 Screen Center

Capability shall be provided for displaying an electronic screen center indication.

3.2.1.4.2 Video Display Unit - Line Resolution

The black and white video display unit shall be capable of accepting both a 1000 line and 525 line composite video signal. The display unit upon command shall be able to switch from one to the other. The performance characteristics of the 525 line system shall conform to EIA standard RS-170.

3.2.2 Physical

The physical requirements for the MFDS are included under paragraph 3.2.1 presented herein.

3.2.3 Reliability

Reliability provisions shall be in accordance with NHB 5300.4 (ID-1).

3.2.3.1 Critical Single Failure Points

As a design goal, the MFDS shall have no single failure that will jeopardize achieving the experiment objectives. In systems where this is not practical, sufficient safety margins should be used to minimize the probability of occurrence.

3.2.3.2 Failure Deterrent and Detection

The design shall incorporate the following:

a. The MFDS shall be designed such that transient out-of-tolerance conditions or component failures will not cause other damage to, or failure of, other components.

b. Threaded parts and fasteners shall be positively locked to prevent loosening during service.

c. Bypass circuits used in checkout or calibration procedures shall not override electrical system protective devices.

d. Solid state switches and amplifiers shall be given preference over electromechanical relays and other vibration-sensitive electrical/electronic parts.

e. Unidirectional components or piece parts shall be designed to preclude backward installation by using nonsymmetry of configuration, different connecting sizes, or comparable means.

3.2.3.3 Reliability Goals

The reliability goal of the MFDS operation shall be TBD.

The probability that no MFDS failures will prevent successful experiment command or display objectives shall be TBD for on-orbit operation.

3.2.4 Maintainability

The MFDS elements subject to maintenance shall be designed, selected and installed to facilitate the performance of such tasks in a reasonable period.

of time with minimum hazard to equipment and personnel. Maintainability criteria in accordance with MIL-STD-470 shall be used. The design shall provide for maximum use of standard tools and test equipment.

3.2.4.1 Installation/Removal/Replacement Operations

The installation or removal of the payload dedicated controls and displays panels or consoles shall be accomplished at the launch site upon the return of the Space Shuttle Orbiter. The servicing of the payload dedicated controls and displays panels or consoles shall be consistent within the payload turnaround time constraints as specified by JSC 07700, Vol. XIV and JSC 07700, Vol. I-014-PIV-01.

The design shall provide for ease of removal, replacement, alignment, integration, and test.

3.2.4.2 Scheduled Servicing

The MFDS design shall be such that scheduled maintenance frequencies for critical-limited items are not less than TBD years.

3.2.5 Operational Availability

This preliminary Part I CEI shall be updated as required by the PS Contractor. The PS Contractor shall maintain this document in the final Part I CEI form through the change control system established.

The Part I CEI document shall be submitted at the Preliminary Design Review (PDR) for final approval by MSFC prior to the start of the Development Phase. Review Item Disposition (RIDs) written against the CEI and approved shall be incorporated into the Part I CEI. After acceptance by MSFC, this document will be Government property, and shall be formally controlled as such in accordance with the requirements of the procuring activity.

3.2.6 Safety

Requirements for the MFDS necessary to preclude hazards to personnel and equipment shall be as specified in the Safety paragraph of JSC 07700, Volume XIV, or contained herein. Hazard definition, classification categories, and hazard reduction precedence shall be as specified in NHB 5300.4 (1D-1), Safety, Reliability, Maintainability and Quality Provisions for the Space Shuttle Program, and NHB 1700.1, NASA Safety Manual.

3.2.6.1 Crash Safety

The MFDS or any part or component of the AFD core C&D shall not endanger the crew as a result of the crash landing conditions specified in the JSC-07700, Volume XIV.

3.2.7 Environment

3.2.7.1 Natural

3.2.7.1.1 Transportation and Storage

The MFDS shall perform as specified herein after exposure in a nonoperating condition to any combination of the environments and ranges specified in JSC-07700, Volume XIV and MJ070-0001-1B.

3.2.7.1.2 Handling

The MFDS shall perform as specified herein after exposure to the environmental ranges specified in JSC-07700, Volume XIV when handled unpackaged.

3.2.7.2 Induced

3.2.7.2.1 Flight Operational

The MFDS shall be capable of meeting the operating performance requirements specified herein during and after exposure to any feasible combination of the following conditions:

a.	Temperature:	Minimum:	Minus 20°F (operational) Plus 35°F (full performance requirements)
		Maximum:	Plus 120°F (full performance requirements)
b.	Pressure:	Minimum:	12.36 psia, continuous; 8 psia for 2 hours
		Maximum:	18.0 psia
c.	Humidity:	Minimum:	8 percent relative
		Maximum:	100 percent relative

d. Salt Fog: Exposure to 1-percent salt solution by weight

e. Lightning: In accordance with JSC-07636 for indirect effects

f. Random Vibration:

1) Qualification - Acceptance Vibration Test (AVT)

Acceleration Spectral Density

20 to 80 Hz	Increasing, at plus 3 dB/octave, to 0.067 g^2/Hz at 80 Hz
80 to 350 Hz	Constant at 0.067 g^2/Hz
350 to 2000 Hz	Decreasing, at 3 dB/octave, from 0.067 g^2/Hz at 350 Hz to 2000 Hz
Duration:	Five times AVT per axis

2) Flight

Acceleration Spectral Density

20 to 150 Hz	Increasing at plus 6 dB/octave, to 0.09 g^2/Hz at 150 Hz
150 to 900 Hz	Constant at 0.09 g^2/Hz
900 to 2000 Hz	Decreasing, at minus 9 dB/octave, from 0.09 g^2/Hz at 900 Hz
Duration:	48 minutes per axis

g. Acceleration: Plus and minus 5 g's in all major axes

h. Shock

1) Landing: Rectangular pulses of the following peak accelerations, time durations, and number of applications in the vertical (up) direction during landing.

Acceleration (g peak)	Duration (ms)	Application
0.23	170	22
0.28	280	37
0.35	330	32
0.43	360	20

Acceleration (g peak)	Duration (ms)	Application
0.56	350	9
0.72	320	4
1.50	260	1

2) Transient: 5 to 35 Hz; plus and minus 0.25 g peak.

(Transient shock may be simulated by vibration one sweep from 5 to 35 Hz at one octave per minute.)

3.2.7.2.2 Nonoperational

The MFDS shall be capable of meeting the operating performance requirement specified herein after exposure to the following conditions:

a. Temperature: Minimum: Minus 65°F
Maximum: Plus 120°F with extremes of 150°F for 6 hours per day

b. Pressure: Minimum: 3.28 psia
Maximum: 18.0 psia

c. Shock:

1) Bench Handling: As specified in MIL-STD-810, Method 516.1, Procedure V.

2) Basic Design: 20-g terminal sawtooth shock pulse of 11-ms duration in each of three orthognal axes (both directions).

3) Crash Safety: 40-g terminal sawtooth shock pulse of 11-ms duration in each of three orthognal axes (both directions). Equipment and its mounting attachments shall not break loose, create a hazard to personnel, or prevent egress from crashed vehicle. Operating performance is not required after this test.

d. Ozone: 3 to 6 parts per hundred million (phm). Total oxidant concentrations may reach 60 phm for 1 to 3 hours in any 24-hour period.

e. Fungus: As specified in MIL-STD-810.

3.2.8 Transportability/Transportation

The MFDS shall be shipped in a GSE container specifically designed to protect the hardware during highway and air transportation. Vibration, shock, pressure, temperature, humidity and contamination shall be controlled to levels specified below. Provisions shall be made in the MFDS structure for suitable tie-down, lift and attachment points. All handling and transportation equipment shall be compatible with applicable structural and environmental limits. The MFDS shall be designed to be transported in either the horizontal or vertical position.

3.2.9 Storage

The MFDS shall have a storage life of ten years. Control shall be maintained on all parts and materials which are sensitive to age or the storage environments specified in paragraphs 3.2.7.1.1 and 3.2.7.1.2. These parts and materials shall be identified, and if deterioration is a factor during storage or after installation for use, the maintenance procedures shall indicate a replacement cycle or the necessary retesting.

3.2.10 Operability

3.2.10.1 Operating Life

The MFDS shall be capable of performing all operations specified herein for a minimum of 18,000 hours.

3.2.10.2 Useful Life

The MFDS shall have a minimum useful life of 24,000 hours which is equivalent to 100 orbital missions in a 10-year period from date of delivery. The average orbital mission will be seven days; however, the design shall not preclude the capability to extend the orbital staytime up to 30 days.

3.2.10.3 Shelf Life

The MFDS shall be capable of operating in accordance with the requirements specified herein for a time period of 10 years from date of delivery.

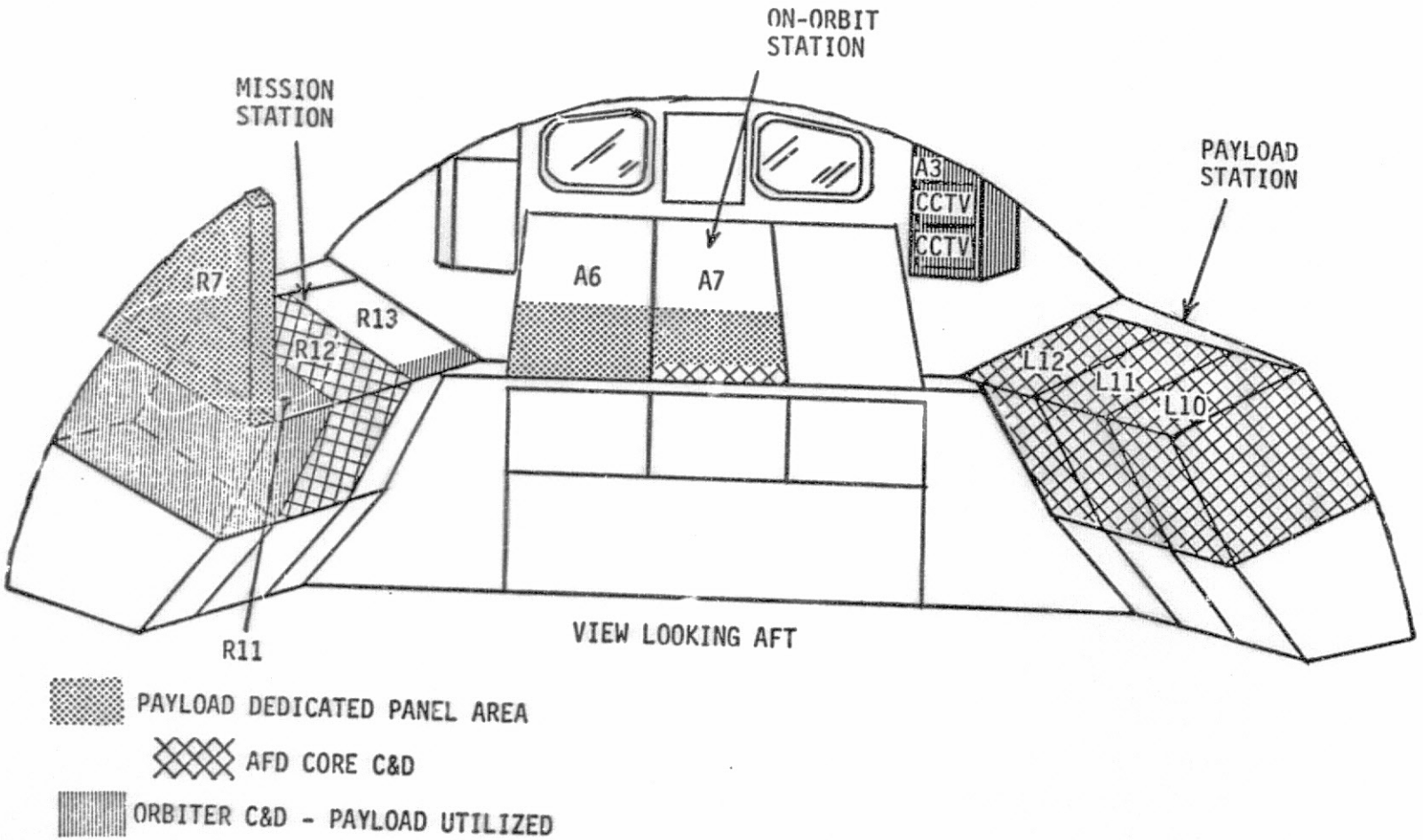

Figure 3.2-1 Orbiter AFD C&D Utilization

3.3 Design and Construction Standards

3.3.1 Selection of Specifications and Standards

Specifications and standards necessary for the design and development of hardware, in addition to those specified in this document shall be selected in the following order of preference except as otherwise specified:

a) NASA specifications and standards.

b) Federal specifications and standards.

c) Military specifications and standards (MIL, JAN, or MS).

d) Other Governmental specifications and standards.

e) Specification and standards released by nationally recognized associations, committees, and technical societies.

f) Supplier specifications and standards.

Specifications and standards shall be selected using MIL-STD-143 as a guide.

3.3.2 General

3.3.2.1 Materials, Parts and Processes

Materials, Parts, and Processes shall be in accordance with MSFC-STD-506. The contractor shall prepare and provide a materials selection and verification plan defining a proposed method for coordinating and officially documenting and approving all engineering drawings for flight hardware before design concepts are finalized. Approval of engineering drawings and all changes shall include sign-off by the materials and engineering discipline for each materials application utilized.

3.3.2.2 Flammability Requirements

Materials used in the design of the MFDS or contained in equipment installed therein, shall be compatible with the flammability requirements specified in NHB 8060.1A. SE-004-002-2H shall be used as a guideline to identify flammability hazards in air.

3.3.2.3 Outgassing of Materials

3.3.2.3.1 Internal Materials

All materials used within the MFDS shall meet the requirements of MSFC-DWG-10M90221 and MSFC-DWG-40M51264.

3.3.2.3.2 External Materials

High vapor pressure materials on the exterior surfaces of the MFDS in line-of-sight with optically critical surfaces shall conform to the material requirements of MSFC-DWG-50M02442. Materials not conforming to this requirement shall be submitted to MSFC for approval.

3.3.2.4 Lubrication

The lubrication for all moving parts exposed to the vacuum of space shall be selected in accordance with MSFC-STD-509.

3.3.2.5 Soldering

Soldering of all electrical connections in the MFDS shall comply with NHB 5300.4(3A). Solder connections shall meet the requirements of RA064-001-1A, Sections 4 through 15 for inspection purposes, except that references to NASA Quality Publication NPC200-4; MSC Supplement to NPC200-4, MSC-ASPO-S-6A; and MSC-ASPO-S-5C, MSC-ASPO Soldering Specification shall be deleted and replaced by NHB 5300.4(3A). Any requirement of RA064-001-1A that is inconsistent with the provisions of NHB 5300.4(3A) is superseded by NHB 5300.4(3A).

3.3.2.6 Restriction of Use of Mercury

Mercury in liquid or vapor form shall not be used in the MFDS. Where no satisfactory substitute exists or an alternate design or method cannot be used, the justification for the use of mercury, the protection provided to prevent its release, and a plan for decontamination in the event of its release shall be submitted to NASA/MSFC for approval.

3.3.3 Aeronautical

Not applicable.

3.3.4 Civil

Not applicable.

3.3.5 Electrical

3.3.5.1 Electrical Wiring

a. The wiring installation shall consist of cable harnesses where required. All wire bundles, harnesses and cables external to the component or vehicle shall conform to MSFC-DWG-40M39582. Wire used in cable harnesses shall conform to Specification MIL-C-17.

b. When etching of wire insulation is required in the MFDS to provide satisfactory bonding to potting materials, the open end of the wire shall not be exposed to the etchant. The preferred process is to form thb wire into a "U" shape, immerse only the bent portion in the etchant, and hold the open ends above the etchant level. The unetched end of the wire shall not be cut off prior to neutralization of the etchant. Electrical wire or cable insulated or coated with polyetrafluoroethylene or fluorinated ethylene propylene shall be etched prior to potting to assure mechanical bond strength and environmental seal. Potting shall be accomplished within three weeks after etching.

3.3.5.2 Electrical Connector Keying

All electrical plugs and receptacles used in the AFD core C&D panels shall be keyed or otherwise configured to prevent incorrect connection with other accessible plugs or receptacles.

3.3.5.3 Electrical Connector Pin Assignment and Pin or Socket Selection

a. Electrical circuits for the AFD core C&D panels shall not be routed through adjacent pins of an electrical connector if a short circuit between them would constitute a single point failure as defined in paragraph 3.2.3.

b. Cable connections of the AFD core C&D panels shall be designed so that pin and socket connectors are properly used to prevent power from shorting to ground. They also shall be designed to protect personnel both when connected and disconnected through the use of dead facing, explosion-proof connectors, or similar means.

3.3.5.4 Protection of Electrical and Electronic Devices

Electrical and electronic devices used in the MFDS 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.

3.3.5.5 Electrical and Electronic Piece-Parts, Closure Construction

Electrical and electronic piece-parts with all welded closure construction shall be used in preference to piece-parts with other types of closure construction. Other types of construction may be used if adequate program controls are imposed to assure that internal contamination cannot cause part degradation and failure under zero gravity environment.

3.3.5.6 Electrical Grounding

a. Primary DC Power Grounding - The MFDS negative buses shall be referenced to structure at one point. The conductor from the main power return point to the single-point ground shall be designed to carry the maximum fault current. The single point ground shall be capable of being connected to the Shuttle.

b. Component Grounding - The primary DC power shall be isolated from all component structure. The component case ground shall be per MIL-B-5087B.

3.3.5.7 Electromagnetic Interference

3.3.5.7.1 Electromagnetic Compatibility (EMC)

The MFDS shall be designed for electromagnetic self-compatibility and for electromagnetic compatibility (EMC) for all phases of the mission, and for EMC with the Orbiter AFD during on-orbit operations. The electrical and electronic equipment shall not be a source of, nor be susceptible to, electromagnetic interference as defined by MIL-STD-461A and 462.

3.3.5.7.2 Corona Suppression

Electrical and electronic subsystems and components shall be designed so that their proper performance will not be impaired by corona discharge in normal operating environments and shall not be a source of interference which adversely affects the operation of other equipment.

3.3.5.7.3 Lightning Protection

Electrical and electronic components shall be adequately protected from high currents induced by the lightning occurring at the launch site. The case ground shall be accomplished with the case connected to the structure through low-impedance conductive mounting surfaces. Where shock mounts or thermal isolation prevent this, then wide, flat, short bonding jumpers may be used in accordance with the bonding specification MIL-B-5087.

3.3.6 Mechanical

3.3.6.1 Design Safety Factors

The design safety factors shall have an ultimate safety factor of 3.0 and a yield safety factor of 2.0.

3.3.6.2 Fasteners

Threaded fasteners used for securing a single component, wherever possible, shall be the same type, size and tensile strength. Use of blind fasteners shall be minimized. Threaded fasteners shall be torqued per MSFC-STD-486.

3.3.6.2.1 Accessibility of Fasteners

Assembly and subassembly installations shall be designed such that access to threaded fasteners may be accomplished with the use of conventional tools.

3.3.6.2.2 Screw Threads

Screw threads for threaded fasteners used on Shuttle system hardware (except for GSE) shall be of unified thread form, Class 2, in accordance with MIL-S-7742 or MIL-S-8879, as applicable:

a. Material tensile ultimate strength levels up to, but not including, 160 KSI may be threaded per MIL-S-7742 or MIL-S-8879. Rolled threads are preferred.

b. Material strength levels of 160 KSI and above shall be threaded per MIL-S-8879. External threads shall be rolled after heat treatment. Screw threads used on airborne fluid systems fittings shall be of unified thread form, Class 2, in accordance with MIL-S-7742 or MIL-S-8879.

3.3.7 Nuclear

Not applicable.

3.3.8 Moisture, Humidity, and Fungus Resistance

Except as otherwise required by detail design considerations, only materials which resist the corrosive action of salt air and damage from moisture/humidity and fungus shall be used which conforms to MIL-STD-810.

3.3.9 Corrosion of Metal Parts

Metal parts shall be protected from corrosion by stress-relieving, plating, anodizing, chemical coatings, organic finishes, or combination thereof, provided that such protection is compatible with the operating and space environmental requirements.

3.3.9.1 Dissimilar Metals

Dissimilar metals, as defined in MIL-STD-889, shall not be used in combination unless they are suitably coated to prevent electrolytic corrosion.

3.3.9.2 Finish

The MFDS finish shall be in accordance with MSFC-SPEC-250, except for special thermal finishes.

3.3.10 Contamination Control

The MFDS cleanliness requirement is 100K clean class per FED-STD-209.

3.3.11 Coordinate System

Not applicable.

3.3.12 Interchangeability and Replaceability

The MFDS shall be designed for ease of manufacture, assembly, inspectio and maintenance. Insofar as practicable, the MFDS subpanels shall be interchangeable and/or replaceable in accordance with MIL-STD-189. The MFDS subpanels will be designed for installation in both the Orbiter AFD or the Spacela pressurized module.

3.3.13 Identification and Marking

3.3.13.1 Identification of Parts

Each part fabricated shall be identified with a part number. The same specification or part number shall be used to identify all like materials, processes, and parts. Seller shall assign a new part number to the part when authorized changes make the superseded part not interchangeable with respect to interface, reliability, safety, logistics, traceability or performance. For traceable items, the part identification shall additionally include the manufacturer's identification code in accordance with DOD Handbook H 4-1, and be lot numbered or serial numbered when required.

3.3.13.2 Supplier Part Number

The supplier part number, which is equivalent to the MFDS procurement part number, shall be in accordance with MIL-STD-130.

3.3.13.3 Identification of All Development/Qualification Test Specimens

Test specimens shall be permanently and obviously identified prior to testing with the words "ENG. TEST ONLY" in addition to the identification required by the drawing/specification to preclude their use on production items. The letters shall be indelible and provide a distinctive and vivid contrast with the color of the specimen. The lettering size and identification location shall be clearly visible to casual observation. Materials used for the identification shall be compatible with the test specimen and its operating environment. When the size or configuration of the test specimen is such the identification cannot appear on the specimen, other suitable means such as attached metal tags shall be used.

3.3.13.4 Nameplates

Nameplates shall be marked in accordance with MIL-STD-130 and shall include item name; buyer's part number; Federal North Atlantic Treaty Organization Stock Number (FSN/NATO); manufacturer; buyer; manufacturer's serial number, part number. Abbreviations, in accordance with MIL-STD-12, may be used.

3.3.13.5 Identification of Wiring

Identification of wiring shall not degrade insulation or shielding.

3.3.13.6 Electrical and Electronic Reference Designations

Electrical and electronic reference designations shall be affixed to the hardware in accordance with the USAS Y32.16-1968 (for external electrical connectors).

3.3.13.7 Electrical and Electronic Symbols

If schematic information is affixed to the MFDS, the electrical and electronic symbols shall be in accordance with the requirements of USAS Y32.2-1967.

3.3.13.8 Reidentification

The part number of the MFDS, its components, and parts shall be changed whenever redesign results in a change to dimensional form, fit tolerance, or functional characteristics from the previous configuration.

3.3.14 Workmanship

Workmanship on the MFDS shall be in accordance with the best practice for high quality equipment within the state of the art.

3.3.15 Human Performance/Human Engineering

The design shall consider capabilities and limitations of the human operator wherever a man-machine interface exists, including torques, forces, and other functional design characteristics of controls, displays, and work stations. The principal design guide for the man-machine interface shall be MIL-STD-1472 and MSFC-STD-512.

3.4 Logistics

3.4.1 Maintenance

a. The MFDS shall not require scheduled maintenance.

b. The MFDS shall not be designed to preclude the use of special tools and equipment for site maintenance and repairs. Special tools, if required, and approved by the buyer, shall be designed to withstand the intended use throughout the life of the equipment.

c. The MFDS shall be designed to satisfy the requirements of a Line Replaceable Unit (LRU).

d. The MFDS shall be designed so that routine corrective maintenance can be accomplished by the replacement of Shop Replaceable Units (SRUs). The MFDS design shall be such that isolation to a single malfunctioning SRU can be accomplished during bench maintenance utilizing the LRU interface connectors, BITE or the addition of a system GSE test connector is permissible to provide this isolation capability.

e. The necessity for any maintenance servicing or checkout tasks, other than built-in test capability, to be accomplished during flight is prohibited.

3.4.1.1 Installation

a. The equipment design shall physically prevent the incorrect installation of modules and submodules. Clearly visible color coding and labeling in close proximity to maintenance disconnect points shall be used to facilitate removal and replacement of any subassembly level of equipment.

b. Components shall be mounted in a manner to avoid blind adjustments.

c. Threaded fasteners used for securing a single component, where practical, shall be the same type, size, and tensile strength.

d. Captive fasteners shall be utilized to fasten LRUs.

3.4.1.2 Accessibility

a. Electrical connectors shall be accessible without disassembly or removal of functional equipment or components.

b. Servicing and test points shall be clearly marked and shall be accessible without requiring removal of access plates or covers except service caps. Calibration controls shall be accessible and clearly marked for major functions.

c. All fasteners on a single access cover shall be of the same length, diameter, and type.

3.4.1.3 Replacement

a. Mounting provisions shall permit SRU removal and replacement without disconnecting any equivalent level SRU in the line replaceable unit. If removal of a LRU structural element is required for access, such removal shall not affect electrical or mechanical alignment, nor shall the mechanical strength of the unit be impaired to the point that bending of the unit, its assemblies, electrical harnesses, or plumbing attachments will occur during normal bench handling of the unit.

b. Attachment fittings for components routinely removed shall be operable without hand tools and shall be accessible without requiring removal of access panels or covers.

3.4.2 Supply

The components, subassembly and assembly panels which make up the AFD core C&D design shall be recorded on delivery and tracked to assure that these

components, subassemblies, and assemblies are available in stock and ready for use by each subsequent activity phase that may impact or influence the design.

The following information records shall be maintained for each of the items:

a. Part numbers

b. Name of parts

c. Quantity required and available

d. Required delivery sites

e. Planned use sites

The above records will provide the required information to assure availability of items, and provide sufficient time to resupply components if it may appear that a shortage could occur prior to the next operation.

3.4.3 Facilities and Facility Equipment

Procured parts and mateirals will be received, inspected and stored in existing facilities. These same facilities will provide a bonded area which will store the qualified and acceptance tested parts or assemblies prior to delivery.

No new or unique facilities will be required for the logistic requirements.

3.5 Personnel and Training

Standard aerospace management, engineering, manufacturing, product assurance, and test practices as applied to prior space programs as Gemini, Apollo, Skylab, etc. will be utilized for the PS contractor's design/development phase.

This approach will enable these space program practices to be applied to the PS contractor's activities and, thereby, no new requirements will be needed for personnel training, training equipment and facilities.

MSFC or its designated Government quality representative will verify the adequacy of the discipline practices utilized.

3.6 Interface Requirements

3.6.1 Interprogram Interfaces

Interfaces between the AFD core C&D program, of which this specification is a part, and other programs (e.g., Orbiter, Spacelab, IUS) will be controlled by ICDs to be supplied by the Phase C/D contractor for mechanical electrical and software interfaces.

3.6.2 Intraprogram Interfaces

The relationship between this CEI and the other CEIs within the AFD core C&D program is shown in Figure 3.6-1. Each CEI (project level) defines the specific interface requirements applicable to the individual project.

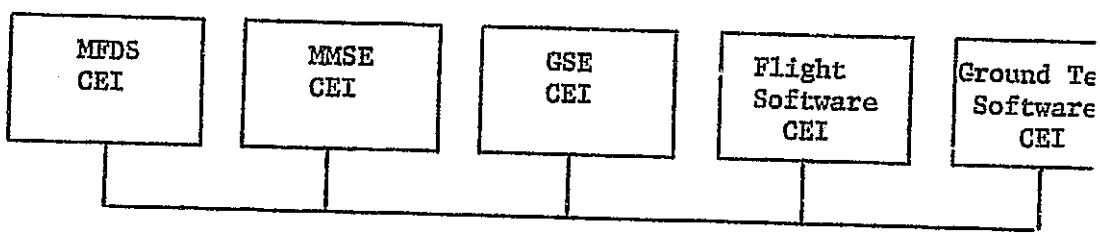

Figure 3.6-1 Intraprogram CEIs

3.6.3 Intraproject Interfaces

Not applicable

4.0 VERIFICATION

The verification program is designed to verify that the MFDS hardware conforms to the design, construction, and performance requirements as specified in Section 3 herein. Each requirement presented in Section 3 will be verified by test or assessment as specified in Section 4.

4.1 General

The following subparagraphs specify the organizational responsibility for accomplishing verification, verification methods to be used, requirements for test/equipment failures, and requirements for phased verification.

4.1.1 Responsibility for Verification

Organizational responsibilities for performing and supporting verification during the various verification phases of Paragraph 4.2 shall be as defined herein. Responsibilities are defined as primary and supportive. It shall be the Government's right to witness and verify the results of all verification accomplished.

Verification Phase	*Organizational Responsibility for Verification. Primary	Supportive or Witness
1. Development	PS Contractor	MSFC
2. Qualification	PS Contractor	MSFC
3. Acceptance	PS Contractor	MSFC

*Legend

MSFC NASA-MSFC

4.1.2 Verification Method Selection

Verification methods shall include test during each verification phase as applicable, or assessment by similarity, analysis, inspection, demonstration, and validation or records. These methods are defined in paragraph 4.3.1.

4.1.2.1 Design Margin Verification Selection

Where integrity is verified by analysis only, the following factors of safety shall be used:

Yield Factor of Safety - 2.0
Ultimate Factor of Safety - 3.0

4.1.3 Flight Hardware Failures

Failures of MFDS hardware occurring during qualification, acceptance and integrated system testing shall require a complete analysis of each failure and corrective action documented by a non-conformance report. The PS contractor shall secure agreement from the designated NASA representative concerning adequacy of the corrective action before these tests can be resumed after the occurrence of each failure. Retest or assessment shall be performed to establish the adequacy or corrective action and restore validity of previous testing. The PS contractor shall report immediately to MSFC any unusual phenomenon, occurrence, difficulty, or questionable condition occurring in the conduct of the test.

4.1.4 Test/Equipment Failures

Test policy for the MFDS shall include tests which demonstrate a completely checked out end item within specification performance of all systems for flight readiness. To this end, the test program shall encompass: all component and system malfunctions corrected or satisfactorily explained and accepted to certify flight readiness, and appropriate reverification required following equipment replacement because of failure or other reasons.

Retest shall be performed after failure or equipment replacement to the extent necessary to restore confidence in the equipment. The retest requirements shall be specified at time of failure or replacement and shall be a part of the controlling documentation. Reverification may be deferred to the next scheduled functional test of the affected hardware. Reverification must be accomplished prior to launch for flight equipment.

4.2 Phased Verification Requirements

Phased verification of the Section 3 requirements shall be as specified in the Paragraph 4.3 Verification Cross Reference Index. Definitions of the verification phases follow in Paragraph 4.2.1 through 4.2.8.

4.2.1 Development

Development verification is the process for verifying the feasibility of the design approach and to provide confidence in the ability of the hardware to pass qualification. Where visibility and control of vendor hardware development is required, appropriate direction shall be included in the applicable procurement drawings/specifications.

4.2.2 Qualification

The MFDS including all components shall be qualified prior to launch. Where visibility and control of vendor hardware is required, appropriate direction shall be included in the applicable procurement drawings/specifications.

Test types, durations and levels shall be specified. Qualification shall be accomplished by any one or more of the following:

a. Test - Qualification Testing.

b. Assessment - (1) Similarity; (2) Analysis; (3) Inspection; (4) Demonstration; (5) Validation of Records.

Qualification testing methods are defined in the following paragraphs. Assessment methods definitions are presented in Paragraph 4.3.1.

4.2.2.1 Qualification Testing

Qualification testing is an individual or series of performance/functional and environmental tests conducted on flight hardware at environmental test conditions normally more severe than acceptance test conditions to establish that the hardware will perform satisfactorily in the use environments with sufficient margin.

4.2.3 Acceptance

The MFDS including all components, shall be acceptance tested prior to launch. Where visibility and control of vendor hardware is required, appropriate direction shall be included in the applicable drawings/specifications. Test types, durations and levels shall be specified. Acceptance testing shall be applicable to component through system level.

4.2.3.1 Component Acceptance Testing

Component acceptance tests consist of performance/functional and acceptance level environmental tests to assure compliance with required specifications. This testing is conducted to detect manufacturing flaws and workmanship defects that cannot be detected by normal inspection techniques as well as verify functional conformance to design specifications including environmental exposures.

4.2.3.2 Subsystem/Systems Acceptance Tests

These tests shall be performed as appropriate following component acceptance tests to demonstrate compliance to specifications. Subsystem and system verification in various operating modes and interfaces at normal flight supply voltages will be considered.

4.2.3.3 MFDS Acceptance Testing

The MFDS shall be acceptance tested as an end item prior to its delivery to the next higher level of hardware assembly. Testing includes system to system interface checks, operation of individual MFDS systems,

combined systems functional and mission sequence simulation tests. Test types, durations and levels shall be specified.

4.2.4 Integrated Systems

This phase consists of the testing performed after the mating of the MFDS with the Orbiter or Spacelab subsystems, and will be the responsibility of the Mission Contractor. The PS Contractor shall support the Mission Contractor.

4.2.5 Prelaunch Checkout

This phase of testing will be the responsibility of the Mission Contractor, and the PS Contractor shall support the Mission Contractor.

4.2.6 Launch

This phase of testing will be the responsibility of the Mission Contractor, and the PS Contractor shall support the Mission Contractor.

4.2.7 Flight/Mission Operations

This phase of testing will be the responsibility of the Mission Contractor.

4.2.8 Post-Flight

This phase of testing will be the responsibility of the Mission Contractor.

4.3 Verification Cross-Reference Index

The verification cross-reference index provides a one-for-one cross reference of each verification requirement for each Section 3 requirement. Verification shall be by test or assessment. Test types and phases were described in Paragraph 4.2. Assessment methods are described below.

4.3.1 Assessment Methods

Assessment methods include: (a) similarity; (b) analysis; (c) inspection; (d) validation of records; and (e) demonstration. A brief definition of the methods as used herein follows:

a. Similarity - Qualification by similarity shall be considered if it can be demonstrated, by review of prior test data or application of hardware (flight or usage experience), that the article is similar or identical in design and manufacturing process to another article that has previously been qualified to equivalent or more stringent environmental criteria (e.g., Skylab, Apollo and/or Gemini hardware).

b. Analysis - Analysis may be used for verification in lieu of, or in addition to testing to verify compliance to specification requirements. The selected techniques may include, typically, systems engineering analysis, statistics, qualitative analysis, analog, modeling, and computer simulations. Analysis may be considered when it can be determined that:

1) Rigorous and accurate analysis is possible.
2) Test is not cost-effective.
3) Similarity is not applicable.
4) Verification by inspection is not adequate.

c. Inspection (End-Item) - Inspection techniques (e.g., verification of compliance with drawings, wire coding, material compliance, etc) may be used in lieu of or in conjunction with testing to verify design features (e.g., dimensions, bonding, assembly methods, etc).

d. Validation of Records - Manufacturing records may be used at end-item acceptance to verify latent construction features and processes for flight hardware and associated support equipment.

e. Demonstration - Demonstration techniques (e.g., service access, tranportability, crew-hardware interfaces, replacement provisions, etc) may be used in lieu of or in conjunction with test to verify compliance with the requirements.

4.3.2 MFDS Verification Requirements Matrix

Verification requirements for Section 3 paragraphs are identified in Table 4.1. The left-hand column of the matrix identifies each Section 3 requirement by paragraph number and where required, by sentence number of the paragraph. The verification method(s) for the various verification phases are presented in the matrix. The right hand column identifies the applicable Verification Plan paragraph number which defines and directs implementation of each verification requirement.

4.4 Test Support Requirements

Test support including test facilities and equipment, bench setups, test software and test interfaces shall be as defined.

4.4.1 Facilities and Equipment

a. Existing facilities/equipment with NASA or other Government agencies and contractors shall be utilized to the maximum extent practicable.

b. MFDS test activities including test facilities/equipment, personnel, and procedures shall be established and included in the Verification Plan.

c. Maximum use of the same or common MFDS test equipment shall be used for testing at multiple locations to assure uniformity of test results.

d. All test equipment shall be designed with a fail-safe goal such that test equipment failure will not degrade flight hardware. All test equipment shall be tested prior to interfacing with flight equipment to ensure that no damage or degradation to flight hardware will be induced. Appropriate tolerances shall be identified in the procedures, taking into account test equipment capabilities and flight hardware specifications, such that the test results will verify compliance with the flight hardware specifications.

4.4.2 Articles

Test articles, if required to support the test program, shall be as identified.

4.4.3 Software

Requirements governing software utilization in support of verification operations shall be as identified.

4.4.4 Interfaces

Where verification requires interfacing of the MFDS with other STS Project facilities/equipment, the Mission contractor shall direct and support the test activities in accordance with the applicable contractual agreement(s).

TABLE 4-1 VERIFICATION CROSS-REFERENCE

REQUIREMENTS FOR VERIFICATION

NOMENCLATURE:	CRIT. CAT:
CEI NO.	CEI SPEC NO.

VERIFICATION METHOD

1. TEST
2. ASSESSMENT
   a. SIMILARITY
   b. ANALYSIS
   c. INSPECTION
   d. DEMONSTRATION
   e. VALIDATION OF RECORDS

N/A = NOT APPLICABLE

VERIFICATION PHASES

A. DEVELOPMENT
B. QUALIFICATION
C. ACCEPTANCE
D. INTEGRATED SYSTEM
E. PRELAUNCH CHECKOUT
F. FLIGHT VERIFICATION
G. LAUNCH
H. POST FLIGHT

PERFORMANCE/DESIGN REQUIREMENT REFERENCE	VERIFICATION METHOD									TEST/ASSESSMENT REQUIREMENT REFERENCE
	N/A	A	B	C	D	E	F	G	H	
3.2.1.1 Display Units		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.1.1 Brightness		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.1.1.1 Manual Brightness Control		2d	2d	2d						4.3.1.e
3.2.1.1.1.2 Automatic Brightness "		1	2d	2d						4.2.1, 4.3.1.e
3.2.1.1.2 Contrast		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.1.3.1 TV Scan Resolution		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.1.3.2 Line Width		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.1.3.3 Resolution		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.1.3.4 Video Bandwidth		1	1	1						4.2.1, 4.2.2, 4.2.3

Table 4-1 Verification Cross-Reference

REQUIREMENTS FOR VERIFICATION

NOMENCLATURE:									SHEET 2 OF 7
CEI NO.				CEI SPEC NO.					CRIT CAT:
PERFORMANCE/DESIGN REQUIREMENT REFERENCE	VERIFICATION METHOD								TEST/ASSESSMENT REQUIREMENT REFERENCE
	N/A	A	B	C	D	E	F	G	H
3.2.1.1.4 Linearity		1	1	1					4.2.1, 4.2.2, 4.2.3
3.2.1.1.5 Jitter		1	1	1					4.2.1, 4.2.2, 4.2.3
3.2.1.1.6 Position Stability		1	1	1					4.2.1, 4.2.2, 4.2.3
3.2.1.1.7 Positional Error		1	1	1					4.2.1, 4.2.2, 4.2.3
3.2.1.1.8 Display Centering		1	1	1					4.2.1, 4.2.2, 4.2.3
3.2.1.1.9 Phosphor		2d	1	1					4.3.1.e, 4.2.2, 4.2.3
3.2.1.1.10 Bite		1	1	1					4.2.1, 4.2.2, 4.2.3
3.2.1.1.11 Color		2d	2d	2d					4.3.1.e
3.2.1.1.12 Screen Area		2c	-	-					4.3.1.c
3.2.1.1.13.1 Input Power		1	1	1					4.2.1, 4.2.2, 4.2.3
3.2.1.1.13.2 Grounding & Isolation		2c	-	-					4.3.1.c
3.2.1.1.13.3 Power Dissipation		1	1	1					4.2.1, 4.2.2, 4.2.3
3.2.1.1.13.4 Power Conversion		1	1	1					4.2.1, 4.2.2, 4.2.3
3.2.1.1.13.5 Power-on Sequence		1	1	1					4.2.1, 4.2.2, 4.2.3
3.2.1.1.13.6 Power-off Sequence		1	1	1					4.2.1, 4.2.2, 4.2.3
3.2.1.1.13.7 Normal Power Transient		1	1	1					4.2.1, 4.2.2, 4.2.3
3.2.1.1.13.8 Abnormal Power Transients		2b	-	-					4.3.1.b
3.2.1.1.13.9 Power Interruption		1	1	1					4.2.1, 4.2.2, 4.2.3
3.2.1.1.14 Weight		2d	-	-					4.3.1.e
3.2.1.1.15 Dimensions		2c	-	-					4.3.1.c
3.2.1.2 Electronics Unit		1	1	1					4.2.1, 4.2.2, 4.2.3
3.2.1.2.1 Symbol Arrays		1	1	1					4.2.1, 4.2.2, 4.2.3
3.2.1.2.2 Symbol Elements		1	1	1					4.2.1, 4.2.2, 4.2.3

Table 4-1 Verification Cross-Reference

REQUIREMENTS FOR VERIFICATION

NOMENCLATURE: SHEET 3 OF 7

CEI NO. CEI SPEC NO. CRIT CAT:

PERFORMANCE/DESIGN REQUIREMENT REFERENCE	VERIFICATION METHOD									TEST/ASSESSMENT REQUIREMENT REFERENCE
	N/A	A	B	C	D	E	F	G	H	
3.2.1.2.3.1 Circles		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.2.3.2 Vectors		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.2.4.1 Flash		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.2.4.2 Dash		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.2.4.3 Rotate		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.2.4.4 Translation		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.2.4.5 Character Size		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.2.4.6 Intensity		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.2.4.7 Blanking		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.2.4.8 Text Presentation		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.2.4.9 Scratch Pad		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.2.4.10 Computer Specified Symbols		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.2.5.1 Text Data		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.2.5.2 Character Relationships		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.2.5.3 Character Size		2d	2d	2d						4.3.1.e
3.2.1.2.5.4 Number of Intensity Levels		2d	2d	2d						4.3.1.e
3.2.1.2.5.5 Refresh Rate		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.2.5.6 Character Generation		2c	-	-						4.3.1.c
3.2.1.2.5.7 Position Matrix		2c	-	-						4.3.1.c
3.2.1.2.5.8 Occlusion Zone		2d	-	-						4.3.1.e
3.2.1.2.6 Display Information		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.2.7 Memory		2c	-	-						4.3.1.c
3.2.1.2.8 Bite		1	1	1						4.2.1, 4.2.2, 4.2.3

Table 4-1 Verification Cross-Reference

REQUIREMENTS FOR VERIFICATION

NOMENCLATURE:

CEI NO.

CEI SPEC NO.

CRIT CAT:

PERFORMANCE/DESIGN REQUIREMENT REFERENCE	VERIFICATION METHOD									TEST/ASSESSMENT REQUIREMENT REFERENCE
	N/A	A	B	C	D	E	F	G	H	
3.2.1.2.9.1 Input Power		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.2.9.2 Grounding & Isolation		2c	-	-						4.3.1.c
3.2.1.2.9.3 Power Dissipation		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.2.9.4 Power Conversion		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.2.9.5 Power-on Sequence		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.2.9.6 Power-off Sequence		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.2.9.7 Normal Power Transient		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.2.9.8 Abnormal Power Transients		2b	-	-						4.3.1.b
3.2.1.2.9.9 Power Interruption		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.2.10 Weight		2d	-	-						4.3.1.e
3.2.1.2.11 Dimensions		2c	-	-						4.3.1.c
3.2.1.3.1 General Keyboard		2c	-	-						4.3.1.c
3.2.1.3.1.1 Key Functions		1	-	1						4.2.1, 4.2.3
3.2.1.3.1.2 Key Layout & Nomenclature		2c	-	-						4.3.1.c
3.2.1.3.1.3 Control & Status		2c	-	-						4.3.1.c
3.2.1.3.1.4 Bite		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.3.1.5										
(a) Input power		1	1	1						4.2.1, 4.2.2, 4.2.3
(b) Grounding & Isolation		2c	-	-						4.3.1.c
(c) Power Dissipation		1	1	1						4.2.1, 4.2.2, 4.2.3
(d) Normal Power Transient		1	1	1						4.2.1, 4.2.2, 4.2.3
(e) Abnormal Power Transients		2b	-	-						4.3.1.b
(f) Power Interruption		1	1	1						4.2.1, 4.2.2, 4.2.3

Table 4 I Verification Cross-Reference

REQUIREMENTS FOR VERIFICATION

NOMENCLATURE:										
CEI NO.					CEI SPEC NO.					CRIT CAT:
PERFORMANCE/DESIGN REQUIREMENT REFERENCE	VERIFICATION METHOD									TEST/ASSESSMENT REQUIREMENT REFERENCE
	N/A	A	B	C	D	E	F	G	H	
3.2.1.3.1.6 Weight		2d	-	-						4.3.1.e
3.2.1.3.1.7 Dimensions		2c	-	-						4.3.1.c
3.2.1.3.2 Secondary Keyboard		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.3.2.1 Power										
(Verification Method same as 3.2.1.3.15	a thru f)									
3.2.1.4.1 Crosshair Pointing		1	-	1						4.2.1, 4.2.3
3.2.1.4.1.1 Position Crosshair		1	-	1						4.2.1, 4.2.3
3.2.1.4.1.2 Reposition Command		1	-	1						4.2.1, 4.2.3
3.2.1.4.1.3 Crosshair Updating		1	-	1						4.2.1, 4.2.3
3.2.1.4.1.4 Screen Center		2d	-	-						4.3.1.e
3.2.1.4.2 Video Display Unit-		1	1	1						4.2.1, 4.2.2, 4.2.3
Line Resolution										
3.2.2 Physical		2c	-	-						4.3.1.c
3.2.3 Reliability	X									
3.2.3.1 Critical Single Failure Points			1							4.2.2
3.2.3.2 Failure Deterrent and Detection			1							4.2.2
3.2.3.3 Reliability Goals			1							4.2.2
3.2.4 Maintainability	X									
3.2.4.1 Installation/Removal/Replacement			1							4.2.2
Operations										
3.2.4.2 Scheduled Servicing			1							4.2.2
3.2.5 Operational Availability	X									
3.2.6 Safety			1							4.2.2

Table 4-1 Verification Cross-Reference

REQUIREMENTS FOR VERIFICATION

NOMENCLATURE: SHEET 6 OF 7

CEI NO. CEI SPEC NO. CRIT CAT:

PERFORMANCE/DESIGN REQUIREMENT REFERENCE	VERIFICATION METHOD (*)									TEST/ASSESSMENT REQUIREMENT REFERENCE
	N/A	A	B	C	D	E	F	G	H	
3.2.6.1 Crash Safety			1							4.2.2
3.2.7 Environment	X									
3.2.7.1 Natural	X									
3.2.7.1.1 Transportation and Storage			1							4.2.2
3.2.7.1.2 Handling			1							4.2.2
3.2.7.2 Induced	X									
3.2.7.2.1 Flight Operational			1							4.2.2
3.2.7.2.1.a Temperature			1							4.2.2
3.2.7.2.1.b Pressure			2b							4.3.1.b
3.2.7.2.1.c Humidity			1							4.2.2
3.2.7.2.1.d Salt Fog			2a							4.3.1.a
3.2.7.2.1.e Lightning			2a							4.3.1.a
3.2.7.2.1.f Random Vibration			1							4.2.2
3.2.7.2.1.g Acceleration			2b							4.3.1.b
3.2.7.2.1.h Shock			2b							4.3.1.b
3.2.7.2.2 Nonoperational			2b							4.3.1.b
3.2.7.2.2.a Temperature			2b							4.3.1.b
3.2.7.2.2.b Pressure			2b							4.3.1.b
3.2.7.2.2.c Shock			1							4.2.2
3.2.7.2.2.d Ozone			2b							4.3.1.b
3.2.7.2.2.e Fungus			2b							4.3.1.b
3.2.8 Transportability/Transportation	X									
3.2.10 Storage	X									

Table 4-1 Verification Cross-Reference

REQUIREMENTS FOR VERIFICATION

SHEET 7 OF 7

NOMENCLATURE:										
CEI NO.					CEI SPEC NO.				CRIT CAT:	
PERFORMANCE/DESIGN REQUIREMENT REFERENCE	VERIFICATION METHOD									TEST/ASSESSMENT REQUIREMENT REFERENCE
	N/A	A	B	C	D	E	F	G	H	
3.2.10 Operability	X									
3.2.10.1 Operating Life			2a							4.3.1.a
3.2.10.2 Useful Life			2a							4.3.1.a
3.2.10.3 Shelf Life			2a							4.3.1.a

5.0 PREPARATION FOR DELIVERY

Not applicable

6.0 NOTES

6.1 Definition and Design Terms

Multifunction Display System - AFD Hardware (located at Panels L-11 & L-10) consisting of two CRT displays, electronic unit and keyboard. The system is used to control & monitor payload experiments on orbit.

Built-in-Test Equipment - Circuitry provided to perform continuous monitoring of specific parameters, groups of parameters, or functions of the LRU to provide a go/no-go indication. This type of built-in-test capability represents those implementational techniques that are autonomous and provide continuous real-time monitoring, but do not interrupt normal operation of the LRU.

Closed Circuit Television - Orbiter equipment consisting of TV cameras (located in the payload bay and forward section of the orbiter) and TV monitors (located at the Aft Flight Deck). The system is used for monitoring of payload bay and cabin area activities.

Display Unit - The display unit consists of one CRT monitor (either black and white or color) and forms a integral part of the multifunction display system. The display unit is used to present experiment status and data in the form of alpha numerics, graphics and video.

Electronic Unit - The electronics unit is an integral part of the multifunction display system. It interfaces with the various flight computers and interprets computer commands. It creates and controls all displays for the display unit.

Ground Support Equipment - This ground equipment consists of a minicomputer, CRT display keyboard unit, mass storage, line printer and input/output units. It is used to checkout and verify the AFD core controls and displays hardware.

Interconnecting Stations - Spacelab equipment used to tie AFD core equipment to either the Spacelab subsystem or experiment data buses. The interconnecting stations isolate and protect the buses from the equipment on the buses.

Input-Output - Interfacing hardware/softwa -- between a computer and the equipment it is monitoring or controlling.

Input/Output Processor - Similar to input/output but with additional data formatting and processing.

Remote Acquisition Unit - Spacelab equipment used to interface a Spacelab computer to various experiments for monitoring and control.

Read Only Memory - A device used for the storage of information in digital form. This information cannot be changed. Information can only be obtained (read) from this memory.

Read/Write Memory - A device used for the storage of information in digital form. This information may be changed as required. Information in memory can either be obtained (read) from memory or placed (written) into memory.

Line Replaceable Unit - A combination of components, units, parts, assemblies, subassemblies, etc. that are contained in one package or are so arranged that together the combination is common to one mounting and, in addition, provides a complete function to the larger entity within which is operates.

Shop Replaceable Unit - An integral subassembly of an LRU consisting of units and parts or a combination of parts so arranged that together the combination is common to one mounting and, in addition, provides a complete function to the larger entity within which it operates.

6.2 List of Acronyms

AC	Alternating Current
AFD	Aft Flight Deck
AVT	Acceptance Verification Test
BITE	Built-In-Test Equipment
B&W	Black & White
CCTV	Closed Circuit Television
CDR	Critical Design Review
CEI	Contractor End Item
CIL	Critical Item List
CRT	Cathode Ray Tube
C&D	Controls & Displays
DC	Direct Current
DDU	Data Display Unit
DU	Display Unit
EMC	Electromagnetic Compatibility
EU	Electronic Unit
FMEA	Failure Modes & Effects Analysis
GPC	General Purpose Computer
GSE	Ground Support Equipment
Hz	Hertz
I/O	Input/Output
IOP	Input Output Processor
IPS	Instrument Pointing System
IS	Interconnecting Station

KB	Keyboard
LRU	Line Replaceable Unit
MFDS	Multifunction Display System
MHz	Mega Hertz
ms	Milliseconds
MS	Mission Station
OOS	On-Orbit Station
PDB	Power Distribution Box
PDR	Preliminary Design Review
Phm	Parts per Hundred Million
PS	Payload Station
RAU	Remote Acquisition Unit
RID	Review Item Disposition
ROM	Read Only Memory
R/W	Read and Write
SE&I	Systems Engineering & Integration
S/L	Spacelab
SRU	Shop Replaceable Unit
STE	Support Test Equipment
TBD	To Be Determined
TV	Television
WBS	Work Breakdown Structure

Multi-Use Mission Support Equipment (MMSE) Specification

PRIME EQUIPMENT DETAIL SPECIFICATION

PART I

PERFORMANCE, DESIGN AND VERIFICATION REQUIREMENTS

MULTI-USE MISSION SUPPORT EQUIPMENT

CEI NO. _____

FOR

AFT FLIGHT DECK CORE

CONTROLS & DISPLAYS

APPROVED BY _____

CODE IDENTIFICATION _____

DATE _____

APPROVED BY _____
NASA

DATE _____

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

TABLE OF CONTENTS (Cont.)

1.0 SCOPE

This specification provides preliminary performance requirements for a set of multi-use mission support equipment (MMSE) to be used in the Shuttle Orbiter aft flight deck (AFD) in support of payload operations. The principal interface requirements for the MMSE are also identified herein.

Figure 1.0-1 shows the AFD and indicates payload dedicated panel areas. The MMSE described herein will be located at panels L12, L11 and A7, as part of the AFD core C&D.

2.0 APPLICABLE DOCUMENTS

The following documents, of exact issue shown, form a part of this specification to the extent specified herein. In event of conflict between documents referenced here and other detail content of this specification, the detail requirements herein shall be considered superseding. Contractor specifications satisfying the intent of the below-listed documents may be used in lieu of the specifically listed documents after review and approval by MSFC. Reference to these documents contained herein shall be by basic number only.

2.1 Specifications

MSFC Specifications		CEI Para.
MSFC-SPEC-250 Amendment 1 26 February 1964	Protective Finishes for Space Vehicles Structures and Associated Flight Equipment, General Specification	3.3.9.2

2.2 Standards

MSFC Standards		
MSFC-STD-512 12 August 1974	Standard Man/Systems Design Criteria for Manned Orbiting Payloads	3.3.15
MSFC-STD-486 Amendment 1 July 1970	Threaded Fasteners, Torque Limits For	3.3.6.2
MSFC-STD-509 October 1972	Lubricant Selection	3.3.2.4
Federal Standards		
FED-STD-209B 24 April 1973	Clean Room and Work Station Req. Controlled Environment	3.3.10

Military Standards and Specifications		CEI Para.
MIL-STD-143B 12 November 1969	Standards and Specifications, Order of Precedence for the Selection of	3.3.1
MIL-C-17E 12 July 1974	Cables, RF, Coaxial, Dual Coaxial, Twin Conductors and Twin Lead	3.3.5.1
MIL-STD-1472B 31 December 1974	Human Engineering Design Criteria for Military Systems, Equipment and Facilities	3.3.15
MIL-STD-130D 1 August 1973	Identification Marking of U.S. Military Property	3.3.13.2 3.3.13.4
MIL-STD-810(C) 10 March 1975	Environmental Test Methods	3.2.7.2.2 3.3.8
MIL-STD-470 21 March 1966	Maintainability Program Requirements	3.2.4
MIL-STD-889A 5 May 1972	Dissimilar Metals	3.3.9.1
MIL-B-5087B(2) 31 August 1970	Bonding, Electrical and Lightning Protection, for Aerospace Systems	3.3.5.6 3.3.5.7.3
MIL-S-7742B 15 March 1973	Screw Threads, Standard, Optimum Selected Series, General Specification For	3.3.6.2.2
MIL-S-8879A(1) Notice 1 15 March 1973	Screw Threads, Controlled Radius Root With Increased Minor Diameter, General Specification For	3.3.6.2.2
MIL-STD-461A Amendment 4 June 1973	Notice 1, 2, 3 Electromagnetic Interference Characteristics, Req. for	3.3.5.7.1
MIL-STD-462(2) 1 May 1970	Notice 1, 2 - Electromagnetic Interference Characteristics, Measurement of	3.3.5.7.1

Military Standards and Specifications		CEI Para.
MIL-STD-189 Notice 2 14 March 1961	Racks, Electrical Equipment, 19-Inch and Associated Panels	3.3.12 3.2.1.1.15
MIL-R-94D	Potentiometer Requirements	3.2.1.5
MIL-STD-12C(2) 1 February 1971	Abbreviations for Use on Drawings, Specifications, Standards, and in Technical Documents	3.3.13.4

2.3 Drawings

MSFC Drawings		CEI Para.
MSFC-DWG-40M51264(A)	Outgassing, Thermal Vacuum, Spec. for	3.3.2.3.1
MSFC-DWG-10M90221	Materials Management Plan for Contamination Control	3.3.2.3.1
MSFC-DWG-40M39582	Harnesses, Electrical Design	3.3.5.1
MSFC-DWG-50M02442	ATM Material Control for Contamination due to Outgassing	3.3.2.3.2

2.4 Shuttle Program Publications

National Aeronautics and Space Administration		CEI Para.
JSC-07700, Vol. XIV, Revision D Change No. 17 27 July 1976	Space Shuttle System, Payload Accommodations, Program Definition and Requirements	3.2.4.1 3.2.6 3.2.7.1.1 3.2.7.1.2
JSC-07700, Vol. III Change No. 16 27 July 1976	Program Planning and Analysis	3.1.2
JSC-07700, Vol. I-014-PIV-01 Change No. 1 1 June 1976	Payload Interface Verification; Vol. I, General Approach and Requirements	3.2.4.1

Contractor Specifications (RI)		CEI Para.
MJ070-0001-1B 15 January 1976	Orbiter Vehicle End Item Specification for The Space Shuttle System Part I; Performance and Design Requirements	3.2.7.1.1
MC452-0049	Procurement Specification for Rotary Switch	3.2.1.8 3.2.1.5
MC456-0053	Procurement Specification for Event Timer	3.2.1.2 3.2.1.6
MC452-0102	Procurement Specification for Hermetically Sealed Toggle Switch	3.2.1.9 3.2.1.6 3.2.1.5
MC432-0222	Procurement Specification for Event Indicator	3.2.1.1 3.2.1.1

Contractor Drawings (RI)	
ME452-0102-X105	3.2.1.6,3.2.1.1
ME452-0102-X106	3.2.1.8,3.2.1.1
ME452-0093-1013	3.2.1.5,3.2.1.2 3.2.1.4
ME452-0102-X251	3.2.1.9,3.2.1.3
ME444-0059-1001	3.2.1.5

Contractor Specifications		
Bendix Corporation Spec. 1941022	Manual Pointing Controller	3.2.1.8

2.5 Other Publications

NHB-5300.4 (1D-1) August 1974	Safety, Reliability, Maintainability and Quality Provisions for the Space Shuttle Program	3.2.3 3.2.6
NHB 5300.4 (3A) May 1968	Requirements for Soldered Electrical Connections	3.3.2.5

Other Publications

DOD Handbook H4-1 Latest Revision	Federal Supply Code of Manufacturers Name to Code	3.3.13.1
MA-06, Vol. III Part I 12 November 1976	Work Breakdown Structure	3.1.5.2
NHB 1700.1 (VI) July 1969	NASA Safety Manual	3.2.6
JSC-07636 September 1973	Space Shuttle Lightning Protection Criteria Document	3.2.7.2.1
NPC-200-4 August 1964	NASA Quality Publication	3.3.2.5
NHB 8060.1A November 1971	Flammability, Odor, and Offgassing Req. and Test Procedures for Materials in Environment that Support Combustion	3.3.2.2
SE-004-002-2H	Guidelines for Identifying Flammability Hazards in Air	3.3.2.2

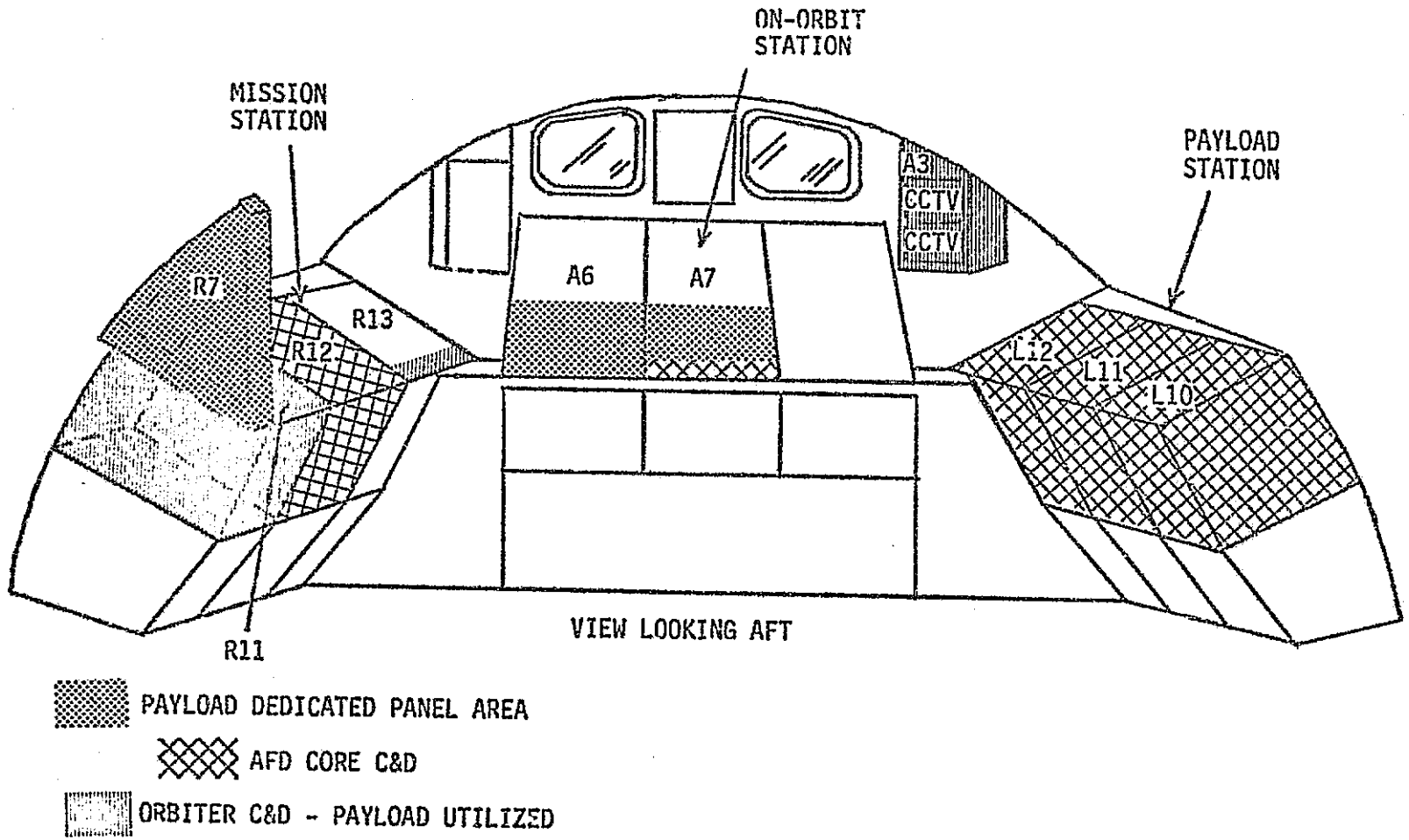

Figure 1.0-1 Orbiter Aft Flight Deck - C&D Utilization

3.0 REQUIREMENTS

3.1 CEI Definition

3.1.1 General Description

The multi-use mission support equipment (MMSE) set shall consist of nine separate subpanels of the configurations described in Table 3.1-1. The subpanels designated for use at payload station panel L12 (A1 through A5) will comprise that entire panel and shall, when arranged together, conform to the total overall panel surface dimensions of 19 inches wide x 21 inches high. Figure 3.1.1-1 shows a typical MMSE layout for panel L12. Other layouts, consistent with the requirements specified herein and with human factors considerations, may also be utilized. The remaining subpanels of the MMSE set will be located within and form parts of panels L11 and A7 in the aft flight deck (AFD), and shall utilize minimum panel surface area consistent with requirements detailed in this specification.

3.1.2 Missions

The MMSE described herein is generally applicable to STS mission during the 1980s. The Shuttle Program scheduling, operations planning, flight hardware, ground system requirements, and costs shall be based on the Shuttle Program mission model described in JSC-07700, Volume III. The first use of the MMSE will be for the first operational flight utilizing the AFD core C&D capability, the Spacelab 2 mission. Early missions will utilize that portion of the MMSE contained on subpanels L12-A1, L11-A3 and A4 (manual operation only), L11-A5 and A7-A2. Later missions which are more complex and involve multiple-payload operation will require the additional MMSE on subpanels L12-A2, -A3, -A4, -A5 together with the capability for software activation and control of the event timers on L11-A3 and -A4.

3.1.3 Operational Concepts

The MMSE will provide the capability for direct control of payload operational functions from the aft flight deck of the Orbiter vehicle. The MMSE is intended to increase user operational flexibility by providing dedicated switches and indicators applicable to specific mission requirements. The MMSE described herein will be used in conjunction with MFDS equipment (see MFDS CEI Specification) and, within the limits described herein, with flight software (see Flight Software CEI).

Table 3.1-1 Description of MMSE Set

Subpanel Designation	Component Description	Qty
L12-A1	• 2-position momentary toggle switch • 3-position event indicator • 3-position toggle switch	13 10 1
L12-A2	• 12-position rotary switch • 5-character programmable digital display • 2-position momentary toggle switch • 15-character programmable alphanumeric display • 10-character programmable alphanumeric display	2 2 2 2 2
L12-A3	• 2-position locked toggle switch • 3-position event indicator	18 6
L12-A4	• 12-position rotary switch • Horizontal analog meters	1 3
L12-A5	• Potentiometer, single turn, friction • 12-position rotary switch • 2-position momentary toggle switch • 3-position event indicator	5 3 9 9
L11-A3	• event timer • 10-character programmable alphanumeric display • 2-position momentary toggle switch	1 1 3
L11-A4	Same as L11-A3	Same as L11-A3
L11-A5	• manual pointing controller • 12-position rotary switch • 2-position momentary toggle switch • 3-position toggle switch	1 1 2 1
A7-A2	• 2-position locked toggle switch	12

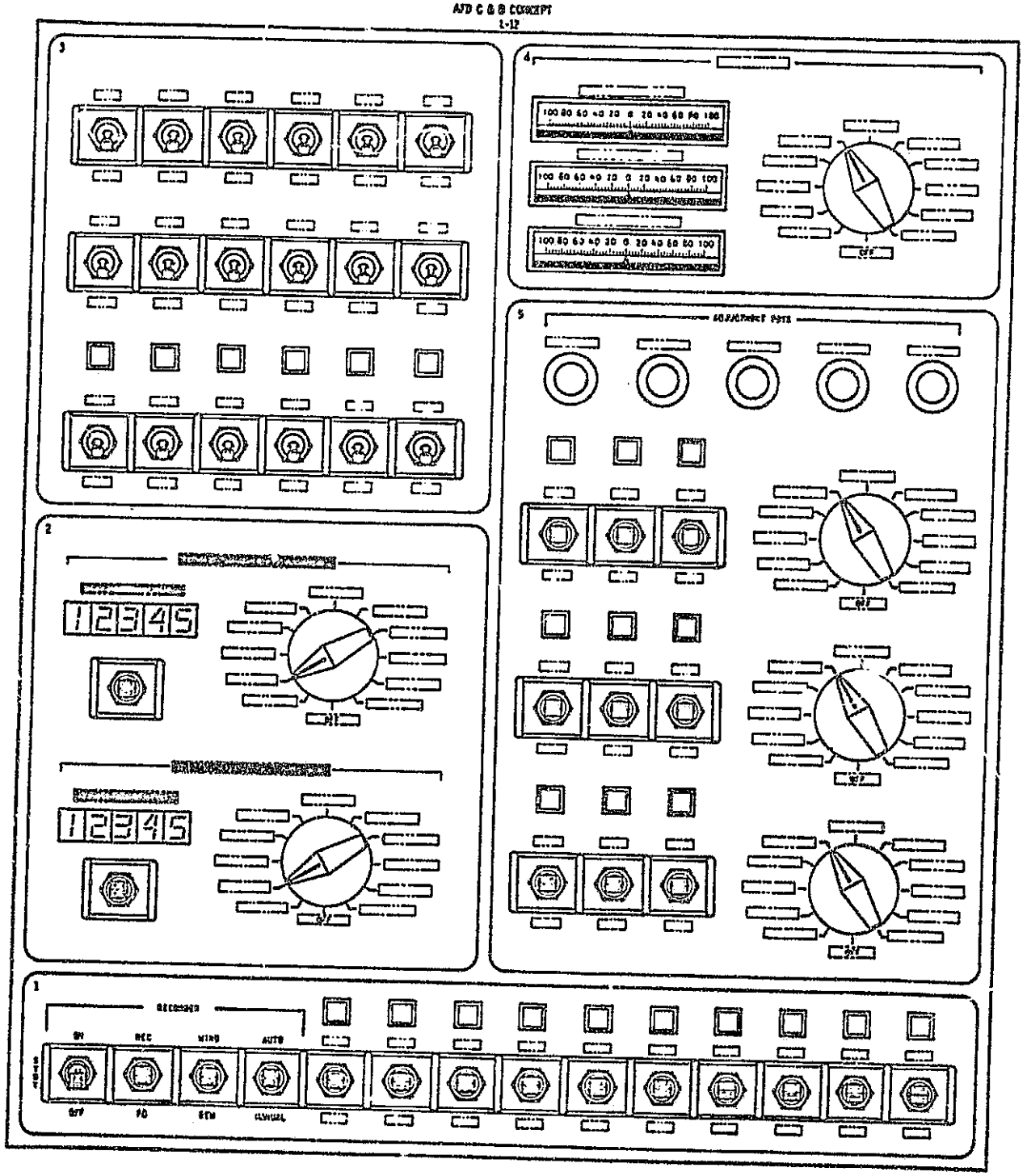

Figure 3.1.1-1 Typical MMSE Layout for Panel L12

3.1.4 Organizational and Management Relationship

MSFC has been designated as the development management center for the Aft Flight Deck core controls and display (C&D) program. The core C&D equipment will be located in the Orbiter AFD,and, therefore, JSC will be required to ensure interface control documentation compatibility.

3.1.5 Systems Engineering Requirements

3.1.5.1 Systems Engineering and Integration

Systems engineering and integration will include performance of the analyses and studies necessary to define requirements for the Aft Flight Deck Payload Core C&D, interfaces, ground support equipment (GSE) and support test equipment (STE), and product assurance. Systems design and integration, operations requirements analyses, GSE and STE requirements, and systems test requirements are all a part of the Aft Flight Deck (AFD) Core C&D engineering and integration (SE&I) task. Also included are interface analyses and definition, PSS specification development and weight management. The objective of the SE&I analysis is to assure an integrated AFD core C&D design that provides a core capability for operating and controlling the many anticipated payloads for the Shuttle Orbiter, at the lowest life cycle cost to the Shuttle Program, compatible with the required level of capability and limitation information to prospective payload developers.

3.1.5.2 Work Breakdown Structure (WBS)

The WBS for the AFD core C&D will be in accordance with MA-06, reference Volume III, Part I.

3.1.6 Government Furnished Property List

Not applicable.

3.1.7 Critical Components

3.1.7.1 Engineering Critical Components List

Not applicable.

3.1.7.2 Logistics Critical Components List

The failure mode and effects analysis (FMEA) will be performed and will be used to prepare the Critical Items List (CIL), which will be used to identify critical spares. This CIL shall include the Single Failure Point Summary and Critical Redundant Items. The corrective action required and/or rationale for retention shall be determined for each critical single failure point.

3.2 Characteristics

3.2.1 Performance

3.2.1.1 Subpanel L12-A1 MMSE

Subpanel L12-A1 shall contain a row of 14 toggle switches. Thirteen of these switches shall be momentary two-position switches and shall conform to the requirements specified in the Shuttle Program procurement specification MC452-0102, sections 3.2 and 3.3, control drawing number ME452-0102-X105. One switch shall be a three position switch conforming to the above specification under control drawing number ME452-0102-X106. Ten event indicators shall also be provided on this subpanel for use in conjunction with ten of the toggle switches, and these indicators shall conform with the requirements specified in MC432-0222, sections 3.1, 3.2 and 3.3, part number MC432-0222-0024.

3.2.1.2 Subpanel L12-A2 MMSE

Subpanel L12-A2 shall contain two 12-position rotary switches; associated with each rotary shall be a 5-character digital display, a 2-position momentary toggle switch, and two programmable alphanumeric displays. The rotary switches shall conform to the requirements specified in MC452-0049, sections 3.2 and 3.3. The applicable specification control drawing number is ME452-0093-1013. Two 5-character programmable digital displays shall be provided and shall conform to the requirements specified by the Phase C/D contractor. One 2-position momentary toggle switch shall be supplied to drive each digital display. These switches shall conform to the requirements specified in MC452-0102, sections 3.2 and 3.3, drawing number ME452-0102-X105. A ten-character programmable alphanumeric display (legend) shall be located above each digital display and a 15-character alphanumeric display shall be located above each rotary switch. These legends shall be provided and shall conform to the requirements specified by the Phase C/D contractor.

3.2.1.3 Subpanel L12-A3 MMSE

Subpanel L12-A3 shall contain 18 locked two-position toggle switches conforming to the requirements specified in MC452-0102, sections 3.2 and 3.3, drawing number ME452-0102-X251. Six 3-position event indicators shall also be provided, and shall conform to the requirements specified in MC432-0222, sections 3.2 and 3.3, part number MC432-0222-0024.

3.2.1.4 Subpanel L12-A4 MMSE

Subpanel L12-A4 shall contain a rotary switch and three analog panel meters. The rotary switch shall be a 12-position switch and shall conform to the requirements specified in MC452-0049, sections 3.2 and 3.3, drawing number ME452-0093-1013. The panel meters shall be designed to be equivalent to Weston Instruments, Inc., model 1879, type 465 LW, modified as necessary to conform to the requirements specified by the Phase C/D contractor.

3.2.1.5 Subpanel L12-A5 MMSE

Subpanel L12-A5 shall contain three 12-position rotary switches; associated with each rotary switch shall be three 2-position momentary toggle switches and three 3-position event indicators. Also, contained on this subpanel shall be five single-turn potentiometers. The rotary switches shall conform to the requirements specified in MC452-0049, sections 3.2 and 3.3, drawing number ME452-0093-1013. The toggle switches shall conform to the requirements specified in MC452-0102, sections 3.2 and 3.3, control drawing number ME452-0102-X105. The event indicators shall conform to the requirements specified in MC432-0222, sections 3.2 and 3.3, part number MC432-0222-0024. The potentiometers shall conform to the requirements specified in MIL-R-94D, control drawing number ME444-0059-1001.

3.2.1.6 Subpanel L11-A3 MMSE

Subpanel L11-A3 shall contain an event timer, a 10-character programmable alphanumeric display, and three 2-position momentary toggle switches for event timer control. The event timer shall conform to the requirements specified in procurement specification MC456-0053, sections 3.2 and 3.3. An alphanumeric display shall be provided and shall conform to the requirements specified by the Phase C/D contractor. The toggle switches shall conform to the requirements specified in MC452-0102, sections 3.2 and 3.3, control drawing number ME452-0102-X105.

3.2.1.7 Subpanel L11-A4 MMSE

The requirements for subpanel L11-A4 are the same as those for subpanel L11-A3 (paragraph 3.2.1.6).

3.2.1.8 Subpanel L11-A5 MMSE

Subpanel L11-A5 shall contain a 12-position rotary switch, a manual pointing controller, two 2-position momentary toggle switches and one 3-position toggle switch. The rotary switch shall conform to the requirements specified in MC452-0049, sections 3.2 and 3.3, control drawing number ME452-0093-1013. The manual pointing controller shall conform to the requirements specified in Bendix Corporation Specification 1941022, part number 1944808-1. The 2-position momentary toggle switches shall conform to the requirements specified in MC452-0102, sections 3.2 and 3.3, drawing number ME452-0102-X105. The 3-position toggle switch shall conform to the requirements specified in MC452-0102, sections 3.2 and 3.3, drawing number ME452-0102-X106.

3.2.1.9 Subpanel A7-A2 MMSE

Subpanel A7-A2 shall contain a row of twelve 2-position locked toggle switches conforming to the requirements specified in MC452-0102, sections 3.2 and 3.3, drawing number ME452-0102-X251.

3.2.2 Physical

Applicable physical requirements for the MMSE set are contained in paragraph 3.2.1.

3.2.3 Reliability

Reliability provisions shall be in accordance with NHB 5300.4 (ID-1).

3.2.3.1 Critical Single Failure Points

As a design goal, the MMSE shall have no single failure that will jeopardize achieving the experiment objectives. In systems where this is not practical, sufficient safety margins should be used to minimize the probability of occurrence.

3.2.3.2 Failure Deterrent and Detection

The design shall incorporate the following:

a. The MMSE shall be designed such that transient out-of-tolerance conditions or component failures will not cause other damage to, or failure of, other components.

b. Threaded parts and fasteners shall be positively locked to prevent loosening during service.

c. Bypass circuits used in checkout or calibration procedures shall not override electrical system protective devices.

d. Solid state switches and amplifiers shall be given preference over electromechanical relays and other vibration-sensitive electrical/electronic parts.

e. Unidirectional components or piece parts shall be designed to preclude backward installation by using nonsymmetry of configuration, different connecting sizes, or comparable means.

3.2.3.3 Reliability Goals

The reliability goal of the MMSE operation shall be TBD.

The probability that no MMSE failures will prevent successful experiment command or display objectives shall be TBD for on-orbit operation.

3.2.4 Maintainability

The MMSE elements subject to maintenance shall be designed, selected and installed to facilitate the performance of such tasks in a reasonable period

of time with minimum hazard to equipment and personnel. Maintainability criteria in accordance with MIL-STD-470 shall be used. The design shall provide for maximum use of standard tools and test equipment.

3.2.4.1 Installation/Removal/Replacement Operations

The installation or removal of the payload dedicated controls and displays panels or consoles shall be accomplished at the launch site upon the return of the Space Shuttle Orbiter. The servicing of the payload dedicated controls and displays panels or consoles shall be consistent within the payload turnaround time constraints as specified by JSC 07700, Vol. XIV and JSC 07700, Vol. I-014-PIV-01.

The design shall provide for ease of removal, replacement, alignment, integration, and test.

3.2.4.2 Scheduled Servicing

The MMSE design shall be such that scheduled maintenance frequencies for critical-limited items are not less than TBD years.

3.2.5 Operational Availability

This preliminary Part I CEI shall be updated as required by the PS Contractor. The PS Contractor shall maintain this document in the final Part I CEI form through the change control system established.

The Part I CEI document shall be submitted at the Preliminary Design Review (PDR) for final approval by MSFC prior to the start of the Development Phase. Review Item Dispositions (RIDs) written against the CEI and approved shall be incorporated into the Part I CEI. After acceptance by MSFC, this document will be Government property, and shall be formally controlled as such in accordance with the requirements of the procuring activity.

3.2.6 Safety

Requirements for the MMSE necessary to preclude hazards to personnel and equipment shall be as specified in the Safety paragraph of JSC 07700, Volume XIV, or contained herein. Hazard definition, classification categories, and hazard reduction precedence shall be as specified in NHB 5300.4 (1D-1), Safety, Reliability, Maintainability and Quality Provisions for the Space Shuttle Program, and NHB 1700.1, NASA Safety Manual.

3.2.6.1 Crash Safety

The MMSE or any part or component of the AFD core C&D shall not endanger the crew as a result of the crash landing conditions specified in the JSC-07700, Volume XIV.

3.2.7 Environment

3.2.7.1 Natural

3.2.7.1.1 Transportation and Storage

The MMSE shall perform as specified herein after exposure in a nonoperating condition to any combination of the environments and ranges specified in JSC-07700, Volume XIV and MJ070-0001-1B.

3.2.7.1.2 Handling

The MMSE shall perform as specified herein after exposure to the environmental ranges specified in JSC-07700, Volume XIV when handled unpackaged.

3.2.7.2 Induced

3.2.7.2.1 Flight Operational

The MMSE shall be capable of meeting the operating performance requirements specified herein during and after exposure to any feasible combination of the following conditions:

a.	Temperature:	Minimum:	Minus 20°F (operational) Plus 35°F (full performance requirements)
		Maximum:	Plus 120°F (full performance requirements)
b.	Pressure:	Minimum:	12.36 psia, continuous; 8 psia for 2 hours
		Maximum:	18.0 psia
c.	Humidity:	Minimum:	8 percent relative
		Maximum:	100 percent relative

d. Salt Fog: Exposure to 1-percent salt solution by weight

e. Lightning: In accordance with JSC-07636 for indirect effects

f. Random Vibration:

1) Qualification - Acceptance Vibration Test (AVT)

Acceleration Spectral Density

20 to 80 Hz	Increasing, at plus 3 dB/octave, to 0.067 g^2/Hz at 80 Hz
80 to 350 Hz	Constant at 0.067 g^2/Hz
350 to 2000 Hz	Decreasing, at 3 dB/octave, from 0.067 g^2/Hz at 350 Hz to 2000 Hz
Duration:	Five times AVT per axis

2) Flight

Acceleration Spectral Density

20 to 150 Hz	Increasing at plus 6 dB/octave, to 0.09 g^2/Hz at 150 Hz
150 to 900 Hz	Constant at 0.09 g^2/Hz
900 to 2000 Hz	Decreasing, at minus 9 dB/octave, from 0.09 g^2/Hz at 900 Hz
Duration:	48 minutes per axis

g. Acceleration: Plus and minus 5 g's in all major axes

h. Shock

1) Landing: Rectangular pulses of the following peak accelerations, time durations, and number of applications in the vertical (up) direction during landing:

Acceleration (g peak)	Duration (ms)	Application
0.23	170	22
0.28	280	37
0.35	330	32
0.43	360	20

Acceleration (g peak)	Duration (ms)	Application
0.56	350	9
0.72	320	4
1.50	260	1

2) Transient: 5 to 35 Hz; plus and minus 0.25 g peak.

(Transient shock may be simulated by vibration one sweep from 5 to 35 Hz at one octave per minute.)

3.2.7.2.2 Nonoperational

The MMSE shall be capable of meeting the operating performance requirement specified herein after exposure to the following conditions:

a. Temperature: Minimum: Minus 65°F
Maximum: Plus 120°F with extremes of 150°F for 6 hours per day

b. Pressure: Minimum: 3.28 psia
Maximum: 18.0 psia

c. Shock:

1) Bench Handling: As specified in MIL-STD-810, Method 516.1, Procedure V.

2) Basic Design: 20-g terminal sawtooth shock pulse of 11-ms duration in each of three orthognal axes (both directions).

3) Crash Safety: 40-g terminal sawtooth shock pulse of 11-ms duration in each of three orthognal axes (both directions). Equipment and its mounting attachments shall not break loose, create a hazard to personnel, or prevent egress from crashed vehicle. Operating performance is not required after this test.

d. Ozone: 3 to 6 parts per hundred million (phm). Total oxidant concentrations may reach 60 phm for 1 to 3 hours in any 24-hour period.

e. Fungus: As specified in MIL-STD-810.

3.2.8 Transportability/Transportation

The MMSE shall be shipped in a GSE container specifically designed to protect the hardware during highway and air transportation. Vibration, shock, pressure, temperature, humidity and contamination shall be controlled to levels specified below. Provisions shall be made in the MMSE structure for suitable tie-down, lift and attachment points. All handling and transportation equipment shall be compatible with applicable structural and environmental limits. The MMSE shall be designed to be transported in either the horizontal or vertical position.

3.2.9 Storage

The MMSE shall have a storage life of ten years. Control shall be maintained on all parts and materials which are sensitive to age or the storage environments specified in paragraphs 3.2.7.1.1 and 3.2.7.1.2. These parts and materials shall be identified, and if deterioration is a factor during storage or after installation for use, the maintenance procedures shall indicate a replacement cycle or the necessary retesting.

3.2.10 Operability

3.2.10.1 Operating Life

The MMSE shall be capable of performing all operations specified herein for a minimum of 2500 cycles and 18,000 hours.

3.2.10.2 Useful Life

The MMSE shall have a minimum useful life of 3500 cycles and 24,000 hours which is equivalent to 100 orbital missions in a 10-year period from date of delivery. The average orbital mission will be seven days; however, the design shall not preclude the capability to extend the orbital staytime up to 30 days.

3.2.10.3 Shelf Life

The MMSE shall be capable of operating in accordance with the requirements specified herein for a time period of 10 years from date of delivery.

3.3 Design and Construction Standards

3.3.1 Selection of Specifications and Standards

Specifications and standards necessary for the design and development of hardware, in addition to those specified in this document shall be selected in the following order of preference except as otherwise specified:

a) NASA specifications and standards.

b) Federal specifications and standards.

c) Military specifications and standards (MIL, JAN, or MS).

d) Other Governmental specifications and standards.

e) Specification and standards released by nationally recognized associations, committees, and technical societies.

f) Supplier specifications and standards.

Specifications and standards shall be selected using MIL-STD-143 as a guide.

3.3.2 General

3.3.2.1 Materials, Parts and Processes

Materials, Parts, and Processes shall be in accordance with MSFC-STD-506. The contractor shall prepare and provide a materials selection and verification plan defining a proposed method for coordinating and officially documenting and approving all engineering drawings for flight hardware before design concepts are finalized. Approval of engineering drawings and all changes shall include sign-off by the materials and engineering discipline for each materials application utilized.

3.3.2.2 Flammability Requirements

Materials used in the design of the MMSE or contained in equipment installed therein, shall be compatible with the flammability requirements specified in NHB 8060.1A. SE-004-002-2H shall be used as a guideline to identify flammability hazards in air.

3.3.2.3 Outgassing of Materials

3.3.2.3.1 Internal Materials

All materials used within the MMSE shall meet the requirements of MSFC-DWG-10M90221 and MSFC-DWG-40M51264.

3.3.2.3.2 External Materials

High vapor pressure materials on the exterior surfaces of the MMSE in line-of-sight with optically critical surfaces shall conform to the material requirements of MSFC-DWG-50M02442. Materials not conforming to this requirement shall be submitted to MSFC for approval.

3.3.2.4 Lubrication

The lubrication for all moving parts exposed to the vacuum of space shall be selected in accordance with MSFC-STD-509.

3.3.2.5 Soldering

Soldering of all electrical connections in the MMSE shall comply with NHB 5300.4(3A). Solder connections shall meet the requirements of RA064-001-1A, Sections 4 through 15 for inspection purposes, except that references to NASA Quality Publication NPC200-4; MSC Supplement to NPC200-4, MSC-ASPO-S-6A; and MSC-ASPO-S-5C, MSC-ASPO Soldering Specification shall be deleted and replaced by NHB 5300.4(3A). Any requirement of RA064-001-1A that is inconsistent with the provisions of NHB 5300.4(3A) is superseded by NHB 5300.4(3A).

3.3.2.6 Restriction of Use of Mercury

Mercury in liquid or vapor form shall not be used in the MMSE. Where no satisfactory substitute exists or an alternate design or method cannot be used, the justification for the use of mercury, the protection provided to prevent its release, and a plan for decontamination in the event of its release shall be submitted to NASA/MSFC for approval.

3.3.3 Aeronautical

Not applicable.

3.3.4 Civil

Not applicable.

3.3.5 Electrical

3.3.5.1 Electrical Wiring

a. The wiring installation shall consist of cable harnesses where required. All wire bundles, harnesses and cables external to the component or vehicle shall conform to MSFC-DWG-40M39582. Wire used in cable harnesses shall conform to Specification MIL-C-17.

b. When etching of wire insulation is required in the MMSE to provide satisfactory bonding to potting materials, the open end of the wire shall not be exposed to the etchant. The preferred process is to form thb wire into a "U" shape, immerse only the bent portion in the etchant, and hold the open ends above the etchant level. The unetched end of the wire shall not be cut off prior to neutralization of the etchant. Electrical wire or cable insulated or coated with polyetrafluoroethylene or fluorinated ethylene propylene shall be etched prior to potting to assure mechanical bond strength and environmental seal. Potting shall be accomplished within three weeks after etching.

3.3.5.2 Electrical Connector Keying

All electrical plugs and receptacles used in the AFD core C&D panels shall be keyed or otherwise configured to prevent incorrect connection with other accessible plugs or receptacles.

3.3.5.3 Electrical Connector Pin Assignment and Pin or Socket Selection

a. Electrical circuits for the AFD core C&D panels shall not be routed through adjacent pins of an electrical connector if a short circuit between them would constitute a single point failure as defined in paragraph

b. Cable connections of the AFD core C&D panels shall be designed so that pin and socket connectors are properly used to prevent power from shorting to ground. They also shall be designed to protect personnel both when connected and disconnected through the use of dead facing, explosion-proof connectors, or similar means.

3.3.5.4 Protection of Electrical and Electronic Devices

Electrical and electronic devices used in the MMSE 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.

3.3.5.5 Electrical and Electronic Piece-Parts, Closure Construction

Electrical and electronic piece-parts with all welded closure construction shall be used in preference to piece-parts with other types of closure construction. Other types of construction may be used if adequate program controls are imposed to assure that internal contamination cannot cause part degradation and failure under zero gravity environment.

3.3.5.6 Electrical Grounding

a. Primary DC Power Grounding - The MMSE negative buses shall be referenced to structure at one point. The conductor from the main power return point to the single-point ground shall be designed to carry the maximum fault current. The single point ground shall be capable of being connected to the Shuttle.

b. Component Grounding - The primary DC power shall be isolated from all component structure. The component case ground shall be per MIL-B-5087B.

3.3.5.7 Electromagnetic Interference

3.3.5.7.1 Electromagnetic Compatibility (EMC)

The MMSE shall be designed for electromagnetic self-compatibility and for electromagnetic compatibility (EMC) for all phases of the mission, and for EMC with the Orbiter AFD during on-orbit operations. The electrical and electronic equipment shall not be a source of, nor be susceptible to, electromagnetic interference as defined by MIL-STD-461A and 462.

3.3.5.7.2 Corona Suppression

Electrical and electronic subsystems and components shall be designed so that their proper performance will not be impaired by corona discharge in normal operating environments and shall not be a source of interference which adversely affects the operation of other equipment.

3.3.5.7.3 Lightning Protection

Electrical and electronic components shall be adequately protected from high currents induced by the lightning occurring at the launch site. The case ground shall be accomplished with the case connected to the structure through low-impedance conductive mounting surfaces. Where shock mounts or thermal isolation prevent this, then wide, flat, short bonding jumpers may be used in accordance with the bonding specification MIL-B-5087.

3.3.6 Mechanical

3.3.6.1 Design Safety Factors

The design safety factors shall have an ultimate safety factor of 3.0 and a yield safety factor of 2.0.

3.3.6.2 Fasteners

Threaded fasteners used for securing a single component, wherever possible, shall be the same type, size and tensile strength. Use of blind fasteners shall be minimized. Threaded fasteners shall be torqued per MSFC-STD-486.

3.3.6.2.1 Accessibility of Fasteners

Assembly and subassembly installations shall be designed such that access to threaded fasteners may be accomplished with the use of conventional tools.

3.3.6.2.2 Screw Threads

Screw threads for threaded fasteners used on Shuttle system hardware (except for GSE) shall be of unified thread form, Class 2, in accordance with MIL-S-7742 or MIL-S-8879, as applicable:

a. Material tensile ultimate strength levels up to, but not including, 160 KSI may be threaded per MIL-S-7742 or MIL-S-8879. Rolled threads are preferred.

b. Material strength levels of 160 KSI and above shall be threaded per MIL-S-8879. External threads shall be rolled after heat treatment. Screw threads used on airborne fluid systems fittings shall be of unified thread form, Class 2, in accordance with MIL-S-7742 or MIL-S-8879.

3.3.7 Nuclear

Not applicable.

3.3.8 Moisture, Humidity, and Fungus Resistance

Except as otherwise required by detail design considerations, only materials which resist the corrosive action of salt air and damage from moisture/humidity and fungus shall be used which conforms to MIL-STD-810.

3.3.9 Corrosion of Metal Parts

Metal parts shall be protected from corrosion by stress-relieving, plating, anodizing, chemical coatings, organic finishes, or combination thereof, provided that such protection is compatible with the operating and space environmental requirements.

3.3.9.1 Dissimilar Metals

Dissimilar metals, as defined in MIL-STD-889, shall not be used in combination unless they are suitably coated to prevent electrolytic corrosion.

3.3.9.2 Finish

The MMSE finish shall be in accordance with MSFC-SPEC-250, except for special thermal finishes.

3.3.10 Contamination Control

The MMSE cleanliness requirement is 100K clean class per FED-STD-209.

3.3.11 Coordinate System

Not applicable.

3.3.12 Interchangeability and Replaceability

The MMSE shall be designed for ease of manufacture, assembly, inspection and maintenance. Insofar as practicable, the MMSE subpanels shall be interchangeable and/or replaceable in accordance with MIL-STD-189. The MMSE subpanels will be designed for installation in both the Orbiter AFD or the Spacelab pressurized module.

3.3.13 Identification and Marking

3.3.13.1 Identification of Parts

Each part fabricated shall be identified with a part number. The same specification or part number shall be used to identify all like materials, processes, and parts. Seller shall assign a new part number to the part when authorized changes make the superseded part not interchangeable with respect to interface, reliability, safety, logistics, traceability or performance. For traceable items, the part identification shall additionally include the manufacturer's identification code in accordance with DOD Handbook H 4-1, and be lot numbered or serial numbered when required.

3.3.13.2 Supplier Part Number

The supplier part number, which is equivalent to the MMSE procurement part number, shall be in accordance with MIL-STD-130.

3.3.13.3 Identification of All Development/Qualification Test Specimens

Test specimens shall be permanently and obviously identified prior to testing with the words "ENG. TEST ONLY" in addition to the identification required by the drawing/specification to preclude their use on production items. The letters shall be indelible and provide a distinctive and vivid contrast with the color of the specimen. The lettering size and identification location shall be clearly visible to casual observation. Materials used for the identification shall be compatible with the test specimen and its operating environment. When the size or configuration of the test specimen is such the identification cannot appear on the specimen, other suitable means such as attached metal tags shall be used.

3.3.13.4 Nameplates

Nameplates shall be marked in accordance with MIL-STD-130 and shall include item name; buyer's part number; Federal North Atlantic Treaty Organization Stock Number (FSN/NATO); manufacturer; buyer; manufacturer's serial number, part number. Abbreviations, in accordance with MIL-STD-12, may be used.

3.3.13.5 Identification of Wiring

Identification of wiring shall not degrade insulation or shielding.

3.3.13.6 Electrical and Electronic Reference Designations

Electrical and electronic reference designations shall be affixed to the hardware in accordance with the USAS Y32.16-1968 (for external electrical connectors).

3.3.13.7 Electrical and Electronic Symbols

If schematic information is affixed to the MMSE, the electrical and electronic symbols shall be in accordance with the requirements of USAS Y32.2-1967.

3.3.13.8 Reidentification

The part number of the MMSE, its components, and parts shall be changed whenever redesign results in a change to dimensional form, fit tolerance, or functional characteristics from the previous configuration.

3.3.14 Workmanship

Workmanship on the MMSE shall be in accordance with the best practice for high quality equipment within the state of the art.

3.3.15 Human Performance/Human Engineering

The design shall consider the capabilities and limitations of the human operator wherever a man-machine interface exists, including torques, forces, and other functional design characteristics of controls, displays, and work stations. The principal design guide for the man-machine interface shall be MIL-STD-1472 and MSFC-STD-512.

3.4 Logistics

3.4.1 Maintenance

a. The MMSE shall not require scheduled maintenance.

b. The MMSE shall not be designed to preclude the use of special tools and equipment for site maintenance and repairs. Special tools, if required, and approved by the buyer, shall be designed to withstand the intended use throughout the life of the equipment.

c. The MMSE shall be designed to satisfy the requirements of a Line Replaceable Unit (LRU).

d. The MMSE shall be designed so that routine corrective maintenance can be accomplished by the replacement of Shop Replaceable Units (SRUs). The design shall be such that isolation to a single malfunctioning SRU can be accomplished during bench maintenance utilizing the LRU interface connectors or the addition of a system GSE test connector is permissible to provide this isolation capability.

e. The necessity for any maintenance servicing or checkout tasks, other than built-in test capability, to be accomplished during flight is prohibited.

3.4.1.1 Installation

a. The equipment design shall physically prevent the incorrect installation of modules and submodules. Clearly visible color coding and labeling in close proximity to maintenance disconnect points shall be used to facilitate removal and replacement of any subassembly level of equipment.

b. Components shall be mounted in a manner to avoid blind adjustments.

c. Threaded fasteners used for securing a single component, where practical, shall be the same type, size, and tensile strength.

d. Captive fasteners shall be utilized to fasten LRUs.

3.4.1.2 Accessibility

a. Electrical connectors shall be accessible without disassembly or removal of functional equipment or components.

b. Servicing and test points shall be clearly marked and shall be accessible without requiring removal of access plates or covers except service caps. Calibration controls shall be accessible and clearly marked for major functions.

c. All fasteners on a single access cover shall be of the same length, diameter, and type.

3.4.1.3 Replacement

a. Mounting provisions shall permit SRU removal and replacement without disconnecting any equivalent level SRU in the line replaceable unit. If removal of a LRU structural element is required for access, such removal shall not affect electrical or mechanical alignment, nor shall the mechanical strength of the unit be impaired to the point that bending of the unit, its assemblies, electrical harnesses, or plumbing attachments will occur during normal bench handling of the unit.

b. Attachment fittings for components routinely removed shall be operable without hand tools and shall be accessible without requiring removal of access panels or covers.

3.4.2 Supply

The components, subassembly and assembly panels which make up the AFD core C&D design shall be recorded on delivery and tracked to assure that these

components, subassemblies, and assemblies are available in stock and ready for use by each subsequent activity phase that may impact or influence the design.

The following information records shall be maintained for each of the items:

a. Part numbers

b. Name of parts

c. Quantity required and available

d. Required delivery sites

e. Planned use sites

The above records will provide the required information to assure availability of items, and provide sufficient time to resupply components if it may appear that a shortage could occur prior to the next operation.

3.4.3 Facilities and Facility Equipment

Procured parts and mateirals will be received, inspected and stored in existing facilities. These same facilities will provide a bonded area which will store the qualified and acceptance tested parts or assemblies prior to delivery.

No new or unique facilities will be required for the logistic requirements.

3.5 Personnel and Training

Standard aerospace management, engineering, manufacturing, product assurance, and test practices as applied to prior space programs as Gemini, Apollo, Skylab, etc. will be utilized for the PS contractor's design/development phase.

This approach will enable these space program practices to be applied to the PS contractor's activities and, thereby, no new requirements will be needed for personnel training, training equipment and facilities.

MSFC or its designated Government quality representative will verify the adequacy of the discipline practices utilized.

3.6 Interface Requirements

3.6.1 Interprogram Interfaces

Interfaces between the AFD core C & D program, of which this specification is a part, and other programs (e.g., Orbiter, Spacelab, IUS) will be controlled by ICDs to be supplied by the Phase C/D contractor. These will include mechanical, electrical and software interface definition.

3.6.2 Intraprogram Interfaces

The relationship between this CEI and the other CEIs within the AFD core C&D program is shown in Figure 3.6.2-1. Each CEI (project level) defines the specific interface requirements applicable to the individual project.

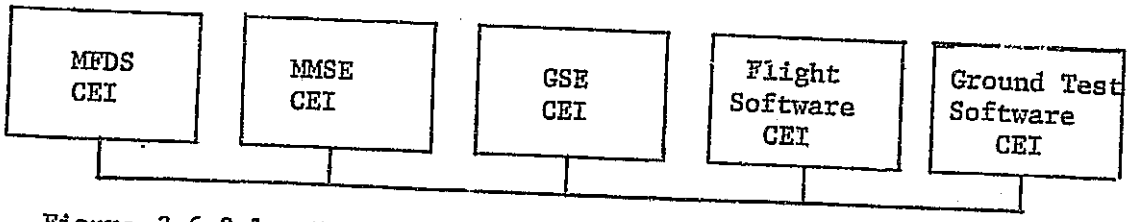

Figure 3.6.2-1 Intraprogram CEIs

3.6.3 Intraproject Interfaces

The following paragraphs are supplied, as information only, to describe the functional interfaces required to ensure proper utilization of the MMSE.

3.6.3.1 Subpanel L12-A1 Functional Interfaces

The MMSE at subpanel L12-A1 will interface with control electronics such that momentary switch closure precipitates a discrete condition which is maintained until the opposite switch command is completed.

3.6.3.2 Subpanel L12-A2 Functional Interfaces

The MMSE at subpanel L12-A2 will interface with core C&D software control (see core C&D Flight Software CEI) such that the selection of a particular position on the rotary switch will cause a preprogrammed legend to appear on the associated 10 and 15-character alphanumeric displays and the proper digital information to appear on the 5-character digital display. Interfacing electronics will supply the proper inputs to the individual displays. The toggle switch associated with each digital display will be utilized as a control over the specific parameter in question; that is, the data bus interface will allow the digital display to be changed via the toggle switch. The command signal from the switch to the display (via interfacing electronics) will be maintained as long as the switch position is maintained.

3.6.3.3 Subpanel L12-A3 Functional Interfaces

The MMSE at subpanel L12-A3 will have direct hardwire interfaces. Each toggle switch is lockable in either of two positions. The event indicators receive discrete commands via the hardwire interface.

3.6.3.4 Subpanel L12-A4 Functional Interfaces

The MMSE at subpanel L12-A4 will be under core C&D software control such that selection of a specific position on the rotary switch determines the parameters to be displayed on the three analog meters. Interfacing electronics will supply the proper analog inputs to the meters.

3.6.3.5 Subpanel L12-A5 Functional Interfaces

The potentiometers on subpanel L12-A5 incorporate a direct hardwire interface. The remaining MMSE at this subpanel will be under core C&D software control. The parameters to be controlled by the toggle switches are determined by the specific position on the associated rotary switch (via core C&D software). Control electronics will be provided such that momentary switch closure precipitates a discrete condition which is maintained until the opposite switch command is completed. The event indicator associated with each toggle switch receives discrete signals under core C&D software control.

3.6.3.6 Subpanel L11-A3 Functional Interfaces

The MMSE at subpanel L11-A3 will interface with core C&D software control such that the 10-character alphanumeric legend will display characters commanded by software as decoded by interfacing electronics. The toggle switches will drive the event timer via interfacing control electronics; switch position must be manually maintained to maintain the control signal. Interfacing electronics will also allow the event timer to be updated and commanded (start/stop) via software control.

3.6.3.7 Subpanel L11-A4 Functional Interfaces

Functional interfaces for the MMSE at subpanel L11-A4 are the same as those for subpanel L11-A3.

3.6.3.8 Subpanel L11-A5 Functional Interfaces

The MMSE at subpanel L11-A5 will interface with core C&D software control such that the manual pointing controller (MPC) and the associated toggle switches interface with the applicable pointing system via the proper position of the rotary switch. One of the toggle switches interfaces with control electronics such that momentary switch closure precipitates a discrete condition which is maintained until the opposite switch command is completed. The second 2-position switch produces a command signal via the interface electronics as long as the switch position is maintained. The third toggle switch produces a

continuous command signal in each of its three-positions. The MPC position produces command signals to interfacing electronics for software interpretation.

3.6.3.9 Subpanel A7-A2 Functional Interfaces

The MMSE at subpanel A7-A2 will incorporate a direct hardwire interface. Each toggle switch shall be lockable in either of two positions.

4.0 VERIFICATION

The verification program is designed to verify that the MMSE hardware conforms to the design, construction, and performance requirements as specified in Section 3 herein. Each requirement presented in Section 3 will be verified by test or assessment as specified in Section 4.

4.1 General

The following subparagraphs specify the organizational responsibility for accomplishing verification, verification methods to be used, requirements for test/equipment failures, and requirements for phased verification.

4.1.1 Responsibility for Verification

Organizational responsibilities for performing and supporting verification during the various verification phases of Paragraph 4.2 shall be as defined herein. Responsibilities are defined as primary and supportive. It shall be the Government's right to witness and verify the results of all verification accomplished.

Verification Phase	*Organizational Responsibility for Verification. Primary	Supportive or Witness
1. Development	PS Contractor	MSFC
2. Qualification	PS Contractor	MSFC
3. Acceptance	PS Contractor	MSFC

*Legend

MSFC NASA-MSFC

4.1.2 Verification Method Selection

Verification methods shall include test during each verification phase as applicable, or assessment by similarity, analysis, inspection, demonstration, and validation or records. These methods are defined in paragraph 4.3.1.

4.1.2.1 Design Margin Verification Selection

Where integrity is verified by analysis only, the following factors of safety shall be used:

Yield Factor of Safety - 2.0
Ultimate Factor of Safety - 3.0

4.1.3 Flight Hardware Failures

Failures of MMSE hardware occurring during qualification, acceptance and integrated system testing shall require a complete analysis of each failure and corrective action documented by a non-conformance report. The PS contractor shall secure agreement from the designated NASA representative concerning adequacy of the corrective action before these tests can be resumed after the occurrence of each failure. Retest or assessment shall be performed to establish the adequacy or corrective action and restore validity of previous testing. The PS contractor shall report immediately to MSFC any unusual phenomenon, occurrence, difficulty, or questionable condition occurring in the conduct of the test.

4.1.4 Test/Equipment Failures

Test policy for the MMSE shall include tests which demonstrate a completely checked out end item within specification performance of all systems for flight readiness. To this end, the test program shall encompass: all component and system malfunctions corrected or satisfactorily explained and accepted to certify flight readiness, and appropriate reverification required following equipment replacement because of failure or other reasons.

Retest shall be performed after failure or equipment replacement to the extent necessary to restore confidence in the equipment. The retest requirements shall be specified at time of failure or replacement and shall be a part of the controlling documentation. Reverification may be deferred to the next scheduled functional test of the affected hardware. Reverification must be accomplished prior to launch for flight equipment.

4.2 Phased Verification Requirements

Phased verification of the Section 3 requirements shall be as specified in the Paragraph 4.3 Verification Cross Reference Index. Definitions of the verification phases follow in Paragraph 4.2.1 through 4.2.8.

4.2.1 Development

Development verification is the process for verifying the feasibility of the design approach and to provide confidence in the ability of the hardware to pass qualification. Where visibility and control of vendor hardware development is required, appropriate direction shall be included in the applicable procurement drawings/specifications.

4.2.2 Qualification

The MMSE including all components shall be qualified prior to launch. Where visibility and control of vendor hardware is required, appropriate direction shall be included in the applicable procurement drawings/specifications.

Test types, durations and levels shall be specified. Qualification shall be accomplished by any one or more of the following:

a. Test - Qualification Testing.

b. Assessment - (1) Similarity; (2) Analysis; (3) Inspection; (4) Demonstration; (5) Validation of Records.

Qualification testing methods are defined in the following paragraphs. Assessment methods definitions are presented in Paragraph 4.3.1.

4.2.2.1 Qualification Testing

Qualification testing is an individual or series of performance/functional and environmental tests conducted on flight hardware at environmental test conditions normally more severe than acceptance test conditions to establish that the hardware will perform satisfactorily in the use environments with sufficient margin.

4.2.3 Acceptance

The MMSE including all components, shall be acceptance tested prior to launch. Where visibility and control of vendor hardware is required, appropriate direction shall be included in the applicable drawings/specifications. Test types, durations and levels shall be specified. Acceptance testing shall be applicable to component through MMSE hardware levels.

4.2.3.1 Component Acceptance Testing

Component acceptance tests consist of performance/functional and acceptance level environmental tests to assure compliance with required specifications. This testing is conducted to detect manufacturing flaws and workmanship defects that cannot be detected by normal inspection techniques as well as verify functional conformance to design specifications including environmental exposures.

4.2.3.2 Subsystem/Systems Acceptance Tests

These tests shall be performed as appropriate following component acceptance tests to demonstrate compliance to specifications. Subsystem and system verification in various operating modes and interfaces at normal flight supply voltages will be considered.

4.2.3.3 MMSE Acceptance Testing

The MMSE shall be acceptance tested as an end item prior to its delivery to the next higher level of hardware assembly. Testing includes system to system interface checks, operation of individual MMSE systems,

combined systems functional and mission sequence simulation tests. Test types, durations and levels shall be specified.

4.2.4 Integrated Systems

This phase consists of the testing performed after the mating of the MMSE with the Orbiter or Spacelab subsystems, and will be the responsibility of the Mission Contractor. The PS Contractor shall support the Mission Contractor.

4.2.5 Prelaunch Checkout

This phase of testing will be the responsibility of the Mission Contractor, and the PS Contractor shall support the Mission Contractor.

4.2.6 Launch

This phase of testing will be the responsibility of the Mission Contractor, and the PS Contractor shall support the Mission Contractor.

4.2.7 Flight/Mission Operations

This phase of testing will be the responsibility of the Mission Contractor.

4.2.8 Post-Flight

This phase of testing will be the responsibility of the Mission Contractor.

4.3 Verification Cross-Reference Index

The verification cross-reference index provides a one-for-one cross reference of each verification requirement for each Section 3 requirement. Verification shall be by test or assessment. Test types and phases were described in Paragraph 4.2. Assessment methods are described below.

4.3.1 Assessment Methods

Assessment methods include: (a) similarity; (b) analysis; (c) inspection; (d) validation of records; and (e) demonstration. A brief definition of the methods as used herein follows:

a. Similarity - Qualification by similarity shall be considered if it can be demonstrated, by review of prior test data or application of hardware (flight or usage experience), that the article is similar or identical in design and manufacturing process to another article that has previously been qualified to equivalent or more stringent environmental criteria (e.g., Skylab, Apollo and/or Gemini hardware).

b. Analysis - Analysis may be used for verification in lieu of, or in addition to testing to verify compliance to specification requirements. The selected techniques may include, typically, systems engineering analysis, statistics, qualitative analysis, analog, modeling, and computer simulations. Analysis may be considered when it can be determined that:

1) Rigorous and accurate analysis is possible.
2) Test is not cost-effective.
3) Similarity is not applicable.
4) Verification by inspection is not adequate.

c. Inspection (End-Item) - Inspection techniques (e.g., verification of compliance with drawings, wire coding, material compliance, etc) may be used in lieu of or in conjunction with testing to verify design features (e.g., dimensions, bonding, assembly methods, etc).

d. Validation of Records - Manufacturing records may be used at end-item acceptance to verify latent construction features and processes for flight hardware and associated support equipment.

e. Demonstration - Demonstration techniques (e.g., service access, tranportability, crew-hardware interfaces, replacement provisions, etc) may be used in lieu of or in conjunction with test to verify compliance with the requirements.

4.3.2 MMSE Verification Requirements Matrix

Verification requirements for Section 3 paragraphs are identified in Table 4.1. The left-hand column of the matrix identifies each Section 3 requirement by paragraph number and where required, by sentence number of the paragraph. The verification method(s) for the various verification phases are presented in the matrix. The right hand column identifies the applicable Verification Plan paragraph number which defines and directs implementation of each verification requirement.

4.4 Test Support Requirements

Test support including test facilities and equipment, bench setups, test software and test interfaces shall be as defined.

4.4.1 Facilities and Equipment

a. Existing facilities/equipment with NASA or other Government agencies and contractors shall be utilized to the maximum extent practicable.

TABLE 4-1 VERIFICATION CROSS-REFERENCE

REQUIREMENTS FOR VERIFICATION

SHEET 1 OF 1

NOMENCLATURE: MMSE	CRIT. CAT:
CEI NO.	CEI SPEC NO.

VERIFICATION METHOD

1. TEST
2. ASSESSMENT
   a. SIMILARITY
   b. ANALYSIS
   c. INSPECTION
   d. DEMONSTRATION
   e. VALIDATION OF RECORDS

N/A = NOT APPLICABLE

VERIFICATION PHASES

A. DEVELOPMENT
B. QUALIFICATION
C. ACCEPTANCE
D. INTEGRATED SYSTEM
E. PRELAUNCH CHECKOUT
F. FLIGHT VERIFICATION
G. LAUNCH
H. POST FLIGHT

PERFORMANCE/DESIGN REQUIREMENT REFERENCE	VERIFICATION METHOD									TEST/ASSESSMENT REQUIREMENT REFERENCE
	N/A	A	B	C	D	E	F	G	H	
3.2.1.1 Subpanel L12-A1 MMSE		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.2 Subpanel L12-A2 MMSE		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.3 Subpanel L12-A3 MMSE		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.4 Subpanel L12-A4 MMSE		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.5 Subpanel L12-A5 MMSE		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.6 Subpanel L11-A3 MMSE		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.7 Subpanel L11-A4 MMSE		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.8 Subpanel L11-A5 MMSE		1	1	1						4.2.1, 4.2.2, 4.2.3
3.2.1.9 Subpanel A7-A2 MMSE		1	1	1						4.2.1, 4.2.2, 4.2.3

b. MMSE test activities including test facilities/equipment, personnel, and procedures shall be established and included in the Verification Plan.

c. Maximum use of the same or common MMSE test equipment shall be used for testing at multiple locations to assure uniformity of test results.

d. All test equipment shall be designed with a fail-safe goal such that test equipment failure will not degrade flight hardware. All test equipment shall be tested prior to interfacing with flight equipment to ensure that no damage or degradation to flight hardware will be induced. Appropriate tolerances shall be identified in the procedures, taking into account test equipment capabilities and flight hardware specifications, such that the test results will verify compliance with the flight hardware specifications.

4.4.2 Articles

Test articles, if required to support the test program, shall be as identified.

4.4.3 Software

Requirements governing software utilization in support of verification operations shall be as identified.

4.4.4 Interfaces

Where verification requires interfacing of the MMSE with other STS Project facilities/equipment, the Mission contractor shall direct and support the test activities in accordance with the applicable contractual agreement(s).

5.0 PREPARATION FOR DELIVERY

Not applicable.

6.0 NOTES

6.1 Definition and Design Terms

AFD core C&D - controls and displays equipment, of which MMSE is a part, to be utilized for payload operations in the Shuttle Orbiter aft flight deck.

Panel/Subpanel - surface area upon which MMSE is arranged; MMSE design includes one full panel (L12) with five subpanels within it (L12-A1, -A2, -A3, -A4, and -A5) and four additional subpanels (L11-A3, L11-A4, and A7-A2).

6.2 List of Acronyms

AFD	Aft Flight Deck
AVT	Acceptance Vibration Test
CDR	Critical Design Review
CEI	Contractor End Item
CIL	Critical Items List
C&D	Controls and Displays
EMC	Electromagnetic Compatibility
FMEA	Failure Modes and Effects Analysis
GSE	Ground Support Equipment
ICD	Interface Control Document
LRU	Line Replaceable Unit
MFDS	Multifunction Display System
MMSE	Multi-use Mission Support Equipment
MPC	Manual Pointing Control
MS	Milliseconds
PDR	Preliminary Design Review
phm	parts per hundred million
PS	Payload Station
RID	Review Item Disposition
SE&I	Systems Engineering and Integration
SRU	Shop Replaceable Unit
STE	Support Test Equipment
WBS	Work Breakdown Structure

Flight Software Specification

Flight Software Specification

COMPUTER PROGRAM DETAIL SPECIFICATION

PART I

PERFORMANCE, DESIGN AND VERIFICATION REQUIREMENTS

FLIGHT SOFTWARE

CEI NO. _____

FOR

AFT FLIGHT DECK CORE

CONTROLS AND DISPLAYS

APPROVED BY _____

CODE IDENTIFICATION _____

DATE _____

APPROVED BY _____
NASA

DATE _____

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TABLE OF CONTENTS (Continued)

FIGURE NO.

1.0 SCOPE

This part of the specification establishes the requirements for performance, design, and verification of a Computer Program (CP) CEI identified as Core Control and Display (CCD) Flight Software for contract end item number TBD. This CP CEI is used to provide top level software requirements. This software is required to realize the full operational capability of the CCD equipment.

2.0 APPLICABLE DOCUMENTS

The following documents, of exact issue shown, form a part of this specification to the extent specified herein. In event of conflict between documents reference here and other detail content of this specification, the detail requirements herein shall be considered superseding. Contractor specifications satisfying the intent of the below-listed documents may be used in lieu of the specifically listed documents after review and approval by MSFC. Reference to these documents contained herein shall be by basic number only.

2.1 Orbiter Interface

SS-P-0002-170	NASA	Computer Program Development Specification Volume I Book 7 System Level Req	6/7/76
SS-P-0002-160	NASA	Computer Program Development Specification Volume I Book 6 System Level Req Payloads	6/10/76

2.2 Spacelab Interface

EQ-MA-0002	MATRA	I/O Unit	5/14/76
EQ-MA-0003	MATRA	RAU Acquisition Unit	5/1/76
EQ-MA-0010	MATRA	Display System	5/15/76
EQ-MA-084	MATRA	Data Bus Interconnecting Station	5/20/76
EQ-MA-0001	MATRA	Data Bus	5/18/76

2.3 Standards

TBD

2.4 Other Publications

JSC	07700	Space Shuttle Systems, Payload Accommodations, Volume XIV, Revision C, Change No. 12.

3.0 REQUIREMENTS

3.1 CPCEI Definition

3.1.1 General Description

This document is limited to the specification of top level software requirements. This software is required to realize the full operational capability of the Aft Flight Deck (AFD) CRT/KB display and the software driven controls and displays.

The software to implement these requirements may be partially or totally located in four different computers/processors depending on the particular mission flown (Spacelab Experiment Computer, Payload Peculiar Computer, Orbiter GPC, and the Display Electronics digital processor). It will be the responsibility of the phase C/D contractor, under WBS 07 01, to perform trade study analyses to determine the best location of this software to best satisfy the top level requirements of this specification, and provide the detailed Computer Program Specification Documents (CPSD). These CPSD will constitute the "code to" specifications for building the software programs.

This top level specification is independent of the equipment type and location of software programs. It represents the results of a software requirements analysis performed on NASA contract NAS8-31789. This analysis determined that the software required to support each payload in the mission model had many common requirements. These common software modules are defined in this specification and are referred to as the Core Control and Display (CCD) systems software. This CCD software will fly on every flight requiring software driven CCD hardware, and can be thought of as an extension of the systems software provided by the main computer (Orbiter, Spacelab or payload provided) interfacing with the CCD.

3.1.2 Missions

The software controlled by this CPCEI is limited to the CCD software. The relationship (mission) between this software module and payload application or systems software is defined in this section.

The application software is mission unique software. The requirements and development of the applications software will be the responsibility of the payloads. This software will interface with and utilize the services provided by the systems software and the CCD software. In addition, the systems software will provide executive structure and control for the payload provided applications software.

The systems software is resident in the main computer (Orbiter GPC, Spacelab Experiment Computer, or Payload provided computer) at all times and flies on every mission. It is that software required to control and communicate with peripheral hardware, schedule application software programs, and to

handle data management of all communication formats. This software will be provided by the supplier of the main computer.

The Core Control and Display (CCD) software is a combination of the display software contained in the CCD electronics unit, and the CCD software located in the main computer. The main computer CCD software is an extension of the systems software. This combination of software is a fixed service and will therefore fly on every mission. The top level requirements for this combination of software are defined in this document and represent the purpose of this CEI.

3.1.3 Operational Concepts

This paragraph is not applicable to a CP CEI detailed specification.

3.1.4 Organizational and Management Relationship

MSFC has been designated as the lead NASA center for the Aft Flight Deck Payload dedicated controls and displays program. The core C&D equipment will be located in the Orbiter AFD, and therefore JSC will be required to ensure ICD compatability.

3.1.5 Systems Engineering Requirements

3.1.5.1 Systems Engineering and Integration

Systems engineering and integration will include performance of the analyses and studies necessary to define requirements for the Aft Flight Deck Payload Core C&D, interfaces, ground support equipment (GSE) and special test equipment (STE), and product assurance. Systems design and integration, operations requirements analyses, GSE and STE requirements, and systems test requirements are all a part of the Aft Flight Deck (AFD) Core C&D engineering and integration (SE&I) task. Also included are interface analyses and definition, PSS specification development and weight management. The objective of the SE&I analysis is to assure an integrated AFD core C&D design that provides a core capability for operating and controlling the many anticipated payloads for the Shuttle Orbiter, at the lowest life cycle cost to the Shuttle Program, compatible with the required level of capability and limitation information to prospective payload developers.

3.1.5.2 Work Breakdown Structure (WBS)

The WBS for the AFD core C&D will be in accordance with MA-06, reference Volume III, Part I.

3.1.6 Government Furnished Property List

This CP CEI will not incorporate any GFP computer programs; however, the core C&D software will include both software resident in the MFDS electronics unit as well as in the Spacelab Experiments Computer.

3.1.7 Critical Components

Not applicable.

3.2 Characteristics

3.2.1 Performance

3.2.1.1 System Requirements

There shall be four peripheral functions serviced by the main computer via three Spacelab type data buses (Figure 3.2-1). Three display and keyboard sets will be serviced on two of the data buses, and the MMSE (panels L-11 and L-12) shall be serviced via a RAU on the remaining experiment data bus. Each keyboard and display shall have the capability of communication with either the subsystem or experiment data bus. All functions on the experiment bus connected to the RAU shall be serviced TBD times per second to assure prompt recognition of commands and timely display of data response.

In addition, the electronics unit driving the Multifunction Display System (MFDS) shall have the capability to interface with the Orbiter data bus (DK-4).

3.2.1.2 Operational Requirements

The operational requirements divide into two basic types. The first type are the display functions and the second type are the MMSE RAU functions. Each of these categories contain several subfunctions which are presented in the following paragraphs.

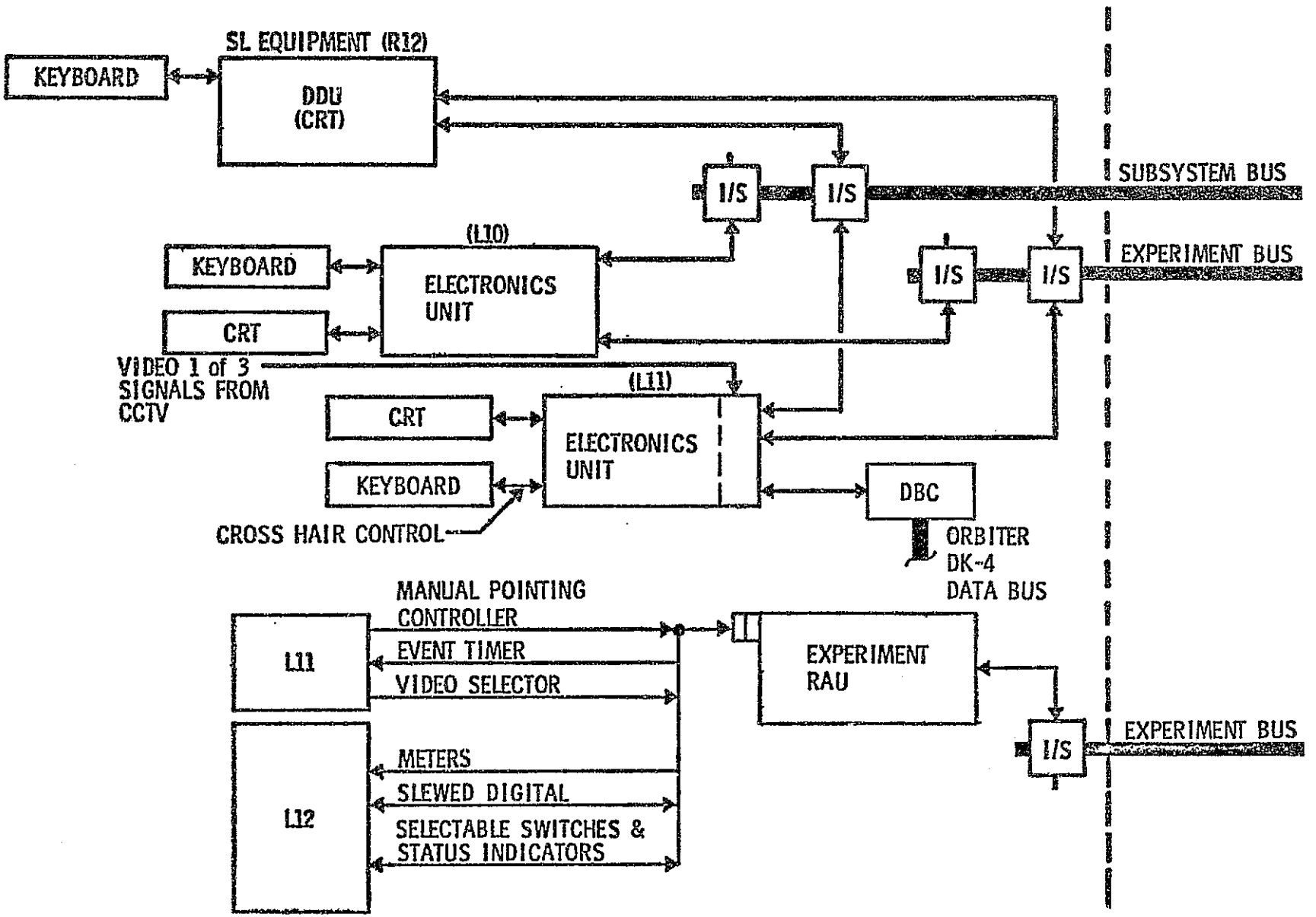

Figure 3.2-1 Software System Interfaces

3.2.1.2.1 RAU - Event Timer

Provide an "Event Timer" (ET) module with functional characteristics shown in Figure 3.2-2 and detailed requirements defined in the following paragraphs. This software module shall interface through a RAU interface with event timer electronics.

3.2.1.2.1.1 Input

The ET module shall be capable of receiving commands either from a keyboard or a data base, via application software. A KB request for event timer setup followed by information specifying KB or data base data control shall call up the event timer software module and specify its subsequent operation. The controlling input data shall be page ID, timer number, start time, up/down control, and data initiate.

3.2.1.2.1.2 Output

The output from the ET module shall consist of start, up, and down controls, combined with a starting time value.

3.2.1.2.1.3 Processing

When data base control is requested the ET shall use the current page ID number to obtain all subsequent inputs from the data base. If KB entry is requested the input data shall be supplied from the mission unique application software via the KB. The ET module shall format the time into four transmissions of 4-bit coded data, one for each time character. Using the input timer number it shall also format the address code for the time character (1 of 8) being addressed. The start input shall specify the address of the variable which the ET module shall monitor to determine when to send the start signal.

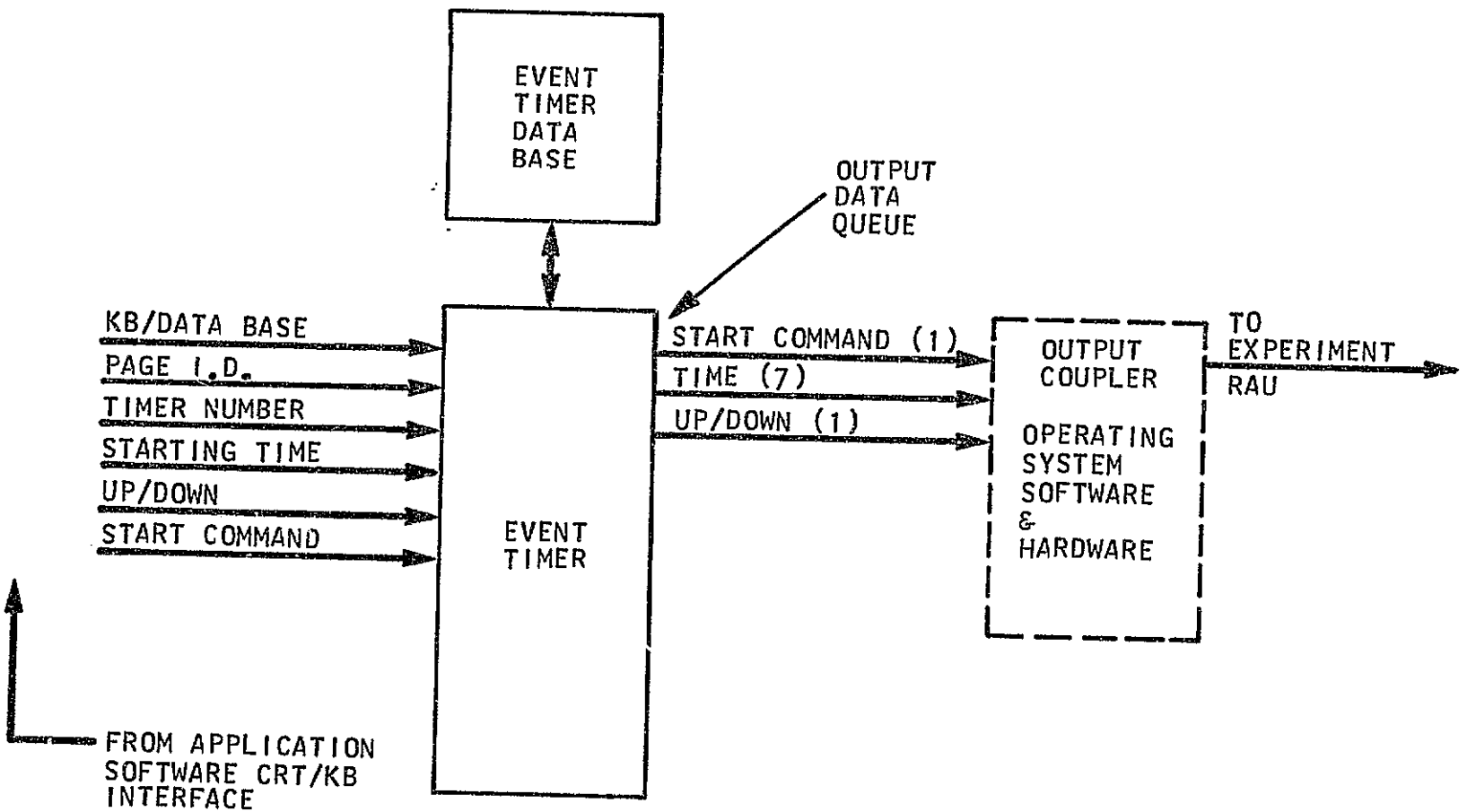

Figure 3.2-2 Event Timer

3.2.1.2.2 RAU - Manual Pointing Control

Provide a "Manual Pointing Control" (MPC) module with functional characteristics shown in Figure 3.2-3 and detailed requirements defined in the following paragraphs. This software module shall interface through a RAU interface with a MPC subpanel.

3.2.1.2.2.1 Input

There are 19 bilevel and four proportional input signals to the MPC software module.

4	Proportional - ± pitch, ± yaw
2	Bilevel - ccw, cw control
3	Bilevel - high, medium, low
12	Bilevel - selector switch
2	Bilevel - on, off

These input variables will be obtained from the RAU interface via the main computer system software input data queue.

3.2.1.2.2.2 Output

The output of the MPC module shall consist of 36 pointing variables representing pitch, yaw and roll control for up to 12 different pointing systems. The 36 variables shall interface with mission unique application software.

3.2.1.2.2.3 Processing

The MPC software module shall determine if pointing control is required by monitoring the on/off input. If off is commanded all output variables shall be set to zero. If on is commanded the following processing will be performed. First the selector switch shall be examined to determine which data base and output variables are currently active. Second the pitch, yaw and roll rate shall be determined by multiplying the rate inputs by a scale factor obtained from the data base. Finally, the three scaled outputs shall be placed in the selected output data queue.

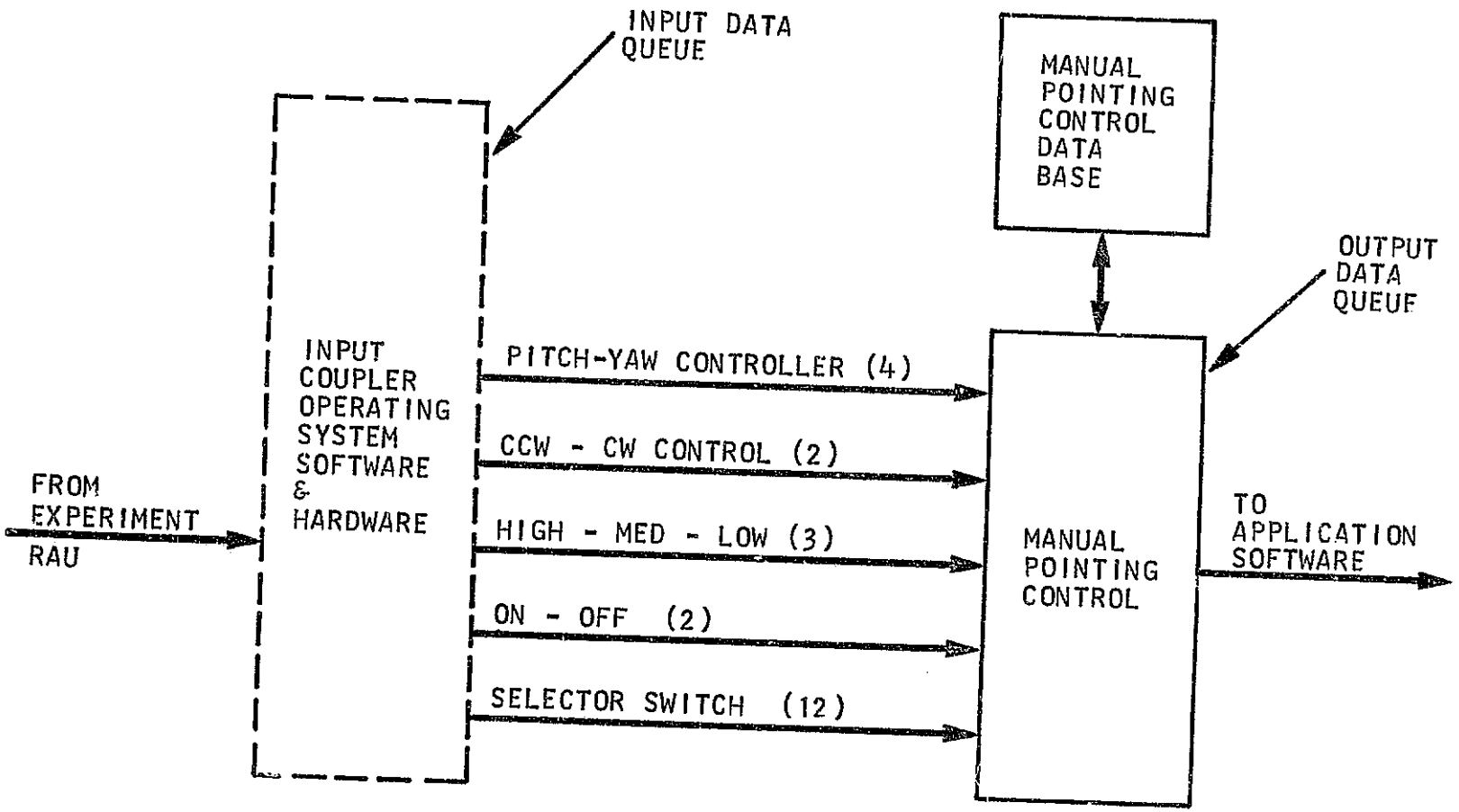

Figure 3.2-3 Manual Pointing Control

3.2.1.2.3 RAU-Selectable Slewed Digital Displays

Provide two "Selectable Slewable Digital Display" (SSDD) modules with functional characteristics shown in Figure 3.2-4 and detailed requirements defined in the following paragraphs. This software module shall interface through a RAU interface with digital displays.

3.2.1.2.3.1 Inputs

The SSDD module shall receive 12 bilevel inputs from a selector switch and two bilevel signals from the slew command, via the RAU interface. One proportional input is required from the application software to define the display value. In addition, the data base shall supply the information for the two LED displays.

3.2.1.2.3.2 Outputs

All outputs from the SSDD module shall be placed in an output data queue to be utilized by either system software or application software.

3.2.1.2.3.3 Processing

The SSDD module shall monitor 12 bilevel signals and determine which mission unique application has been requested. This selection shall set an index which will control the data base selection. The data base will furnish the address of the digital data to be displayed and the titles for the two LED displays. The SSDD module shall then interrogate the slew command and place its status in the address specified by the data base. Finally the SSDD shall place the digital display data, obtained from the application software in the output data queue for processing by the output coupler. This output function shall include address encoding for communication with the system software serial data bus.

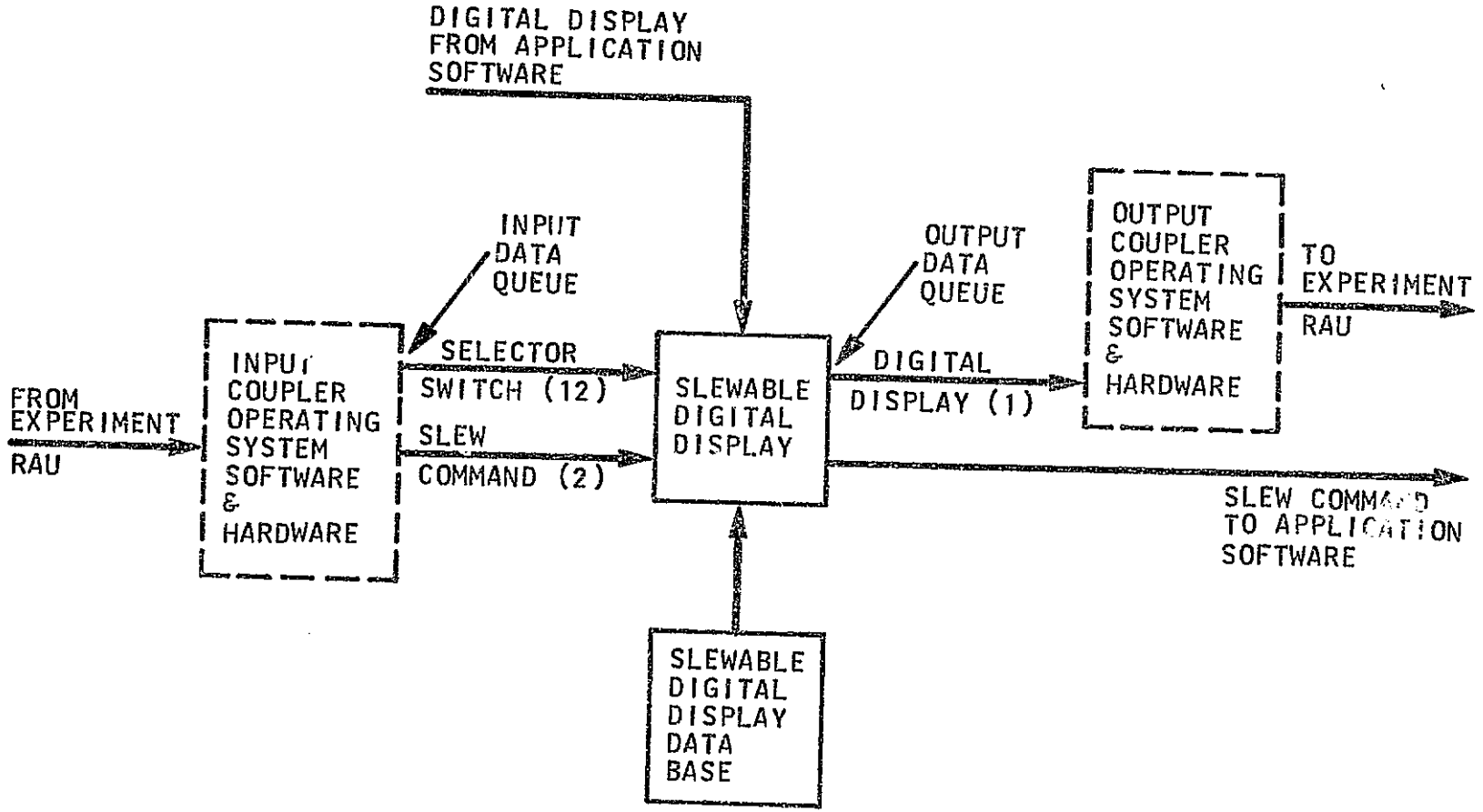

Figure 3.2-4 Slewed Digital Displays

3.2.1.2.4 RAU - Meter Displays

Provide a "Meter Display" (MD) module with functional characteristics shown in Figure 3.2-5 and detailed requirements defined in the following paragraphs. This software module shall interface through a RAU with an analog meter.

3.2.1.2.4.1 Inputs

The MD module shall receive 12 bilevel signals from the input data queue of system software. In addition, it shall receive three proportional signals from the mission unique application software.

3.2.1.2.4.2 Outputs

The output of the MD module shall consist of three proportional variables to be placed in the system software output data queue. The system software shall use this data to drive the analog meters.

3.2.1.2.4.3 Processing

The MD shall monitor 12 bilevel variables in the input data queue and derive an index to be utilized by the data base. Under index control the data base shall specify to the MD the address of where the selected 3 of 36 application software variables are, to be processed for meter display. In addition it shall provide the address encoding to communicate with the RAU serial interfaces.

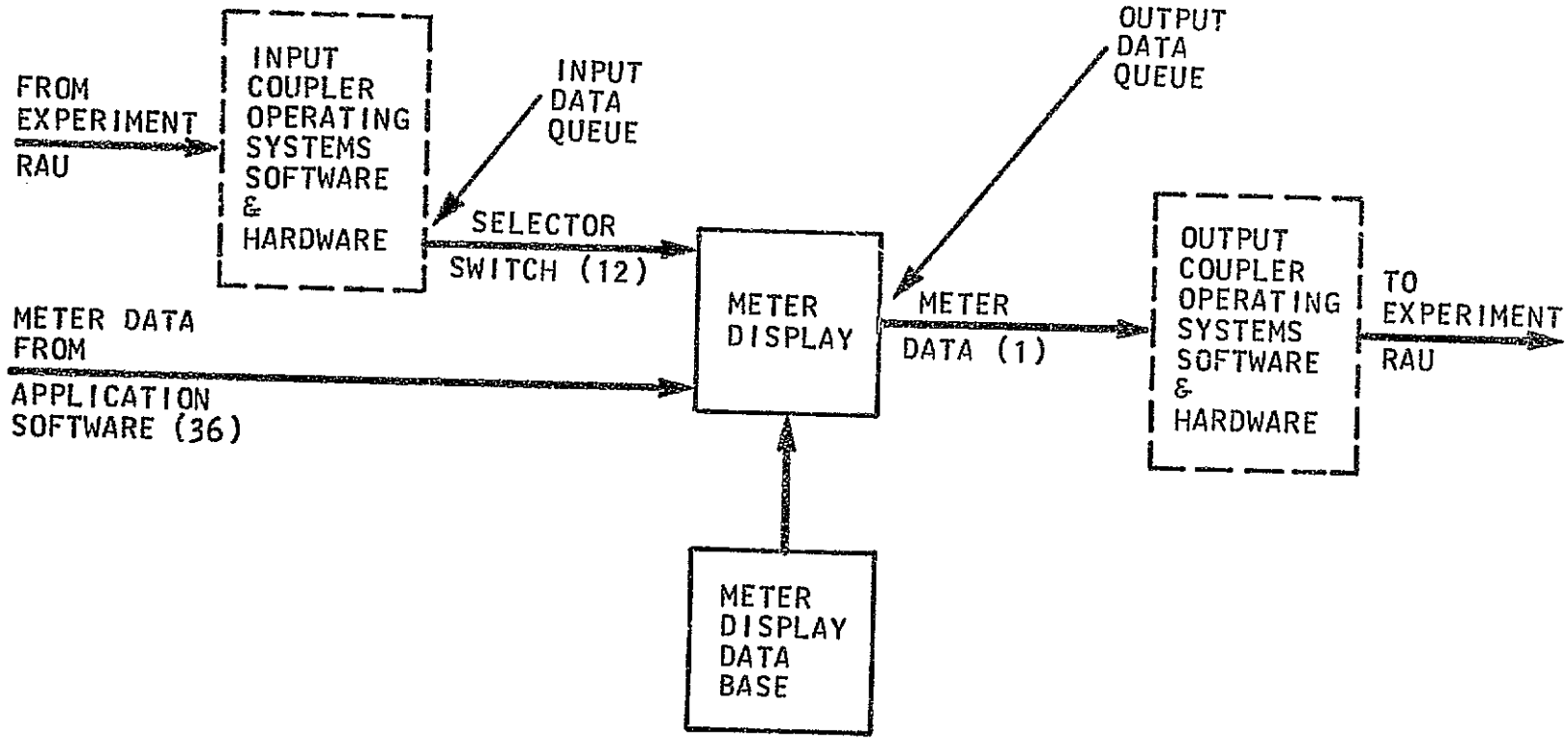

Figure 3.2-5 Meter Display

3.2.1.2.5 RAU - Selectable Switches and Status Flags

Provide three "Selectable Switch and Status Flag" (SSSF) modules with functional characteristics shown in Figure 3.2-6 and detailed requirements defined in the following paragraphs. This software module shall interface through an experiment RAU with these switches.

3.2.1.2.5.1 Inputs

The following inputs are required by the SSSF module:

12 Bilevel-switch selector
6 Bilevel-discrete commands
6 Bilevel-status flag commands

3.2.1.2.5.2 Outputs

The SSSF module shall supply six bilevel outputs to the system software output data queue. The 6 output variables shall be placed in 6 of 72 variable locations representing one of 12 switch selections. These variables shall drive the status flags via the experiment RAU.

3.2.1.2.5.3 Processing

The SSSF module shall monitor the 12 bilevel input commands and set an index to be used to control selection of data from the data base. The data base will supply address to specify where the discrete commands are to be sent (6 of 72), and where in the application software the status flag commands are located (6 of 72).

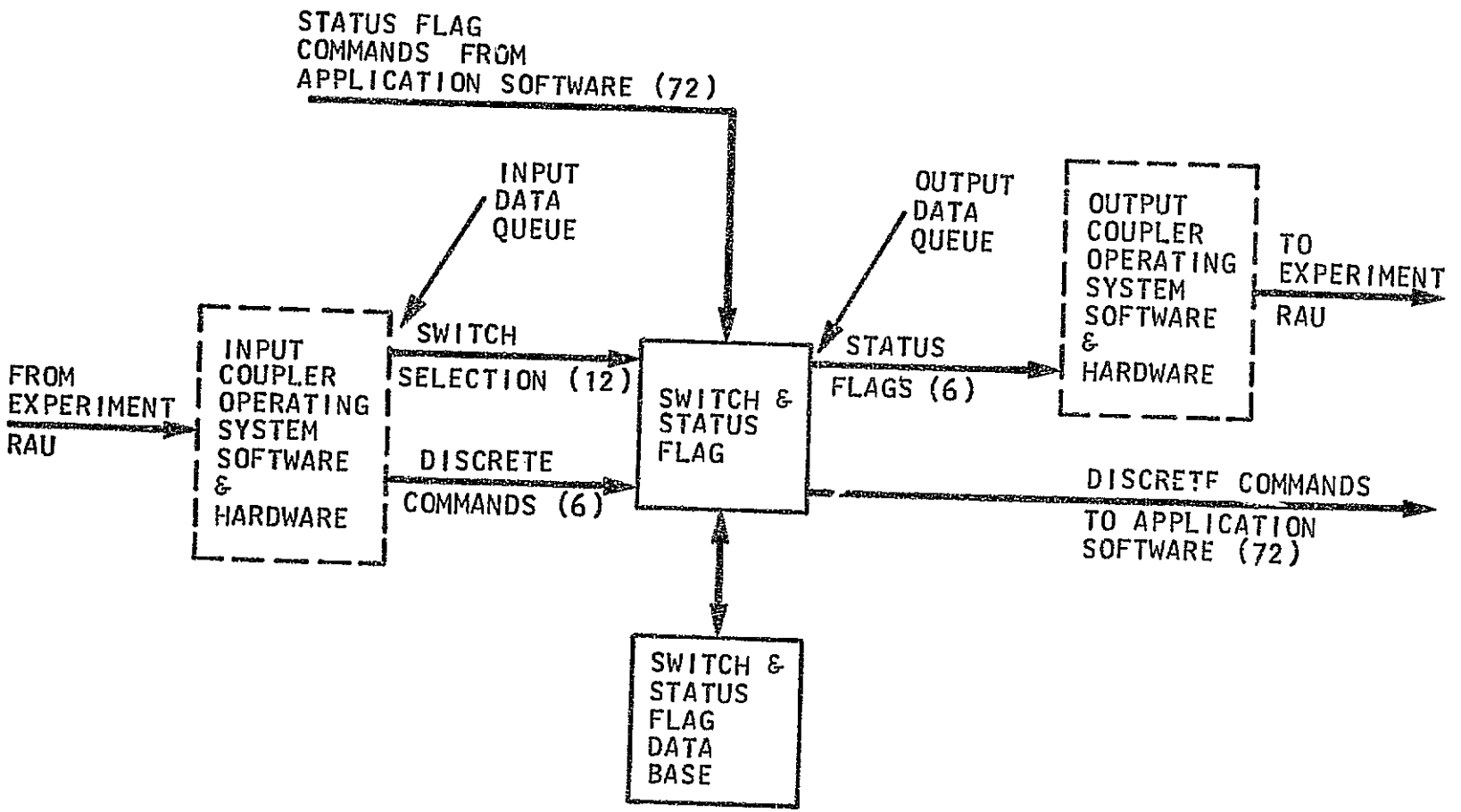

Figure 3.2-6 Selectable Switches and Status Flag

3.2.1.2.6 Display - Experiment Alert

Provide an "Experiment Alert" (EA) module with the functional characteristics shown in Figure 3.2-7 and the detailed requirements defined in the following paragraphs. This software module shall interface with the display data buses to provide alert status on the bottom line of all three displays.

3.2.1.2.6.1 Input

The input to the EA module shall be a data base driven table containing addresses of 200 applications software variables.

3.2.1.2.6.2 Output

The output of the EA shall be the out-of-tolerance alert variable, based on a first in first out bases. When requested the status of all 200 alert parameters currently being monitored shall also be displayed.

3.2.1.2.6.3 Processing

The EA module shall monitor up to 200 variables for out-of-tolerance conditions. The variable name, location, scale factor, upper limit, lower limit, and system identification shall be stored in the EA data base. If more than 200 variables are required, the system software, under control of the mission unique software shall be able to change the 200 variable data base. The EA module shall sequentially check the 200 specified addresses to see that each variable is within tolerance.

The status of all 200 variables shall be stored in a table for and display upon KB request. The first alarm entered into this table shall be sent to all displays using a first in, first out (FIFO) data flow.

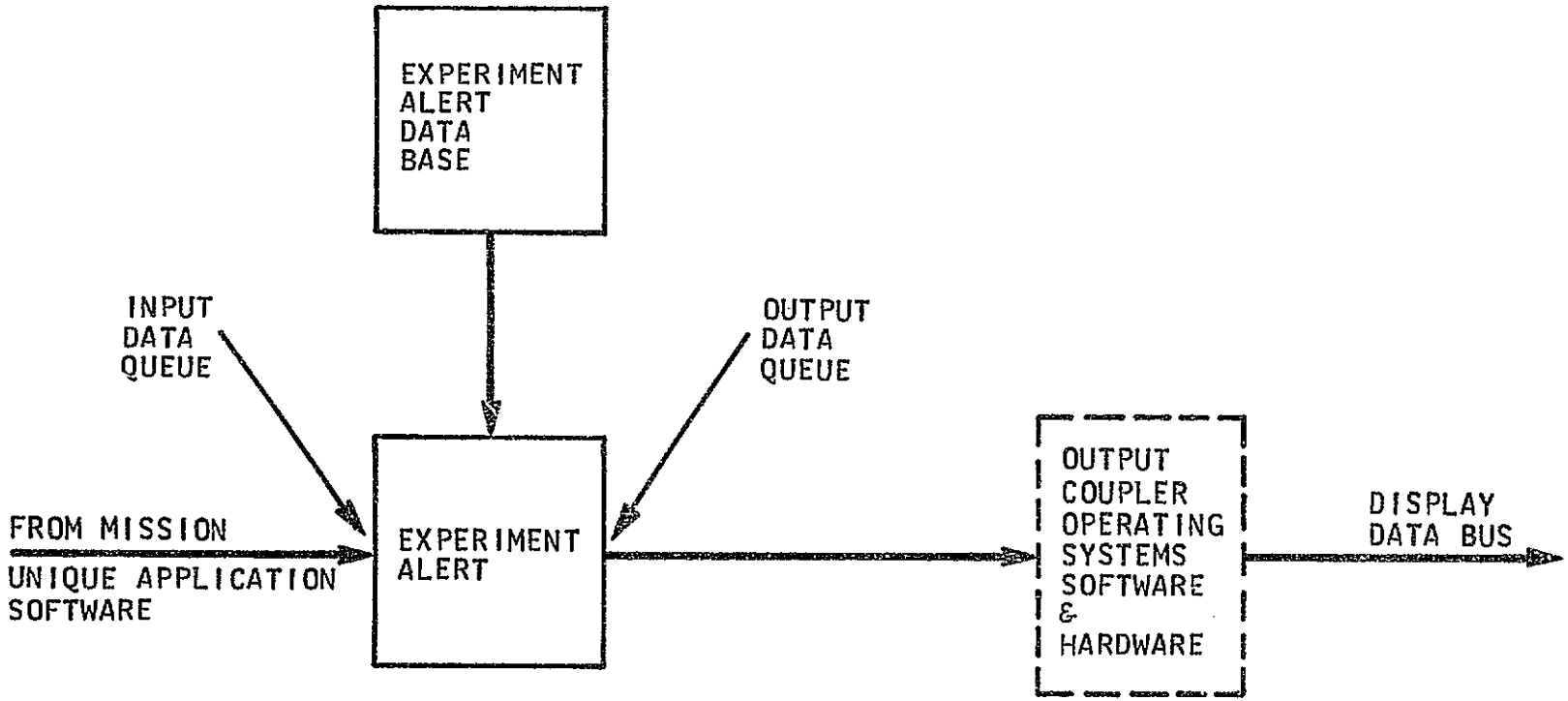

Figure 3.2-7 Experiment Alert

3.2.1.2.7 Display - Crosshair Pointing Control L11-2

Provide a "Crosshair Pointing" (CP) module with functional characteristics shown in Figure 3.2-8 and detailed requirements defined in the following paragraphs. This software module shall interface with the crosshair adjustments, and the video display. This software module shall allow setup of the next pointing while data is being taken on the current sighting.

3.2.1.2.7.1 Input

The CP module requires the following inputs:

12	Bilevel-switch positions
1	Bilevel-control request
1	Bilevel-pointing execution
TBD	Crosshair position signals

3.2.1.2.7.2 Output

The CP module shall output signals to the electronics unit to position "crosshairs" and to the application software for pointing system control.

3.2.1.2.7.3 Processing

The CP module shall monitor the 12 bilevel switch positions from the experiment RAU to determine which pointing system has been requested. Next a determination shall be made if crosshair control has been selected. If so the crosshair position signals shall be monitored to determine the placement of the crosshairs on the video monitor. During this operation the crosshair pointing execution command shall be monitored to determine when point error signals are to be computed.

When pointing execution is requested the CP module shall determine the display scale factor from the data base indexed by the switch selection and compute the difference between video screen center and the crosshair location. This output shall be made available to application software for pointing control.

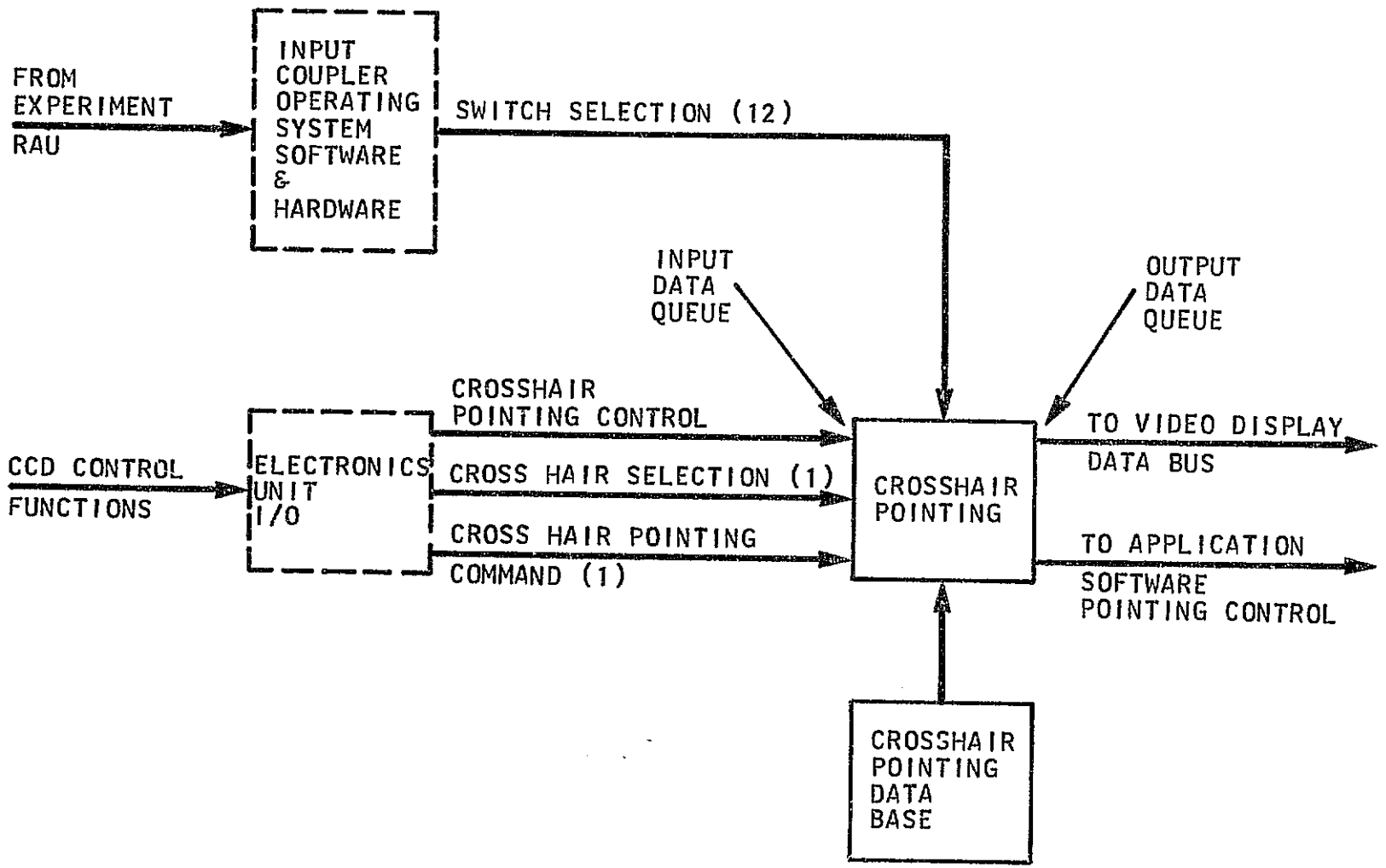

Figure 3.2-8 Crosshair Pointing Control

3.2.1.2.8 Display - Plot

Provide a plot module with functional characteristics shown in Figure 3.2-9 and detailed requirements defined in the following paragraphs. This software module shall interface with the display data bus.

3.2.1.2.8.1 Input

The plot module shall receive inputs from data base storage, display variable storage and plot variable storage. These inputs shall be supplied by the payload user via his mission unique application software.

3.2.1.2.8.2 Output

The output from the plot module shall be a block of data providing an integrated plot for display on the CRT.

3.2.1.2.8.3 Processing

Mission unique application software shall supply the data base requirements together with variable display and plot information to the plot module. It shall be the function of the plot module to integrate these five different types of input information into a plot display and output the information to the display data bus.

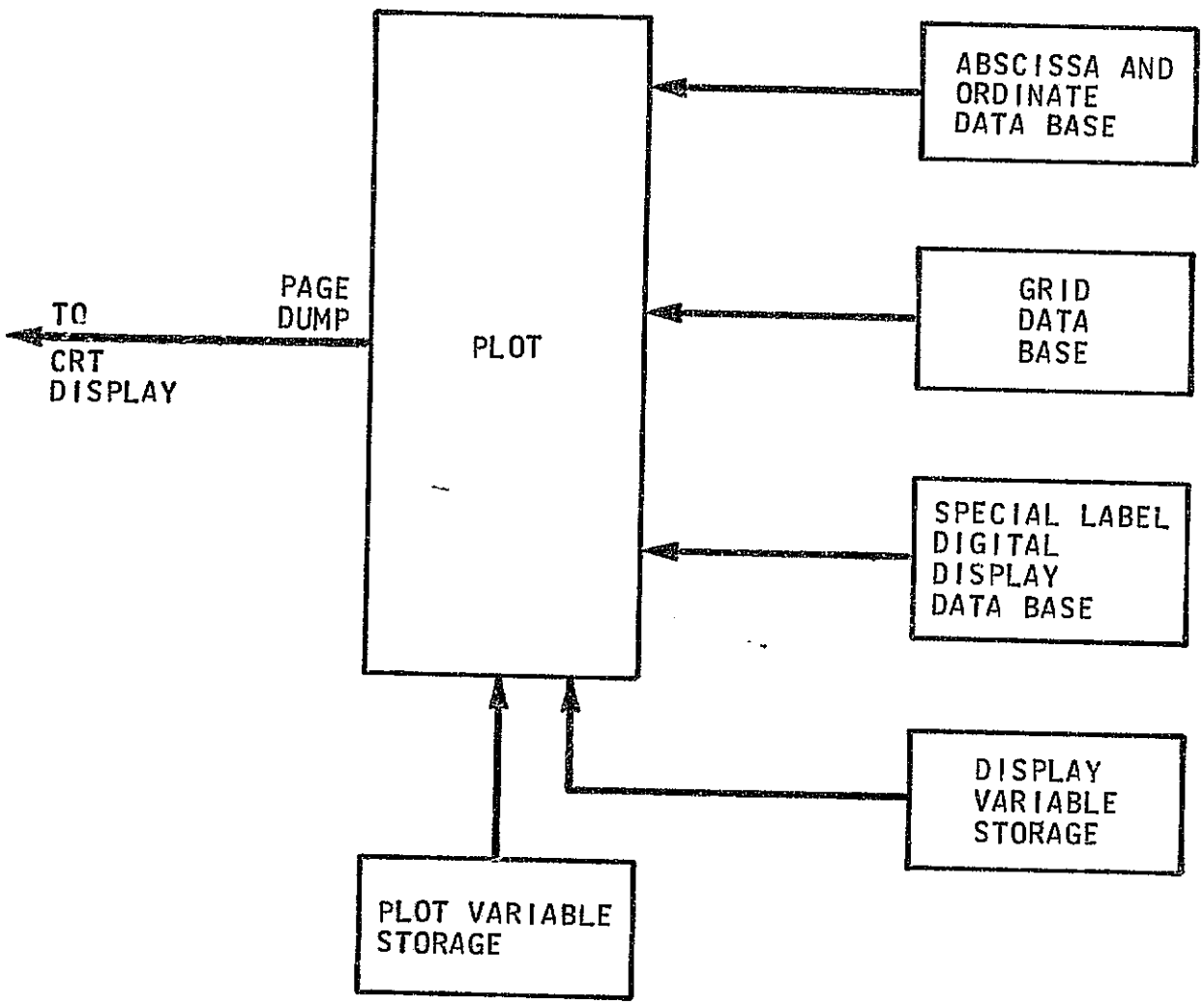

Figure 3.2-9 Plot Display

3.2.1.2.9 Display - Set N Bilevel

The majority of all actions on the CRT/KB take the form of selecting between several items. Because of this, two (one for each keyboard) data base driven programs which select N bilevel options displayed on a CRT and respond with the status of the command action shall be provided for payload use. A functional sketch of this software requirement is shown in Figure 3.2-10 and the detailed requirements are defined in the following paragraphs. The "Set N Bilevel" (SNB) module requires that a page of alphanumeric procedures has been generated by payload mission unique application software and identified with a unique page number. It further requires that each bilevel selection has a unique identification number within the text page.

3.2.1.2.9.1 Input

The inputs for the SNB module are the CRT page number, the KB command number, and the input data queue from the systems software.

3.2.1.2.9.2 Output

The output for the SNB module are variables placed in the output data queue, and response word messages to the display systems software.

3.2.1.2.9.3 Processing

The SNB module shall select the current data base under control of the CRT page number. The portion of this data base, which is active, shall be controlled by the KB command number. When the KB command number is received, the SNB module shall look up in the data base the address of the current command number (i.e., on-address or off-address for power) and place the table specified command action in the output data queue.

This same KB command shall also direct the monitor module to obtain the address of the variables to be monitored in the input data queue. These variables shall be monitored for true or false readings if bilevel and checked against upper lower limits if proportional. The monitor module shall then send the bilevel response generator module a good or bad message associated with that command, together with the KB command and page number. This information shall activate the bilevel response generator (BRG) module to obtain from its data base the payload specified alphanumeric response and the location of this response. The BRG module shall send this information to the display systems software for transmission to the CRT display which activated this sequence.

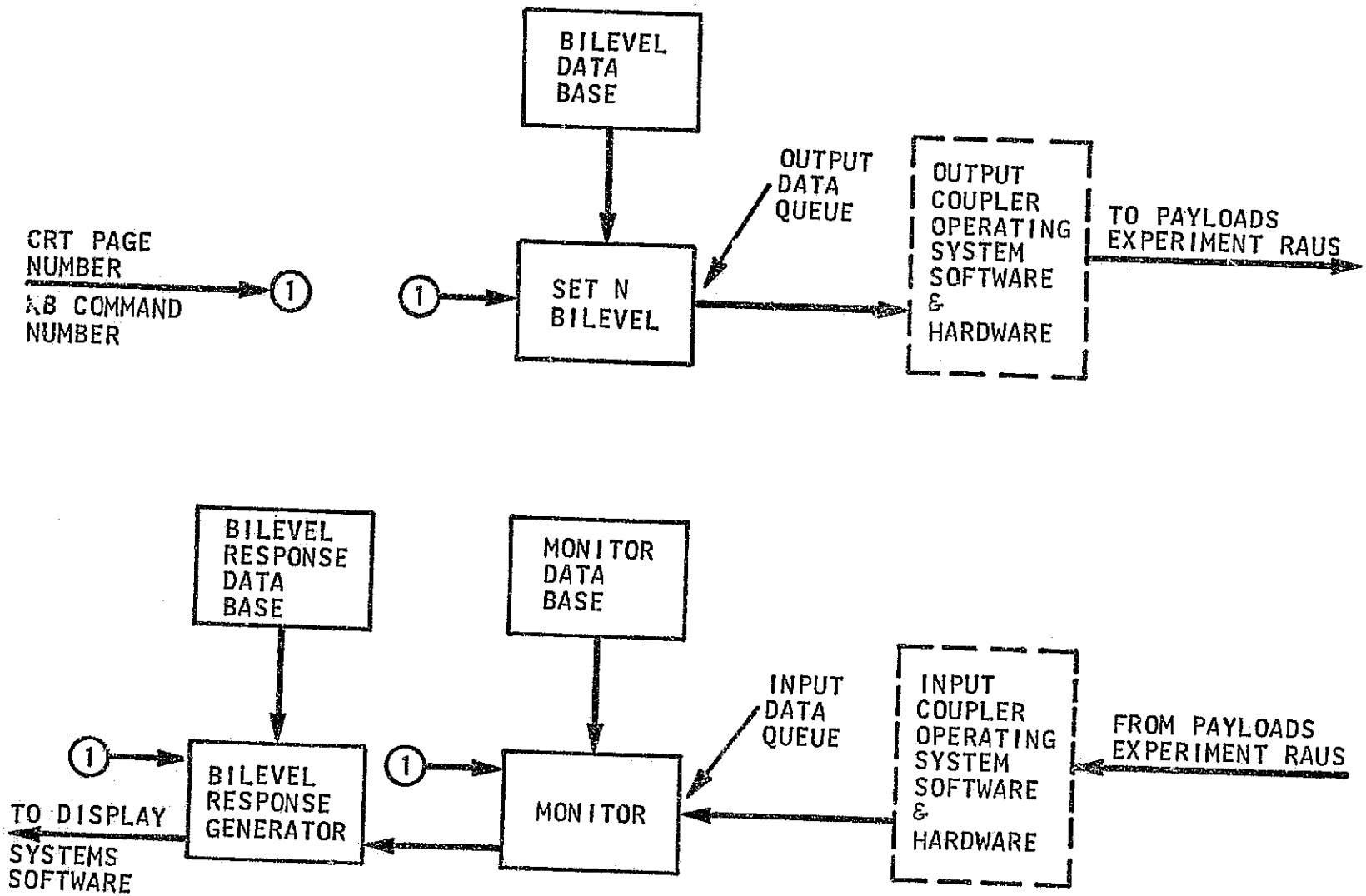

Figure 3.2-10 Set N Bilevel

3.2.1.2.10 Display - Set N Proportional

Two "Set N Proportional" (SNP) modules (one for each KB) to set digital numbers in response to a KB command shall be provided. A functional diagram of this control and display is shown in Figure 3.2-11 and the detailed requirements are defined below.

3.2.1.2.10.1 Input

The inputs for the SNP module are a CRT page number and a KB command number, and the payload data variables from the mission unique application software.

3.2.1.2.10.2 Output

The output for the SNP module are proportional command variables for application software and the response data words to be sent to the CRT display.

3.2.1.2.10.3 Processing

The SNP module shall obtain the data base defined by the CRT page command, and operate on that portion specified by the KB command number. The data requested on the display shall be sent to the address specified by the data base for use by mission unique application software. In addition, if specified by the payload user in the proportional response data base, data will be sent to the display. The address of this data shall be obtained from the proportional response data indexed by the page and KB command number. These response variables and any associated alphanumeric message shall be sent to the display system software for presentation on the display which generated the original command.

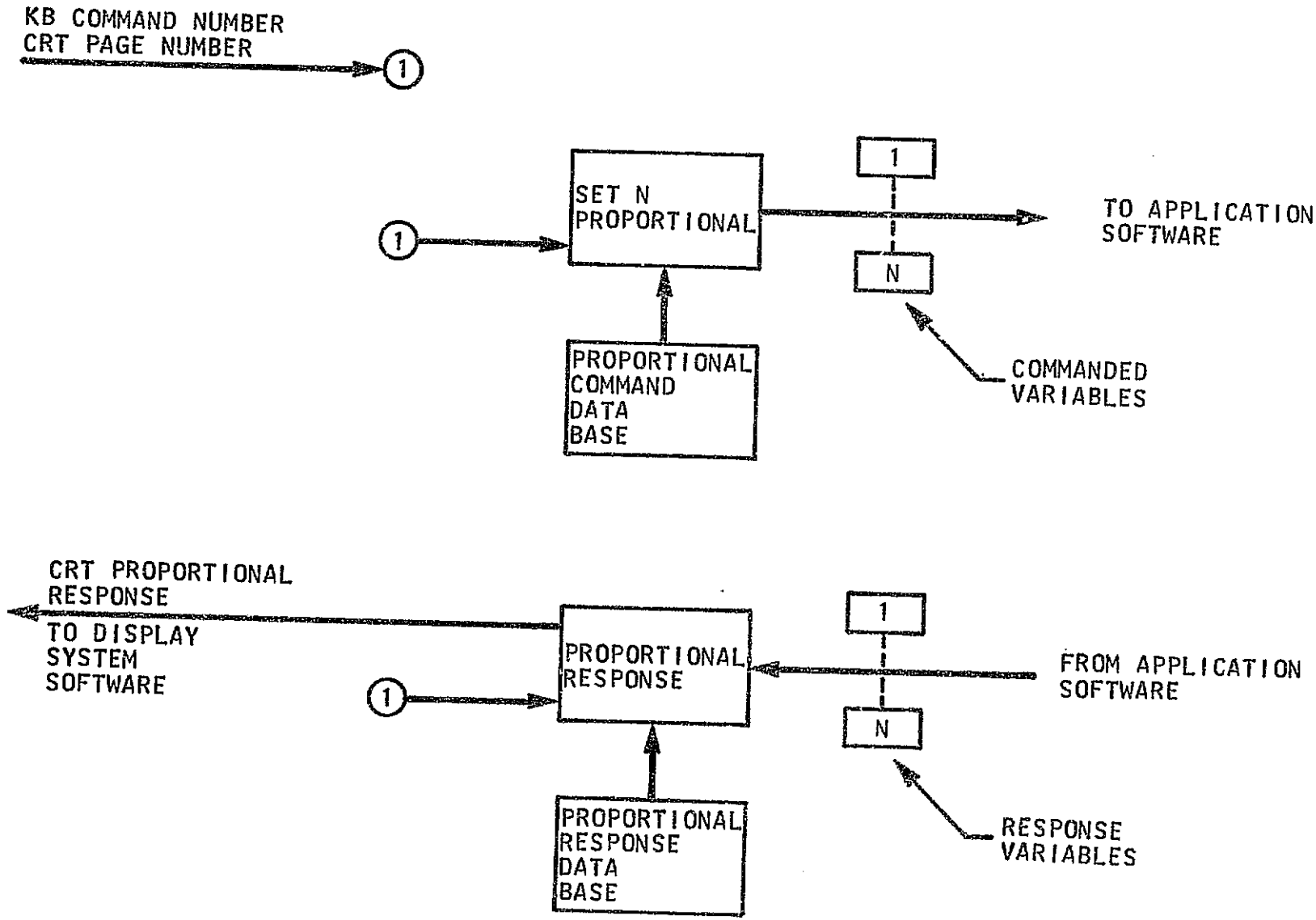

Figure 3.2-11 Set N Proportional

3.2.1.2.11 Display

Memory and logic shall be provided to generate 20 display formats. TBD shall be fixed and furnished to all payloads and TBD shall be available for mission unique requirements. The standard displays shall include:

1. Proportional tables.
2. Bilevel tables.
3. Orbiter Payload Bay Look angle.
4. Segmented (split screen) table formats.

3.2.1.2.11.1 Input

Display number and mission unique application software variables.

3.2.1.2.11.2 Output

A block of data containing the integrating foreground and background information for display

3.2.1.2.11.3 Processing

The display number shall command the display module to access the display data base and the subset specified by the display number. This data base shall contain all the background information for the standard display and the addresss of the application software variables. The data specified by the data base address shall be obtained, scaled, and inserted in the specified locations of the data block. The display module shall then output this integrated data block to the display systems software for output to the CRT/KB which requested the display.

3.2.1.3 Data Base Requirements

The data base requirements for each functional module are specified in paragraph 3.2.1.2.

3.2.2 Reliability

The CCD software shall be classified as error free. Sufficient verification and validation testing shall be performed to check all functional operating requirements.

3.2.3 Environment

3.2.3.1 Transportation and Storage

The flight software shall perform as specified herein after exposure in a nonoperating condition to any combination of the environments and ranges specified in JSC-07700, Volume XIV and MJ070-0001-1B.

3.2.3.2 Handling

The flight software shall perform as specified herein after exposure to the environmental ranges specified in JSC-07700, Volume XIV when handled unpackaged.

3.2.4 Operational Availability

This preliminary Part I CEI shall be updated as required by the PS contractor. The PS contractor shall maintain this document in the final Part I CEI form through the change control system established.

The Part I CEI document shall be submitted at the Preliminary Design Review (PDR) for final approval by MSFC prior to the start of the Development Phase. Review Item Disposition, (RIDs) written against the CEI and approved, shall be incorporated into the Part I CEI. After acceptance by MSFC, this document will be Government property, and shall be formally controlled as such in accordance with the requirements of the procuring activity. The software controlled by this CPCEI shall become fully operational after development and acceptance in the Software Development Laboratory.

3.2.5 Transportability/Transportation

The flight software shall be shipped in a container specifically designed to protect the software during highway and air transportation. Vibration, shock, pressure, temperature, humidity, contamination, and magnetic fields shall be controlled to levels specified below. All handling and transportation equipment shall be compatible with applicable structural and environmental limits.

3.2.6 Storage

The flight software shall have a storage life of ten years. Control shall be maintained on all parts and materials which are sensitive to age or the storage environments specified in paragraphs 3.2.3.1 and 3.2.3.2. These parts and materials shall be identified, and if deterioration is a factor during storage or after installation for use, the maintenance procedures shall indicate a replacement cycle or the necessary retesting.

3.3 Design Requirements

3.3.1 General Design and Programming Standards

Since the CCD software requirements spans two computers, the detailed design and programming standards will be different for each computer. The general standards should comply with a modular design controlled by the function definition of paragraph 3.2.1. Each function shall be capable of being developed independently to a common set of standards which control at least flow chart symbols, input and output processing, documentation, coding techniques, and verification testing.

3.3.2 Human Performance/Human Engineering Standards

The display and MMSE software functions shall be serviced at least TBD times per second to assure commands are serviced and displays are refreshed in a timely manner.

3.4 Logistics

This paragraph is not applicable to a CPCEI specification.

3.5 Personnel and Training

The CCD software cor 'd by this CPCEI will be developed by two contractors - the payload stati. ontractor and the mission contractor. The personnel to maintain the software and train payloads in the use of it shall be the responsibility of the mission contractor. The payload station contractor shall furnish a computer program description document for use by the mission contractor.

3.6 Interface Requirements

3.6.1 Interprogram Interface Requirements

Interfaces between the AFD core C&D program, of which this specification is part, and other programs (e.g., Orbiter, Spacelab, IUS) will be controlled by ICDs to be supplied by the Phase C/D Contractor. This will include mechanical, electrical, and software interfaces.

This CPCEI (CCD Flight Software) defines the total software requirements to deliver an operational flight CCD system. It will impact the software CPCEI of the main computer utilized, and interfaces with the CCD system (Figure 3.6-2). The software relationships between the main computer systems software and application software versus the portion of the CCD software in the electronics unit processor is defined in paragraph 3.1.2.

Early in the Phase C/D contract, trade studies shall be performed to determine which portion of the software functions in this CPCEI will be implemented in the electronic unit processor.

At this time an ICD will be written which defines the electronic unit and RAU hardware to software data bus interface functions. This document shall include enough information to totally define to a payload user the communication protocol of the interface. This shall include but not be limited to:

a. Command formats

b. Response request formats

c. Software to hardware operating descritpion

3.6.2 Intraprogram Interface Requirements

The relationship between this CEI and the other CEIs within the AFD core C&D program is shown in Figure 3.6-1. Each CEI (project level) defines the specific interface requirements applicable to the individual project.

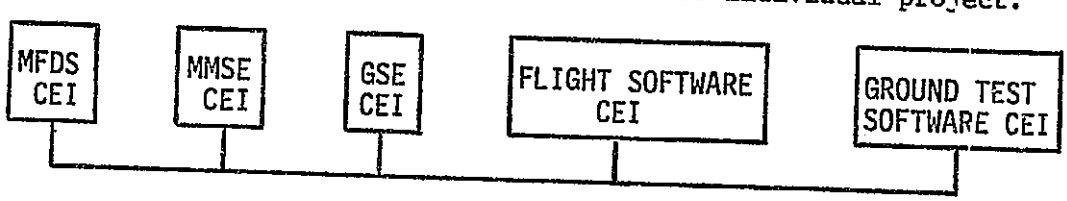

Figure 3.6-1 Intraprogram CEIs

3.6.3 Intraproject Interface Requirements

Not applicable.

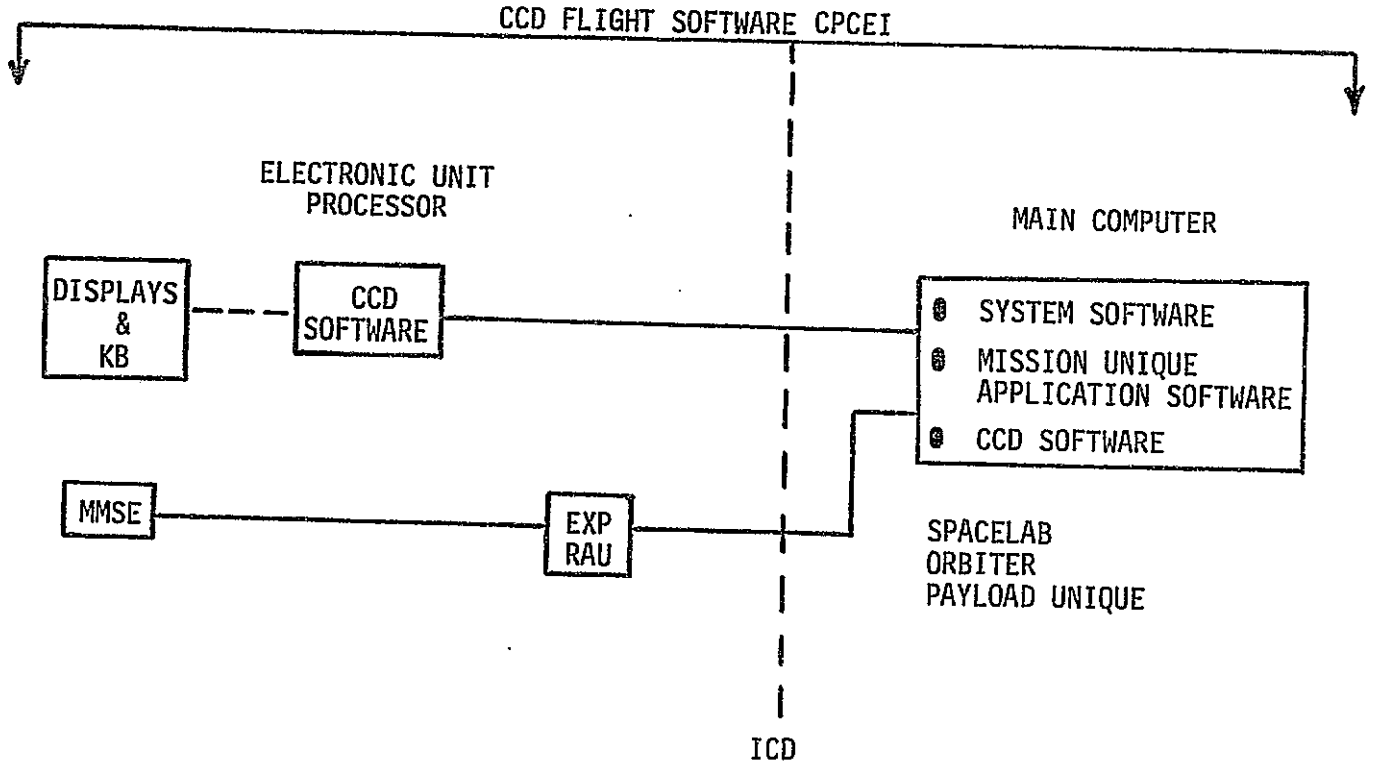

Figure 3.6-2 Software Interface Relationships

4.0 VERIFICATION

The verification program is designed to verify that the flight software conforms to the design and performance requirements as specified in Section 3 herein. Each requirement presented in Section 3 shall be verified by analysis or test as specified in this section.

4.1 General

The following subparagraphs specify the organizational responsibility for accomplishing verification, verification methods and the relationship of verification to management reviews.

4.1.1 Responsibility for Verification

The CCD flight software controlled by this CPCEI will be implemented in two processors as defined in paragraph 3.6. The portion which is implemented in the display electronics unit will be developed and verified by the Payload Station Contractor. The portion which is implemented in the main computer will be verified by the Mission Contractor. The combined integrated testing of the CCD flight software will be verified and accepted in the software development laboratory.

4.1.2 Verification Method Selection

Verification methods shall include test during each verification phase as applicable. An assessment shall be made whether verification shall be accomplished by similarity, analysis, inspection, demonstration or test.

4.1.3 Relationship to Management Reviews

For development of flight software there shall be five management reviews:

Preliminary Design Review

Critical Design Review

Test Readiness Review

Verification Review

Acceptance Review

These reviews relative to the flight software development shall be as shown in Figure 4.1-1.

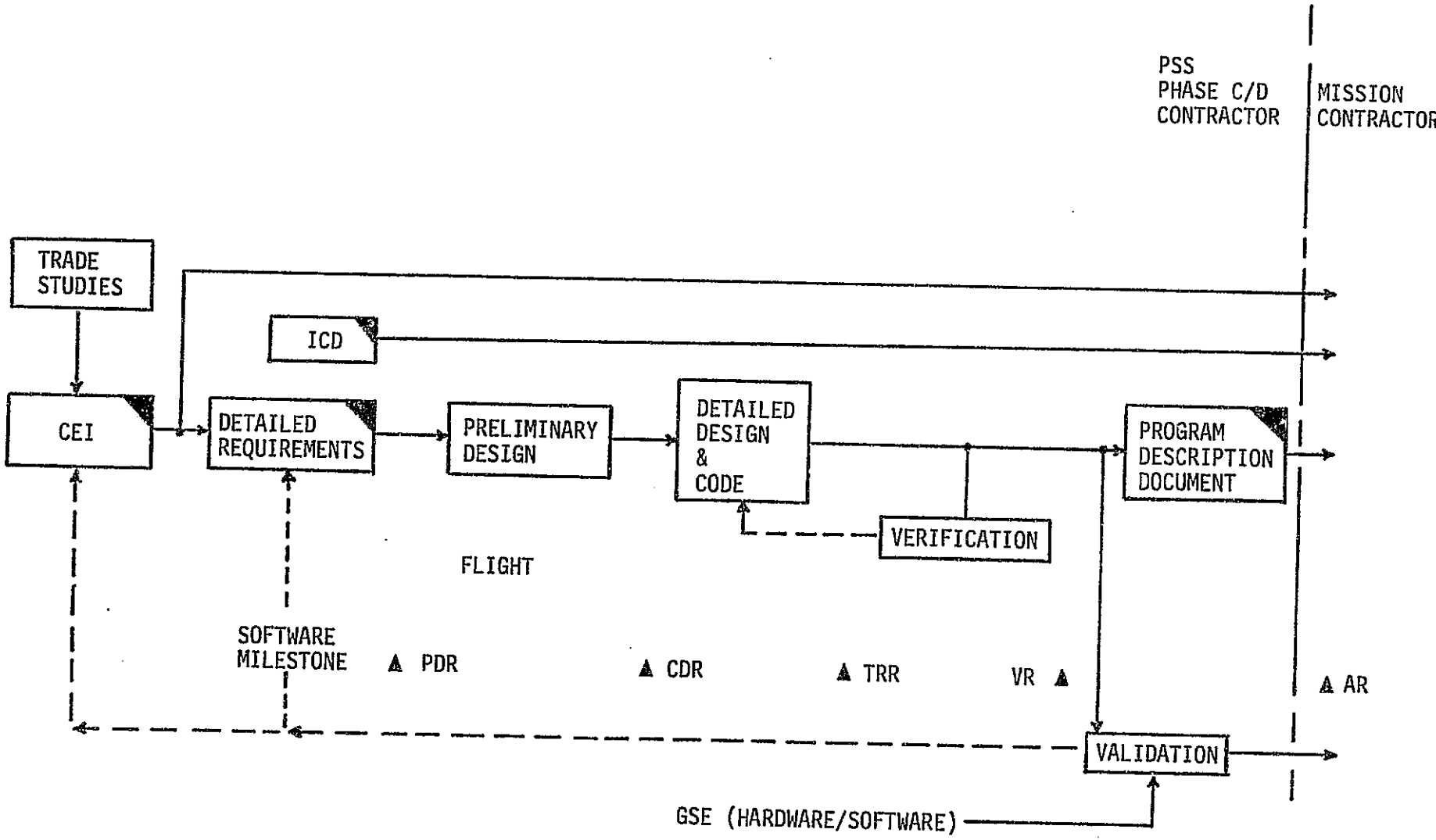

Figure 4.1-1 Management Reviews

4.2 Phased Verification Requirements

4.2.1 Development

During the development phase, independent and parallel development will be taking place on the two parts of this CPCEI (electronics processor and main computer). To assure first time operating compatibility between the two software programs, a high degree of customer and mission contractor visibility in the form of verification by analysis is required. This shall include an assessment of the ICD software modules to assure that development details which impact the interface are thoroughly analyzed for systems interface compatibilities. Tests shall be developed by both contractors to verify the interfaces which are being developed per the ICD. These tests shall be verified by the customer during the early phase of acceptance.

4.2.2 Qualification

Not applicable.

4.2.3 Acceptance

Since there are two programs which make up the total software package satisfying this CPCEI acceptance shall be performed in two parts. The first part shall be a combination of verification and validation as shown in Figure 4.1-1. The development tests defined in 4.2.1 will be exercised as a part of early acceptance testing. The Payload Station Contractor shall utilize the GSE to simulate and test all software interfaces with the main computer.

The second part of acceptance shall be a combined integrated Payload Station Contractor and Mission Contractor test. This test will constitute final acceptance of this CPCEI and shall be performed in the software development laboratory.

4.2.4 Integrated Systems

This phase consists of the testing performed after the mating of the flight software with the Orbiter or Spacelab subsystems, and will be the responsibility of the Mission Contractor. The PS Contractor shall support the Mission Contractor.

4.2.5 Prelaunch Checkout

This phase of testing will be the responsibility of the Mission Contractor, and the PS Contractor shall support the Mission Contractor.

4.2.6 Flight/Mission Operations

This phase of testing will be the responsibility of the Mission Contractor.

4.2.7 Post-Flight

This phase of testing will be the responsibility of the Mission Contractor.

4.3 Verification Cross-Reference Index

A verification cross-reference index shall be provided to cross-reference each verification requirement with each Section 3 requirement. The detailed verification requirement reference for all items shall be defined in software section of the Master Verification Plan. Only analyses and test methods shall be used in verification during the development and acceptance phases. Analysis shall consist of automatic and manual verification, which assures that the end item code meets the requirements of the detailed code to specification approved during the PDR and CDR review cycle (see Figure 4.1-1). The test method shall be called Validation. Validation shall test the end item code against detailed requirements ICD and CEI specifications. All functions controlled by this CPCEI shall be validated in a systems test configuration using the flight hardware and software.

4.4 Test Support Requirements

Test support including test facilities and equipment, bench setups, test software and test interfaces shall be as defined.

4.4.1 Facilities and Equipment

a. Existing facilities/equipment with NASA or other Government agencies and contractors shall be utilized to the maximum extent practicable.

b. Test activities including test facilities/equipment, personnel, and procedures shall be established and included in the Verification Plan.

c. Maximum use of the same or common test equipment shall be used for testing at multiple locations to assure uniformity of test results.

d. All test equipment shall be designed with a fail-safe goal such that test equipment failure will not degrade flight hardware. All test equipment shall be tested prior to interfacing with flight equipment to ensure that no damage or degradation to flight hardware will be induced. Appropriate tolerances shall be identified in the procedures, taking into account test equipment capabilities and flight hardware specifications, such that the test results will verify compliance with the flight hardware specifications.

4.4.2 Articles

Test articles, if required to support the test program, shall be as identified.

4.4.3 Software

Requirements governing software utilization in support of verification operations shall be as identified.

4.4.4 Interfaces

All software interfaces between the Payload Station Contractor and the flight software in the main payload computer shall be verified by the Mission Contractor in a Software Development Laboratory.

5.0 PREPARATION FOR DELIVERY

Not applicable.

6.0 NOTES

6.1 Abbreviations and Acronyms

AFD	Aft flight deck
AR	Acceptance Review
BRG	Bilevel Response Generator
CCD	Core control and displays
C&D, C/D	Controls and displays; Procurement Phases C and D
CDR	Critical design review
CPCEI	Computer Program Contract End Item
CP	Crosshair Pointing
CRT	Cathode ray tube
DBC	Data bus coupler
DDU	Data display unit
DEU	Display electronics unit
EA	Experiment Alert
ET	Event Timer
EU	Electronics Unit
FIFO	First In First Out
GFE	Government furnished equipment
GPC	General purpose computer (Orbiter)
GSE	Ground support equipment
ICD	Interface Control Document
ID	Identification
I/O, IOP	Input/Output Processor
I/S	Interconnecting station (Spacelab)
IUS	Interim Upper Stage
KB	Keyboard
LED	Light emitting diode

MD	Meter Display
MDM	Multiplexer-demultiplexer
MFDS	Multi-Function Display System
MMSE	Multi-use Mission Support Equipment
MPC	Manual pointing controller
MS, MSS	Mission Station, Mission Specialist, Mission Specialist Station
NSP	Network signal processor
OOS	On-orbit station
PCMMU	Pulse code modulation master unit
PDI	Payload data interleaver
PDR	Preliminary design review
PL, P/L	Payload
PS, PSS	Payload Station, Payload Specialist, Payload Specialist Station
PSP	Payload signal processor
RAU	Remote acquisition unit
RID	Review Item Disposition
SE&I	Systems engineering and integration
SIPS	Small Instrument Pointing System
SL	Spacelab
SLC	Spacelab computer
SM	Systems management
SNB	Set N Bilevel
SNP	Set N Proportional
SS, S/S	Subsystem
SSDD	Selectable Slewable Digital Display
SSSF	Selectable Switch & Status Flag
STE	Space test equipment
STS	Space Transportation System
SW, S/W	Software
TP	Twisted pair
TRR	Test Readiness Review
TSP	Twisted shielded pair
VR	Verification Review
WBS	Work breakdown structure

Ground Test Software Specification

Ground Test Software Specification

COMPUTER PROGRAM DETAIL SPECIFICATION

PART I

PERFORMANCE, DESIGN AND VERIFICATION REQUIREMENTS

GROUND TEST SOFTWARE

CET NO. _____

FOR

AFT FLIGHT DECK CORE

CONTROLS AND DISPLAYS

APPROVED BY _____

CODE IDENTIFICATION _____

DATE _____

APPROVED BY _____
NASA

DATE _____

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1.0 SCOPE

This part of the specification establishes the requirements for performance, design, and verification of a Computer Program (CP) CEI identified as Core Control and Display (CCD) Ground Test Software for contract end item number TBD. This CPCEI is used to provide top level software requirements necessary to control software programs in the GSE. The combination of the GSE CEI and this CPCEI will constitute a system capable of testing and isolating CCD problems to the replaceable subpanel level.

2.0 APPLICABLE DOCUMENTS

The following documents, of exact issue shown, form a part of this specification to the extent specified herein. In event of conflict between documents referenced here and other detail content of this specification, the detail requirements herein shall be considered superseding. Contractor specifications satisfying the intent of the below-listed documents may be used in lieu of the specifically listed documents after review and approval by MSFC. Reference to these documents contained herein shall be by basic number only.

2.1 Orbiter Interface

SS-P-0002-170	NASA	Computer Program Development Specification Volume I Book 7 System Level Requirements	6/7/76
SS-P-0002-160	NASA	Computer Program Development Specification Volume I book 6 System Level Requirements Payloads	6/10/76

2.2 Spacelab Interface

EQ-MA-0002	MATRA	I/O Unit	5/14/76
EQ-MA-0003	MATRA	RAU Acquisition Unit	5/01/76
EQ-MA-0010	MATRA	Display System	5/15/76
EQ-MA-084	MATRA	Data Bus Interconnecting Station	5/20/76
EQ-MA-001	MATRA	Data Bus	5/18/76

2.3 Standards

TBD

3.0 REQUIREMENTS

3.1 CPCEI Definition

3.1.1 General Description

This CPCEI shall control three major functions. The first is the I/O processor module. This module shall provide communication with hardware circuits which interface with the AFD CCD equipment. The second function is the executive and interpreter. This module shall sequentially execute command and monitor functions as specified by the test sequence. It will utilize the I/O software module to interface with the hardware. The third module is the test sequence. This module is the largest and contains all test intelligence to allow the GSE to perform its function.

3.1.2 Missions

This CPCEI will be used to accept and test all AFD CCD equipment.

3.1.3 Operational Concepts

This paragraph is not applicable to a CPCEI detailed specification.

3.1.4 Organizational and Management Relationship

MSFC has been designated as the lead NASA center for the Aft Flight Deck Payload dedicated controls and displays program. The core C&D equipment will be located in the Orbiter AFD, and therefore, JSC will be required to ensure ICD compatability.

3.1.5 Systems Engineering

3.1.5.1 Systems Engineering and Integration

Systems engineering and integration will include performance of the analyses and studies necessary to define requirements for the Aft Flight Deck Payload Core C&D, interfaces, ground support equipment (GSE) and special test equipment (STE), and product assurance. Systems design and integration, operations requirements analyses, GSE and STE requirements, and systems test requirements are all a part of the Aft Flight Deck (AFD) Core C&D engineering and integration (SE&I) task.

3.1.5.2 Work Breakdown Structure (WBS)

The WBS for the AFD core C&D will be in accordance with MA-06, reference Volume III, Part I.

3.1.6 Government Furnished Property List

This CPCEI will not incorporate any GFP computer programs.

3.1.7 Critical Components

Not applicable.

3.2 Characteristics

3.2.1 Performance

3.2.1.1 System Requirements

The GSE which is controlled by this CPCEI is described in The Ground Support Equipment CEI. Figure 3.2-1 shows the three major software functions and their relationship to each other and the peripheral hardware.

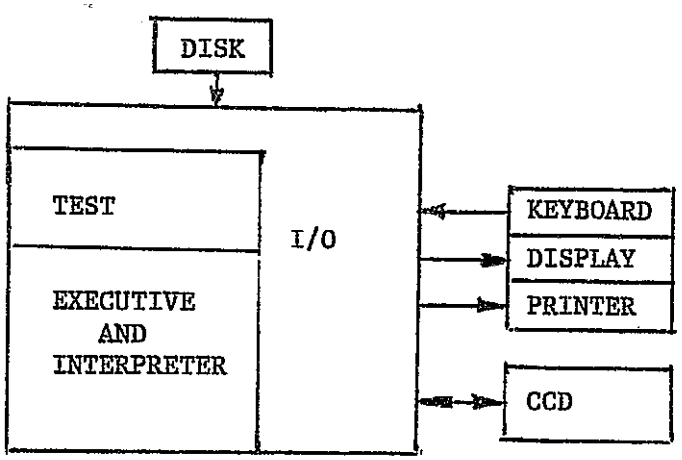

Figure 3.2-1 GSE Software Functions

The Executive and Interpreter (EI) module will request a test from the Test Sequence (TS) Module stored on the disk. The Interpreter in the EI module will sequentially decode each test instruction. The first instruction shall contain the text page for the CRT display. This text shall define the test objective command, response and success criteria. The second instruction shall contain the stimulus to be applied to the CCD I/O. The third instruction shall contain the delay required before the response instruction is executed. Finally, the total test result shall be dumped to the printer for a permanent record.

3.2.1.2 Operational Requirements

3.2.1.2.1 I/O Module

The I/O module shall be capable of commanding and monitoring the following devices specified in the GSE CEI:

Printer
Disk
CRT Display
CCD Equipment
Keyboard

3.2.1.2.2 Executive-Interpreter (EI)

The EI module shall be capable of sequencing through the tests stored on the disk, executing commands within the test, displaying the test and results on the CRT, and printing the final test result on the printer.

3.2.1.2.3 Test Sequence (TS)

The Test Sequence (TS) module shall contain a series of tests which check all functions of the CCD equipment to the replaceable subpanel. This TS module shall include, but not be limited to, the tests defined in Table 3.2-1.

3.2.1.3 Data Base Requirements

No data base requirements are required for this CPCEI.

3.2.2 Reliability

The software shall be capable of isolating problems to the replaceable subpanel without error.

TABLE 3.2-1 CCD TEST SOFTWARE REQUIREMENTS

MMSE TYPE	TEST OBJECTIVE	COMMAND	RESPONSE	SUCCESS CRITERIA
Rotary Switch	Verify each position	Manual	Bilevel	Bilevel received
Toggle Switch	Verify each position	Manual	Bilevel	Bilevel received
Momentary Toggle Switch	Verify each position	Manual	Bilevel	Bilevel received
Status Indicators	Verify each position	Bilevel	Manual	Position activated
Analog Meters	Verify full-scale deflection and null	Digital Word	Manual	Full-scale deflection and null received with TBD% accuracy of full-scale
Digital Displays	Verify the ability of the digital display to accept addressed commands from the experiment RAU and display properly the required numeric characters.	Digital Commands	Manual	Appropriate characters displayed
Alphanumeric Displays	Verify the ability of the display to accept addressed commands from the experiment RAU and display properly the required alphanumeric characters.	Digital Commands	Manual	Appropriate characters displayed

TABLE 3.2-1 (Continued)

MMSE TYPE	TEST OBJECTIVE	COMMAND	RESPONSE	SUCCESS CRITERIA
Event Timer	Verify the ability of the timer to accept from either the experiment RAU or manual input switches preset times, count up/down commands and start/stop commands. Verify the ability of the timer to count up/down as required.	Manual or Digital Word	Manual	Appropriate count up/down sequences
Potentiometers and MPC	Verify the capability of the potentiometers and MPC to supply the full range of analog voltage.	Manual	Analog Voltage	Proper range of analog voltage received

TABLE 3.2-1 (Continued)

DISPLAY UNIT	TEST OBJECTIVE	COMMAND			RESPONSE	SUCCESS CRITERIA
		TEST PATTERN	BITE	SELF TEST PROGRAM		
	Horizontal Deflection Amplifier	X	X	X	Manual/Digital	No Errors
	Vertical Deflection Amplifier	X	X	X		
	Video Amplifier	X	X			
	CRT	X				
	High Voltage Power Supply	X				
	BIT		X	X		
	Low Voltage Power Supply	X	X	X		
	Low Voltage Control	X	X	X		
	Front Panel	X		X		
	Harness	X				

TABLE 3.2-1 (Continued)

ELECTRONICS UNIT / TEST OBJECTIVE	COMMAND: TEST PATTERN	COMMAND: BITE	COMMAND: SELF-TEST PROGRAM	RESPONSE	SUCCESS CRITERIA
Interface Adapter	X	X	X	Manual/Digital	No Errors
Keyboard Adapter	X	X	X		
CPU	X	X	X		
Data Flow	X	X	X		
Memory	X	X	X		
Character Generator	X	X	X		
Circles and Vectors	X	X	X		
Status Register	X	X	X		
BITE Control	X	X	X		
Graphics Generator	X	X	X		
Rotation	X	X	X		
X-Y Deflection Intensity	X	X	X		
Backpanel	X	X	X		
Connectors	X	X	X		
Power Supply	X	X	X		

TABLE 3.2-1 (Continued)

	TEST OBJECTIVE	COMMAND	RESPONSE	SUCCESS CRITERIA
KEYBOARD	Verify the operability of all keys	Manually depress all keys	Key function displayed on CRT	All key functions correct
VIDEO	Verify video capability	Composite video signal with alphanumeric graphic overlay	Manual	Test pattern verified correct

3.2.3 Environment

3.2.3.1 Transportation and Storage

The ground test software shall perform as specified herein after exposure in a nonoperating condition to any combination of the environments and ranges specified in JSC-07700, Volume XIV and MJ070-0001-1B.

3.2.3.2 Handling

The ground test software shall perform as specified herein after exposure to the environmental ranges specified in JSC-07700, Volume XIV when handled unpackaged.

3.2.4 Operational Availability

This preliminary Part I CEI shall be updated as required by the PS contractor. The PS contractor shall maintain this document in the final Part I CEI form through the change control system established.

The Part I CEI document shall be submitted at the Preliminary Design Review (PDR) for final approval by MSFC prior to the start of the Development Phase. Review Item Discrepancies, (RIDs) written against the CEI and approved, shall be incorporated into the Part I CEI. After acceptance by MSFC, this document will be Government property, and shall be formally controlled as such in accordance with the requirements of the procuring activity. The software controlled by this CPCEI shall become fully operational after development and acceptance in the Software Development Laboratory.

3.2.5 Transportability/Transportation

The ground test software shall be shipped in a container specifically designed to protect the software during highway and air transportation. Vibration, shock, pressure, temperature, humidity, contamination, and magnetic fields shall be controlled to levels specified below. All handling and transportation equipment shall be compatible with applicable structural and environmental limits.

3.2.6 Storage

The ground test software shall have a storage life of ten years. Control shall be maintained on all parts and materials which are sensitive to age or the storage environments specified in paragraphs 3.2.3.1 and 3.2.3.2. These parts and materials shall be identified, and if deterioration is a factor during storage or after installation for use, the maintenance procedures shall indicate a replacement cycle or the necessary retesting.

3.3 Design Requirements

3.3.1 General Design and Programming Standards

The general standards should comply with a modular design controlled by the function definition of paragraph 3.2.1. Each function shall be capable of being developed independently to a common set of standards which control at least flow chart symbols, input and output signals, documentation, coding techniques, and verification testing.

3.3.2 Human Performance/Human Engineering Standards

The display and test software functions shall be serviced at least TBD times per second to assure commands are serviced and displays are refreshed in a timely manner.

3.4 Logistics

This paragraph is not applicable to a CPCEI specification.

3.5 Personnel and Training

The personnel to maintain the software and train payloads in the use of it shall be the responsibility of the mission contractor. The payload station contractor shall furnish a computer program description document for use by the mission contractor.

3.6 Interface Requirements

3.6.1 Interprogram Interfaces Requirements

Interfaces between the core AFD C&D programs, of which this specification is a part, and other programs (e.g., Orbiter, Spacelab, IUS) will be controlled by ICDs to be supplied by the Phase C/D contractor for mechanical, electrical and software interfaces.

3.6.2 Intraprogram Interfaces Requirements

The relationship between this CEI and the other CEIs within the AFD core C&D program is shown in Figure 3.6-1. Each CEI (project level) defines the specific interface requirements applicable to the individual project. The Ground Test software CEI will interface with all other CEIs shown to assure that all input output requirements are met.

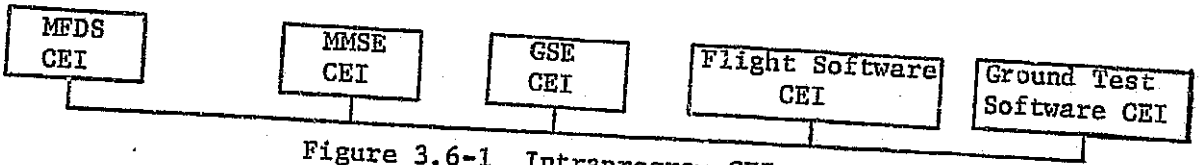

Figure 3.6-1 Intraprogram CEIs

3.6.3 Intraproject Interface Requirements

N/A

4.0 VERIFICATION

The verification program is designed to verify that the ground test software conforms to the design and performance requirements as specified in Section 3 herein. Each requirements presented in Section 3 shall be verified by analysis or test as specified in this section.

4.1 General

The following subparagraphs specify the organization responsibility for accomplishing verification, verification methods and the relationship of verification to Management reviews.

4.1.1 Responsibility for Verification

The Ground Test Software controlled by this CPCEI will be verified by the Payload Station Contractor. The acceptance of the AFD C&D equipment with the GSE and this CPCEI software will complete the verification task.

4.1.2 Verification Method Selection

The verification methods shall include test during each verification phase as applicable and analysis.

4.1.3 Relationship to Management Reviews

For development of Ground Test software there shall be 5 management reviews.

Preliminary Design Review
Critical Design Review
Test Readiness Review
Verification Review
Acceptance Review

These reviews relative to the Ground Test software development shall be as shown in Figure 4.1-1.

4.2 Phased Verification Requirements

4.2.1 Development

The GSE test software is straightforward and simple in that it consists of a series of commands and stimulus under manual control of a CRT/KB. Verification of this software shall be performed by analysis prior to combined system testing.

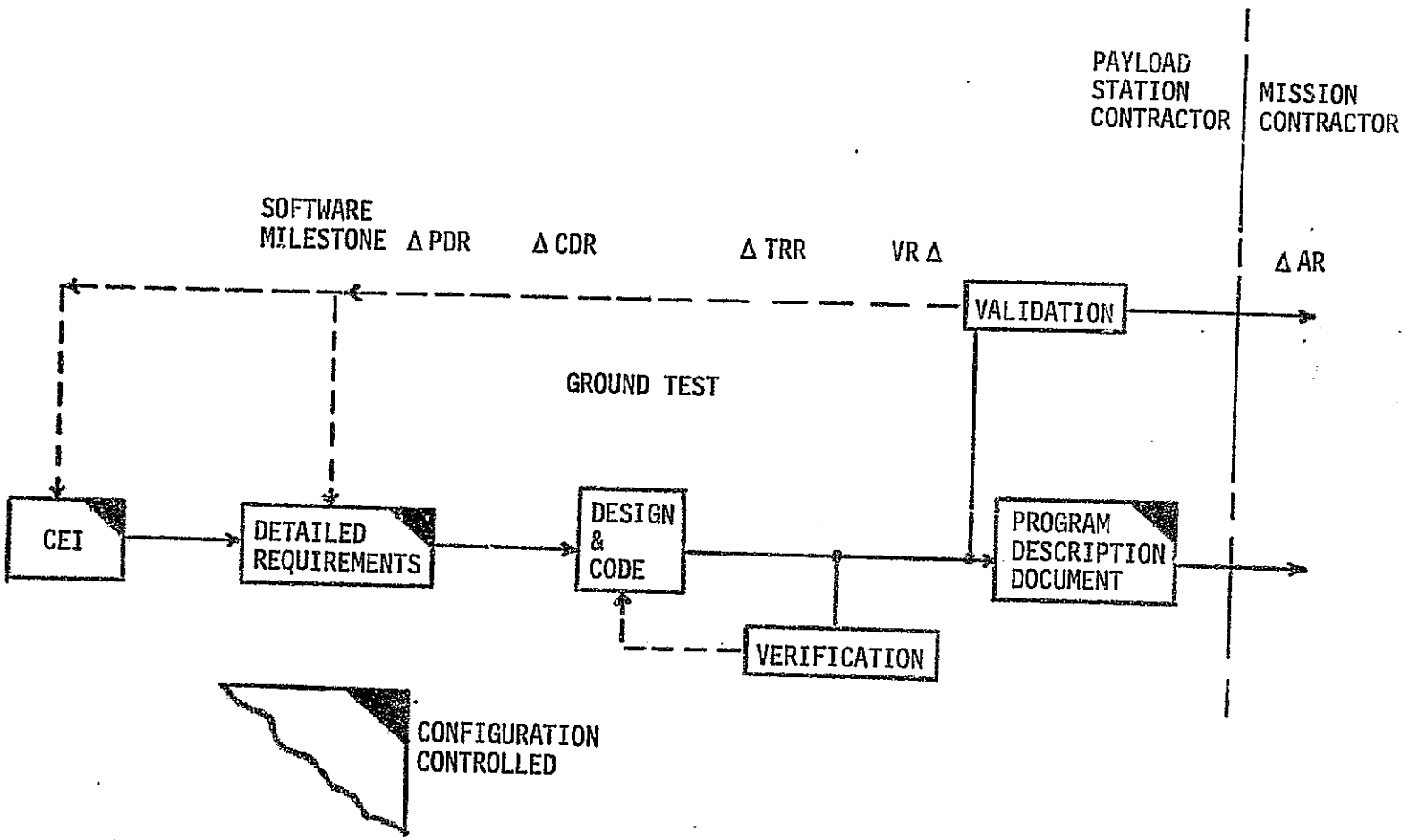

Figure 4.1-1 Ground Test Software Development

4.2.2 Qualification

N/A

4.2.3 Acceptance

Verification of ground test software at acceptance shall be accomplished by successful completion of CCD equipment checkout. Both anomalous and operating checks shall be performed.

4.2.4 Integrated Systems

This phase consists of the testing performed after the mating of the CCD with the Orbiter or Spacelab subsystems, and will be the responsibility of the Mission Contractor. The PS Contractor shall support the Mission Contractor.

4.2.5 Prelaunch Checkout

This phase of testing will be the responsibility of the Mission Contractor, and the PS Contractor shall support the Mission Contractor.

4.2.6 Flight/Mission Operations

This phase of testing will be the responsibility of the Mission Contractor.

4.2.7 Post-Flight

This phase of testing will be the responsibility of the Mission Contractor.

4.3 Verification Cross-Reference Index

The verification cross-reference index provides a cross reference of each verification requirement for each Section 3 requirement. The detailed verification requirement for all items shall be defined in software section of the Master Verification Plan. Only analysis and test methods shall be used in verification during the development and acceptance phases. Analysis shall consist of automatic and manual verification, which assures that the end item code meets the requirements of the detailed code to specification approved during the PDR and CDR review cycle (see Figure 4.1-1). The test method shall be called validation. Validation shall test the end item code against detailed requirements ICDs and CEIs specifications. All functions controlled by this CPCEI shall be validated in a systems test configuration using the flight hardware and software.

4.4 Test Support Requirements

Test support including test facilities and equipment, bench setups, test software and test interfaces shall be as defined.

4.4.1 Facilities and Equipment

a. Existing facilities/equipment with NASA or other Government agencies and contractors shall be utilized to the maximum extent practicable.

b. Test activities including test facilities/equipment, personnel, and procedures shall be established and included in the Verification Plan.

c. Maximum use of the same or common test equipment shall be used for testing at multiple locations to assure uniformity of test results.

d. All test equipment shall be designed with a fail-safe goal such that test equipment failure will not degrade flight hardware. All test equipment shall be tested prior to interfacing with flight equipment to ensure that no damage or degradation to flight hardware will be induced. Appropriate tolerances shall be identified in the procedures, taking into account test equipment capabilities and flight hardware specifications, such that the test results will verify compliance with the flight hardware specifications.

4.4.2 Articles

Test articles, if required to support the test program, shall be as identified.

4.4.3 Software

Requirements governing software utilization in support of verification operations shall be as identified.

4.4.4 Interfaces

N/A

5.0 PREPARATION FOR DELIVERY

N/A

6.0 NOTES

6.1 Abbreviations and Acronyms

AFD	Aft Flight Deck
AR	Acceptance Review
CCD	Core control and displays

C&D, C/D	Controls and Displays; Procurement Phases C and D
CPCEI	Computer Program Contract End Item
CRT	Cathode Ray Tube
EI	Executive Interpreter
GFE	Government Furnished Equipment
GSE	Ground Support Equipment
ICD	Interface Control Document
I/O, IOP	Input/Output Processor
IUS	Interim Upper Stage
KB	Keyboard
MFDS	Multifunction Display System
MMSE	Multi-use Mission Support Equipment
PDR	Preliminary Design Review
RID	Review Item Discrepancies
SE&I	Systems Engineering and Integration
STE	Special Test Equipment
TRR	Test Readiness Review
TS	Test Sequence
VR	Verification Review

Ground Support Equipment Specification

PRIME EQUIPMENT DETAIL SPECIFICATION

PART I

PERFORMANCE, DESIGN AND VERIFICATION REQUIREMENTS

GROUND SUPPORT EQUIPMENT

CEI NO. _____

FOR

PAYLOAD DEDICATED

CONTROLS AND DISPLAYS

APPROVED BY _____ APPROVED BY _____

CODE IDENTIFICATION _____ DATE _____ NASA

DATE _____

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1.0 SCOPE

This part of this preliminary specification establishes the requirements of performance, design and verification of equipment identified as the GROUND SUPPORT EQUIPMENT (GSE), Contract End Item (CEI) Number (TBD).

The ground support equipment (GSE) along with associated software and operator shall provide the capability to checkout and verify the PS station core controls and displays (CCD) equipment. The GSE shall be able to perform the checkout and verification with or without Spacelab equipment (experiment RAU). It shall provide the necessary stimuli (discrete and analog) to the CCD and it shall monitor the resulting responses. The GSE shall analyze test data (wherever possible) and provide a go/no-go indication. It shall inform the operator as to the test sequence to be followed.

2.0 APPLICABLE DOCUMENTS

The following documents, of the exact issue shown, form a part of this specification to the extent specified herein. In event of conflict between documents referenced here and other detail content of this specification, the detail requirements herein shall be considered superseding. Contractor specifications satisfying the intent of the below-listed documents may be used in lieu of the specifically listed documents after review and approval by MSFC. Reference to these documents contained herein shall be by basic number only.

2.1 Specifications

Rockwell International/Space Division Specifications		CEI Para.
MC615-0010	Adapter, Interface, Serial Multiplexer	3.2.1.3.1 3.2.1.3.4
NASA Specifications		
SS-P-0002-170	Computer Program Development Specification Volume I Book 7 System Level Requirements	3.2.1.3.1 3.2.1.3.4
SS-P-0002-160	Computer Program Development Specification Volume I Book 6 System Level Requirements Payloads	3.2.1.3.1 3.2.1.3.4
Spacelab Specifications		
IF-MA-0001	Spacelab Data Bus System Specification	3.2.1.3.1 3.2.1.3.3

2.2 Standards

MSFC Standards		
MSFC-STD-512 12 August 1974	Standard Man/Systems Design Criteria for Manned Orbiting Payloads	3.3.15
MSFC-STD-486 Amendment 1 July 1970	Threaded Fasteners, Torque Limits For	3.3.6.2
Military Standards and Specifications		
MIL-STD-143B 12 November 1969	Standards and Specifications, Order of Precedence for the Selection of	3.3.1

Military Standards and Specifications		CEI Para.
MIL-C-17E 12 July 1974	Cables, RF, Coaxial, Dual Coaxial, Twin Conductors and Twin Lead	3.3.5.1
MIL-STD-1472B 31 December 1974	Human Engineering Design Criteria for Military Systems, Equipment and Facilities	3.3.15
MIL-STD-130D 1 August 1973	Identification Marking of U.S. Military Property	3.3.13.2 3.3.13.4
MIL-STD-810(C) 10 March 1975	Environmental Test Methods	3.3.8
MIL-STD-470 21 March 1966	Maintainability Program Requirements	3.2.4
MIL-STD-889A 5 May 1972	Dissimilar Metals	3.3.9.1
MIL-B-5087B(2) 31 August 1970	Bonding, Electrical and Lightning Protection, for Aerospace Systems	3.3.5.6 3.3.5.7.3
MIL-S-7742B 15 March 1973	Screw Threads, Standard, Optimum Selected Serial, General Specification for	3.3.6.2.2
MIL-S-8879A(1) Notice 1 15 March 1973	Screw Threads, Controlled Radius Post With Increased Minor Diameter, General Specification for	3.3.6.2.2
MIL-STD-461A Amendment 4 June 1973	Notice 1, 2, 3 Electromagnetic Interference Characteristics, Req. for	3.3.5.7.1
MIL-STD-462(2) 1 May 1970	Notice 1, 2 - Electromagnetic Interference Characteristics, Measurement of	3.3.5.7.1
MIL-STD-12C(2) 1 February 1971	Abbreviations for Use on Drawings, Specifications, Standards and Technical Documents	3.3.13.4
MIL-STD-129 30 March 1973	Marking for Shipment and Storage	5.4

2.3 Drawings

MSFC Drawings

		CEI Para.
MSFC-DWG-40M39582	Harnesses, Electrical Design	3.3.5.1

2.4 Shuttle Program Publications

National Aeronautics and Space Administration

JSC-07700, Vol. XIV Revision D Change No. 17 27 July 1976	Space Shuttle System, Payload Accommodations; Program Definition and Requirements	3.2.4.1 3.2.6 3.2.7.1.1 3.2.7.1.2
JSC-07700, Vol. III Change No. 16 27 July 1976	Program Planning and Analysis	3.1.2
JSC-07700, Vol. I-014-PIV-01 Change No. 1 1 June 1976	Payload Interface Verification; Vol. I General Approach and Requirements	3.2.4.1

European Space Agency

EQ-MA-0010, Issue 1 15 May 1976	Data Display System	3.2.1.3.1
EQ-MA-084, Issue 1 20 May 1976	Data Bus Interconnecting Station	3.2.1.3.1
EQ-MA-0002 Preliminary 14 May 1976	Input Output Unit	3.2.1.3.1

Contractor (RI)

MJ070-0001-1B 15 January 1976	Orbiter Vehicle End Item Specification for the Space Shuttle System Part I; Performance and Design Requirements	3.2.7.1.1

2.5 Other Publications

NHB 5300.4(1D-1) August 1974	Safety, Reliability, Maintainability and Quality Provisions for the Space Shuttle Program	3.2.3 3.2.5

Other Publications

		CEI Para.
NHB 8060.1A November 1971	Flammability, Odor, and Offgassing Req. and Test Procedures for Materials in Environment that Support Combustion	3.3.2.2
SE-004-002-2H	Guidelines for Identifying Flammability Hazards in Air	3.3.2.2
NHB 1700.1(VI) July 1969	NASA Safety Manual	3.2.6
DOD Handbook H4-1 Latest Revision	Federal Supply Code of Manufacturers Name to Code	3.3.13.1
MA-06, Vol. III Part I	Work Breakdown Structure	3.1.5.2
EIA STD RS-170	Electrical Performance Standard Monochrome Television Studio Facilities, Electronic Industries Association	3.2.1.1

3.0 REQUIREMENTS

3.1 CEI Definition

3.1.1 General Description

The Ground Support Equipment (GSE) shall be comprised of the following pieces of equipment: central processor; input/output; mass storage; CRT display and keyboard; and line printer. Except for part of the I/O hardware, all the equipment shall be standard commercial equipment.

3.1.2 Missions

The Shuttle Program scheduling, operations planning, flight hardware, ground system requirements, and costs shall be based on the Shuttle Program mission model described in JSC-07700, Volume III. The first use of the GSE will be for the first operational flight utilizing the AFD core C&D capability, the Spacelab (SL) 2 mission.

3.1.3 Operational Concepts

The Ground Support Equipment (GSE) shall be used to checkout and verify the AFD core controls and displays. The GSE will be used to perform acceptance testing of the MFDS. Prior to installation of the AFD C&D equipment into the Aft Flight Deck, GSE is required to verify the core C&D equipment during system integration both at KSC and MSFC.

3.1.4 Organizational and Management Relationship

MSFC has been designated as the development management center for the Aft Flight Deck Payload dedicated controls and displays program. The core C&D equipment will be located in the orbiter AFD and therefore JSC will be required to ensure ICD compatibility.

3.1.5 Systems Engineering Requirements

3.1.5.1 Systems Engineering and Integration

Systems engineering and integration will include performance of the analyses and studies necessary to define requirements for the Aft Flight Deck Payload Core C&D, interfaces, ground support equipment (GSE) and support test equipment (STE), and product assurance. Systems design and integration, operations requirements analyses, GSE and STE requirements, and systems test requirements are all a part of the Aft Flight Deck (AFD) Core C&D engineering and integration (SE&I) task. Also included are interface analyses and definition, PSS Specification development and weight management. The objective of the SE&I analysis is to assure an integrated AFD core C&D design that provides a core capability for operating and controlling the many anticipated payloads for the Shuttle Orbiter, at the lowest life cycle cost to the Shuttle Program, compatible with the required level of capability and limitation formation to prospective payload developers.

3.1.5.2 Work Breakdown Structure (WBS)

The WBS for the AFD core C&D will be in accordance with MA-06 reference Volume III, Part I.

3.1.6 Government Furnished Property List

Orbiter TV camera to checkout and verify the EU video channel.

3.1.7 Critical Components

3.1.7.1 Engineering Critical Components List

Not pplicable.

3.1.7.2 Logistics Critical Components List

The failure mode and effects analysis (FMEA) will be performed and will be used to prepare the Critical Items List (CIL), which will be used to identify critical spares. This CIL shall include the Single Failure Point Summary and Critical Redundant Items. The corrective action required and/or rationale for retention shall be determined for each critical single failure point.

3.2 Characteristics

3.2.1 Performance

3.2.1.1 General Performance

The Ground Support Equipment (GSE) along with associated software and operator shall provide the capability to checkout and verify the Aft Flight Deck core controls and displays (C&D) equipment. The GSE shall be able to perform the checkout and verification with or without Spacelab equipment (experiment Remote Acquisition Unit, RAU). It shall provide the necessary stimuli (discrete and analog) to the C&D and it shall monitor the resulting responses. The GSE shall analyze test data (wherever possible) and provide a go/no-go indication. It shall inform the operator as to the test sequence to be followed. The GSE shall provide the capability to load and dump the applicable sections of memory within the electronics unit. The load and dump shall be performed via the data buses between the electronics unit and the GSE. The primary operational load mode shall be via the CDMS system, however providing this capability within the GSE will be useful for system checkout and integration.

The GSE shall be able to detect failures within the Multi-Use Mission Support Equipment (MMSE) at the component level. The GSE along with the proper test pattern interpretation by an operator and the Built-In-Test Equipment (BITE) test results shall detect failures within the Cathode Ray Tube (CRT)/Electronics Unit (EU)/Keyboard at the card level.

The video capability of the black and white CRT monitor of the MFDS shall be verified by providing a video signal from an appropriate orbiter camera. The TV camera shall be supplied as government furnished property. The video signal shall be in compliance with EIA-STD-RS-170.

The Ground Test Software which will control the various pieces of GSE hardware is defined in the ground test software CEI.

A complete set of GSE shall be comprised of the following pieces of equipment: central processor; Input/Output (I/O); mass storage; Display Unit (DU) and keyboard; and line printer. Except for part of the I/O hardware which will require a special design, all the equipment shall be standard commercial equipment. The most important characteristics of each piece of equipment is listed herein (Sections 3.2.1.2 through 3.2.1.6). Characteristics not mentioned will generally be satisfied by the presently available standard commercial equipment.

3.2.1.2 Central Processor

The central processor shall execute the software modules as defined in the Ground Test Software CEI. The central processor shall control and transfer data between the various items of GSE hardware and the core controls and displays.

3.2.1.2.1 Architecture

3.2.1.2.1.1 Word Length

The word length shall be 16 bits minimum.

3.2.1.2.1.2 Direct Memory Access (DMA)

There shall be a minimum of six DMA channels.

3.2.1.2.1.3 General Purpose Registers

There shall be a minimum of four general purpose registers.

3.2.1.2.1.4 Instruction Set

The central processor shall have a flexible group of input/output and bit manipulation instructions.

3.2.1.2.1.5 Vectored Priority Interrupt Levels

The central processor shall contain several levels of vectored priority interrupts.

3.2.1.2.2 Memory

3.2.1.2.2.1 Memory Size

Central processor shall contain a minimum of 16K core read/write memory. The first GSE set delivered shall contain a minimum of 48K core read/write memory. This additional memory will be required to allow development of ground test software.

3.2.1.2.2.2 Memory Parity

The core memory of the central processor shall contain memory parity circuitry.

3.2.1.2.3 Power Fail Safe/Auto Start

The highest priority level interrupt shall occur anytime AC power is turned on or off.

3.2.1.2.4 Real Time Clock

The real time clock shall cause an interrupt every 500 ms minimum.

3.2.1.2.5 Operator Control Panel

3.2.1.2.5.1 Control Panel Interrupt

The central processor shall be interrupted upon command from the control panel.

3.2.1.2.6 Hardware Floating Point Arithmetic

The central processor shall contain a hardware floating point arithmetic unit.

3.2.1.3 Input/Output Hardware

The input/output hardware shall provide the required (hardware) interface between the GSE and core control and display equipment. It shall provide the necessary discrete and analog inputs and outputs, along with various high speed serial digital I/O channels.

3.2.1.3.1 Digital Serial

The I/O hardware shall provide the necessary interface with the primary and redundant experiment and subsystem data buses. It shall also provide the necessary interface with the orbiter data bus. The interface shall consist of providing the correct parity checks, data formatting and timing signals as required to send and receive data over these buses. The GSE data and electrical input/output interface characteristics shall be compatible with the voltage, data rate, impedance, waveforms and performance requirements in IF-MA-0001, SS-P-0002-170, SS-P-0002-160, MC615-0010, EQ-MA-0010, EQ-MA-084 and EQ-MA-0002.

3.2.1.3.2 Subsystem Data Buses

The GSE via the subsystem data buses shall interface with the electronics unit(s) associated with the black and white CRT and tri-color CRT located at panels L-10 and L-11. The GSE shall interface to the electronic units stated above via both the primary and redundant subsystem data buses. The GSE shall be able to send commands to each electronic unit and receive responses from each electronic unit in the identical manner as the Spacelab subsystem computer.

3.2.1.3.3 Experiment Data Buses

The GSE via the experiment data buses shall interface with the electronics unit(s) associated with the black and white CRT and tri-color CRT located at panels L-10 and L-11. The GSE shall interface to the electronic units stated above via both the primary and redundant

experiment data buses. The GSE shall be able to send commands to each electronic unit and receive responses from each identical manner as the Spacelab experiment computer. The GSE electrical characteristics shall be compatible with the voltage, data rate, impedance, wave forms and performance requirements in IF-MA-0001.

3.2.1.3.4 Orbiter Data Bus

The GSE via the simulated orbiter data bus shall interface with the electronics unit(s) associated with the black and white CRT and tri-color CRT located at panels L-10 and L-11. The GSE shall be able to send commands to each electronic unit and receive responses from each electronic unit in the identical manner as the orbiter computer. The GSE electrical and data characteristics shall be compatible with the voltage, data rate, impedance, wave forms and performance requirements in SS-P-0002-170, SS-P-0002-160 and MC615-0010.

3.2.1.3.5 Multi-Use Mission Support Equipment (MMSE)

The GSE shall checkout and verify all items of MMSE. This includes all MMSE interfacing with a RAU or that which is handwired. The GSE via the experiment data buses shall interface indirectly with the MMSE located at panels L-12 and L-11 through the experiment RAU located in the AFD. The GSE shall interface to the RAU via both the primary and redundant experiment data buses. The GSE shall be able to send commands to the RAU and receive responses from the RAU in the identical manner as the Spacelab experiment computer. Also, the GSE shall be capable of interfacing directly to the MMSE located at panels L-12 and L-11 without the Spacelab RAU. The GSE shall provide all the discrete, analog and serial digital outputs in the identical manner as a Spacelab experiment RAU. The GSE shall also accept the identical discrete and analog inputs as required by the Spacelab experiment RAU.

3.2.1.4 Mass Storage

The mass storage unit shall store the operating procedures and various software modules. Its information shall be loaded into the central processor upon request from the central processor. The first GSE set delivered shall contain additional mass storage to facilitate development of ground test software.

3.2.1.4.1 Mass Storage Type

The type of mass storage shall be either a fixed head or moving head disc.

3.2.1.4.2 Storage Capacity

The total mass storage shall be a minimum of 1.0 million 16 bit words. In additional mass storage to facilitate development of ground test software will be required.

3.2.1.5 Display and Keyboard Unit

The CRT display and keyboard shall provide the operator the means to observe the test requirements and test results, and shall allow him to interact (via the keyboard) with the test program.

3.2.1.5.1 Screen Size

The screen size shall be 12 inches diagonal (minimum).

3.2.1.5.2 Display Format

The display format shall be 20 lines minimum, 80 characters.

3.2.1.5.3 Character Repertoire

There shall be 64 alpha-numerics and symbols ASCII coded.

3.2.1.5.4 Editing Features

The editing features shall include character and line insert/delete, character over write horizontal.

3.2.1.5.5 Input Power

The input power supply source shall be 115 volts 60 HZ.

3.2.1.6 Line Printer

The line printer shall provide a hard copy of the test sequence and test results.

3.2.1.6.1 Printing Rate

The printing rate shall be a minimum of 60 lines per minute.

3.2.1.6.2 Character Set

The character set shall consist of 10 numeric digits (0 through 9). 26 upper case letters (A through Z) and 26 special characters. All characters shall be ASCII compatible.

3.2.1.6.3 Columns

There shall be the standard 132 maximum columns per line.

3.2.1.6.4 Controls

The following controls are a minimum requirement.

3.2.1.6.4.1 Stop/Start Switch

The start/stop switch shall be lighted when "on".

3.2.1.6.4.2 Top of Form Switch

The top of form switch shall allow manual slewing to top of form.

3.2.1.6.4.3 Forms Override Switch

The override switch shall allow the operator to complete the form being printed before changing paper.

3.2.1.6.5 Input Power

The input power shall be 115 VAC, 60 HZ.

3.2.1.7 Tape Drive Unit

Tape drive for intercomputer program transfer (development unit only). One tape drive shall be required to enable development of core C&D software on an IBM 360/370 for transfer to the electronics units' memory in the MFDS.

3.2.2 Physical

Physical characteristics pertaining to the GSE shall be obtained from applicable sections of paragraph 3.2.1.

3.2.3 Reliability

Reliability provisions shall be in accordance with NHB5300.4 (1D-1).

3.2.3.1 Critical Single Failure Points

As a design goal, the GSE shall have no single failure that will jeopardize achieving the test objectives. In systems where this is not practical, sufficient safety margins should be used to minimize the probability of occurrence.

3.2.3.2 Failure Deterrent and Detection

The design shall incorporate the following:

a. The GSE shall be designed such that transient out-of-tolerance conditions or component failures will not cause other damage to, or failure of, other components.

b. Threaded parts and fasteners shall be positively locked to prevent loosening during service.

c. Bypass circuits used in checkout or calibration procedures shall not override electrical system protective devices.

d. Solid state switches and amplifiers shall be given preference over electromechanical relays and other vibration-sensitive electrical/electronic parts.

e. Unidirectional components or piece parts shall be designed to preclude backward installation by using non-symmetry of configuration, different connecting sizes, or comparable means.

3.2.3.3 Reliability Goals

The reliability goal of the GSE operation shall be TBD.

The probability that no GSE failures will prevent successful experiment command or display objectives shall be TBD for on-orbit operation.

3.2.4 Maintainability

The GSE elements subject to maintenance shall be designed, selected and installed to facilitate the performance of such tasks in a reasonable period of time with minimum hazard to equipment and personnel. Maintainability criteria in accordance with MIL-STD-470 shall be used. The design shall provide for maximum use of standard tools and test equipment.

3.2.4.1 Installation/Removal/Replacement Operations

The installation or removal of the payload dedicated controls and displays panels or consoles shall be accomplished at the launch site upon the return of the Space Shuttle Orbiter. The servicing of the payload dedicated controls and displays panels or consoles shall be consistent within the payload turnaround time constraints as specified by JSC 07700, Volume XIV and JSC 07700, Volume I-014-PIV-01.

The design shall provide for ease of removal, replacement, alignment, integration, and test.

3.2.4.2 Scheduled Servicing

The GSE design shall be such that scheduled maintenance frequencies for critical-limited items are not less than TBD years.

3.2.5 Operational Availability

This preliminary Part I CEI shall be updated as required by the PS Contractor. The PS Contractor shall maintain this document in the final Part I CEI form through the change control system established.

The Part I CEI document shall be submitted at the Preliminary Design Review (PDR) for final approval by MSFC prior to the start of the Development Phase. Review Item Disposition (RIDs) written against the CEI and approved shall be incorporated into the Part I CEI. After acceptance by MSFC, this document will be Government property, and shall be formally controlled as such in accordance with the requirements of the procuring activity.

3.2.6 Safety

Requirements for the GSE necessary to preclude hazards to personnel and equipment shall be as specified in the Safety paragraph of JSC 07700, Volume XIV, or contained herein. Hazard definition, classification categories, and hazard reduction precedence shall be as specified in NHB 5300.4 (1D-1), Safety, Reliability, Maintainability and Quality Provisions for the Space Shuttle Program, and NHB1700.1, NASA Safety Manual.

3.2.6.1 Crash Safety

Not applicable.

3.2.7 Environment

3.2.7.1 Natural

3.2.7.1.1 Transportation and Storage

The GSE shall perform as specified herein after exposure in a nonoperating condition to any combination of the environments and ranges specified in JSC-07700, Volume XIV and MJ070-0001-1B.

3.2.7.1.2 Handling

The GSE shall perform as specified herein after exposure to the environmental ranges specified in JSC-07700, Volume XIV when handled unpackaged.

3.2.7.2 Induced

3.2.7.2.1 Flight Operational

Not applicable.

3.2.7.2.2 Nonoperational

Not applicable.

3.2.8 Transportability/Transportation

The GSE shall be shipped in a container specifically designed to protect the hardware during highway and air transportation. Vibration, shock, pressure, temperature, humidity and contamination shall be controlled to levels specified below. Provisions shall be made in the GSE structure for suitable tie-down, lift and attachment points. All handling and transportation equipment shall be compatible with applicable structural and environmental limits. The GSE shall be designed to be transported in either the horizontal or vertical position.

3.2.9 Storage

The GSEshall have a storage life of ten years. Control shall be maintained on all parts and materials which are sensitive to age or the storage environments specified in paragraphs 3.2.7.1.1 and 3.2.7.1.2. These parts and materials shall be identified, and if deterioration is a factor during storage or after installation for use, the maintenance procedures shall indicate a replacement cycle or the necessary retesting.

3.2.10 Operability

3.2.10.1 Operating Life

TBD

3.2.10.2 Useful Life

The GSE shall have a minimum useful life to support up to 100 orbital missions in a 10-year period from date of delivery.

3.2.10.3 Shelf Life

The GSE shall be capable of operating in accordance with the requirements specified herein for a time period of 10 years from date of delivery.

3.3 Design and Construction Standards

3.3.1 Selection of Specifications and Standards

Specifications and standards necessary for the design and development of hardware, in addition to those specified in this document shall be selected in the following order of preference except as otherwise specified:

a. NASA specifications and standards.

b. Federal specifications and standards.

c. Military specifications and standards (MIL, JAN, or MS).

d. Other governmental specifications and standards.

e. Specification and standards released by nationally recognized associations, committees, and technical societies.

f. Supplier specifications and standards.

Specifications and standards shall be selected using MIL-STD-143 as a guide.

3.3.2 General

3.3.2.1 Materials, Parts and Processes

Not applicable.

3.3.2.2 Flammability Requirements

Materials used in the design of the GSE or contained in equipment installed therein, shall be compatible with the flammability requirements specified in NHB 8060.1A. SE-004-002-2H shall be used as a guideline to identify flammability hazards in air.

3.3.2.3 Outgassing of Materials

3.3.2.3.1 Internal Materials

Not applicable.

3.3.2.3.2 External Materials

Not applicable.

3.3.2.4 Lubrication

Not applicable.

3.3.2.5 Soldering

Not applicable.

3.3.2.6 Restriction of Use of Mercury

Mercury in liquid or vapor form shall not be used in the GSE. Where no satisfactory substitute exists or an alternate design or method cannot be used, the justification for the use of mercury, the protection provided to prevent its release, and a plan for decontamination in the event of its release shall be submitted to NASA/MSFC for approval.

3.3.3 Aeronautical

Not applicable.

3.3.4 Civil

Not applicable.

3.3.5 Electrical

3.3.5.1 Electrical Wiring

a. The wiring installation shall consist of cable harnesses where required. All wire bundles, harnesses and cables external to the component or vehicle shall conform to MSFC-DWG-40M39582. Wire used in cable harnesses shall shall conform to Specification MIL-C-17.

b. When etching of wire insulation is required in the GSE to provide satisfactory bonding to potting materials, the open end of the wire shall not be exposed to the etchant. The preferred process is to form the wire into a "U" shape, immerse only the bent portion in the etchant, and hold the open ends above the etchant level. The unetched end of the wire shall not be cut off prior to neutralization of the etchant. Electrical wire or cable insulated or coated with polyetrafluoroethylene or fluorinated ethylene propylene shall be etched prior to potting to assure mechanical bond strength and environmental seal. Potting shall be accomplished within three weeks after etching.

3.3.5.2 Electrical Connector Keying

All electrical plugs and receptacles used in the AFD core C&D panels shall be keyed or otherwise configured to prevent incorrect connection with other accessible plugs or receptacles.

3.3.5.3 Electrical Connector Pin Assignment and Pin or Socket Selection

a. Electrical circuits for the AFD core C&D panels shall not be routed through adjacent pins of an electrical connector if a short circuit between them would constitute a single point failure as defined in paragraph 3.2.3.

b. Cable connections of the AFD core C&D panels shall be designed so that pin and socket connectors are properly used to prevent power from shorting to ground. They also shall be designed to protect personnel both when connected and disconnected through the use of dead facing, explosion-proof connectors, or similar means.

3.3.5.4 Protection of Electrical and Electronic Devices

Electrical and electronic devices used in the GSE 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.

3.3.5.5 Electrical and Electronic Piece-Parts, Closure Construction

Not applicable.

3.3.5.6 Electrical Grounding

a. Primary DC Power Grounding - The GSE negative buses shall be referenced to structure at one point. The conductor from the main power return point to the single-point ground shall be designed to carry the maximum fault current. The single point ground shall be capable of being connected to the Shuttle.

b. Component Grounding - The primary DC power shall be isolated from all component structure. The component case ground shall be per MIL-B-5087B.

3.3.5.7 Electromagnetic Interference

3.3.5.7.1 Electromagnetic Compatibility (EMC)

The GSE shall be designed for electromagnetic self-compatibility and for electromagnetic compatibility (EMC) and for EMC with the Space Shuttle for phases that the GSE is active and in proximity with the Shuttle. The electrical and electronic equipment shall not be a source of, nor be susceptible to, electromagnetic interference as defined by MIL-STD-461A and 462.

3.3.5.7.2 Corona Suppression

Not applicable.

3.3.5.7.3 Lightning Protection

Electrical and electronic components shall be adequately protected from high currents induced by the lightning occurring at the launch site. The case ground shall be accomplished with the case connected to the structure through low-impedance conductive mounting surfaces. Where shock mounts or thermal isolation prevent this, then wide, flat, short bonding jumpers may be used in accordance with the bonding specification MIL-B-5087.

3.3.6 Mechanical

3.3.6.1 Design Safety Factors

The design safety factors shall have an ultimate safety factor of 3.0 and a yield safety factor of 2.0.

3.3.6.2 Fasteners

Threaded fasteners used for securing a single component, wherever possible, shall be the same type, size and tensile strength. Use of blind fasteners shall be minimized. Threaded fasteners shall be torqued per MSFC-STD-486.

3.3.6.2.1 Accessibility of Fasteners

Assembly and subassembly installations shall be designed such that access to threaded fasteners may be accomplished with the use of conventional tools.

3.3.6.2.2 Screw Threads

Screw threads for threaded fasteners used on Shuttle system hardware (except for GSE) shall be of unified thread form, Class 2, in accordance with MIL-S-7742 or MIL-S-8879, as applicable:

a. Material tensile ultimate strength levels up to, but not including, 160 KSI may be threaded per MIL-S-7742 or MIL-S-8879. Rolled threads are preferred.

b. Material strength levels of 160 KSI and above shall be threaded per MIL-S-8879. External threads shall be rolled after heat treatment. Screw threads used on airborne fluid systems fittings shall be of unified thread form, Class 2, in accordance with MIL-S-7742 or MIL-S-8879.

3.3.7 Nuclear

Not applicable.

3.3.8 Moisture, Humidity, and Fungus Resistance

Except as otherwise required by detail design considerations, only materials which resist the corrosive action of salt air and damage from moisture/humidity and fungus shall be used which conforms to MIL-STD-810.

3.3.9 Corrosion of Metal Parts

Metal parts shall be protected from corrosion by stress-relieving, plating, anodizing, chemical coatings, organic finishes, or combination thereof, provided that such protection is compatible with the operating and space environmental requirements.

3.3.9.1 Dissimilar Metals

Dissimilar metals, as defined in MIL-STD-889, shall not be used in combination unless they are suitably coated to prevent electrolytic corrosion.

3.3.9.2 Finish

Not applicable.

3.3.10 Contamination Control

Not applicable.

3.3.11 Coordinate System

Not applicable.

3.3.12 Interchangeability and Replaceability

The GSE shall be designed for ease of manufacture, assembly, inspection and maintenance. Insofar as practicable, the GSE components shall be interchangeable and/or replaceable in accordance with MIL-I-8500.

3.3.13 Identification and Marking

3.3.13.1 Identification of Parts

Each part fabricated shall be identified with a part number. The same specification or part number shall be used to identify all like materials, processes, and parts. Seller shall assign a new part number to the part when authorized changes make the superseded part not interchangeable with respect to interface, reliability, safety, logistics, traceability or performance. For traceable items, the part identification shall additionally include the manufacturer's identification code in accordance with DOD Handbook H 4-1, and be lot numbered or serial numbered when required.

3.3.13.2 Supplier Part Number

The supplier part number, which is equivalent to the GSE procurement part number, shall be in accordance with MIL-STL-310.

3.3.13.3 Identification of All Development/Qualification Test Specimens

Test specimens shall be permanently and obviously identified prior to testing with the words "ENG. TEST ONLY" in addition to the identification required by the drawing/specification to preclude their use on production items. The letters shall be idelible and provide a distinctive and vivid contrast with the color of the specimen. The lettering size and identification location shall be clearly visible to casual observation. Materials used for the identification shall be compatible with the test specimen and its operating environment. When the size or configuration of the test specimen is such the identification cannot appear on the specimen, other suitable means such as attached metal tags shall be used.

3.3.13.4 Nameplates

Nameplates shall be marked in accordance with MIL-STD-130 and shall include item name; buyer's part number; Federal North Atlantic Treaty Organization Stock Number (FSN/NATO); manufacturer; buyer; manufacturer's serial number, part number. Abbreviations, in accordance with MIL-STD-12, may be used.

3.3.13.5 Identification of Wiring

Identification of wiring shall not degrade insulation or shielding.

3.3.13.6 Electrical and Electronic Reference Designations

Electrical and electronic reference designations shall be affixed to the hardware in accordance with the USAS Y32.16-1968 (for external electrical connectors).

3.3.13.7 Electrical and Electronic Symbols

If schematic information is affixed to the GSE, the electrical and electronic symbols shall be in accordance with the requirements of USASY32.2-1967.

3.3.13.8 Reidentification

The part number of the GSE, its components, and parts shall be changed whenever redesign results in a change to dimensional form, fit tolerance, or functional characteristics from the previous configuration.

3.3.14 Workmanship

Workmanship on the GSE shall be in accordance with the best practice for high quality equipment within the state of the art.

3.3.15 Human Performance/Human Engineering

The design shall consider the capabilities and limitations of the human operator wherever a man-machine interface exists, including torques, forces, and other functional design characteristics of controls, displays, and work stations. The principal design guide for the man-machine interface shall be MIL-STD-1472 and MSFC-STD-512.

3.4 Logistics

3.4.1 Maintenance

a. The GSE shall not require scheduled maintenance.

b. The GSE shall not be designed to preclude the use of special tools and equipment for site maintenance and repairs. Special tools, if required, and approved by the buyer, shall be designed to withstand the intended use throughout the life of the equipment.

c. The GSE shall be designed to satisfy the requirements of a Line Replaceable Unit (LRU).

d. The GSE shall be designed so that routine corrective maintenance can be accomplished by the replacement of Shop Replaceable Units (SRUs). The GSE design shall be such that isolation to a single malfunctioning SRU can be accomplished during bench maintenance utilizing the LRU interface connectors or the addition of a system test connector is permissible to provide this isolation capability.

3.4.1.1 Installation

a. The equipment design shall physically prevent the incorrect installation of modules and submodules. Clearly visible color coding and labeling in close proximity to maintenance disconnect points shall be used to facilitate removal and replacement of any subassembly level of equipment.

b. Components shall be mounted in a manner to avoid blind adjustments.

c. Threaded fasteners used for securing a single component, where practical, shall be the same type, size, and tensile strength.

d. Captive fasteners shall be utilized to fasten LRUs.

3.4.1.2 Accessibility

a. Electrical connectors shall be accessible without disassembly or removal of functional equipment or components.

b. Servicing and test points shall be clearly marked and shall be accessible without requiring removal of access plates or covers except service caps. Calibration controls shall be accessible and clearly marked for major functions.

c. All fasteners on a single access cover shall be of the same length, diameter, and type.

3.4.1.3 Replacement

a. Mounting provisions shall permit SRU removal and replacement without disconnecting any equivalent level SRU in the line replaceable unit. If removal of a LRU structural element is required for access, such removal shall not affect electrical or mechanical alignment, nor shall the mechanical strength of the unit be impaired to the point that bending of the unit, its assemblies, electrical harnesses, or plumbing attachments will occur during normal bench handling of the unit.

b. Attachment fittings for components routinely removed shall be operable without hand tools and shall be accessible without requiring removal of access panels or covers.

3.4.2 Supply

The components, subassembly and assembly panels which make up the AFD core C&D design shall be recorded on delivery and tracked to assure that these components, subassemblies, and assemblies are available in stock and ready for use by each subsequent activity phase that may impact or influence the design.

The following information records shall be maintained for each of the items:

a. Part numbers.

b. Name of parts.

c. Quantity required and available.

d. Required delivery sites.

e. Planned use sites.

The above records will provide the required information to assure availability of items, and provide sufficient time to resupply components if it may appear that a shortage could occur prior to the next operation.

3.4.3 Facilities and Facility Equipment

Procured parts and materials will be received, inspected and stored in existing facilities. These same facilities will provide a bonded area which will store the qualified and acceptance tested parts or assemblies prior to delivery.

No new or unique facilities will be required for the logistics requirements.

3.5 Personnel and Training

Standard aerospace management, engineering, manufacturing, product assurance, and test practices as applied to prior space programs as Gemini, Apollo, Skylab, etc. will be utilized for the PS contractor's design/development phase.

This approach will enable these space program practices to be applied to the PS contractor's activities and, thereby, no new requirements will be needed for personnel training, training equipment and facilities.

MSFC or its designated government quality representative will verify the adequacy of the discipline practices utilized.

3.6 Interface Requirements

3.6.1 Interprogram Interfaces

Interfaces between the AFD core C&D program, of which this specification is a part, and other programs (e.g., Orbiter, Spacelab, IUS) will be controlled by ICDs to be supplied by the Phase C/D contractor for mechanical, electrical and software interfaces.

3.6.2 Intraprogram Interfaces

The relationship between this CEI and the other CEIs within the AFD core C&D program is shown in Figure 3.6.3-1. Each CEI (project level) defines the specific interface requirements applicable to the individual project.

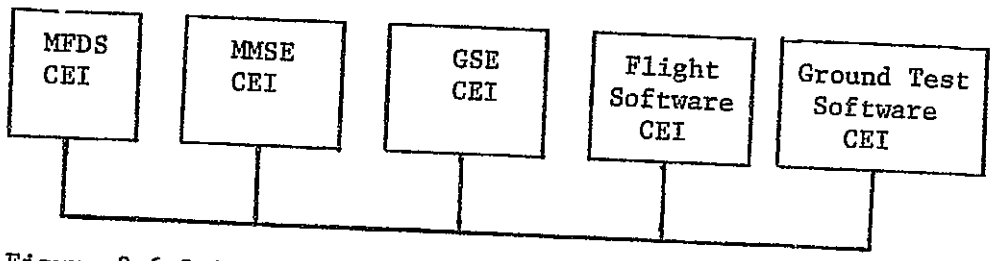

Figure 3.6.3-1 Intraprogram CEIs

3.6.3 Intraproject Interfaces

3.6.3.1 CRT and Keyboard/Central Processor

The CRT and Keyboard shall be connected to the central processor via any of the standard asynchronous interfaces.

3.6.3.2 Mass Storage/Central Processor

The mass storage unit shall be connected to the central processor via either a parallel data bus or a direct memory access channel.

3.6.3.3 Line Printer/Central Processor

The line printer shall be connected to the central processor via either a serial or parallel data bus interface.

4.0 VERIFICATION

The verification program is designed to verify that the GSE hardware conforms to the design, construction, and performance requirements as specified in Section 3 herein. Each requirement presented in Section 3 will be verified by test or assessment as specified in Section 4.

4.1 General

The following subparagraphs specify the organizational responsibility for accomplishing verification, verification methods to be used, requirements for test/equipment failures, and requirements for phased verification.

4.1.1 Responsibility for Verification

Organizational responsibilities for performing and supporting verification during the various verification phases of Paragraph 4.2 shall be as defined herein. Responsibilities are defined as primary and supportive. It shall be the Government's right to witness and verify the results of all verification accomplished.

Verification Phase	*Organizational Responsibility for Verification.	
	Primary	Supportive or Witness
1. Development	PS Contractor	MSFC
2. Qualification	PS Contractor	MSFC
3. Acceptance	PS Contractor	MSFC

*Legend

MSFC NASA-MSFC

4.1.2 Verification Method Selection

Verification methods shall include test during each verification phase as applicable, or assessment by similarity, analysis, inspection, demonstration, and validation or records. These methods are defined in paragraph 4.3.1.

4.1.2.1 Design Margin Verification Selection

Where integrity is verified by analysis only, the following factors of safety shall be used:

Yield Factor of Safety - 2.0
Ultimate Factor of Safety - 3.0

4.1.3 Flight Hardware Failures

Not applicable.

4.1.4 Test/Equipment Failures

Test policy for the GSE shall include tests which demonstrate a completely checked out end item within specification performance of all systems. To this end, the test program shall encompass: all component and system malfunctions corrected or satisfactorily explained and accepted and appropriate reverification required following equipment replacement because of failure or other reasons.

Retest shall be performed after failure or equipment replacement to the extent necessary to restore confidence in the equipment. The retest requirements shall be specified at time of failure or replacement and shall be a part of the controlling documentation. Reverification may be deferred to the next scheduled functional test of the affected hardware. Reverification must be accomplished prior to launch for flight equipment.

4.2 Phased Verification Requirements

Phased verification of the Section 3 requirements shall be as specified in the Paragraph 4.3 Verification Cross Reference Index. Definitions of the verification phases follow in Paragraph 4.2.1 through 4.2.8.

4.2.1 Development

Development verification is the process for verifying the feasibility of the design approach and to provide confidence in the ability of the hardware to pass qualification. Where visibility and control of vendor hardware development is required, appropriate direction shall be included in the applicable procurement drawings/specifications.

4.2.2 Qualification

The GSE including all components shall be qualified prior to launch. Where visibility and control of vendor hardware is required, appropriate direction shall be included in the applicable procurement drawings/specifications. Test types, durations and levels shall be specified. Qualification shall be accomplished by any one or more of the following:

a. Test - Qualification Testing

b. Assessment - (1) Similarity; (2) Analysis; (3) Inspection; (4) Demonstration; (5) Validation of Records.

Qualification testing methods are defined in the following paragraphs. Assessment methods definitions are presented in Paragraph 4.3.1.

4.2.2.1 Qualification Testing

Qualification testing is an individual or series of performance/functional and environmental tests conducted on hardware at environmental test conditions normally more severe than acceptance test conditions to establish that the hardware will perform satisfactorily in the use environments with sufficient margin.

4.2 3 Acceptance

The GSE including all components, shall be acceptance tested prior to launch. Where visibility and control of vendor hardware is required, appropriate direction shall be included in the applicable drawings/specifications. Test types, durations and levels shall be specified. Acceptance testing shall be applicable to component through system level.

4.2.3.1 Component Acceptance Testing

Component acceptance tests consist of performance/functional and acceptance level environmental tests to assure compliance with required specifications. This testing is conducted to detect manufacturing flaws and workmanship defects that cannot be detected by normal inspection techniques as well as verify functional conformance to design specifications including environmental exposures.

4.2.3.2 Subsystem/Systems Acceptance Test

These tests shall be performed as appropriate following component acceptance tests to demonstrate compliance to specifications. Subsystem and system verification in various operating modes and interfaces at normal supply voltages will be considered.

4.2.3.3 GSE Acceptance Testing

The GSE shall be acceptance tested as an end item prior to its delivery to the next higher level of hardware assembly. Testing includes system to system interface checks, operation of individual GSE systems, combined systems functional and mission sequence simulation tests. Test types, durations and levels shall be specified.

4.2.4 Integrated Systems

This phase consists of the testing performed after the mating of the GSE with the Orbiter or Spacelab subsystems, and will be the responsibility of the Mission Contractor. The PS Contractor shall support the Mission Contractor.

4.2.5 Prelaunch Checkout

This phase of testing will be the responsibility of the Mission Contractor, and the PS Contractor shall support the Mission Contractor.

4.2.6 Launch

This phase of testing will be the responsibility of the Mission Contractor.

4.2.7 Flight/Mission Operations

This phase of testing will be the responsibility of the Mission Contractor.

4.2.8 Post-Flight

This phase of testing will be the responsibility of the Mission Contractor.

4.3 Verification Cross-Reference Index

The verification cross-reference index provides a one-for-one cross reference of each verification requirement for each Section 3 requirement. Verification shall be by test or assessment. Test types and phases were described in Paragraph 4.2. Assessment methods are described below.

4.3.1 Assessment Methods

Assessment methods include: (a) similarity; (b) analysis; (c) inspection; (d) validation of records; and (e) demonstration. A brief definition of the methods as used herein follows:

a. Similarity - Qualification by similarity shall be considered if it can be demonstrated, by review of prior test data or application of hardware (flight or usage experience), that the article is similar or identical in design and manufacturing process to another article that has previously been qualified to equivalent or more stringent environmental criteria (e.g., Skylab, Apollo and/or Gemini hardware).

b. Analysis - Analysis may be used for verification in lieu of, or in addition to testing to verify compliance to specification requirements. The selected techniques may include, typically, systems engineering analysis, statistics, qualitative analysis, analog, modeling, and computer simulations. Analysis may be considered when it can be determined that:

   1) Rigorous and accurate analysis is possible.
   2) Test is not cost-effective.
   3) Similarity is not applicable.
   4) Verification by inspection is not adequate.

c. Inspection (End-Item) - Inspection techniques (e.g., verification of compliance with drawings, wire coding, material compliance, etc) may be used in lieu of or in conjunction with testing to verify design features (e.g., dimensions, bonding, assembly methods, etc).

d. Validation of Records - Manufacturing records may be used at end-item acceptance to verify latent construction features and processes for flight hardware and associated support equipment.

e. Demonstration - Demonstration techniques (e.g., service access, transportability, crew-hardware interfaces, replacement provisions, etc) may be used in lieu of or in conjunction with test to verify compliance with the requirements.

4.3.2 GSE Verification Requirements Matrix

Verification requirements for Section 3 paragraphs are identified in Table 4.1. The left-hand column of the matrix identifies each Section 3 requirement by paragraph number and where required, by sentence number of the paragraph. The verification method(s) for the various verification phases are presented in the matrix. The right hand column identifies the applicable Verification Plan paragraph number which defines and directs implementation of each verification requirement.

4.4 Test Support Requirements

Test support including test facilities and equipment, bench setups, test software and test interfaces shall be as defined.

4.4.1 Facilities and Equipment

a. Existing facilities/equipment with NASA or other government agencies and contractors shall be utilized to the maximum extent practicable.

b. GSE test activities including test facilities/equipment, personnel, and procedures shall be established and included in the Verification Plan.

c. Maximum use of the same or common GSE test equipment shall be used for testing at multiple locations to assure uniformity of test results.

d. All test equipment shall be designed with a fail-safe goal such that test equipment failure will not degrade flight hardware. All test equipment shall be tested prior to interfacing with flight equipment to ensure that no damage or degradation to flight hardware will be induced. Appropriate tolerances shall be identified in the procedures, taking into account test equipment capabilities and flight hardware specifications, such that the test results will verify compliance with the flight hardware specifications.

4.4.2 Articles

Test articles, if required to support the test program, shall be as identified.

4.4.3 Software

Requirements governing software utilization in support of verification operations shall be as identified.

4.4.4 Interfaces

Where verification requires interfacing of the GSE with other STS project equipment/facilities, the Mission Contractor shall direct and support the test activities in accordance with the applicable contractual agreement(s).

TABLE 4-1 VERIFICATION CROSS-REFERENCE

REQUIREMENTS FOR VERIFICATION

NOMENCLATURE:	CRIT. CAT:
CEI NO.	CEI SPEC NO.

VERIFICATION METHOD

1. TEST
2. ASSESSMENT
   a. SIMILARITY
   b. ANALYSIS
   c. INSPECTION
   d. DEMONSTRATION
   e. VALIDATION OF RECORDS

N/A = NOT APPLICABLE

VERIFICATION PHASES

A. DEVELOPMENT
B. QUALIFICATION
C. ACCEPTANCE
D. INTEGRATED SYSTEM
E. PRELAUNCH CHECKOUT
F. FLIGHT VERIFICATION
G. LAUNCH
H. POST FLIGHT

PERFORMANCE/DESIGN REQUIREMENT REFERENCE	VERIFICATION METHOD									TEST/ASSESSMENT REQUIREMENT REFERENCE
	N/A	A	B	C	D	E	F	G	H	
3.2.1.1 General Performance		-	-	1						4.2.3
3.2.1.2 Central Processor	x	-	-	-						
3.2.1.2.1 Architecture		-	-	2C						4.3.1.C
3.2.1.2.2 Memory		-	-	2C						4.3.1.C
3.2.1.2.3 Power Fail Safe/Auto Start		-	-	1						4.2.3
3.2.1.2.4 Real Time Clock		-	-	1						4.2.3
3.2.1.2.5 Operator Control Panel		-	-	1						4.2.3
3.2.1.2.6 Hardware Floating Point		-	-	1						4.2.3
3.2.1.3 Input/Output		1	1	1						4.2.1, 4.2.2, 4.2.3

Table 4-1 Verification Cross-Reference

REQUIREMENTS FOR VERIFICATION

NOMENCLATURE:										SHEET 2 OF 2
CEI NO.				CEI SPEC NO.						CRIT CAT:
PERFORMANCE/DESIGN REQUIREMENT REFERENCE	VERIFICATION METHOD									TEST/ASSESSMENT REQUIREMENT REFERENCE
	N/A	A	B	C	D	E	F	G	H	
3.2.1.3.1 Digital Serial		-	-	1						4.2.3
3.2.1.3.2 Subsystem Data Buses		-	-	1						4.2.3
3.2.1.3.3 Experiment Data Buses		-	-	1						4.2.3
3.2.1.3.4 Orbiter Data Bus		-	-	1						4.2.3
3.2.1.3.5 MMSE		-	-	1						4.2.3
3.2.1.4 Mass Storage		-	-	1						4.2.3
3.2.1.4.1 Mass Storage Type		-	-	2C						4.3.1.C
3.2.1.4.2 Storage Capacity		-	-	2C						4.3.1.C
3.2.1.5 Display & Keyboard Unit		-	-	1						4.2.3
3.2.1.5.1 Screen Size		-	-	2C						4.3.1.C
3.2.1.5.2 Display Format		-	-	2C						4.3.1.C
3.2.1.5.3 Character Repertoire		-	-	1						4.2.3
3.2.1.5.4 Editing Features		-	-	1						4.2.3
3.2.1.5.5 Input Power		-	-	2C						4.3.1.C
3.2.1.6 Line Printer		-	-	1						4.2.3
3.2.1.6.1 Printing Rate		-	-	2C						4.3.1.C
3.2.1.6.2 Character Set		-	-	1						4.2.3
3.2.1.6.3 Columns		-	-	2C						4.3.1.C
3.2.1.6.4 Controls		-	-	2C						4.3.1.C
3.2.1.6.5 Input Power		-	-	2C						4.3.1.C

5.0 PREPARATION FOR DELIVERY

Preservation and Packaging - GSE end items shall be preserved and packaged in accordance with the following:

5.1 Physical Protection

Containers shall be compatible with on-site transportation, handling and storage methods. For convenient handling and stacking, containers having a gross weight of more than 150 pounds shall be provided with integral skids or pallets for shipment. Attach points shall be provided where applicable for crane hoist and tie-down. Padded van shipments will generally be utilized for racks and consoles.

5.2 Weight and Size

The weight and dubic displacement of packaging and packing shall be held to a minimum consistent with the requirement of the item and the method of transportation. GSE shall be designed so that the configuration (i.e., item)may be disassembled as required and packaged for shipment.

5.3 Parts Protection

There shall be an efficient, reliable and economical system for the protection of all GSE parts during manufacturing processes and in-plant handling and storage. There shall be standardization of parts protection procedures, methods, materials and devices such as carts, boxes, containers or transportation vehicles necessary to prevent damage to parts.

5.4 Marking

Containers shall be marked according to the requirements contained in MIL-STD-129.

6.0 NOTES

6.1 Definition and Design Terms

Multifunction Display System - AFD hardware (located at panels L-11 and L-10) consisting of two CRT displays, electronic unit and keyboard. The system is used to control and monitor payload experiments on orbit.

Built-In-Test Equipment - Circuitry provided to perform continuous monitoring of specific parameters, groups of parameters, or functions of the LRU to provide a go/no-go indication. This type of built-in-test capability represents those implementational techniques that are autonomous and provide continuous real-time monitoring, but do not interrupt normal operation of the LRU.

Closed Circuit Television - Orbiter equipment consisting of TV cameras (located in the payload bay and forward section of the orbiter) and TV monitors (located at the aft flight deck). The system is used for monitoring of payload bay and cabin area activities.

Display Unit - The display unit consists of one CRT monitor (either black and white or color) and forms a integral part of the multifunction display system. The display unit is used to present experiment status and data in the form of alpha numerics, graphics and video.

Electronic Unit - The electronics unit is an integral part of the multifunction display system. It interfaces with the various flight computers and interprets computer commands. It creates and controls all displays for the display unit.

Ground Support Equipment - This ground equipment consists of a minicomputer, CRT display keyboard unit, mass storage, line printer and input/output units. It is used to checkout and verify the AFD core controls and displays hardware.

Interconnecting Stations - Spacelab equipment used to tie AFD core equipment to either the Spacelab subsystem or experiment data buses. The interconnecting stations isolate and protect the buses from the equipment on the buses.

Input/Output - Interfacing hardware/software between a computer and the equipment it is monitoring or controlling.

Input/Output Processor - Similar to input/output but with additional data formatting and processing.

Remote Acquisition Unit - Spacelab equipment used to interface a spacelab computer to various experiments for monitoring and control.

Read Only Memory - A device used for the storage of information in digital form. This information cannot be changed. Information can only be obtained (read) from this memory.

Read/Write Memory - A device used for the storage of information in digital form. This information may be changed as required. Information in memory can either be obtained (read) from memory or placed (written) into memory.

Line Replaceable Unit - A combination of components, units, parts, assemblies, subassemblies, etc., that are contained in one package or are so arranged that together the combination is common to one mounting and, in addition, provides a complete function to the larger entity within which it operates.

Shop Replaceable Unit - An integral subassembly of an LRU consisting of units and parts or a combination of parts so arranged that together the combination is common to one mounting and, in addition, provides a complete function to the larger entity within which it operates.

Standard Commercial Equipment - Standard commercial equipment as utilized herein shall be defined as equipment identical to, or modified from equipment items which are normally, or have been, sold or offered to the public commercially by any supplier and which are incorporated as component parts/assemblies in or to be used with the GSE.

6.2 List of Acronyms

AC	Alternating Current
ASCII	American Standard Code for Information Interchange
AVT	Acceptance Verification Test
AFD	Aft Flight Deck
BITE	Built-In-Test Equipment
B&W	Black & White
CCD	Core Controls and Displays
CCTV	Closed Circuit Television
CDR	Critical Design Review
CEI	Contractor End Item
CEL	Critical Item List
CRT	Cathode Ray Tube
C&D	Controls & Displays
DC	Direct Current
DDU	Data Display Unit
DU	Display Unit
EMC	Electromagnetic Compatibility
EU	Electronic Unit
FMEA	Failure Modes & Effects Analysis
GPC	General Purpose Computer
GSE	Ground Support Equipment
HZ	Hertz
I/O	Input/Output
IOP	Input Output Processor
IPS	Instrument Pointing System
IS	Interconnecting Station
KB	Keyboard
LRU	Line Replaceable Unit

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MFDS	Multifunction Display System
MHZ	Mega Hertz
ms	Milliseconds
MS	Mission Station
OOS	On-Orbit Station
PDB	Power Distribution Box
PDR	Preliminary Design Review
Phm	Parts Per Hundred Million
PS	Payload Station
RAU	Remote Acquisition Unit
RID	Review Item Disposition
ROM	Read only Memory
R/W	Read and Write
SE&I	Systems Engineering & Integration
S/L	Spacelab
SRU	Shop Replaceable Unit
STE	Support Test Equipment
TBD	To Be Determined
TV	Television
WBS	Work Breakdown Structure

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