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Houston, Texas 77058**

Hardware Requirements Document (HRD)
for the
Human Research Facility
Ultrasound System

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for the
Human Research Facility
Ultrasound System

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ACRONYMS AND ABBREVIATIONS

2D	Two-dimensional
3D	Three-dimensional
ADP	Acceptance Data Package
ASE	Airborne Support Equipment
AVT	Acceptance Vibration Test
CCB	Configuration Control Board
CDR	Critical Design Review
CHIP	Common Hardware Implementation Plan
CIL	Critical Items List
COTS	Commercial-off-the-Shelf
CR	Change Request
CSCI	Computer Software Configuration Item
CSI	Contrast Specific Imaging
CW	Continuous Wave
dB	Decibels
DC	Direct Current
DICOM	Digital Imaging and Communications in Medicine
DMD	Dynamic Mode Differentiation
DR	Discrepancy Report
ECG	Electrocardiogram
EEE	Electrical, Electronic, and Electromechanical
EIA/TIA	Electronics Industries Association/Telecommunications Industries Association
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EXT	External
FIAR	Failure Investigation Action Report
FMEA	Failure Modes and Effects Analysis
FRD	Functional Requirements Document
g_{rms}	gravity (g), root mean square
GCAR	Government Certification Approval Request
GSE	Ground Support Equipment (Engineering)
HCI	Human-Computer Interface
HFE	Human Factors Engineering
HRD	Hardware Requirements Document
HRF	Human Research Facility
HW	Hardware
Hz	Hertz

ACRONYMS AND ABBREVIATIONS (Cont'd)

ICD	Interface Control Document
INT	Internal
I/O	Input/Output
ISS	International Space Station
IVA	Intravehicular Activity
JHB	Johnson Handbook
JSC	Johnson Space Center
JSCM	Johnson Space Center Manual
LAN	Local Area Network
LED	Light Emitting Diode
LS	Life Sciences
MB	Megabyte(s)
MHz	Megahertz
MIL-STD	Military Standard
M-Mode	Motion Mode
MO	Magneto-Optical
MSFC	Marshall Space Flight Center
MTBF	Mean Time Between Failures
NASA	National Aeronautics and Space Administration
NHB	NASA Handbook
NPSL	NASA Parts Selection List
NSTS	National Space Transportation System
oct	octave
PCS	Portable Computer System
PDA	Pre-delivery Acceptance
PIA	Pre-installation Acceptance
PRD	Program Requirements Document
psi	pounds per square inch
psia	pounds per square inch, absolute
PU	Panel Unit
QA	Quality Assurance
QAVT	Qualification Acceptance Vibration Test
QEPM&L	Qualified Electrical, Electronic, Electromechanical Parts, Manufacturers and Laboratories
QVT	Qualification Vibration Test
RGB	Red, Green, Blue (video)

ACRONYMS AND ABBREVIATIONS (Cont'd)

S&MA	Safety and Mission Assurance
SAR	Stress Analysis Report
SCPR	Support Contractor Purchase Request
SDP	Software Development Plan
SIR	Standard Interface Rack
SRS	Software Requirements Specifications
SSP	Space Station Program
TBD	To Be Determined
TCD	Transcranial Doppler
TGC	Time Gain Compensation
TIs/TIb	Thermal Index soft tissue/bone
TPS	Task Performance Sheet
TR	Trace
TRR	Test Readiness Review
TSC	Telescience Center
UOF	User Operations Facility
US	Ultrasound/Ultrasound System
VC-S	'visibly clean'-sensitive
VTR	Video Tape Recorder

1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this Hardware Requirements Document (HRD) is to describe and delineate the methods by which the National Aeronautics and Space Administration (NASA) Lyndon B. Johnson Space Center (JSC) will design, develop, test, and certify the Ultrasound System for the International Space Station (ISS) Human Research Facility (HRF). This document was prepared by following the HRF HRD template, LS-71099, as established by the HRF program.

1.2 SCOPE

The requirements established herein are applicable only to the Ultrasound System. This HRD identifies unique, general construction, and environmental design requirements in Sections 3, 4 and 5 respectively. Section 6 identifies the certification approach. For HRF, certification is defined as the combination of acceptance and qualification. Sections 7 and 8 describe the acceptance and qualification approach and tests respectively. Detailed facility and functional test plans will be written separately for specific certification tests as they are required. These detailed test plans (not necessarily formalized documents) will include sections on specific test procedures, instrumentation requirements, and test support fixture configuration.

2.0 APPLICABLE DOCUMENTS

The following specifications, standards, and publications are considered applicable to this HRD because they are each specifically called out in individual requirements in this HRD. No document/specification will appear in this section without being referenced in a HRD requirement section. Revision letters shall accompany the document call-outs so that work authorization documents can be written from this HRD. If the HRF Master List of Documents is revised to reflect an updated document revision, any required changes to this document will be made via a Change Request (CR) processed through the Configuration Control Board (CCB).

(NOTE: If no revision is indicated, the basic release is implied.)

2.1 SPECIFICATIONS

JSC-20793	Manned Space Vehicle Battery Safety Handbook
JSC-27301A	Materials Control Plan for JSC Flight Hardware
MIL-S-7742B Ch 1	General Specification for Screw Threads, Standard, Optimum Selected Series
MIL-S-8879C Ch 1	General Specification Screw Threads, Controlled Radius Root With Increased Minor Diameter
MIL-PRF-19500L	Performance Specification: Semiconductor Devices, General Specification for
MIL-S-33540	General Specification for Liquid Locking Compounds
MSFC-SPEC-522B Ch 1	Design Criteria for Controlling Stress Corrosion Cracking
MS33540J Ch 1	General Practices for Safety Wiring and Cotter Pinning
NSTS-1700.7B Ch 4	Safety Policy and Requirements for Payloads Using the Space Transportation System
NSTS-1700.7B ISS Addendum	Safety Policy and Requirements for Payloads Using the International Space Station
SE-M-0096A	General Specification for Materials and Processes, Requirements for JSC Controlled Payloads
SN-C-0005D Ch 6	Space Shuttle Contamination Control Requirements
SP-T-0023B	Specification, Environmental Acceptance Testing
SSP-30237D	Space Station Electromagnetic Emission and Susceptibility Requirements
SSP-30245D Ch 4	Space Station Electrical Bonding Requirements
SSP-30312F	Electrical, Electronic, and Electromechanical (EEE) and Mechanical Parts Management and Implementation Plan for Space Station Program
SSP-30695A	Acceptance Data Package Requirements Specification

2.2 STANDARDS

EIA/TIA-232-E	Interface Between Data Terminal Equipment and Data Circuit - Terminating Equipment Employing Serial Binary Data Interchange
JSC-23642C	JSC Fastener Integrity Testing Program
JHB 8080.5	JSC Design and Procedural Standards Manual
JPG 8500.4	Engineering Drawing System Manual
MIL-STD 810E	Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests
MIL-STD-794E Ch 2	Procedures for Packing of Parts and Equipment NASA Parts Selection List (NPSL)
SSP-50005B Ch 1	International Space Station Flight Crew Integration Standard
SSP-50008B	International Space Station Interior Color Scheme

2.3 PUBLICATIONS

JHB-5322	Contamination Control Requirements Manual
LS-71000	Program Requirements Document for the Human Research Facility
LS-71001A	Functional Requirement Document for the Human Research Facility
LS-71002	System Safety Program Plan for the Human Research Facility
LS-71003A	Concept of Operations for the Human Research Facility
LS-71005	Configuration Management Plan for the Human Research Facility
LS-71010	Fracture Control Plan for the Human Research Facility Payload and Racks
LS-71011	Acoustic Noise Control and Analysis Plan for the Human Research Facility Payload and Racks
LS-71012	Structural Analysis Plan for the Human Research Facility Payload and Racks
LS-71013	Logistics and Maintenance Plan for the Human Research Facility
LS-71016	Electromagnetic Compatibility Control Plan for the Human Research Facility
LS-71019	Data System Architecture Definition for the Human Research Facility
LS-71020 Ch 1	Software Development Plan for the Human Research Facility

LS-71026	Reliability Plan for the Human Research Facility
LS-71030 Draft 10/97	Quality Assurance Plan for the Human Research Facility
LS-71040-2 Draft 7/1/97	Interface Control Document (ICD) for the Ultrasound System, Human Research Facility
LS-71042-2	Hardware Requirements Document for the Human Research Facility Workstation
LS-71062	Software Requirement Specification (SRS) for the Human Research Facility Common Software
LS-71098	Common Hardware Implementation Plan (CHIP) for the Human Research Facility
LS-71130	Human Research Facility Human-Computer Interface (HCI) Design Guide
SSP-30423F	Space Station Approved Electrical, Electronic, and Electromechanical (EEE) Parts List
SSP-30512C	Space Station Ionizing Radiation Design Environment
SSQ-25002A Ch 6	Supplemental List of Qualified Electrical, Electronic, Electromechanical (EEE) Parts, Manufacturers, and Laboratories (QEPM&L).

2.4 SELECTION OF SPECIFICATIONS AND STANDARDS

Specifications and standards necessary for design and development shall be selected in the following order of preference, except as otherwise specified in this document. The exact issue shown is to be used, unless otherwise specified in this document.

In the event of conflict, the order of precedence shall be:

1. LS-71000, Program Requirements Document (PRD) for the Human Research Facility
2. JSC Drawing number(s), as referenced in this document.
3. NASA specifications and standards
4. Manned spacecraft criteria and standards
5. Federal specifications and standards
6. Military specifications and standards
7. Other governmental specifications and standards
8. Specifications released by nationally recognized associations, committees, and technical societies

3.0 UNIQUE DESIGN REQUIREMENTS

This hardware requirements section contains a general hardware system description (for reference) and the requirements for hardware system performance, load, physical (e.g., weight, envelope, etc.), interface, and software design. The Certification Matrix found in Appendix B specifies the method of compliance for each of the following requirements.

3.1 ULTRASOUND SYSTEM

3.1.1 Description

The HRF Ultrasound System is a medical instrument that utilizes ultrasound energy to perform medical imaging and to measure flow rates. The system generates and receives ultrasound signals using hand-held probes. The system contains hardware and software to display and analyze sonographic information. The user controls the software and hardware with a user interface consisting of a keyboard, control switches, knobs and a trackball. The system performs functions to support the following applications:

- Cardiac ultrasound
- Abdominal ultrasound (deep organ)
- Vascular ultrasound
- Gynecological ultrasound
- Muscle and tendon ultrasound
- Transcranial ultrasound
- Ultrasound contrast studies
- Small parts ultrasound
- Veterinary ultrasound

The physical configuration of the Ultrasound System consists of a main electronics unit, keyboard, and stowed ultrasound items (Figure 3-1). The main electronics unit is a rack-mounted 16-panel unit (PU) assembly that contains the ultrasound system electronics, main electronics power supply modules, Hi-8 mm video tape recorder (VTR), and ventilation system (Figure 3-2). The main electronics unit shall be compatible with the HRF Rack (Figure 3-3).

Stowed items shall consist of a keyboard, keyboard and display cables, ultrasound probes, Electrocardiogram (ECG) cables, stereo headphones, microphone, Hi-8mm video cassettes, magneto-optical (MO) disks, and acoustic coupling gel. The probes consists of a probehead, integral cable, and connector for interface to the main electronics unit. ECG cables shall be used to connect surface ECG electrodes to the main electronics unit. The stereo headphones will be used for Doppler flow measurements and the microphone for dictation. Both devices include a cable and connector for the audio interface on the keyboard.

During launch and landing and on-orbit operations, the main electronics unit shall be rack-mounted. During launch and landing, stowed items shall be contained in stowage

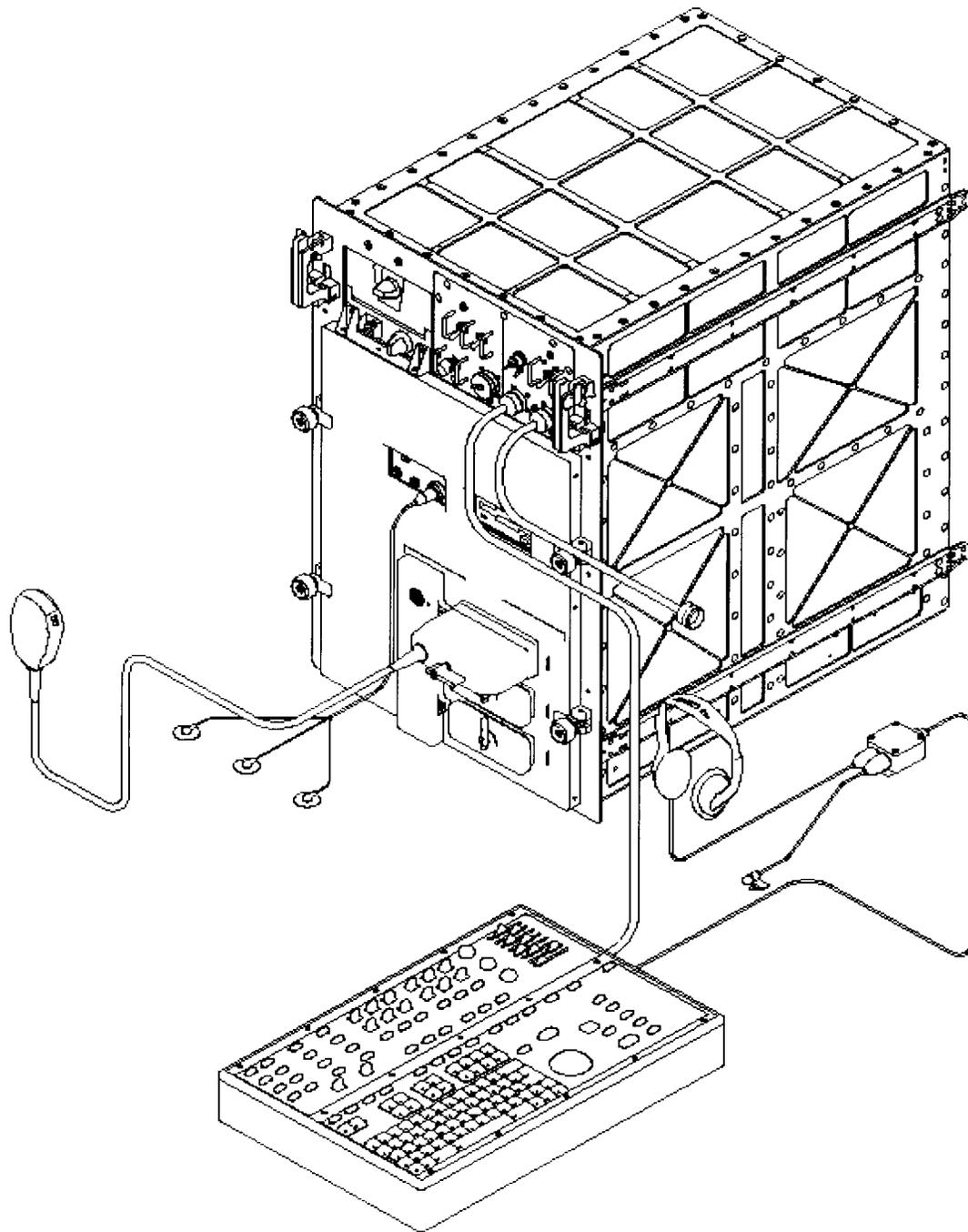


Figure 3-1. Ultrasound System

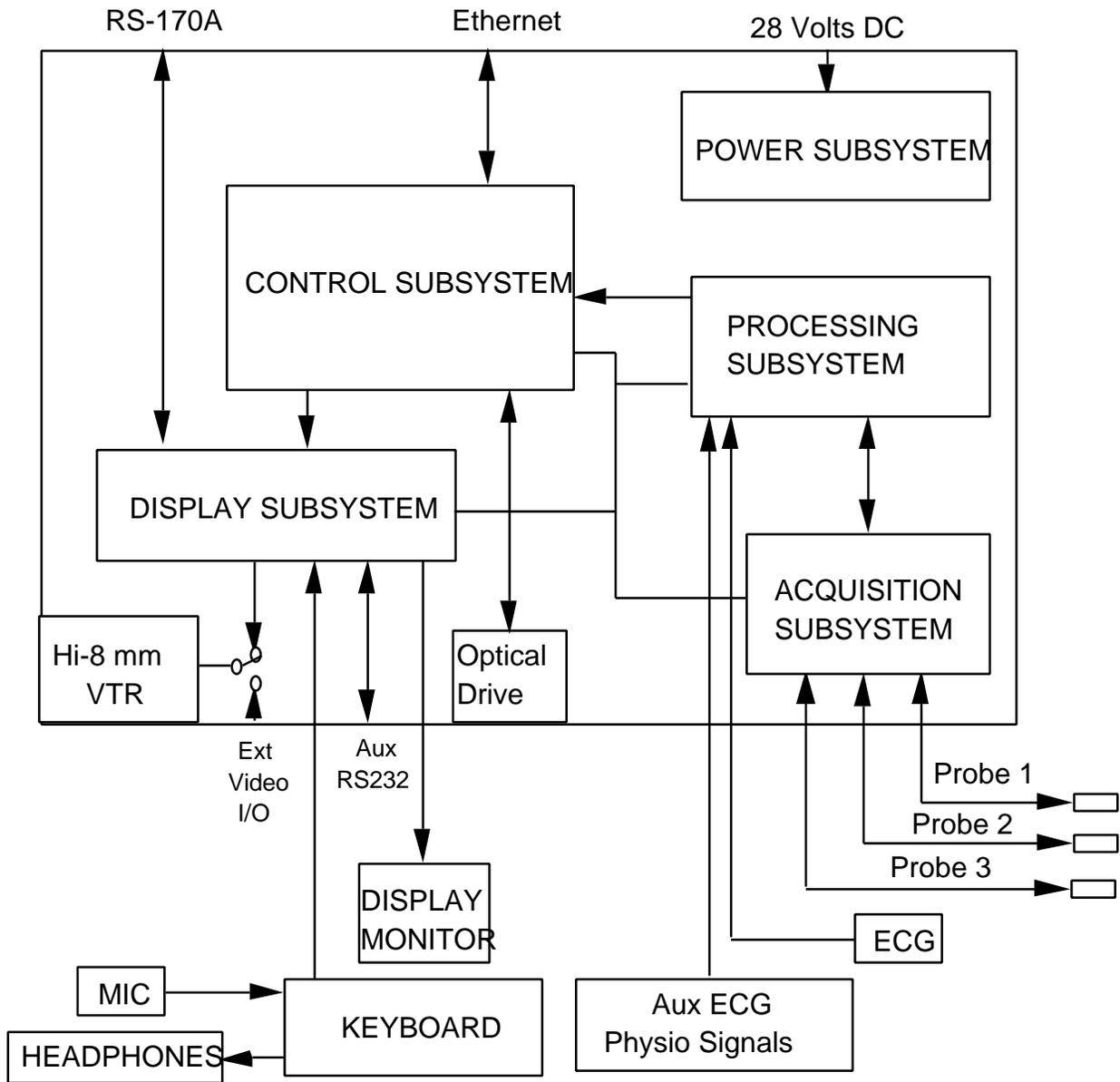


Figure 3-2. Ultrasound Functional Block Diagram

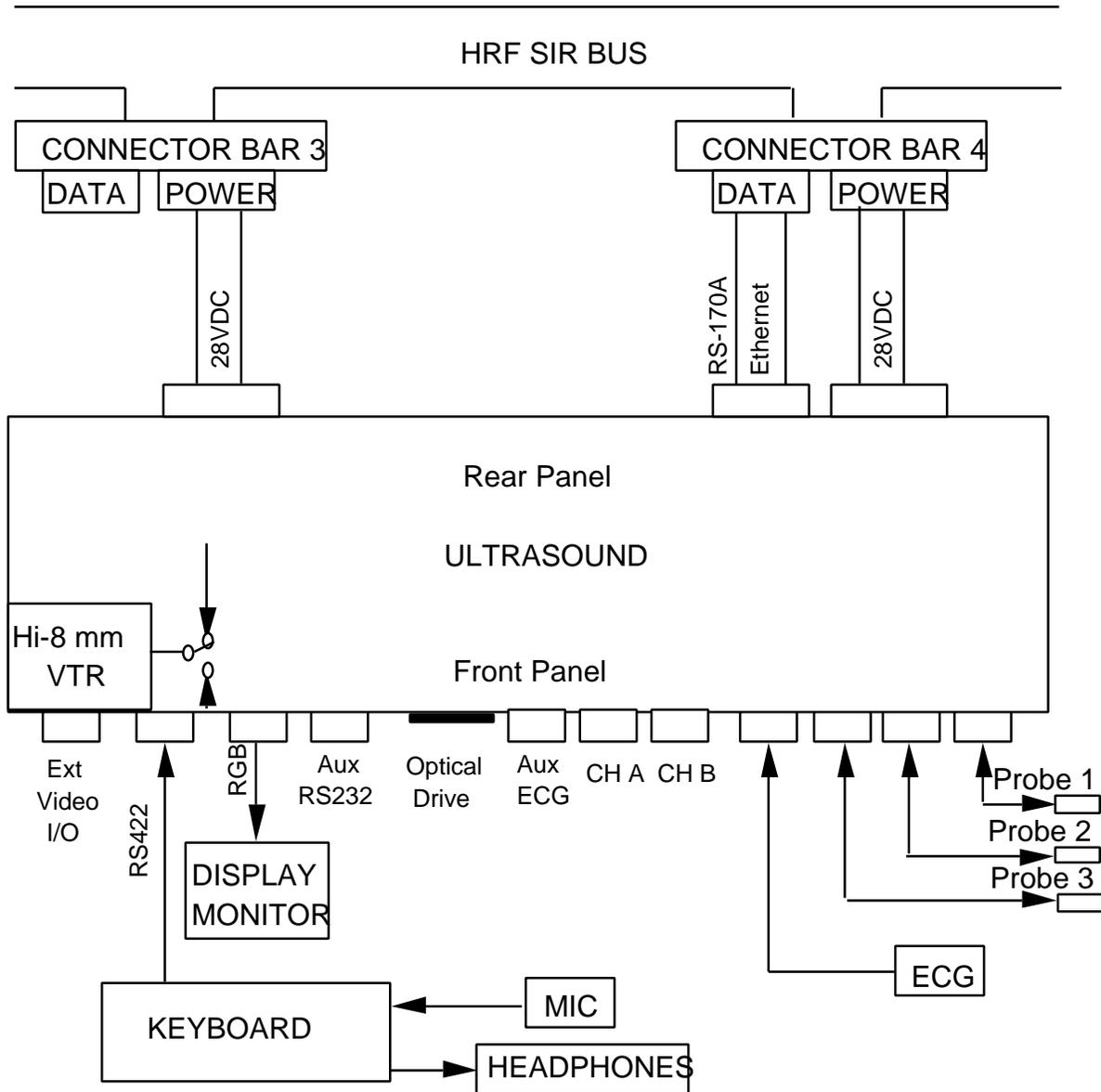


Figure 3-3. Ultrasound Interface Block Diagram

drawers. During on-orbit operations, the keyboard is necessary for ultrasound operation. The keyboard interface cable shall be mated to the keyboard connector on the main unit. Other stowed items shall be deployed as required during on-orbit operations. The display interface cable shall be connected to the display connector on the main electronics unit and the common monitor. Three scanheads and 1 pencil probe can be deployed at once. One ECG cable shall be used to connect 3 disposable surface ECG electrodes to the main electronics unit. The headphones and microphone shall be connected to audio connectors on the keyboard.

3.1.1.1 Operations

Operation of the Ultrasound System on-orbit requires a specific start-up format. The keyboard is deployed and the keyboard cable is mated to the “Keyboard” connector on the front panel and the “Front Panel” connector on the keyboard (Figure 3.1). The common monitor is deployed from its allocated stowage position (if not already) and the display cable is mated to the connection designated as “Display” on the front panel.

The proper HRF Rack power bars are turned on using the power control switches at the top portion of the rack. Once the light emitting diodes (LEDs) at the top portion of the rack are lit and steady, indicating positive power to the rack power bars, the switch designated as “Main Power” on the front panel under the “ULTRASOUND” header is toggled to the “On” position. The LED designated as “Main Power” will light, indicating power has been supplied to the power subsystem. The Ultrasound System is now in standby mode. The switch designated as “Keyboard Power” on the keyboard side panel, is toggled to the “On” position. The LEDs on the keyboard will flash as the Ultrasound System powers up from standby to active mode. The switch on the front panel under the “VIDEO TAPE RECORDER” header designated as “Power” is toggled to the “On” position. The LED designated as “Power” on the front panel under the “VIDEO TAPE RECORDER” header will light to confirm positive power to the common monitor and to the VTR. The common monitor will be activated by toggling the monitor power switch to the “On” position. An LED on the common monitor will light and hold steady to indicate that power on status has been achieved for the common monitor. Deployment of the stereo headphones, microphone, ECG, scanheads, and other accessories will be experiment-unique.

3.1.1.2 Deliverables

<u>Part Number</u>	<u>Description</u>	<u>Class I</u>	<u>Quantity</u> <u>Class II</u>	<u>Class III</u>
SEG46114600-301	Ultrasound System	3	1	1

3.1.2 Performance Requirements

This HRD uses LS-71001, “Functional Requirements Document (FRD) for the Human Research Facility” to, in part, derive the HRD performance requirements. Section I of the applicability matrix found in Appendix A is a one-to-one mapping of the hardware item functional requirements (functional and technical) to the performance requirements within this HRD (Section 3.1.2). In cases where the FRD requirement has been allocated into a design requirement, that specific HRD requirement paragraph number is indicated. The annotation “DELETION” shall indicate that a functional requirement has not been implemented into the design and the traceability matrix. The comment field will indicate the reason. The annotation “ADDITION” shall indicate a functional requirement that is now in the design but was not in the FRD.

3.1.2.1 Functional Requirements

3.1.2.1.1 Ultrasound Operating Modes

- a. Real Time 2D: The system shall be capable of displaying a two-dimensional representation of the internal body structures
- b. Color Flow Doppler: The system shall be capable of displaying the real time 2D image with a user assignable color overlay where the color represents the direction of flow
- c. Color Power Imaging: The system shall be capable of displaying a high sensitivity mode for visualization of small vessels
- d. M(otion)-Mode (gray and color): The system shall be capable of displaying a time versus motion plot along user selectable lines within the 2D display
- e. Pulsed Wave Doppler: The system shall be capable of displaying a pulsed wave Doppler flow graph with audible flow sounds
- f. Continuous Wave Doppler: The system shall be capable of displaying a continuous wave Doppler flow graph with audible flow sounds
- g. Dual Image Capability: The system shall be capable of displaying the 2D image and the M-mode image together to allow for positioning of the M-Mode marker
- h. ECG Display (triggered 2D): The system shall have the capability to detect and display the electrocardiograph to be used as a trigger for the 2D display
- i. Respiratory Trace Display: The system shall be compatible with a respiratory trace application
- j. Post-image 3D (three-dimensional) construction capability (real-time 3D capability if technology exists): The system shall be capable of being upgraded with 3D construction capability

3.1.2.1.2 General Physical Features

- a. Main Electronics Unit: The main electronic unit is a rack-mounted electronic enclosure. Electrical connections for probes, ECG, physiological trigger, keyboard, and display shall be located on the front panel. Electrical connections for rack power and data will be on the rear panel. The main electronics unit shall also provide data interface connectors for video and digital signals on the front panel. It also shall contain a 3.5" MO disk drive and an internal hard drive.
- b. Video Tape Recorder: A Hi-8mm format VTR shall be part of the main electronics unit. The VTR shall be a front loading device with a front control knob. It shall contain an electrical connection for video and audio input and output.
- c. Keyboard: The keyboard shall be a portable input device containing the operating controls for the main electronics unit. It includes an alphanumeric keyboard, a trackball, switches, and slide controls. It shall contain the appropriate electrical connections for data and command signals from the keyboard to the main electronics unit. The keyboard shall act as an audio interface for the stereo headphones and the microphone.
- d. Ultrasound Probes: The ultrasound probes shall be hand-held devices that can transmit and receive ultrasound energy. They include an integral cable and locking connector. The connector shall be labeled to identify the scanhead.

- e. Headphones: The headphones shall be a stereo device used to relay Doppler information to the operator. It shall include an integral cable and connector to interface with the keyboard.
- f. Microphone: The microphone shall be a device used for dictation. The microphone shall connect to the lapel/collar of the user. It shall include an integral cable and connector to interface with the keyboard.
- g. Consumables: Consumables are accessory items that are used to support ultrasound function. These items include acoustic coupling gel, Hi-8mm VTR cassettes, and MO disks.

3.1.2.2 Technical Requirements

3.1.2.2.1 Imaging Technologies

The ultrasound system shall be compatible with the probes listed in the table below. The imaging applications available with each probe shall be as shown in Table 3.1.2.2-1.

TABLE 3.1.2.2-1. IMAGING TECHNOLOGIES

Probe Name	Type	Clinical Options
C4-2 40R	Curved Array	Abdomen, Generic
C5-2 40R	Curved Array	Abdomen, Contrast Specific Imaging (CSI)
C7-4 40R	Curved Array	Abdomen, Generic
CL10-5 26mm	Linear Array	Small Parts, Cerebrovascular, Generic, Musculoskeletal, Peripheral Vascular
L7-4 38mm	Linear Array	Small Parts, Cerebrovascular, Generic, Musculoskeletal, Peripheral Vascular
L10-5 38mm	Linear Array	Small Parts, Cerebrovascular, Generic, Musculoskeletal, Peripheral Vascular
L12-5 38mm	Linear Array	Small Parts, Cerebrovascular, Generic, Musculoskeletal, Peripheral Vascular
P3-2 20mm	Phased Array	Abdomen, Cardiology, Transcranial Doppler (TCD), Generic
P5-3 16mm	Phased Array	Abdomen, Cardiology, Generic
P6-3 28mm	Phased Array	Abdomen, Generic
P7-4 11mm	Phased Array	Cardiology, Cerebrovascular, Generic
D2 TC	Pencil Probe	TCD, Generic
D2 CW	Pencil Probe	Cardiology, Generic
D5 CW	Pencil Probe	Cerebrovascular, Generic, Peripheral Vascular
D10 CW	Pencil Probe	Generic, Peripheral Vascular

3.1.2.2.2 Operating Modes

The ultrasound system shall provide the operating mode menu controls listed in Table 3.1.2.2-2.

TABLE 3.1.2.2-2. OPERATING MODES

Menu Label	Function	
2D/MM	GREY MAPS DYNAMIC RANGE CHROMA MAPS PERSISTENCE TIs/TIb BIOPSY SEL	LINE DENSITY FRAME RATE BIOPSY SPEED DISPLAY
CINE/3D	PLAY/PAUSE + SPEED - SPEED SWEEP/LOOP TRIM	CREATE 3D VIEWS SLICE CINE
COLOR	COLOR MAPS PERSISTENCE SENSITIVITY LINE DENSITY	MODE DYNAMIC MOTION DIFFERENTIATION (DMD) UNITS
DOPPLER	2D UPDATE GREY MAPS CHROMA MAPS	SCALE UNITS SPEED DISPLAY
NET/DISK	FORMAT DISK EJECT DISK LIST HARD DISK EXAMS	LIST OPTICAL DISK EXAMS DISK CAPACITY STATUS
PHYSIO	+ECG GAIN - ECG GAIN + ECG POSITION	- ECG POSITION TRIGGERS ECG
PWR	POWER MAPS PERSISTENCE SENSITIVITY LINE DENSITY	DMD BACKGROUND DISPLAY DYNAMIC RANGE

3.1.2.2.3 Color/Doppler Functions

The ultrasound system shall provide the Color/Doppler functions listed in Table 3.1.2.2-3.

TABLE 3.1.2.2-3. COLOR/DOPPLER FUNCTIONS

Control Label	Function
SCALE	CHANGES VELOCITY/FREQUENCY SCALE.
PRIORITY	CHANGES THE GREY SCALE/COLOR THRESHOLD LEVEL ON THE COLOR BAR.
FILTER	SELECTS WALL FILTER SETTINGS: LOW, MEDIUM, HIGH
BASELINE	SHIFTS DOPPLER BASELINE ON VELOCITY SCALE.
ANG COR	ROTATES THE FLOW DIRECTION CURSOR.
SV SIZE	CHANGES THE SAMPLE VOLUME SIZE ON THE SAMPLE VOLUME CURSOR.
0/60°	SETS FLOW DIRECTION AT 0 OR $\pm 60^\circ$
STEER	CHANGES STEERING ANGLE FOR LINEAR ARRAY SCANHEADS ON M-MODE LINE.
INVERT	INVERTS DISPLAY.

3.1.2.2.4 2D/M-Mode Functions

The ultrasound system shall provide the 2D/M-Mode functions listed in Table 3.1.2.2-4.

TABLE 3.1.2.2-4. 2D/M-MODE FUNCTIONS

Control Label	Function
M CURSOR	SELECTS M LINE OVER 2D IMAGE.
ZONES	CHANGES THE NUMBER OF FOCAL ZONES ON THE TGC SCALE.
FOCUS	CHANGES THE POSITION OF THE FOCAL ZONES ON THE TGC SCALE.
DEPTH	CHANGES THE 2D IMAGING DEPTH ON THE DEPTH SCALE.
TOP/BOT	SWITCHES THE TOP AND BOTTOM ORIENTATION OF THE IMAGE DISPLAY.
SEC WIDTH	CHANGES THE WIDTH OF THE 2D SECTOR IMAGE.
ZOOM	CHANGES THE MAGNIFICATION OF THE IMAGE.
L/R INVERT	SWITCHES THE LEFT AND RIGHT ORIENTATION OF THE IMAGE DISPLAY.
HD ZOOM	SELECTS HIGH DEFINITION MODE.

3.1.2.2.5 Imaging Functions

The ultrasound system shall provide the imaging controls listed in Table 3.1.2.2-5.

TABLE 3.1.2.2-5. IMAGING CONTROLS

Control Label	Function
OUTPUT	ADJUSTS THE ULTRASOUND POWER OUTPUT ON TI AND MI INDEX.
VOLUME	ADJUSTS AUDIO VOLUME.
2D GAIN	ADJUSTS RECEIVER GAIN FOR 2D AND M-MODE IMAGE DISPLAYS.
DOP GAIN	ADJUSTS RECEIVER GAIN FOR DOPPLER IMAGE DISPLAYS.
COL GAIN	ADJUSTS RECEIVER GAIN FOR COLOR AND POWER IMAGE DISPLAYS.
TGC	ADJUSTS DEPTH GAIN CURVE ON TGC (TIME GAIN COMPENSATION) SCALE.

3.1.2.2.6 Measurement Functions

The ultrasound system shall provide the measurement functions listed in the Table 3.1.2.2-6.

TABLE 3.1.2.2-6. MEASUREMENT FUNCTIONS

Control Label	Function								
HIGH Q	TOGGLE THE PEAK DOPPLER TRACE DISPLAY.								
DISTANCE	ACTIVATES DISTANCE MEASUREMENT AND DISPLAYS DISTANCE CURSOR.								
AREA	ACTIVATES AREA MEASUREMENT AND DISPLAYS AREA CURSOR.								
DEL MEAS	DELETES MEASUREMENT FROM DISPLAY.								
CALCS	DISPLAYS MENU OF APPLICATION SPECIFIC CALCULATIONS.								
ADV MEAS	<table> <tbody> <tr> <td>VOLUME</td> <td>CALIBRATE</td> </tr> <tr> <td>VOLUME METHOD</td> <td>SET REGION</td> </tr> <tr> <td>HEART RATE</td> <td>MEAN TR</td> </tr> <tr> <td>TIME/SLOPE</td> <td>TRACE</td> </tr> </tbody> </table>	VOLUME	CALIBRATE	VOLUME METHOD	SET REGION	HEART RATE	MEAN TR	TIME/SLOPE	TRACE
VOLUME	CALIBRATE								
VOLUME METHOD	SET REGION								
HEART RATE	MEAN TR								
TIME/SLOPE	TRACE								

3.1.2.2.7 Storage and Review Functions

The ultrasound system shall provide the storage and review functions listed in Table 3.1.2.2-7.

TABLE 3.1.2.2-7. STORAGE AND REVIEW FUNCTIONS

Control Label	Function
FREEZE	FREEZES THE DISPLAYED IMAGE AND CAPTURES FRAMES FOR CINE-LOOP REVIEW.
LOOP	CLEARs CINE-LOOP MEMORY BUFFER.
REVIEW	DISPLAY STORED IMAGES FROM THE SELECTED DISK.
DEL IMG	DELETES STORED IMAGES FROM THE SELECTED DISK.
PRINT	STORE IMAGES TO THE SELECTED DISK.

3.1.2.2.8 Remote Software Interface

The Ultrasound system shall interface with software on the HRF Workstation or HRF Portable Computer System (PCS) to transfer images, perform diagnostics of the Ultrasound System, and support system upgrades.

3.1.3 Limit Load Requirements

The Ultrasound System shall meet the structural requirements of NSTS-1700.7B “Safety Policy and Requirements for Payloads Using the Space Transportation System” as stated in Section 6.2.1.4 of LS-71000. The HRF Program is responsible for defining the general limit load, from Section 6.2.1.4, for all operational conditions. The Space Station Load Analysis and Integration Team shall approve these load conditions.

3.1.3.1 Crew Induced Loads

The Ultrasound System shall meet the requirements found in Section 6.2.1.4.5 of the HRF PRD, LS-71000.

3.1.3.2 Pressure Systems

Not Applicable

3.1.4 Physical Requirements

3.1.4.1 Mass (Weight)

The weight (mass) of the main electronics unit shall not exceed 91.6 kilograms (202 lbs). The weight (mass) of the keyboard shall not exceed 19 kilograms (42 lbs.).

3.1.4.2 Envelope

3.1.4.2.1 Stowed

The stowed length, height, and depth of the keyboard shall not exceed 20.2 in. (51.2 cm), 3 in. (7.6 cm), and 13.7 in. (34.8 cm) respectively.

3.1.4.2.2 Deployed

The deployed length, height, and depth of the keyboard shall not exceed 20.2 in. (51.2 cm), 3 in. (7.6 cm), and 13.7 in. (34.8 cm) respectively.

3.1.4.3 Center of Gravity

The center of gravity of the main electronics unit shall be measured. The center of gravity of the keyboard shall be measured. None of the other accessories will be measured.

3.1.5 Interface

3.1.5.1 Structural and Mechanical Interface Requirements

The structural and mechanical design of the Ultrasound System shall be compatible with the applicable requirements of Section 6.2.1 of the HRF PRD, LS-71000.

3.1.5.2 Electrical Interface Requirements

The electrical design of the Ultrasound system shall be compatible with the applicable requirements of Section 6.2.2 of the HRF PRD. The following sections delineate the electrical interface requirements for the end item of this HRD.

3.1.5.2.1 Ultrasound System to Rack

The electrical interface requirements of the Ultrasound system shall be compatible with the applicable requirements of Section 6.2.2.2 of the HRF PRD.

3.1.5.2.2 Ultrasound System to Other Payloads

Not Applicable

3.1.5.3 Command and Data Handling Interface Requirements

For those HRF devices that will transmit data, the requirements of Section 6.2.3 of the HRF PRD shall apply. The following sections describe the requirements that are applicable for the design.

3.1.5.3.1 Ultrasound System to Rack

The command and data handling interface requirements of the Ultrasound system shall be compatible with the applicable requirements of Section 6.2.3.1 of the HRF PRD.

3.1.5.3.2 Ultrasound System to Other Payloads

The interface that the Ultrasound System provides to other payloads shall be covered in the HRF Ultrasound System Interface Control Document (ICD), LS-71040-2. The command and data handling interfaces available to other HRF payloads are described in the following sections.

3.1.5.3.2.1 Serial (RS232) Connector

The Ultrasound System shall have an RS232 serial interface for the purpose of troubleshooting the Ultrasound System in the event of a malfunction.

3.1.5.3.2.2 Physiological Signal Connectors

The Ultrasound System shall provide an interface for the purpose of synchronizing image acquisition with physiological responses such as ECG, pulse sounds, or respiration.

3.1.5.4 Audio/Video Interface Requirements

For those HRF devices that require audio/visual data transfer, the requirements of Section 6.2.4 of the HRF PRD shall apply. The following sections describe the requirements that are applicable for this hardware's design.

3.1.5.4.1 Ultrasound System to Rack

The video interface requirements of the Ultrasound System shall be compatible with the applicable requirements of Section 6.2.4.1 of the HRF PRD. There are no audio interface requirements with the rack.

3.1.5.4.2 Ultrasound System to Other Payloads

The interfaces that the Ultrasound System provides to other payloads shall be covered in the HRF Ultrasound System ICD. The audio/video interfaces available to other HRF payloads are described in the following sections.

3.1.5.4.2.1 External (EXT) Video Input/Output (I/O) Connector

The Ultrasound System shall provide an interface to record video footage using the BTR and/or an external video source in the Hi-8 mm format.

3.1.5.4.2.2 Display Connector

The Ultrasound System shall provide an interface for the purpose of connecting the Ultrasound System to the HRF Workstation Display.

3.1.5.5 Thermal Control Interface Requirements

The thermal control system of the Ultrasound System shall be compatible with the applicable requirements of Section 6.2.5 of the HRF PRD.

3.1.5.5.1 HRF Rack Common Fan

The Ultrasound System shall incorporate the HRF Rack Common Fan (P/N SEG46116060-701) into its design per HJU1009900413.

3.1.5.5.2 HRF Rack Common Fan Intravehicular Activity (IVA) Replacement

The HRF Rack Common Fan shall be IVA replaceable.

3.1.5.5.3 HRF Rack Common Fan Vibration/Acoustic Isolation

There shall be a vibration/isolation gasket mounted between the HRF Rack Common Fan and the structure/chassis against which it will be mounted.

3.1.5.6 Waste Gas Vent and Vacuum Interface Requirements

Not Applicable.

3.1.5.7 Nitrogen Interface Requirements

Not Applicable.

3.1.6 Software Design Requirements

This section contains the software requirements for the Computer Software Configuration Items (CSCI) associated with the Ultrasound System. Each software requirement shall be traceable back to a functional requirement in this HRD. The requirements traceability matrix is shown in Table 3.1.6-1 below. The requirements allocation matrix is shown in Table 3.1.6-2. The verification process for each CSCI is listed in the Certification Matrix (Appendix B). The type, category, and operational modes required shall be identified for each CSCI. All activities involving software development and software acquisition shall be performed in accordance with the “Software Development Plan for the Human Research Facility,” LS-71020.

TABLE 3.1.6-1. REQUIREMENTS TRACEABILITY MATRIX

HRD Requirement Identifier	CSCI Requirements
3.1.2.2.2	3.1.6.3.1
3.1.2.2.7	3.1.6.3.1
3.1.2.2.8	3.1.6.3.1, 3.1.6.3.2, 3.1.6.3.6, 3.1.6.3.8, 3.1.6.3.9, 3.1.6.3.10, 3.1.6.4.1, 3.1.6.4.6, 3.1.6.4.8, 3.1.6.4.9

TABLE 3.1.6-2. REQUIREMENTS ALLOCATION MATRIX

CSCI Requirements	HRD Requirement Identifier
3.1.6.3.1	3.1.2.2.2, 3.1.2.2.7, 3.1.2.2.8
3.1.6.3.1, 3.1.6.3.2, 3.1.6.3.6, 3.1.6.3.8, 3.1.6.3.9, 3.1.6.3.10, 3.1.6.4.1, 3.1.6.4.6, 3.1.6.4.8, 3.1.6.4.9	3.1.2.2.8

As shown in Figure 3-4, the remote Ultrasound CSCI consists of two parts, the flight CSCI and the ground CSCI. The general architectural approach for the remote software of the Ultrasound System utilizes interfaces, both foreground and background, to transfer images, perform diagnostics, and support upgrades. The Ultrasound Flight CSCI resides on the HRF Workstation/PCS and regulates the interface between the HRF Workstation/PCS and the Ultrasound System. The Ultrasound Ground CSCI resides on a workstation at the Telescience Center within the HRF User Operations Facility (UOF) to regulate ultrasound information between orbit and ground and remote ground sites. The transfer mechanism is outlined in the Data System Architecture Definition for the Human Research Facility (LS-71019). The following paragraphs provide the software design for each CSCI in the Ultrasound System.

3.1.6.1 Definitions

Please refer to LS-71020 for definitions of the Software Type, Software Category, and Configuration Item terms.

3.1.6.2 Modes

3.1.6.2.1 Experimental mode

Experiments are being conducted using the Ultrasound System.

3.1.6.2.2 Diagnostic mode

Diagnostic tests are performed to report the condition of the Ultrasound System.

3.1.6.3 Ultrasound Flight CSCI

This CSCI resides on the HRF Workstation and PCS. The Ultrasound Flight CSCI has two functions.

1. Receive image files from the HRF Ultrasound and convert these image files for transfer to the ground.
2. Perform remote diagnostics to monitor the HRF Ultrasound.

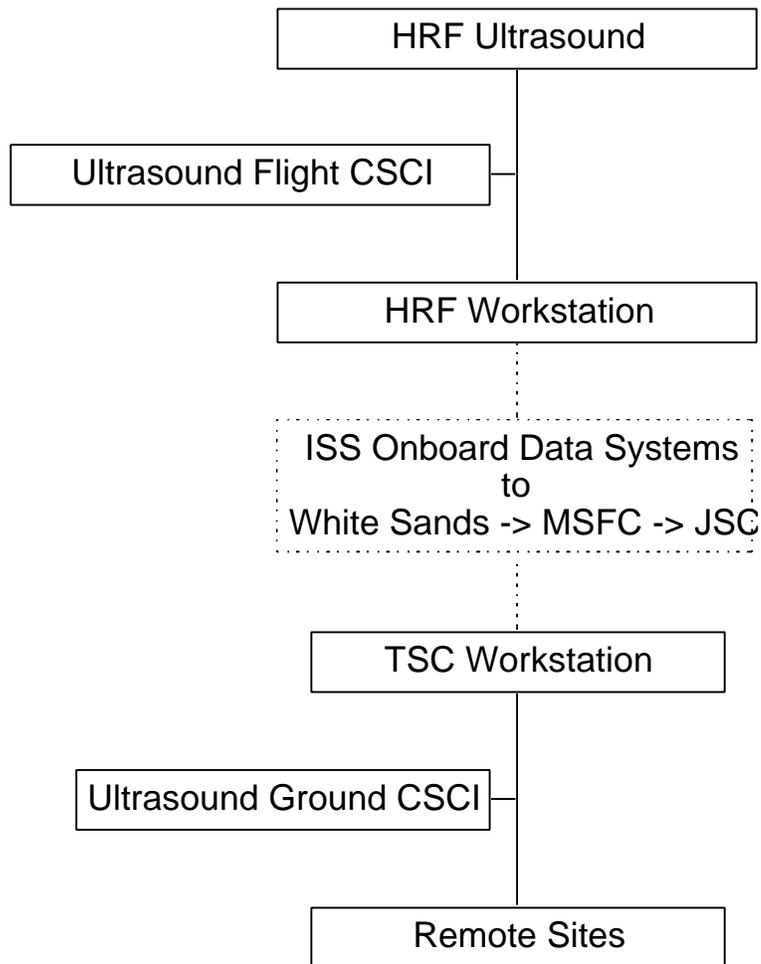


Figure 3-4. System Architecture Of Remote Ultrasound CSCIs

3.1.6.3.1 CSCI Functional and Performance Requirements

Listed below are the functional and performance requirements specific to the Ultrasound Flight CSCI.

In experimental mode, the CSCI shall receive and convert image files from the Ultrasound System. This application is COTS software. The user shall be able to select experiment-unique requirements from a configuration file list. The results of these sessions shall be stored as log files that may then be sent to the ground for support.

In diagnostic mode, the CSCI shall perform diagnostics based on batch files both predetermined and sent from the ground for scheduled, routine, and emergency maintenance. This application is COTS software. The results of these diagnostic sessions shall be stored as log files that may then be sent to the ground for support.

The location of the image file sets and session logs are provided to the HRF Common Software for downlink.

3.1.6.3.2 CSCI External Interface Requirements

The Ultrasound Flight CSCI external interface design shall be defined in the Software Requirements Specification (SRS) for the Human Research Facility Common Software (LS-71062). This external interface shall be used to initiate the execution of the Ultrasound Flight CSCI and is custom-built software. The external interface shall initiate and control the COTS applications. The external interface shall provide a help file that explains each element of the Ultrasound Flight CSCI.

3.1.6.3.3 CSCI Internal Interface Requirements

The Ultrasound Flight CSCI internal interfaces are defined by the vendor.

3.1.6.3.4 CSCI Internal Data Requirements

The Ultrasound Flight CSCI internal data are defined by the vendor.

3.1.6.3.5 CSCI Adaptation Requirements

There are no CSCI adaptation requirements for the Ultrasound Flight CSCI.

3.1.6.3.6 Software Safety Requirements

The Ultrasound Flight CSCI shall not be used to hold, store, or process any safety critical parameters or commands.

3.1.6.3.7 Data Privacy Requirements

There are no CSCI data privacy requirements for the Ultrasound Flight CSCI.

3.1.6.3.8 CSCI Environment Requirements

The Ultrasound Flight CSCI shall execute in the environment described in the SRS for the HRF Common Software (LS-71062).

The Ultrasound Flight CSCI shall utilize a maximum amount of 25 MB of disk space.

The Ultrasound Flight CSCI shall utilize a maximum amount of 8 MB of memory.

3.1.6.3.9 Software Quality Factors

The Ultrasound Flight CSCI executables shall generate consistent results given the same initialization data.

3.1.6.3.10 Design and Implementation Constraints

The HRF Human-Computer Interface (HCI) Design Guide, LS-71130, shall be considered when designing displays for the Ultrasound Flight CSCI.

3.1.6.3.11 Precedence and Criticality Of Requirements

All requirements are equal and not listed in any order of precedence or criticality.

3.1.6.4 Ultrasound Ground CSCI

The ground CSCI resides on a workstation at the HRF UOF. Please refer to the Concept of Operations for the Human Research Facility, LS-71003, for the function of the UOF. The Ultrasound Ground CSCI has two functions.

1. Display for downlinked images. This function is only for verification purposes.
2. Send batch files and receive error logs for diagnostic purposes.

3.1.6.4.1 CSCI Functional and Performance Requirements

Listed below are the functional and performance requirements specific to the Ultrasound Ground CSCI.

In experimental mode, the ground CSCI shall provide an interface to display the downlinked images to confirm successful image transfer. This application is COTS software. Log files from these experiment sessions can be viewed with a simple text editor.

In diagnostic mode, the ground CSCI shall receive session logs from orbit to support the Ultrasound System. This application is COTS software. Batch files that contain diagnostic functions and an updated batch file list for the flight CSCI can be created/edited with a simple text editor.

3.1.6.4.2 CSCI External Interface Requirements

The Ultrasound Ground CSCI external interfaces are defined by the vendor.

3.1.6.4.3 CSCI Internal Interface Requirements

The Ultrasound Ground CSCI internal interfaces are defined by the vendor.

3.1.6.4.4 CSCI Internal Data Requirements

The Ultrasound Ground CSCI internal data are defined by the vendor.

3.1.6.4.5 CSCI Adaptation Requirements

There are no CSCI adaptation requirements for the Ultrasound Ground CSCI.

3.1.6.4.6 Software Safety Requirements

The Ultrasound Ground CSCI shall not be used to hold, store, or process any safety critical parameters or commands.

3.1.6.4.7 Data Privacy Requirements

The data privacy requirements for the Ultrasound Ground CSCI are defined in the Concept of Operations for the Human Research Facility, LS-71003.

3.1.6.4.8 CSCI Environment Requirements

The Ultrasound Ground CSCI shall execute in the environment described in the Concept of Operations for the Human Research Facility, LS-71003.

The Ultrasound Ground CSCI shall utilize a maximum amount of 16 MB of disk space.

The Ultrasound Ground CSCI shall utilize a maximum amount of 8 MB of memory.

3.1.6.4.9 Software Quality Factors

The Ultrasound Ground CSCI executables shall generate consistent results given the same initialization data.

3.1.6.4.10 Design and Implementation Constraints

There are no design and implementation constraints for the Ultrasound Ground CSCI.

3.1.6.4.11 Precedence and Criticality of Requirements

All requirements are equal and not listed in any order of precedence or criticality.

4.0 GENERAL DESIGN REQUIREMENTS

The hardware controlled by this document shall comply with the general design requirements stated in this section. These requirements are present to guide the overall design of the hardware. The majority of the requirements in this section are derived from the HRF PRD, LS-71000.

The applicability of the PRD requirements for the hardware covered by this document is dependent upon several factors. The first factor is the applicability matrix found in Appendix C of the PRD. This matrix identifies what PRD requirements are applicable and should flow down to this HRD. Note that the basis for the PRD direction is the assumption that the Commercial-off-the-Shelf (COTS) item is completely unaltered once delivered from the vendor. Any COTS item delivered and then modified by HRF engineers cannot use PRD Appendix C.

The second factor is what type of HRF payload this HRD covers. The format basis of the PRD is dependent on the hardware type (integrated rack, drawer, stowed, or deployed payload). The following subsections will reflect the appropriate PRD section from which the requirements originate.

The third factor is the requirement for safety. In order to show proper verification of hazards identified, additional design and test requirements may be created for the hardware covered by this document.

4.1 HUMAN FACTORS

The capabilities and limitations of a crew person in plain clothes working in the ISS shall be considered in designing the equipment. The Ultrasound System shall comply with the requirements identified in SSP-50005, "International Space Station Flight Crew Integration Standard" and per the requirements identified in Section 6.2.12 of the PRD. The appropriate human factors standards are identified in Section II of the applicability matrix found in Appendix A.

4.2 MANNED SPACECRAFT CRITERIA AND STANDARDS

The Ultrasound System shall be designed to meet the required technical policies in JHB 8080.5, "JSC Design and Procedural Standards Manual," per Section 6.0 of the PRD. Those standards identified in Section III of the applicability matrix in Appendix A will be relevant, as specified, to the hardware identified in this HRD.

4.3 BONDING CONTINUITY

The Ultrasound System shall be designed to meet the electrical bonding requirements as defined in LS 71016, "Electromagnetic Compatibility Control Plan for the Human Research Facility," Section 5.2.7.

4.4 CLEANLINESS

4.4.1 External Surfaces

The external surfaces of the Ultrasound System shall meet the 'visibly clean-sensitive' (VC-S) requirements found in document SN-C-0005, "Space Shuttle Contamination Control Requirements." Implementation of the requirement shall be per JHB-5322

“Contamination Control Requirements Manual,” and indicated on the hardware top assembly drawings.

4.4.2 Internal Surfaces

Not Applicable

4.4.3 In-Flight Cleanliness/Maintenance

The Ultrasound System in-flight cleanliness/maintenance is to be controlled through an on-orbit operations procedure. This section is not verifiable.

4.5 CONSTRUCTION REQUIREMENTS

4.5.1 Materials and Processes

4.5.1.1 General Materials, Processes, and Parts Interface

There are three requirements that the hardware covered by this HRD shall follow:

- a. Materials and processes shall meet the requirements of SE-M-0096, “General Specification for Materials and Processes, Requirements for JSC Controlled Payloads.”
- b. Materials and processes shall meet the requirements of NSTS-1700.7B and NSTS-1700.7B ISS Addendum, “Safety Policy and Requirements for Payloads Using the International Space System” per Section 6.2.11.1.1 of the HRF PRD.
- c. Material and parts interface shall be in accordance with Section 6.2.11 of the HRF PRD.

4.5.1.2 Stress Corrosion

All materials used shall meet the requirements of MSFC-SPEC-522B, “Design Criteria for Controlling Stress Corrosion Cracking,” per Section 6.2.11.1.3 of the HRF PRD.

4.5.1.3 Fracture/Fatigue

The Ultrasound System shall be designed to prevent the creation or propagation of any material failures per the requirements of LS-71010, “Fracture Control Plan for the Human Research Facility Payload and Racks.”

4.5.2 Screw Threads

All straight screw threads shall be in accordance with MIL-S-7742, “General Specification for Screw Threads, Standard, Optimum Selected Series,” and/or MIL-S-8879, “General Specification for Screw Threads, Controlled Radius Root With Increased Minor Diameter.”

4.5.3 Fasteners

All fasteners shall be purchased with materials certification information included in the delivery and placed in a controlled storage facility. Any fastener over the size designation of a number 8 shall be tested per the requirements of JSC-23642, "JSC Fastener Integrity Testing Program."

Implementation of this requirement is not absolute, particularly for non-structural members. In these cases, non-adherence must be reviewed with and approved by the JSC Structures and Mechanics Working Group.

4.5.4 Locking Devices

4.5.4.1 Thread Locking Adhesive

Any liquid locking substance shall be applied per MIL-S-33540, "General Specification for Liquid Locking Compounds."

4.5.4.2 Lock Wire

Not Applicable.

4.6 WORKMANSHIP

Workmanship shall be of aerospace quality and shall conform to high grade aerospace manufacturing practices as directed by JSC-27301A, "Materials Control Plan for JSC Flight Hardware."

4.7 INTERCHANGEABILITY AND REPLACEABILITY

Interchangeability requirements are not applicable to detail parts of permanent assemblies, such as welded assemblies, or matched detailed parts, such as lapped components. Interchangeability requirements do not apply to custom-fitted or custom-sized items.

All replaceable parts or assemblies having the same part number shall be directly and completely interchangeable with each other with respect to form, fit and function.

4.7.1 Maintainability On-Orbit

The inlet air debris screen shall be vacuumed clean as necessary.

4.7.2 Maintainability Ground

Not Applicable.

4.8 COLOR

4.8.1 Stowed Hardware

Stowed hardware shall be anodized turquoise. The flag note on all drawings shall be as follows

“APPLY ANODIC COATING PER MIL-A-8625F, TYPE II, CLASS 2, DYED TURQUOISE”

4.8.2 Rack-Mounted Hardware

The front panel (window) shall be covered with off-white Lexan decal (P/N 8A13-112) per SSP 50008, “International Space Station Interior Color Scheme” Section 3.2.7. Flag notes shall be as follows:

“MANUFACTURE DECALS FROM LEXAN, PN 8A13-112, 15 MIL MATTE OR NASA-APPROVED EQUAL.”

“NOMENCLATURE TO BE BLACK LETTERS ON WHITE (FED-STD-595B COLOR IDENTIFICATION #27722).” 3M NO. 966 PRESSURE SENSITIVE ADHESIVE OR NASA-APPROVED EQUAL SHALL BE APPLIED TO THE REVERSE SIDE OF THE DECAL.

4.9 NON-IONIZING CONDUCTED RADIATION

The Ultrasound System shall be designed in accordance with LS-71016.

4.9.1 Emission

The Ultrasound System shall be designed in accordance with LS-71016 Section 5.2.1.

4.9.2 Susceptibility

Not Applicable.

4.10 ILLUMINATION

The Ultrasound System shall meet the illumination requirements specified in HRF PRD Section 6.2.9.4.

4.11 GROUND HANDLING

4.11.1 Ground Handling Load Factors

The Ultrasound System shall meet the Ground Handling Load Factor requirements referenced in the HRF PRD Section 6.2.1.8.1. The choice of hardware shipping/storage containers, procedures, and storage environments can minimize or negate this particular environment’s affect on the hardware. Packaging, handling and shipping shall be in accordance with Section 10.4 of this document, “Hardware Delivery for Flight.”

4.11.2 Shock Criteria

The Ultrasound System shall meet the Shock Criteria requirements referenced in HRF PRD Section 6.2.1.8.2.

4.11.3 Bench Handling

The Ultrasound System shall meet the Bench Handling Requirements referenced in MIL-STD 810E, Section 516.4, I-3.8, Procedure 6.

Test conditions shall be identified in the test procedures for both the main electronics unit and keyboard. Tests shall be conducted by TPS.

4.12 USEFUL LIFE

The useful life of the equipment (equivalent to full life) is the sum of operational life and shelf life. This requirement is imposed by the HRF PRD. The Ultrasound System useful life shall be a minimum of 15 years.

4.12.1 Operational Life (Cycles)

Operational life applies to any hardware that deteriorates with the accumulation of operating time and/or cycles and thus requires periodic replacement or refurbishment to maintain acceptable operating characteristics. Operational life includes the usage during flight, ground testing, and pre-launch operations. All components of the Ultrasound System shall have an operational life limit of 10 years except those identified as having limited life, see Section 4.12.3.

4.12.2 Shelf Life

Shelf life is defined as that period of time during which the components of a system can be stored under controlled conditions and put into service without replacement of parts (beyond servicing and installation of consumables). The Ultrasound System has a shelf life limit of 5 years.

4.12.3 Limited Life

Limited life is defined as the life of a component, subassembly, or assembly that expires prior to the stated useful life in Section 4.12 of this HRD. Limited life items or materials, such as soft goods, shall be identified, and the number of operations cycles shall be determined. Limited life items shall be tracked on a limited life list that is maintained as a part of the hardware acceptance data pack. The Ultrasound System has no limited life items.

4.13 ELECTRICAL, ELECTRONIC, AND ELECTROMAGNETIC (EEE) PARTS REQUIREMENTS

4.13.1 General Requirements

Parts shall be controlled in accordance with: SSP 30312, “Electrical, Electronic, and Electromechanical (EEE) and Mechanical Parts Management and Implementation Plan for Space Station Program”

4.13.2 Part Selection

Part selection shall be in accordance with:

- a. “NASA Parts Selection List (NPSL).”
- b. SSP-30423, “Space Station Approved Electrical, Electronic, and Electromechanical (EEE) Parts List.”
- c. SSQ-25002, “Supplemental List of Qualified Electrical, Electronic, Electromechanical (EEE) Parts, Manufacturers, and Laboratories (QEPM&L).”
- d. Semiconductors shall be JANTXV in accordance with MIL-PRF-19500, “General Specifications for Semiconductor Devices.” Diodes shall have a metallurgical bond. Passive parts shall be at least the second highest level of appropriate Military Established Reliability.
- e. SSP-30512, “Space Station Ionizing Radiation Design Environment.”

4.13.3 Commercial-off-the-Shelf (COTS)/Modified COTS

To the extent practical, COTS and modified COTS must meet the above requirements to assure the hardware/design compliance to the EEE part selection criteria for the proposed applications and corresponding criticalities. This includes a risk assessment, electrical stress analysis, and data delivery on information such as designed/as-built EEE parts, list, construction history, Government and Industry Data Exchange Program Alerts, part obsolescence, radiation susceptibility, and/or prior history.

Where no alternative is available, nonmilitary parts, components and subassemblies may be used, but screening of these items shall be accomplished through burn-in. Screening shall be completed (100%) on all flight hardware (units).

Burn-in may be accomplished at the component or assembly level. Burn-in is specified as:

- a. 72 hours continuously at room ambient temperature while functioning.
- b. 96 hours continuously at a specified controlled temperature while functioning.

Controlled temperature is defined as 15 °C below the maximum rating of the device with the lowest temperature rating in the article.

4.14 BATTERY REQUIREMENTS

Batteries shall follow the guidelines of JSC-20793, “Manned Space Vehicle Battery Safety Handbook,” and must be approved for intended usage by the JSC Power Systems Branch (EP5). Batteries must be two failures tolerant to a catastrophic event. Except for high pressure cells (e.g., nickel hydrogen), batteries are considered sealed containers. Those that contain hazardous fluids must be leak-before-burst design. All cells in a battery critical for safety or mission success must be lot certified.

The battery utilized by the HRF Ultrasound is a Lithium Carbon Monofluoride (Li-CF) coin cell and is two-failure tolerant.

5.0 ENVIRONMENTAL DESIGN REQUIREMENTS

5.1 GENERAL

The Ultrasound System shall be designed to meet the performance requirements during and after exposure to the environments specified below. The requirement levels listed below originate from the HRF PRD except in those cases where certain environments have been established by appropriate JSC test, structural, or thermal organizations. In these cases, the hardware will meet the requirements so established. The specific method of compliance for each of the following requirements is described in the Verification Matrix found in Appendix B as well as in the appropriate sections below.

5.2 TEMPERATURE RANGES

The Ultrasound System shall meet the temperature range in the HRF PRD, Section 6.2.9.1.1.

5.2.1 Operating Temperature

The HRF hardware shall be designed to operate at a controlled cabin temperature range (low and high) of 65 °F to 85 °F.

5.2.2 Non-Operating Temperature

The HRF hardware shall be designed to operate after withstanding a Mini-Pressurized Logistical Module (MPLM) air temperature range of 36 °F to 120 °F.

5.3 PRESSURE

The Ultrasound System shall meet the pressure requirements in the HRF PRD, Section 6.2.9.1.2.

5.3.1 Operating Pressure

The HRF hardware shall be designed to operate at a controlled cabin pressure range of 13.9 to 14.9 psia.

5.3.2 Non-Operating Depressurization

The HRF hardware shall be designed such that a safety hazard will not be created after being exposed to a pressure range of 14.9 to 1.9×10^{-7} psia.

5.3.3 Rate of Change

The Ultrasound System shall be designed such that a safety hazard will not be created after being exposed to a rate of de-pressurization equal to .5 psi/minute, and a maximum re-pressurization rate of 2 psi/min, as defined in HRF PRD, Section 6.2.1.7.1.

5.4 HUMIDITY

The Ultrasound System shall meet the humidity requirements in the HRF PRD, Section 6.2.9.1.3. The HRF hardware shall be designed to operate during exposure to a controlled environment having air with 25-70% humidity.

5.5 OXYGEN ENVIRONMENT

The Ultrasound System shall meet the oxygen environment requirements in the HRF PRD, Section 6.2.9.1.4; i.e., the hardware shall be designed to operate in the controlled oxygen environment of less than or equal to 24.1 % oxygen concentration.

5.6 CONTAMINATION AND WASTE MANAGEMENT

Not Applicable.

5.7 RANDOM VIBRATION

The hardware shall be designed to withstand the launch level random vibration environment defined in Section 8.2.3 of this HRD.

5.8 LAUNCH/LANDING LOADS

The Ultrasound System shall meet the requirements found in Section 6.2.1.4 of the HRF PRD.

5.9 ACOUSTIC EMISSION LIMITS

The sound pressure level of the Ultrasound System shall not exceed the value allocated by the procedure described in the HRF Acoustic Noise Control and Analysis Plan, LS-71011, when measured at two feet from the front of the hardware item surface.

Compliance to this requirement will only be tested at the integrated rack level, although engineering development tests may be completed at the hardware system level to acoustically characterize at the box level.

5.10 IONIZING/NON-IONIZING NON-CONDUCTIVE RADIATION

5.10.1 Ionizing

5.10.1.1 Emission

- a. The Ultrasound System shall be designed to meet the ionizing radiation requirement in SSP 50005, Section 5.7.2.2.2C.
- b. Payload ionizing radiation emissions shall not exceed 2 millirads silicon per day measured one centimeter from any surface (in accordance with the HRF PRD Section 6.2.9.3.2). Payloads shall also be in accordance with JHB 8080.5 Section G 26.

5.10.1.2 Susceptibility

Not Applicable.

5.10.2 Non-Ionizing

The Ultrasound System shall be in accordance with LS-71016, “Electromagnetic Compatibility Control Plan for the Human Research Facility.”

5.10.2.1 Emission

The Ultrasound System shall be in accordance with LS-71016, “Electromagnetic Compatibility Control Plan for the Human Research Facility” Section 5.2.3.

5.10.2.2 Susceptibility

Not Applicable.

6.0 CERTIFICATION APPROACH

6.1 GENERAL

A formal design certification program shall be conducted to demonstrate that the Ultrasound System meets all of the design requirements of this HRD. For the HRF program, certification has been established to encompass all of the acceptance and qualification procedures utilized to show compliance with the design requirements. All appropriate documentation resulting from this certification program shall be collected in a certification package (Section 6.3.3) and delivered to JSC Safety and Mission Assurance (S&MA) and engineering organizations for review and approval (i.e., Design Certification Review).

6.2 CERTIFICATION RATIONALE

Certification of the Ultrasound System shall be by similarity, analysis, inspection, demonstration, and/or test at the component and/or the system level. The certification methods are described below.

6.2.1 Similarity

Certification data for hardware and software components previously qualified or flown shall be reviewed to verify that these components prior certification requirements meet or exceed the current mission requirements. The review shall cover structures, materials, environmental, and operational requirements.

6.2.2 Analysis

Hardware and software not previously qualified or flown will be analyzed when analysis is the most efficient way to demonstrate capability to meet or exceed expected environmental conditions.

6.2.3 Inspection

The hardware shall be thoroughly inspected or reviewed to validate that it has been built to the individual assembly drawings. The software shall be thoroughly inspected or reviewed to validate that it has been built to the design requirements. Inspection or review shall also be used when it is more efficient or applicable to demonstrate compliance to requirements rather than perform calculable testing or analysis.

6.2.4 Demonstration

The hardware and software shall be certified by observation that verified the design characteristics such as human factors, maintenance, operation, and access features. The pass/fail criterion of a demonstration is qualitative. Considering the design requirement, the operation or assessment shall be acceptable based upon the judgment of those approved individuals (i.e., quality assurance, human factors, astronaut, etc.) who witness the demonstration.

6.2.5 Test

The hardware shall be tested to verify that the design can withstand the environmental conditions and operate within the specified functional tolerances. The software shall be tested to verify that the design can perform within the environment specified and to the functional requirements identified. Functional tests shall be performed on the hardware before, during (if applicable), and after each environmental test. When testing is the chosen method, the tests shall be performed on appropriate hardware and/or software. All Class I hardware and software shall be subjected to test verifiable acceptance requirements. Qualification level requirement testing will use qualification hardware and software that is of identical configuration as the intended flight end items.

6.3 CERTIFICATION MATRIX

The certification matrix serves a dual purpose. For the HRD, this matrix indicates the acceptance/qualification compliance plan for each applicable requirement (see Appendix B). Once the project has completed all acceptance/qualification procedures on the qualification unit, a certification data pack shall be developed. At this stage the certification matrix will be used as the certification compliance table. Serving as a basis of the certification report, the certification compliance table is attached to the front of the certification data package and provides closure status, reference material, and specific comments applicable to individual requirements.

6.3.1 Certification Plan

The overall certification plan for the Ultrasound System is defined by the completed certification matrix in this HRD. The certification document column is left blank since the matrix is describing the plan not the results. The matrix must detail how the requirements will be verified per the following:

1. Whether the requirement is for acceptance and/or qualification.
2. Which of the previously mentioned certification rationales will be applicable for fulfilling each requirement.
3. Which of the acceptance and/or qualification procedures will be applicable for fulfilling each requirement.
4. An explanation on the compliance procedure or plan in the comment column.
5. Identification of the hardware system test configuration in the comment field.

6.3.2 Certification Compliance

As certification data is completed (e.g., Task Performance Sheet (TPS), analysis, reports, waivers), verification information is added to the certification matrix. This version of the certification matrix is the method of reporting that all certification requirements have been properly met. It will replace a formal document type report and will be the basis of the certification package. The “certification document” column is filled in with documents number(s) (i.e., analysis reports or TPS) that describe how the design requirements were verified. Additional certification information is added to the “comments” column as needed.

6.3.3 Certification Package

The hardware certification package consists of a Government Certification Approval Request (GCAR), the certification matrix containing the completed, “compliance certification” column, and all back up information identified in the compliance table such as TPSs, memos, analyses, software data files, and drawings. The GCAR also includes the safety analysis (a preliminary hazard and operational hazard analysis) performed on the hardware.

6.4 TESTING PROGRAM

All certification tests (both qualification and acceptance type) described in the certification matrix require full quality coverage. Quality personnel must be notified, as required, prior to all certification test activities. Test Readiness Reviews (TRRs) shall be held. It will be the responsibility of the test director and/or the program test coordinator to notify the appropriate personnel to participate in the TRR and attend the testing. Failure to notify Quality personnel of a TRR could result in a delay or voiding of the certification test.

All testing and testing build-up shall be accomplished by TPS in accordance with LS-71030, “Quality Assurance Plan for the Human Research Facility.”

For certification, functional tests shall be performed before, during (if applicable), and after major tests. These functional tests shall verify that the environment or level of the test had no detrimental effects on the hardware. All tests used for certification shall be approved by the JSC technical monitor and quality engineering.

In the event of a failure or non-conformance of a test article to its specified design requirement during the certification tests, perform the following sequence of events:

1. Halt the test.
2. Notify the Project Manager or his representative immediately
3. Immediately initiate a Discrepancy Report (DR) which describes the failure or non-conformance condition and includes events preceding the observed failure. The test will continue at the discretion of the Project Manager or his representative and proper disposition of the DR.
4. The Test Control Board is convened to determine the type and cause of the failure and to establish corrective actions. The Board consists of the appropriate NASA project lead, hardware engineers, and quality and safety representatives.

The rejected item will be withheld from further certification testing until the reason for rejection is eliminated and remedial action has been described on the DR. Upon completion of remedial action, applicable acceptance tests shall be performed and pertinent certification tests repeated.

7.0 ACCEPTANCE APPROACH AND TESTS

7.1 GENERAL

An acceptance validation process shall be conducted on all parts, components, and assemblies to determine conformance to design specifications and to released drawings. This process shall include inspections on parts and materials and tests performed at intermediate points during production, final assembly, and during final shipment of the hardware.

The necessity for an Acceptance Data Package (ADP) for the hardware and software shall be evaluated on a case-by-case basis by the assigned quality engineer. At a minimum for the hardware, JSC form 911 tags shall be used to maintain transfer and usage information instead of a formal ADP. The content of the hardware and software ADP is defined in Appendix A of the HRF PRD and in SSP-30695A, "Acceptance Data Package Requirements Specification."

7.2 ACCEPTANCE TESTS

7.2.1 Pre-Delivery Acceptance (PDA) Test Requirements

A PDA shall be performed by the responsible manufacturing parties after the complete fabrication and assembly has been conducted for all Class I deliverable assemblies. This test shall include verification of software interface and operation. The PDA must be completed before hardware certification testing begins. It is a full functional test and inspection that validates that the hardware operates per the design requirements and that it is constructed per released engineering drawings and workmanship standards. All PDA tests shall be approved by the hardware's JSC technical monitor and quality engineering personnel, as well as the contractor quality engineering personnel (if applicable). The following are standard steps that each PDA test shall contain:

1. Conformance to Drawing. Verify that the hardware conforms to released engineering drawings.
2. No Sharp Edges. Inspect the hardware to verify that there are no sharp edges or corners present.
3. Proper Identifying Markings. Verify that the hardware has the proper part number and serial number (if applicable) on it.
4. Cleanliness. All PDA tests shall include verification that all surfaces (external, internal, etc.) are to the cleanliness level provided in Section 4.4 of this document.

7.2.2 Pre-Installation Acceptance (PIA) Test Requirements

PIA tests shall be conducted on all components and assemblies to determine conformance to design specifications as a basis for acceptance for flight usage. PIA tests shall be performed prior to shipment for flight after all certification testing and analyses are completed. PIA tests can also be performed upon post shipment and/or pre-installation for flight.

7.2.3 Functional Test Requirements

Functional tests are performed to validate the operation of the hardware to the requirements of Section 3.1.2 in this HRD. Functional tests are performed to validate the operation of the software to the requirements of Section 3.1.6 in this HRD. Functionals make up the core of certain tests (like a PDA) and can be performed before and after environmental testing. The functional checkout done prior to testing establishes the functional state (or baseline) of the hardware, while the functional checkout done after testing evaluates its ability to withstand the test levels.

An abbreviated functional test will be used to determine the functional state of the hardware during some environmental testing (i.e., thermal, vibration, bench handling, etc.). The intended use of an abbreviated functional test is to verify nominal hardware function between test stages.

7.2.4 Environmental Acceptance Test Requirements

Certain flight hardware will be exposed to environmental acceptance tests to verify workmanship and manufacturing and assembly conformance to drawings. The flight hardware that is exposed to vibration environments or is of significant complexity shall be exposed to an acceptance vibration test level. The acceptance test levels for HRF hardware are defined in Section 7.2.4.1 of the HRF HRD.

NOTE: Soft goods and disposable items will not require environmental acceptance testing.

7.2.4.1 Acceptance Vibration Test (AVT)

All HRF Class I (flight and qualification units (Class II)) hardware shall be tested to the following acceptance level random vibration environment in a hard-mount configuration to verify that the unit was properly assembled per drawings and procedures:

Frequency	Level	
20 Hz	.010	g^2/Hz
20-80 Hz	+3.0	dB/oct
80-350 Hz	0.04	g^2/Hz
350-2000 Hz	-3.0	dB/oct
2000 Hz	.007	g^2/Hz
Composite	6.1	g_{rms}

The vibration test shall be for 60 seconds for all three axes.

A full functional test must be performed before and after the Acceptance Vibration Test. An abbreviated functional test must be performed after each axis has been tested.

7.2.4.2 Acceptance Thermal Cycle Test

The hardware shall be exposed to a thermal cycle test. The test level shall be developed based upon the limitation of the hardware (especially if COTS items are included). The hardware shall be exposed to the acceptance test value of 50°F above and below the normal operating temperature (75°F), but shall be operated only at the operational range limits of Section 5.2 of this HRD.

The hardware shall be exposed to 1.5 cycles.

NOTE: The 100° sweep does not have to be split 50° up and 50° down. The sweep shall be tailored to the Ultrasound System hardware specifications.

A full functional checkout must be performed pre- and post-test. An abbreviated functional checkout must be performed at selected temperatures during the thermal test.

8.0 QUALIFICATION APPROACH AND TESTS

8.1 GENERAL

The following sections list the qualification testing levels for several of the natural environments listed in Section 5 of this HRD. This information shall be included in the comments column of the certification matrix in Appendix B.

8.2 QUALIFICATION TESTS

8.2.1 Functional Test Requirements

Functional tests are performed to validate the operation of the hardware to the requirements of Section 3.1.2. Functionals make up the core of certain tests (like a PDA) and can be performed before and after environmental testing. The functional checkout done prior to testing establishes the functional state (or baseline) of the hardware, while the functional checkout done after testing evaluates its ability to withstand the test levels.

An abbreviated functional will be used to test the functional state of the hardware during some environmental testing (i.e., thermal, vibration, bench handling, etc.). The intended use of an abbreviated functional is to verify nominal hardware function between test stages.

8.2.2 Qualification Acceptance Random Vibration Test (QAVT)

The Ultrasound System shall be tested to the following qualification acceptance level random vibration environment. All rack-mounted, soft-stowed, and deployed (for launch) hardware shall be exposed to this level by using a qualification flight unit.

Frequency	Level	
20 Hz	0.017	g^2/Hz
20-80 Hz	+3.0	dB/oct
80-350 Hz	0.067	g^2/Hz
350-2000 Hz	-3.0	dB/oct
2000 Hz	0.0118	g^2/Hz
Composite	7.9	g_{rms}

The vibration test shall be for 120 seconds for each of the three axes.

A full functional test must be performed before and after the QAVT. An abbreviated functional test must be performed after each axis has been tested.

Successful completion of the QAVT will certify hardware for one modification/re-acceptance test. Certification for each additional modification requires an additional 60 seconds of QAVT.

8.2.3 Qualification Random Vibration Test (QVT)

The Ultrasound System shall be tested to the following launch level random vibration environment:

Frequency	Level	
20 Hz	0.005	g^2/Hz
20-80 Hz	+5.0	dB/oct
80-350 Hz	0.04	g^2/Hz
350-2000 Hz	-3.9	dB/oct
2000 Hz	0.002	g^2/Hz
Composite	4.4	g_{rms}

The vibration test shall be for 120 seconds (minimum) for each of the three axes.

Successful completion of the QVT will certify rack-mounted hardware for three missions (launch/landing cycles). Certification for each additional mission requires an additional 30 seconds of QVT.

8.2.4 Qualification Thermal Cycle Test

The hardware shall be exposed to a thermal cycle test environment. The test level shall be developed based upon the limitation of the hardware (especially if COTS items are included). The hardware shall be exposed to the certification test value of 55 °F above and below the normal operation temperature (75 °F) per SP-T-0023B. The maximum/minimum operating temperature of the Ultrasound System shall be the limits stated in Section 5.2.1 of this HRD.

The hardware shall be exposed to seven and one-half (7 1/2) cycles. A full functional checkout must be performed pre- and post-test. An abbreviated functional checkout must be performed at selected temperatures during the thermal test.

8.2.5 Limit and Ultimate Loads

The limit loads for the Ultrasound System specified in Section 3.1.3 of this HRD shall be used to calculate the ultimate loads per the instructions of LS-71012, "Structural Analysis Plan for the Human Research Facility Payload and Racks." A stress analysis shall be done to document that the design has positive margins of safety at all limit loads.

A full functional test must be performed pre- and post-test. An abbreviated functional test must be performed at selected temperatures during the thermal test.

8.2.6 Fracture/Fatigue

The Ultrasound System shall be designed to prevent the creation or propagation of any materials failures per the requirements of LS-71010. A fracture analysis shall be done to document that the design does not propagate any materials failure due to loading.

CONFIGURATION AND CHANGE CONTROL

Configuration of this equipment will be established through appropriate design reviews. A baseline configuration for flight hardware will be released via JSC drawings in accordance with JPG 8500.4, "Engineering Drawing System Manual." A baseline design for flight software will be released via this HRD following CDR. The released HRD and these released engineering drawings shall define the configuration sufficient to allow storage accommodations definition, end item identification, end item modification, and end item fabrication/assembly, as appropriate. The end items of this document shall be configured in accordance with the configuration on the top assembly drawings as listed in Section 2.4 of this document. Fabrication and assembly shall comply with approved drawings and Drawing Change Notices.

Any changes to this HRD, the software design, or the released drawings will be approved via a CR to the CCB, as appropriate, via LS-71005, "Configuration Management Plan for the Human Research Facility." Not all drawing or software changes are required to go to the CCB, only those that affect the fit, form, and/or function of the hardware and/or software shall be controlled at the CCB.

10.0 SAFETY AND MISSION ASSURANCE (S&MA) AND QUALITY ASSURANCE PLAN

10.1 GENERAL REQUIREMENTS

The hardware covered by this HRD shall abide by the following HRF system level plans:

1. LS-71002, System Safety Program Plan for the Human Research Facility
2. LS-71013, Logistics and Maintenance Plan for the Human Research Facility Payloads and Racks
3. LS-71026, Reliability Plan for the Human Research Facility
4. LS-71030, Quality Assurance Plan for the Human Research Facility

In addition, this HRD establishes that the design and construction of the hardware and its components shall ensure ease and rapidity of repair and maintenance while on the ground and during mission use. The design shall be such that the use of special tools shall be minimized for normal maintenance and checkout of the hardware.

This HRD serves as the certification plan for the hardware; therefore, a separate certification plan is not required. The plan specified here will be deemed acceptable by S&MA and quality engineering by way of approval signatures for this HRD and will be carried forth through the end of the project activity.

10.2 CRITICALITY

The end items of this HRD shall be assigned a criticality. The criticality will be based upon the analysis found in the hardware Failure Modes and Effects Analysis and Critical Items List (FMEA/CIL) document prepared per LS-71026. The FMEA shall be used to design to minimum risk and increased reliability that ensures mission success and no injury or loss of crew, shuttle, or station. There will be adequate redundancy applied to prevent injury to crew and damage to the shuttle during launch or station during on-orbit operations as identified in the FMEA/CIL documents.

10.3 SAFETY AND MISSION ASSURANCE DOCUMENTATION LIST

Table 10.3-1 on the following page shall be added to the Verification Matrix to indicate compliance with the requirement to produce and approve the certification document.

10.4 HARDWARE DELIVERY FOR FLIGHT

Cleaning, preservation, packaging, handling, storage, and shipping of the end items of this requirements document will be in accordance with MIL-STD-794B. Shipping personnel shall be made aware that these requirements must be followed because the hardware must be protected from handling and transportation damage as well as exposure to natural environments that could cause harm to the hardware. Once the hardware has been prepared for flight delivery, a JSC Form 1027 shall be completed and submitted for approval to quality engineering. Prior to hardware release, the quality assurance records and the flight hardware certification report will be reviewed to ensure compliance and that no open records exist on the specified hardware item.

TABLE 10.3-1. SAFETY AND MISSION ASSURANCE DOCUMENTATION LIST

METHODS

A - Applicable
 N/A - Non-Applicable

10-2

Requirement	Acceptance		Qualification		Verification Document	Open (O) Closed (X)	Comments
	Meth.	Procedure	Meth.	Procedure			
Failure Mode and Effects Analysis			A		LMSMSS-32067	X	Supplied at PDR.
Critical Items List			A		LMSMSS-32067	X	Supplied at CDR.
Limited Life Items List			A		LMSMSS-32453	X	Supplied at CDR.
Certification Report			A		See Comments	O	GCAR and certification package shall constitute the certification report.
Stress Analysis Report			A		LM-EA9810	O	SA per SSP57000, random and quasi-static loads
Fracture Control Analysis			A		LM-EA9810	O	A part of the stress analysis report
Thermal Analysis			A		LM-9805	O	Due 1/8/98
Payload Safety Data Package			A		LS-71027	O	The hardware described in this HRD shall be included in the four HRF phased safety data packages.
Safety Analysis Report			A		TBD	O	
Accident or Incident Report			N/A		See Comments	X	DR system shall be used during the certification and acceptance program.
Failure Report			N/A		See Comments	X	DR system shall be used during the certification and acceptance program.
Redundant Path Verification			A		LMSMSS-32067	X	A part of the FMEA/CIL document.

TABLE 10.3-1. SAFETY AND MISSION ASSURANCE DOCUMENTATION LIST (Cont'd)

METHODS

A - Applicable
 N/A - Non-Applicable

10-3

Requirement	Acceptance		Qualification		Verification Document	Open (O) Closed (X)	Comments
	Meth.	Procedure	Meth.	Procedure			
Separation of Redundant Path			A		LMSMSS-32067	X	A part of the FMEA/CIL document.
Failure Propagation			A		LMSMSS-32067	X	A part of the FMEA/CIL document.
Touch Temperature			A		LM-EA9805	O	A part of the thermal analysis report
Test Plans							
Pre-Delivery Acceptance (PDA)			A		TBD	O	Performed for all flight and certification units.
Pre-Installation Acceptance (PIA)			A		TBD	O	Performed for all flight units.
Qualification Test(s)			A		TBD	O	As required.

10.5 NON-CONFORMANCE REPORTING (PROBLEM REPORTING)

All HRF hardware items must meet the Non-Conformance Reporting requirements specified in HRF PRD, Section 7.4.2.

The DR system will be used on all flight hardware. It is the responsibility of the assigned quality engineer to determine if a Material Review Board disposition is required on the DR.

If the nonconformance represents a problem warranting the use of a Failure Investigation Action Report (FIAR), the FIAR process will be followed. The assigned quality engineer will determine whether a FIAR is required.

APPENDIX A
APPLICABILITY MATRIX

APPENDIX A HRD APPLICABILITY MATRIX

No.	Reference Document Item #	Abbreviated Requirement Title	App.	HRD Parag. #	Comments
X = Applicable N/A = Not Applicable E = Exception					
SECTION I					
FRD PARAG. # FUNCTIONAL REQUIREMENTS SECTION					
	8.2	The Ultrasound/Doppler shall be capable of:		3.1.2.1	
	8.2.1	Being easily upgradeable with new software or modular hardware when available	X	3.1.2.2.8	
	8.2.2	Imaging Modes: - Real Time 2D - Color Flow Doppler - Color Power Imaging (Doppler Tissue Imaging) - M-mode (gray and color) - Pulsed Wave Doppler - Continuous Wave Doppler - Dual Image Capacity - ECG Display (triggered 2D) - Respiratory Trace Display (capacity for respiratory input signal) - Transesophageal - Post-image processing 3d construction capability (real 3D capability if technology exists) Applications: - Echocardiography - Abdominal ultrasound (deep organ) - Vascular ultrasound - Gynecological ultrasound - Muscle and tendon u/s - Transcranial ultrasound - Ultrasound Contrast Studies - Small parts ultrasound - Veterinary ultrasound	X X X X X X X X X N/A X X X N/A X X N/A X N/A X N/A	3.1.2.1.1 a b c d e f g h i N/A j 3.1.2.2.1 N/A N/A N/A N/A N/A	DELETION: Approved per Safety Review Board DELETION: Not a requirement per Science Working Group DELETION: Approved per Safety Review Board DELETION: Not a requirement per Science Working Group
	8.2.3	General Physical Features: - Digital output and storage capability - Main Electronics Unit - 8mm video recorder - Deployable keyboard - Deployable screen(s) - Array of transducers - Video and digital downlink capability - Time and digital synchronized data - Headphones - Test phantoms - Clock display - On-screen date display - Microphone - Consumables	X X X X N/A X X N/A X N/A X X X X X	3.1.2.1.2 a a b c N/A d a; 3.1.2.2.8 N/A e N/A a a f g	ADDITION DELETION: HRF Workstation monitor will be used reference d.Ultrasound Probes DELETION: not currently an element of design ADDITION DELETION: not currently an element of design Main Electronics Unit provides on display Main Electronics Unit provides on display ADDITION
	8.2.4	Cardiac Features: - Flow determination - Volume determination - Pressure determination - Doppler Tissue Imaging	X	3.1.2.2.6	ADDITION
	8.2.5	Transcranial Features: - Headgear	N/A	N/A	DELETION: No longer a requirement
	8.2.6	Muscle Features: - Standoff set for muscle and tendon imaging	N/A	N/A	DELETION: Approved per Safety Review Board
	8.3	Technical Specifications: The Ultrasound shall have:			
	8.3.1	2D imaging/Doppler with multifrequency capability	X	3.1.2.1.1; 3.1.2.2.1	
	8.3.2	Guided continuous wave Doppler (2.5 MHz)	X	3.1.2.1.1; 3.1.2.2.1	
	8.3.3	Non-guided continuous Doppler (2.5 MHz)	X	3.1.2.1.1; 3.1.2.2.1	
	8.3.4	Vascular imaging transducers	X	3.1.2.2.1	
	8.3.5	Multiplane (rotatable) transducers for volumetric determination	N/A	N/A	DELETION: not currently an element of design
	8.3.6	The capability of being rack powered	X	3.1.5.2.1	

APPENDIX A HRD APPLICABILITY MATRIX

No.	Reference Document Item #	Abbreviated Requirement Title	App.	HRD Parag. #	Comments
		X = Applicable N/A = Not Applicable E = Exception			
	n/a	Imaging Technologies - L7-4 38mm - C7-4 40 R - L12-5 38 mm - CL10-5 26mm - L10-5 38mm - D5v static - C5-2 40R - D10 static - C4-2 40R - P6-3 16mm - P3-2 20mm - P5-3 16mm - P7-4 11mm - TCD Static - D2 Static	X	3.1.2.2.1	ADDITION
	n/a	Operating Modes - 2D / MM - Cine / 3D - Color - Doppler - Net / Disk - Physio - PWR	X	3.1.2.2.2	ADDITION
	n/a	Color / Doppler Functions - Scale - Priority - Filter - Baseline - Ang. Cor. - SV Size - 0/60 - Steer - Invert	X	3.1.2.2.3	ADDITION
	n/a	2D / M-Mode Functions - M Cursor - Zones - Focus - Depth - Top / Bot - Sec Width - Zoom - L/R Invert - HD Zoom	X	3.1.2.2.4	ADDITION
	n/a	Imaging Controls - Output - Volume - 2D Gain - Dop Gain - Col Gain - TGC	X	3.1.2.2.5	ADDITION
	n/a	Measurement Functions - High Q - Distance - Area - Del Meas - Calcs - Adv Meas	X	3.1.2.2.6	ADDITION
	n/a	Storage & Review Functions - Freeze - Loop - Review - Del Image - Print	X	3.1.2.2.7	ADDITION
	n/a	Remote Software Interface	X	3.1.2.2.8	ADDITION

APPENDIX A HRD APPLICABILITY MATRIX

No.	Reference Document Item #	Abbreviated Requirement Title	App.	HRD Parag. #	Comments
X = Applicable N/A = Not Applicable E = Exception					
	SECTION II PRD PARAG.#	HUMAN FACTORS REQUIREMENTS SECTION			
	6.2.12.1.1	Anthropometric Design	X	4.1	
	6.2.12.1.2	Payload Orientation	X	4.1	
	6.2.12.1.3	Color	X	4.8	
	6.2.12.1.4	Controls and Display	N/A	N/A	Defined by vendor
	6.2.12.1.5	Labeling/Coding	X	4.1	
	6.2.12.1.6	Drawer/Tray Design	X	4.1	16 PU drawer makes req. applicable
	6.2.12.1.7	Closure/Cover Design	N/A	N/A	
	6.2.12.1.8	Mounting	N/A	N/A	N/A per HFE
	6.2.12.1.9	Portable Item Handles/Grasp Areas	X	4.1	
	6.2.12.1.10	Payload-Unique Crew Restraints	N/A	N/A	N/A per HFE
	6.2.12.1.11	Payload-Unique Equipment Restraints	X	4.1	
	6.2.12.1.12	Payload-Unique Handhold Positions	N/A	N/A	N/A per HFE
	6.2.12.1.13	Fastener Design	X	4.5.3	
	6.2.12.1.14	Connector Design	X	4.1	
	6.2.12.1.15	Hose/Cable Restraints	X	4.1	
	6.2.12.1.16	Packaging Design	X	4.1	
	6.2.12.1.17	Cable Management	X	4.1	Cable management scenarios tested on KC-135
	6.2.12.1.18	Accessibility	X	4.1	
	6.2.12.1.19	Housekeeping	X	4.4	
	6.2.12.1.20	Mechanical Energy Evaluation	N/A	N/A	N/A per HFE
	6.2.12.1.21	Latch Status Display	N/A	N/A	N/A per HFE
	6.2.12.1.22	Mounting Bolt/Fastener Spacing	N/A	N/A	N/A per HFE
	6.2.12.1.23	Hazard Labels	N/A	N/A	

APPENDIX A HRD APPLICABILITY MATRIX

No.	Reference Document Item #	Abbreviated Requirement Title	App.	HRD Parag. #	Comments
X = Applicable N/A = Not Applicable E = Exception					
SECTION III STANDARD #		JHB 8080.5 REQUIREMENTS SECTION			
G-1		Equipment Accessibility for Maintenance	X	4.2	
G-2		Separation of Redundant Equipment	N/A	N/A	N/A to US design
G-3		Systems Checkout Provisions	N/A	N/A	N/A to US design
G-4		Protection of Spacecraft Electrical and Mechanical Systems from Debris	N/A	N/A	N/A to US design
G-5		Interior Design of Spacecraft for Cleanliness	N/A	N/A	N/A to US design
G-6		Redundancy Requirements	N/A	N/A	N/A to US design
G-7		Time Displays	X	4.2	
G-8		Redundant Paths - Verification of Operation	N/A	N/A	N/A to US design
G-9		Shatterable Material - Exclusion From Habitable Compartment	X	4.2	
G-10		Control of Limited- Life Components	N/A	N/A	N/A to US design
G-11		Procurement Document Identification for Manned Space Flight Vehicle Items	X	4.2	Audit SCPRs as necessary
G-12		Application of Previous Qualification Tests	N/A	N/A	The US design will have significant design changes over previous ultrasound units
G-13		Shipping and Handling Protection for Space Flight Hardware	X	4.2	
G-14		Identification and Classification of Flight and Non-flight Equipment	X	4.2	
G-15		Equipment Failure - Verification of Flight Readiness	X	4.2	
G-16		Operating Limits on Temperature - Controlled Equipment	X	4.2	
G-17		Separate Stock for Space Flight Parts and Materials	X	4.2	
G-18		Safety Precautions - Test and Operating Procedures	X	4.2	
G-19		Special Processes - Identification of Drawings	X	4.2	
G-20		Spacecraft Equipment - Protection from System Liquids	N/A	N/A	N/A to US design
G-21		Spacecraft Equipment - Moisture Protection	X	4.2	
G-22		Parts Identification	X	4.2	
G-23		Pressure Garment Wiring - Ignition of Materials by Electrical Current	N/A	N/A	N/A to US design
G-24		Ground Support Equipment and Airborne Support Equipment Protective Devices	X	4.2	
G-25		Thermal Design and Analysis - Thermal Parameters	X	4.2	
G-26		Internally Generated Radiation	N/A	N/A	N/A to US design
G-27		Fire Control	N/A	N/A	N/A to US design
G-28		Sealing - Solid Propellant Rocket Motors	N/A	N/A	N/A to US design
G-29		Reentry Propulsion Subsystem In-Flight Test	N/A	N/A	N/A to US design
G-30		Switch Protection Devices	X	4.2	
G-31		Detachable Crew-Operated Tools - Restriction in Spacecraft	N/A	N/A	N/A to US design
G-32		Measurement Systems That Display Flight Information to the Crew - Indication of Failure	N/A	N/A	N/A to US design
G-33		Surface Temperatures	X	4.2	
G-34		Extravehicular Activity Electronic Connectors	N/A	N/A	N/A to US design
G-35		Enclosure Panels External to the Habitable Modules	N/A	N/A	N/A to US design
G-36		Thermal Blankets - Extravehicular Activity	N/A	N/A	N/A to US design
G-37		Verification of Adequate External Visibility	N/A	N/A	N/A to US design
G-38		Pressurization or Repressurization - Precluding Ingress of Undesirable Elements	N/A	N/A	N/A to US design
G-39		Lightning Protection Design	N/A	N/A	N/A to US design
G-40		Radioactive Luminescent Devices	N/A	N/A	N/A to US design
G-41		Acoustic Noise Criteria	N/A	N/A	N/A to US design
G-42		Solar Wind Environment	N/A	N/A	N/A to US design
G-43		Centralized Subsystem Controls	N/A	N/A	N/A to US design
G-44		Attitude Control Authority	N/A	N/A	N/A to US design
G-45		Solid Propellant Rocket Motors - Ignition Capability with Unsealed Nozzle	N/A	N/A	N/A to US design
G-46		Separation Sensing System - Structural Deformation	N/A	N/A	N/A to US design
G-47		Gyroscopes - Verification of Rotational Speed or Drift Rate	N/A	N/A	N/A to US design
G-48		Onboard Experiments - Required Pre-installation Checklist	X	4.2	
G-49		Temperature and Pressure Monitoring Requirements of Hydrogen Peroxide Systems	N/A	N/A	N/A to US design
G-50		Direct Procurement of Parts	X	4.2	

APPENDIX A HRD APPLICABILITY MATRIX

No.	Reference Document Item #	Abbreviated Requirement Title	App.	HRD Parag. #	Comments
X = Applicable N/A = Not Applicable E = Exception					
	G-51	Flight Hardware - Restriction on Use for Training	X	4.2	
	G-52	Reuse of Flight Hardware	X	4.2	
	ELECTRICAL				
	E-1	Mating Provisions for Electrical Connectors	X	4.2	
	E-2	Protection of Severed Electrical Circuits	N/A	N/A	N/A to US design
	E-3	Electrical and Electronic Devices - Protection from Reverse Polarity and/or Other Improper Electrical Inputs	X	4.2	
	E-4	Electrical Connectors - Moisture Protection	X	4.2	
	E-5	Electrical Connectors - Pin Assignment	X	4.2	
	E-6	Corona Suppression	N/A	N/A	N/A to US design
	E-7	Tantalum Wet Slug Capacitors - Restriction on Use	N/A	N/A	N/A to US design
	E-8	Electrical and Electronic Supplies and Loads - Verification Tests	N/A	N/A	N/A to US design
	E-9	Electrical Circuits - De-energizing Requirements	N/A	N/A	N/A to US design
	E-10	Cleaning of Electrical and Electronic Equipment	X	4.2	
	E-11	Protective Covers or Caps for Electrical Receptacles and Plugs	X	4.2	
	E-12	Electrical Connectors - Disconnection for Troubleshooting and Bench Testing	X	4.2	
	E-13	Bioinstrumentation Systems - Crew Electrical Shock Protection	X	4.2	
	E-14	Electrical Wire Harness - Dielectric Tests	X	4.2	
	E-15	Electrical Power Distribution Circuits - Overload Protection	X	4.2	
	E-16	Testing Protective Devices for Solid-State Circuits	N/A	N/A	N/A to US design
	E-17	Electrical and Electronic Piece Parts - Closure Construction	N/A	N/A	N/A to US design
	E-18	Circuitry for Automatic Shutdown of Launch Vehicle Engine(s)	N/A	N/A	N/A to US design
	E-19	Equipment Design - Power Transients	X	4.2	
	E-20	Control of Electrostatic Discharge for Electronic Parts and Assemblies	N/A	N/A	N/A to US design
	E-21	Electrical Connectors	X	4.2	
	E-22	Ionizing Radiation Effects	N/A	N/A	N/A to US design
	E-23	Transistors - Selection of Types	N/A	N/A	N/A to US design
	E-24	Electrical Wire and Cable Acceptance Tests	X	4.2	
	FLUIDS				
	F-1	Flow Restriction Requirements - Pressurized Sources	N/A	N/A	N/A to US design
	F-2	Moisture Separators in a Zero-Gravity Environment	N/A	N/A	N/A to US design
	F-3	Service Points - Positive Protection From Interchangeability of Fluid Service Lines	N/A	N/A	N/A to US design
	F-4	Ground Service Points - Fluid Systems	N/A	N/A	N/A to US design
	F-5	Fluid Lines - Separation Provisions	N/A	N/A	N/A to US design
	F-6	Temperature and Pressure Monitoring Requirements for Potentially Hazardous Reactive Fluids	N/A	N/A	N/A to US design
	F-7	Capping of Servicing and Test Ports	N/A	N/A	N/A to US design
	F-8	Fluid System Components Whose Function is Dependent on Direction of Flow - Protection Against Incorrect Installation	N/A	N/A	N/A to US design
	F-9	Spacecraft Venting - Induced Perturbing Forces	N/A	N/A	N/A to US design
	F-10	Nozzles and Vents - Protection Prior to Launch	N/A	N/A	N/A to US design
	F-11	Fluid Supplies - Verification Tests	N/A	N/A	N/A to US design
	F-12	Protection of Pressurized Systems from Damage Due to Pressurant Depletion - Ground Support Equipment and Airborne Support Equipment	N/A	N/A	N/A to US design
	F-13	Crew Cabin Module Pressure - Venting Restriction	N/A	N/A	N/A to US design
	F-14	Crew Cabin Module Ventilating Fans - Protection from Debris	N/A	N/A	N/A to US design
	F-15	Separation of Hypergolic Reactants	N/A	N/A	N/A to US design
	F-16	Fluid Line Installation	N/A	N/A	N/A to US design
	F-17	Cleanliness of Flowing Fluids and Associated Systems	N/A	N/A	N/A to US design
	F-18	Pressure Relief Valves - Standardization of Functional Testing	N/A	N/A	N/A to US design
	F-19	Protection for Tubing, Fittings, and Fluid System Components - Flight Hardware and Associated Equipment	N/A	N/A	N/A to US design
	F-20	Fluid Systems - Cleanliness	N/A	N/A	N/A to US design
	F-21	Purge Gases - Temperature and Humidity Requirements	N/A	N/A	N/A to US design

APPENDIX A HRD APPLICABILITY MATRIX

No.	Reference Document Item #	Abbreviated Requirement Title	App.	HRD Parag. #	Comments
X = Applicable N/A = Not Applicable E = Exception					
	F-22	Pressure Garments - Protection Against Failure Propagation	N/A	N/A	N/A to US design
	F-23	Qualification Fluid	N/A	N/A	N/A to US design
	F-24	Fluid Systems - Design for Flushing and Draining	N/A	N/A	N/A to US design
	F-25	Toxicity - Fluids Contained in Systems in the Crew Compartment	N/A	N/A	N/A to US design
	F-26	Atmospheric Pressure and Composition Control	N/A	N/A	N/A to US design
	F-27	Liquid or Gas Containers - Verification of Contents	N/A	N/A	N/A to US design
	F-28	Use of Halogen Method for Coolant System Leak Detection	N/A	N/A	N/A to US design
	F-29	Filter Protection of Active Fluid Components	N/A	N/A	N/A to US design
	F-30	Pressure Relief for Pressure Vessels	N/A	N/A	N/A to US design
	MATERIALS AND PROCESSES				
	M/P-1	Material Selection, Review, and Drawing Sign-off	X	4.2	
	M/P-2	Flammability of Wiring Material	X	4.2	
	M/P-3	Toxicity of Materials Used in Crew Compartments - Wire Insulation, Ties, Identification Marks, and Protective Coverings	X	4.2	
	M/P-4	Metals and Metal Couples - Restriction on Use	X	4.2	
	M/P-5	Solutions Which Contain Ethylene Glycol - Requirements for Silver Chelating Agent	N/A	N/A	N/A to US design
	M/P-6	Toxicity - Requirements for Nonmetallic Materials Proposed for Use Within Crew Compartment	X	4.2	
	M/P-7	Material Detrimental to Electrical Connectors	X	4.2	
	M/P-8	Leak Detectors - Wetting Agents	N/A	N/A	N/A to US design
	M/P-9	Breathing Systems - Requirement to Test for Mercury Contamination	N/A	N/A	N/A to US design
	M/P-10	Liquid Locking Compounds, Restrictions, and Controls	X	4.2	
	M/P-11	Pressure Vessel Design	N/A	N/A	N/A to US design
	M/P-12	Multi-Layer Blanket Bake-Out	N/A	N/A	N/A to US design
	M/P-13	Pressure Vessel Design	N/A	N/A	N/A to US design
	M/P-14	Silicate Ester Coolant System Design	N/A	N/A	N/A to US design
	M/P-15	Mercury - Restriction on Use	N/A	N/A	N/A to US design
	M/P-16	Restriction on Coatings for Areas Subject to Abrasion	X	4.2	
	M/P-17	Radiographic Inspection of Brazed and Welded Tubing Joints	N/A	N/A	N/A to US design
	M/P-18	Etching Fluorocarbon Insulated Electrical Wire	X	4.2	
	M/P-19	Spacecraft Material - Restriction on Use of Polyvinyl Chloride	X	4.2	N/A through analysis
	M/P-20	Titanium or its Alloys - Prohibited Use With Oxygen	X	4.2	N/A through analysis
	M/P-21	Beryllium - Restricted Use Within Crew Components	X	4.2	N/A through analysis
	M/P-22	Brazed Joints - Identification Marks	N/A	N/A	N/A to US design
	M/P-23	Pressure Vessels - Materials Compatibility and Vessel Qualifications Tests	N/A	N/A	N/A to US design
	M/P-24	Cadmium - Restriction on Use	X	4.2	N/A through analysis
	M/P-25	Pressure Vessels - Nondestructive Evaluation Plan	N/A	N/A	N/A to US design
	M/P-26	Repair of Sandwich - Type Structures	N/A	N/A	N/A to US design
	MECHANICAL AND STRUCTURAL				
	M/S-1	Equipment Containers - Design For Rapid Spacecraft Decompression	X	4.2	
	M/S-2	Alignment of Mechanical Systems	N/A	N/A	N/A to US design
	M/S-3	Wire Bundles - Protective Coating	X	4.2	
	M/S-4	Hatches - Repeated Use	N/A	N/A	N/A to US design
	M/S-5	Threaded Fittings - Restrictions on Release of Particles and Foreign Materials	X	4.2	
	M/S-6	Exposed Sharp Surfaces or Protrusions	X	4.2	
	M/S-7	Windows and Glass Structure	N/A	N/A	N/A to US design
	M/S-8	Penetration of Inhabited Spacecraft Compartments	N/A	N/A	N/A to US design
	M/S-9	Mechanisms	N/A	N/A	N/A to US design
	M/S-10	Functional Doors That Operate in Flight	N/A	N/A	N/A to US design
	M/S-11	Meteoroid Protection Levels for Structures	N/A	N/A	N/A to US design
	M/S-12	Spacecraft Recovery Hoist Loops	N/A	N/A	N/A to US design
	M/S-13	Lifting and Hoisting Ground Support Equipment Identification	N/A	N/A	N/A to US design

APPENDIX A HRD APPLICABILITY MATRIX

No.	Reference Document Item #	Abbreviated Requirement Title	App.	HRD Parag. #	Comments
X = Applicable N/A = Not Applicable E = Exception					
	M/S-14	Structural Analysis	X	4.2	
	M/S-15	Stainless Steel Tubing - Method of Joining	N/A	N/A	N/A to US design
	M/S-16	Pressure Vessels - Negative Pressure Damage	N/A	N/A	N/A to US design
	PYROTECHNIC				
	P-1	Explosive Devices - Arming and Disarming	N/A	N/A	N/A to US design
	P-2	Pyrotechnic Devices - Preflight Verification Tests at Launch Sites	N/A	N/A	N/A to US design
	P-3	Wire Splicing	N/A	N/A	N/A to US design
	P-4	Explosive Devices - Packaging Material	N/A	N/A	N/A to US design
	P-5	Explosive Devices - Identification Requirements	N/A	N/A	N/A to US design
	P-6	Protection of Electrical Circuitry for Explosive Devices Employing Hot Bridge Wire Initiators	N/A	N/A	N/A to US design
	P-7	Explosive Devices - Color Coding Requirements	N/A	N/A	N/A to US design

APPENDIX B
ULTRASOUND SYSTEM CERTIFICATION MATRIX

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Paragraph No.	REQUIREMENT	ACCEPT. Method	ACCEPT. Procedure	QUAL. Method	QUAL. Procedure	VERIFICATION DOCUMENT	Open (O) Closed (X)	COMMENTS / HARDWARE CONFIGURATION
3.0	SPECIFIC DESIGN REQUIREMENTS							
3.1	ULTRASOUND SYSTEM							
3.1.2	PERFORMANCE REQUIREMENTS							
3.1.2.1	Functional Req.							
3.1.2.1.1	Ultrasound Operating Modes	I, D	PDA	I, D	PDA			Show machine options, Inspect Keyboard
3.1.2.1.2	General Physical Features	I	PDA	I	PDA			Inspection of drawings and hardware
3.1.2.2	Technical Req.							
3.1.2.2.1	Imaging Technologies	D	PDA	D	PDA			Display machine options
3.1.2.2.2	Operating Modes	D	PDA	D	PDA			Display options for MENU keys
3.1.2.2.3	Color Doppler Functions	I	PDA	I	PDA			Inspection of keyboard interface
3.1.2.2.4	2D M-Mode Functions	I	PDA	I	PDA			Inspection of keyboard interface
3.1.2.2.5	Imaging Functions	I	PDA	I	PDA			Inspection of keyboard interface
3.1.2.2.6	Measurement Functions	I, D	PDA	I, D	PDA			Inspection of keyboard interface, show functions
3.1.2.2.7	Storage and Review Functions	I	PDA	I	PDA			Inspection of keyboard interface
3.1.2.2.8	Remote Software Interface	D	PDA	D	PDA			Reference QSWTP
3.1.3	LIMIT LOAD REQUIREMENTS	N/A		A	See comments			Ref. SA memo
3.1.3.1	Crew Induced Loads	N/A		A	See comments			Ref. SA memo
3.1.3.2	Pressure Systems							
3.1.4	PHYSICAL REQUIREMENTS							
3.1.4.1	Mass (Weight)	T	PDA	T	PDA			Weigh main electronics unit and keyboard
3.1.4.2	Envelope							
3.1.4.2.1	Stowed	I	PDA	I	PDA			Conformance to drawings
3.1.4.2.2	Deployed	I	PDA	I	PDA			Conformance to drawings
3.1.4.3	Center of Gravity	T	PDA	T	PDA			Measure keyboard and main electronics unit
3.1.5	INTERFACE REQUIREMENTS							
3.1.5.1	STRUCTURAL MECHANICAL INTERFACE REQUIREMENTS							
3.1.5.2	ELECTRICAL INTERFACE REQUIREMENTS							
3.1.5.2.1	US to Rack	T	PDA	T	PDA			Test per US ICD
3.1.5.2.2	US to Other Payloads							
3.1.5.3	COMMUNICATION AND DATA HANDLING INTERFACE REQUIREMENTS							
3.1.5.3.1	US to Rack	T	PDA	T	PDA			Test per US ICD
3.1.5.3.2	US to Other Payloads							
3.1.5.3.2.1	Serial (RS232) Connector	T	PDA	T	PDA			Test per US ICD
3.1.5.3.2.2	Physiological Signal Connectors	I	PDA	I	PDA			Inspect front panel
3.1.5.4	AUDIO/VISUAL INTERFACE REQUIREMENTS							
3.1.5.4.1	US to Rack	T	PDA	T	PDA			Test per US ICD
3.1.5.4.2	US to Other Payloads							
3.1.5.4.2.1	External Video I/O Connector	T	PDA	T	PDA			Test per US ICD
3.1.5.4.2.2	Display Connector	T	PDA	T	PDA			Test per US ICD
3.1.5.5	THERMAL CONTROL INTERFACE REQUIREMENTS							
3.1.5.5.1	HRF Rack Common Fan	N/A		I	PDA			Conformance to Drawings
3.1.5.5.2	HRF Rack Common Fan IVA Replacement	N/A		I	PDA			Conformance to Drawings
3.1.5.5.3	HRF Rack Common Fan Vibration/Acoustic Isolation	N/A		I	PDA			Conformance to Drawings
3.1.5.6	WASTE GAS VENT AND VACUUM INTERFACE REQUIREMENT	N/A		N/A				
3.1.5.7	NITROGEN INTERFACE REQUIREMENT	N/A		N/A				
3.1.6	SOFTWARE DESIGN REQUIREMENTS							
3.1.6.1	Definition							
3.1.6.2	Modes							
3.1.6.3	Ultrasound Flight CSCI							
3.1.6.3.1	CSCI Funct. and Perf. Req.	N/A		D	QSWTP			
3.1.6.3.2	External Interface Req.	N/A		D	QSWTP			
3.1.6.3.3	Internal Interface Req.	N/A		N/A				
3.1.6.3.4	Internal Data Req.	N/A		N/A				

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3.1.6.3.5	Adaptation Req.	N/A		N/A				
3.1.6.3.6	Safety Req.	N/A		D	QSWTP			
3.1.6.3.7	Data Privacy Req.	N/A		N/A				
3.1.6.3.8	CSCI Environment Req.	N/A		D	QSWTP			
3.1.6.3.9	Software Quality Factors	N/A		D	QSWTP			
3.1.6.3.10	Constraints	N/A		D	QSWTP			
3.1.6.3.11	Precedence and Criticality	N/A		N/A				
3.1.6.4	Ultrasound Ground CSCI							
3.1.6.4.1	CSCI Funct. and Perf. Req.	N/A		D	QSWTP			
3.1.6.4.2	External Interface Req.	N/A		N/A				
3.1.6.4.3	Internal Interface Req.	N/A		N/A				
3.1.6.4.4	Internal Data Req.	N/A		N/A				
3.1.6.4.5	Adaptation Req.	N/A		N/A				
3.1.6.4.6	Safety Req.	N/A		D	QSWTP			
3.1.6.4.7	Data Privacy Req.	N/A		N/A				
3.1.6.4.8	CSCI Environment Req.	N/A		D	QSWTP			
3.1.6.4.9	Software Quality Factors	N/A		D	QSWTP			
3.1.6.4.10	Constraints	N/A		N/A				
3.1.6.4.11	Precedence and Criticality	N/A		N/A				
4.0	GENERAL DESIGN REQUIREMENTS							
4.1	HUMAN FACTORS							
4.1-1	Anthropometric Design	N/A		I, T	PDA			5-95 Percentile, crew interface test
4.1-2	Payload Orientation	N/A		I	PDA			Conformance to Drawings
4.1-3	Color	N/A		N/A				See 4.8
4.1-4	Controls and Display	N/A		N/A				Defined by vendor
4.1-5	Labeling/Coding	N/A		I	PDA			Review U/S System design & drawings
4.1-6	Drawer/Tray Design	N/A		I	PDA			Review U/S System design & drawings
4.1-7	Closure/Cover Design	N/A		N/A				
4.1-8	Mounting	N/A		N/A				
4.1-9	Portable Item Handles/Grasp Areas	N/A		I	PDA			Review U/S System design & drawings
4.1-10	Payload-Unique Crew Restraints	N/A		N/A				
4.1-11	Payload-Unique Equipment Restraints	N/A		I	PDA			Review U/S System design & drawings
4.1-12	Payload-Unique Handhold Positions	N/A		N/A				
4.1-13	Fastener Design	I	PDA	I	PDA			Inspection of drawings & hardware
4.1-14	Connector Design	I	PDA	I	PDA			Inspection of drawings & hardware
4.1-15	Hose/Cable Restraints	N/A		I	PDA			Review operation procedures
4.1-16	Packaging Design	N/A		I	PDA			Inspection of drawings & hardware
4.1-17	Cable Management	N/A		I	PDA			Review operation procedures
4.1-18	Accessibility	N/A		I	PDA			Inspection of drawings & hardware
4.1-19	Housekeeping	N/A		I	PDA			Inspection of drawings & hardware
4.1-20	Mechanical Energy Evaluation	N/A		N/A				
4.1-21	Latch Status Display	N/A		N/A				
4.1-22	Mounting Bolt/Fastener Spacing	N/A		N/A				
4.1-23	Hazard Labels	N/A		N/A				
4.2	MANNED SPACECRAFT CRITERIA & STANDARDS (JHB 8080.5)							
4.2.G-1	Equipment Access, for Maint.	N/A		I	PDA			Inspect drawings, design, & hardware
4.2.G-2	Separation of Redundant Equip.	N/A		N/A				Criticality 3
4.2.G-3	Systems Checkout Provisions	N/A		N/A				Not an element of subsystems
4.2.G-4	Protection of Spacecraft Elect. & Mech. Systems from Debris	N/A		N/A				Not connected to spacecraft
4.2.G-5	Interior Design of Spacecraft for Cleanliness	N/A		N/A				
4.2.G-6	Redundancy Requirements	N/A		N/A				
4.2.G-7	Time Displays	N/A		I	PDA			Show US Display
4.2.G-8	Redundant Paths- Verification of Operation	N/A		N/A				
4.2.G-9	Shatterable Material- Exclusion From Habitable Compartment	N/A		I	PDA			Inspect US drawings & design
4.2.G-10	Control of Limited-Life Components	N/A		N/A				See HRD, Par. 4.12.3
4.2.G-11	Procurement Document Identification for Manned Space flight Vehicle Items	I	see comment	N/A				Audit SCPRs as necessary
4.2.G-12	Application of Previous Qualification Tests	N/A		N/A				US will have significant design changes over previous U/S units
4.2.G-13	Shipping and Handling Protection for Space flight Hardware	I	PDA	N/A				

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4.2.G-14	Identification and Classification of Flight and Non-flight Equipment	I	PDA	N/A				
4.2.G-15	Equipment Failure- Verification of Flight Readiness	A	see comment	N/A				DR & FIAR system in-place
4.2.G-16	Operating Limits on Temperature-Controlled Equipment	N/A		A, T	see comment			Ref. HRD, Par. 5.2
4.2.G-17	Separate Stock for Space flight Parts and Materials	I	see comment	N/A				Ref. assembly TPS & ADP
4.2.G-18	Safety Precautions-Test and Operating Procedures	I	see comment	I	see comment			Audit Test Procedures
4.2.G-19	Special Processes- Identification of Drawings	N/A		I	see comment			Not sensitive equipment
4.2.G-20	Spacecraft Equipment - Protection from System Liquids	N/A		N/A				N/A to US design
4.2.G-21	Spacecraft Equipment- Moisture Protection	N/A		A, T	see comment			Ref. HRD, Par. 5.4
4.2.G-22	Parts Identification	I	PDA	I	PDA			Ref. assembly TPS & ADP
4.2.G-23	Pressure Garment Wiring-Ignition of Materials by Electrical Current	N/A		N/A				
4.2.G-24	GSE & ASE Protective Devices	I	see comment	I	see comment			Review GSE design and/or drawings
4.2.G-25	Thermal Design and Analysis- Thermal Parameters	N/A		A, T	see comment			Ref. Thermal Analysis report, HRD 5.2
4.2.G-26	Internally Generated Radiation	N/A		N/A				
4.2.G-27	Fire Control	N/A		N/A				
4.2.G-28	Sealing- Solid Propellant Rocket Motors	N/A		N/A				
4.2.G-29	Reentry Propulsion Subsystem In-Flight Test	N/A		N/A				
4.2.G-30	Switch Protection Devices	N/A		I	PDA			Inspection of drawings & hardware
4.2.G-31	Detachable Crew-Operated Tools- Restriction in Spacecraft	N/A		N/A				
4.2.G-32	Measurement Systems that Display Flight Information to the Crew- Indication of Failure	N/A		N/A				
4.2.G-33	Surface Temperatures	N/A		A	see comment			Reference Thermal Analysis Report
4.2.G-34	Extravehicular Activity Electronic Connectors	N/A		N/A				
4.2.G-35	Enclosure Panels External to the Habitable Modules	N/A		N/A				
4.2.G-36	Thermal Blankets- Extravehicular Activity	N/A		N/A				
4.2.G-37	Verification of Adequate External Visibility	N/A		N/A				
4.2.G-38	Pressurization or Repressurization - Precluding Ingress of Undesirable Elements	N/A		N/A				
4.2.G-39	Lightning Protection Design	N/A		N/A				
4.2.G-40	Radioactive Luminescent Devices	N/A		N/A				
4.2.G-41	Acoustic Noise Criteria	N/A		N/A				Integrated Rack only
4.2.G-42	Solar Wind Environment	N/A		N/A				HW will operate in a lower environment
4.2.G-43	Centralized Subsystem Controls	N/A		N/A				
4.2.G-44	Attitude Control Authority	N/A		N/A				
4.2.G-45	Solid Propellant Rocket Motors- Ignition Capability with Unsealed Nozzle	N/A		N/A				
4.2.G-46	Separation Sensing System- Structural Deformation	N/A		N/A				
4.2.G-47	Gyroscopes- Verification of Rotational Speed or Drift Rate	N/A		N/A				
4.2.G-48	Onboard Experiments- Required Pre-installation Checklist	N/A		A	see comment			Rev. FMEA/CIL, SAR, crew training
4.2.G-49	Temp. & Press. Monitoring Rqmt's of Hydrogen Peroxide Systems	N/A		N/A				
4.2.G-50	Direct Procurement of Parts	I	see comment	N/A				Audit SCPRs & SOWs
4.2.G-51	Flt HW- Restriction on Use for Training	I	see comment	I	see comment			Controlled by TPS
4.2.G-52	Reuse of Flight Hardware	A, I, T	FT	N/A				
4.2.E-1	Mating Provisions for Electrical Connectors	N/A		I	see comment			Review design & drawings
4.2.E-2	Protection of Severed Electrical Circuits	N/A		N/A				N/A to US design

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4.2.E-3	Electrical and Electronic Devices- Protection from Reverse Polarity and/or Other Improper Electrical Inputs	N/A		I	see comment			Review design & drawings
4.2.E-4	Electrical Connectors- Moisture Protection	N/A		I	see comment			Review design & drawings
4.2.E-5	Electrical Connectors- Pin Assignment	N/A		I	see comment			Review design & drawings
4.2.E-6	Corona Suppression	N/A		N/A				
4.2.E-7	Tantalum Wet Slug Capacitors- Restriction on Use	N/A		N/A				
4.2.E-8	Electrical and Electronic Supplies and Loads-Verification Tests	N/A		N/A				Does not interfere with station
4.2.E-9	Electrical Circuits- De energizing Requirements	N/A		N/A				
4.2.E-10	Cleaning of Electrical and Electronic Equipment	I	PDA	I	see comment			Review drawings, design, PDA, & data pack
4.2.E-11	Protective Covers or Caps for Electrical Receptacles and Plugs	I	see comment	I	see comment			Review drawings & design
4.2.E-12	Electrical Connect.- Disconnect. for Troubleshoot. & Bench Testing	I	see comment	I	see comment			Controlled by TPS & operation procedures
4.2.E-13	Bioinstrumentation Systems- Crew Electrical Shock Protection	A	PDA					Review safety analysis report
4.2.E-14	Electrical Wire Harness- Dielectric Tests	T	PDA					Ref. assembly TPS & ADP
4.2.E-15	Electrical Power Distribution Circuits- Overload Protection	N/A		I	see comment			Review US design & drawings
4.2.E-16	Testing Protective Devices for Solid-State Circuits	N/A		N/A				
4.2.E-17	Electrical and Electronic Piece Parts- Closure Construction	N/A		N/A				
4.2.E-18	Circuitry for Automatic Shutdown of Launch Vehicle Engine(s)	N/A		N/A				
4.2.E-19	Equipment Design- Power Transients	N/A		I	see comment			Review design & drawings
4.2.E-20	Control of Electrostatic Discharge for Electronic Parts and Assemblies	N/A		N/A				
4.2.E-21	Electrical Connectors	A, I, T	PDA	N/A				
4.2.E-22	Ionizing Radiation Effects	N/A		A, T	PDA			HRD 5.10
4.2.E-23	Transistors- Selection of Types	N/A		N/A				
4.2.E-24	Electrical Wire and Cable Acceptance Tests	A, I	PDA	N/A				Ref. assembly TPS & ADP
4.2.F-1	Flow Restriction Requirements- Pressurized Sources	N/A		N/A				
4.2.F-2	Moisture Separators in a Zero-Gravity Environment	N/A		N/A				
4.2.F-3	Service Points- Positive Protection from Interchangeability of Fluid Service Lines	N/A		N/A				
4.2.F-4	Ground Service Points- Fluid Systems	N/A		N/A				
4.2.F-5	Fluid Lines- Separation Provisions	N/A		N/A				
4.2.F-6	Temperature and Pressure Monitoring Requirements for Potentially Hazardous Reactive Fluids	N/A		N/A				
4.2.F-7	Capping of Servicing and Test Ports	N/A		N/A				
4.2.F-8	Fluid System Components Whose Function is Dependent on Direction of Flow- Protection Against Incorrect Installation	N/A		N/A				
4.2.F-9	Spacecraft Venting- Induced Perturbing Forces	N/A		N/A				
4.2.F-10	Nozzles and Vents- Protection Prior to Launch	N/A		N/A				
4.2.F-11	Fluid Supplies- Verification Tests	N/A		N/A				
4.2.F-12	Protection of Pressurized Systems from Damage Due to Pressurant Depletion- Ground Support Equipment and Airborne Support Equipment	N/A		N/A				

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4.2.F-13	Crew Cabin Module Pressure-Venting Restriction	N/A		N/A				
4.2.F-14	Crew Cabin Module Ventilating Fans-Protection from Debris	N/A		N/A				
4.2.F-15	Separation of Hypergolic Reactants	N/A		N/A				
4.2.F-16	Fluid Line Installation	N/A		N/A				
4.2.F-17	Cleanliness of Flowing Fluids and Associated Systems	N/A		N/A				
4.2.F-18	Pressure Relief Valves- Standardization of Functional Testing	N/A		N/A				
4.2.F-19	Protection for Tubing, Fittings, and Fluid System Components- Flight Hardware and Associated Equipment	N/A		N/A				
4.2.F-20	Fluid Systems- Cleanliness	N/A		N/A				
4.2.F-21	Purge Gases- Temperature and Humidity Requirements	N/A		N/A				
4.2.F-22	Pressure Garments-Protection Against Failure Propagation	N/A		N/A				
4.2.F-23	Qualification Fluid	N/A		N/A				
4.2.F-24	Fluid Systems- Design for Flushing and Draining	N/A		N/A				
4.2.F-25	Toxicity-Fluids Contained in Systems in the Crew Compartment	N/A		N/A				
4.2.F-26	Atmospheric Pressure and Composition Control	N/A		N/A				
4.2.F-27	Liquid or Gas Containers-Verification of Contents	N/A		N/A				
4.2.F-28	Use of Halogen Method for Coolant System Leak Detection	N/A		N/A				
4.2.F-29	Filter Protection of Active Fluid Components	N/A		N/A				
4.2.F-30	Pressure Relief for Pressure Vessels	N/A		N/A				
4.2.M/P-1	Material Selection, Review, and Drawing Sign-off	N/A		I, A	see comment			Review US Material Cert. Rpt.
4.2.M/P-2	Flammability of Wiring Material	N/A		I, A	see comment			Review US Material Cert. Rpt.
4.2.M/P-3	Toxicity of Materials Used in Crew Compartments-Wire Insulation, Ties, Identification Marks, and Protective Coverings	N/A		I, A	see comment			Review US Material Cert. Rpt.
4.2.M/P-4	Metals and Metal Couples- Restriction on Use	N/A		I	see comment			Review US design & drawings
4.2.M/P-5	Solutions which contain Ethylene Glycol-Requirements for Silver Chelating Agent	N/A		N/A				

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4.2.M/P-6	Toxicity-Requirements for Nonmetallic Materials Proposed for Use within Crew Compartment	N/A		A, T	see comment			Review US Material Cert. Rpt.
4.2.M/P-7	Material Detrimental to Electrical Connectors	N/A		I	see comment			Review US design & drawings, material certification memo
4.2.M/P-8	Leak Detectors- Wetting Agents	N/A		N/A				
4.2.M/P-9	Breathing Systems- Requirement to Test for Mercury Contamination	N/A		N/A				
4.2.M/P-10	Liquid Locking Compounds, Restrictions, and Controls	I	PDA	I	PDA			Ref. assembly TPS & ADP, conformance to drawings
4.2.M/P-11	Pressure Vessel Documentation	N/A		N/A				
4.2.M/P-12	Multi-layer Blanket Bake-Out	N/A		N/A				
4.2.M/P-13	Pressure Vessel Design	N/A		N/A				
4.2.M/P-14	Silicate Ester Coolant System Design	N/A		N/A				
4.2.M/P-15	Mercury- Restriction on Use	N/A		N/A				
4.2.M/P-16	Restriction on Coatings for Areas Subject to Abrasion	N/A		N/A				
4.2.M/P-17	Radiographic Inspection of Brazed and Welded Tubing Joints	N/A		N/A				
4.2.M/P-18	Etching Fluorocarbon Insulated Electrical Wire	N/A		I	see comment			Review US design & drawings
4.2.M/P-19	Spacecraft Material- Restriction on Use of Polyvinyl Chloride	N/A		A	see comment			N/A through analysis
4.2.M/P-20	Titanium or Its Alloys- Prohibited Use with Oxygen	N/A		A	see comment			N/A through analysis
4.2.M/P-21	Beryllium- Restricted Use within Crew Components	N/A		A	see comment			N/A through analysis
4.2.M/P-22	Brazed Joints- Identification Marks	N/A		N/A				
4.2.M/P-23	Pressure Vessels- Materials Compatibility and Vessel Qualifications Tests	N/A		N/A				
4.2.M/P-24	Cadmium- Restriction on Use	N/A		A	see comment			N/A through analysis
4.2.M/P-25	Pressure Vessels- Nondestructive Evaluation Plan	N/A		N/A				
4.2.M/P-26	Repair of Sandwich-Type Structures	N/A		N/A				
4.2.M/S-1	Equipment Containers- Design for Rapid Spacecraft Decompression	N/A		A	see comment			Ref. SA report
4.2.M/S-2	Alignment of Mechanical Systems	N/A		N/A				
4.2.M/S-3	Wire Bundles- Protective Coating	N/A		I, T	FT			Review US design, drawings, & test (if necessary)
4.2.M/S-4	Hatches- Repeated Use	N/A		N/A				
4.2.M/S-5	Threaded Fittings- Restrictions on Release of Particles and Foreign Material	N/A		I	PDA			Review US design & drawings
4.2.M/S-6	Exposed Sharp Surfaces or Protrusions	I	PDA	I	PDA			
4.2.M/S-7	Windows and Glass Structure	N/A		N/A				
4.2.M/S-8	Penetration of Inhabited Spacecraft Compartments	N/A		N/A				
4.2.M/S-9	Mechanisms	N/A		N/A				
4.2.M/S-10	Functional Doors that Operate in Flight	N/A		N/A				
4.2.M/S-11	Meteoroid Protection Levels for Structures	N/A		N/A				
4.2.M/S-12	Spacecraft Recovery Hoist Loops	N/A		N/A				
4.2.M/S-13	Lifting and Hoisting Ground Support Equipment Identification	N/A		N/A				
4.2.M/S-14	Structural Analysis	N/A		A	see comment			Review Stress Analysis Rpt.
4.2.M/S-15	Stainless Steel Tubing- Method of Joining	N/A		N/A				
4.2.M/S-16	Pressure Vessels- Negative Pressure Damage	N/A		N/A				
4.2.P-1	Explosive Devices- Arming and Disarming	N/A		N/A				
4.2.P-2	Pyrotechnic Devices- Preflight Verification Tests at Launch Sites	N/A		N/A				
4.2.P-3	Wire Splicing	N/A		N/A				

APPENDIX B ULTRASOUND SYSTEM CERTIFICATION MATRIX

CERTIFICATION METHODS		ACCEPTANCE PROCEDURES			QUALIFICATION PROCEDURES			
T : Test A : Analysis I : Inspection S : Similarity D : Demonstration		PDA : Pre-delivery Acceptance PIA : Pre-installation Acceptance ATT : Acceptance Thermal Test AVT : Acceptance Vibration Test F/C : Fit-Check			LT : Load Test SA : Stress Analysis F/C : Fit-Check FT : Functional Test QTT : Qualification Thermal Test QVT : Qualification Vibration Test QAVT : Qualification Acceptance Vib. Test QSWTP : Qual. Software Test Procedure			
Paragraph No.	REQUIREMENT	ACCEPT. Method	ACCEPT. Procedure	QUAL. Method	QUAL. Procedure	VERIFICATION DOCUMENT	Open (O) Closed (X)	COMMENTS / HARDWARE CONFIGURATION
4.2.P-4	Explosive Devices- Packaging Material	N/A		N/A				
4.2.P-5	Explosive Devices- Identification Requirements	N/A		N/A				
4.2.P-6	Protection of Electrical Circuitry for Explosive Devices Employing Hot Bridge wire Initiators	N/A		N/A				
4.2.P-7	Explosive Devices- Color Coding Requirements	N/A		N/A				
4.3	BONDING CONTINUITY	T	PDA	T	See Comments			Qual reqt. fulfilled at PDA
4.4	CLEANLINESS							
4.4.1	External Surfaces	I	PDA, PIA	N/A				
4.4.2	Internal Surfaces	N/A		N/A				
4.4.3	In-Flight Cleanliness	N/A		N/A				
4.5	CONSTRUCTION REQUIREMENTS							
4.5.1	MATERIALS AND PROCESSES							
4.5.1.1	General Materials and Processes and Parts Interface	N/A		A	See Comments			
4.5.1.2	Stress Corrosion	N/A		A	See Comments			Qual. approval via material cert. memo
4.5.1.3	Fracture/Fatigue	N/A		A	See Comments			Review stress analysis report
4.5.2	SCREW THREADS	N/A		I	See Comments			Approval of Drawings
4.5.3	FASTENERS	T		N/A				Reference TPS
4.5.4	LOCKING DEVICES							
4.5.4.1	Thread Locking Adhesive	I	PDA	N/A				Inspection at assembly
4.5.4.2	Lock Wire	N/A		N/A				
4.6	WORKMANSHIP	I, T	PDA, AVT	N/A				
4.7	INTERCHANGEABILITY AND REPLACEABILITY							
4.7.1	Maintainability On-Orbit	N/A		N/A				Reference procedures
4.7.2	Maintainability Ground	N/A		N/A				
4.8	COLOR							
4.8.1	Stowed Hardware	I	PDA	I	PDA			Review drawings
4.8.2	Rack Mounted Hardware	I	PDA	I	PDA			Review drawings
4.9	NON-IONIZING CONDUCTED RADIATION							
4.9.1	Emission	N/A		T	See Comments			Perform EMI test
4.9.2	Susceptibility	N/A		N/A				
4.10	ILLUMINATION	N/A		I	See Comments			B-9 Mockup
4.11	GROUND HANDLING							
4.11.1	GROUND HANDLING LOAD FACTORS	N/A		A	SA			
4.11.2	SHOCK CRITERIA	N/A		A	SA			Main electronic unit
4.11.3	BENCH HANDLING	N/A		A	SA			Keyboard
4.12	USEFUL LIFE							
4.12.1	OPERATIONAL LIFE	N/A		A	See Comments			LLIL
4.12.2	SHELF LIFE	A	See Comments	A	See Comments			LLIL
4.12.3	LIMITED LIFE	A	See Comments	A	See Comments			LLIL
4.13	EEE PARTS REQUIREMENTS							
4.13.1	GENERAL REQUIREMENTS	N/A		A				Ref. EEE Parts list
4.13.2	PARTS SELECTION	N/A		A				Ref. EEE Parts list
4.13.3	COTS/MODIFIED COTS	T		T				Perform Burn-in/Elevated temperature test, as recommended
4.14	BATTERY REQUIREMENTS	N/A		A				Reference memo
5.0	ENVIRONMENTAL CERTIFICATION REQUIREMENTS							
5.1	GENERAL							
5.2	TEMPERATURE							
5.2.1	OPERATING TEMP	T	ATT	T	QTT			Functional test pre&post test
5.2.2	NON-OPERATING TEMP	T	ATT	T	QTT			Functional test pre&post test
5.3	PRESSURE							
5.3.1	OPERATING PRES.	D	PDA					Perform functional test
5.3.2	NON-OPERATING DEPRESSURIZATION	N/A		A				Ref. Stress Analysis report
5.3.3	RATE OF CHANGE	N/A		A				Ref. Stress Analysis report
5.4	HUMIDITY							
5.4.1	OPERATING HUMIDTY	N/A		A				
5.5	OXYGEN ENVIRONMENT	N/A		A				
5.6	CONTAMINATION AND WASTE MANAGEMENT	N/A		N/A				
5.7	RANDOM VIBRATION	T	AVT	T	QAVT, QVT			AVT performed on all Class I Units; QAVT, QVT on qual. unit only
5.8	LAUNCH/LANDING LOADS	N/A		A	SA			Ref. Stress Analysis report

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Paragraph No.	REQUIREMENT	ACCEPT. Method	ACCEPT. Procedure	QUAL. Method	QUAL. Procedure	VERIFICATION DOCUMENT	Open (O) Closed (X)	COMMENTS / HARDWARE CONFIGURATION
5.9	ACOUSTICS EMISSION	N/A		N/A				Rack level only
5.10	IONIZING/NON-IONIZING CONDUCTED RADIATION							
5.10.1	Ionizing							
5.10.1.1	Emission	N/A		T	See Comments			EMI Test
5.10.1.2	Susceptibility	N/A		N/A				
5.10.2	Non-Ionizing							
5.10.2.1	Emission	N/A		T	See Comments			EMI Test
5.10.2.2	Susceptibility	N/A		N/A				

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