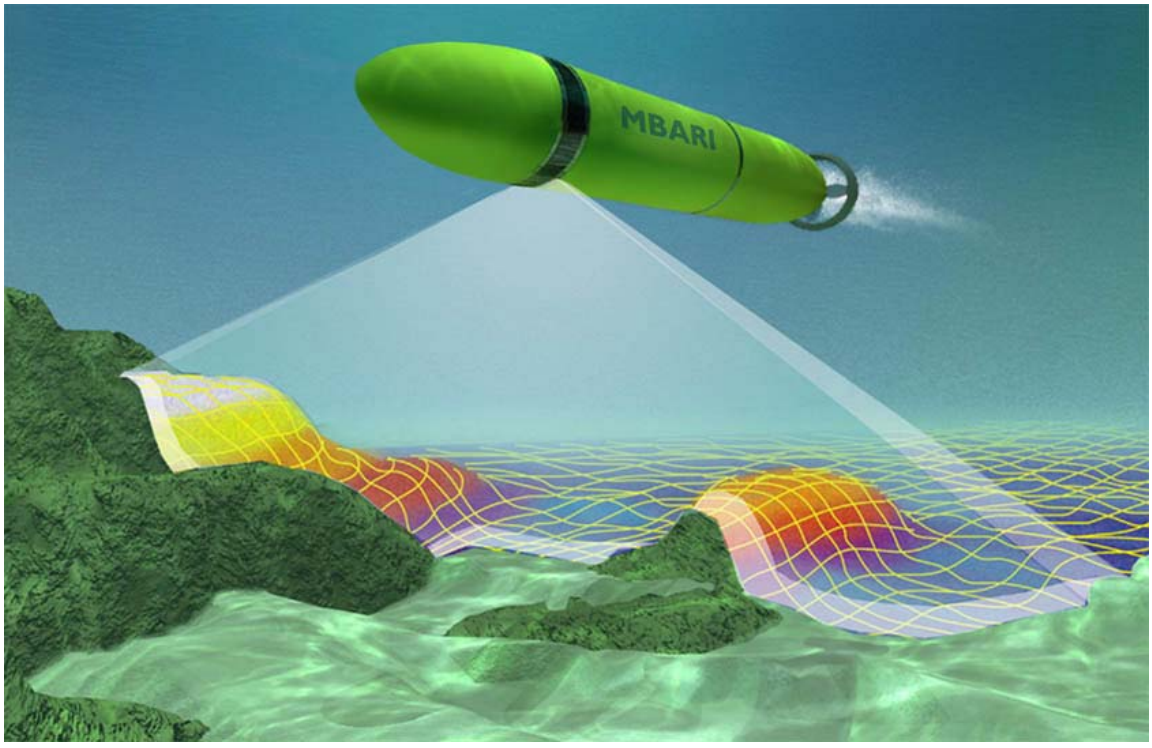
System Specification
SeaBat 7100
Multi-Beam Echo Sounder
for
MBARI AUV



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1 SCOPE

This specification establishes the interface, performance, test, and acceptance requirements for a Multi-beam echosounder subsystem (MBES). MBARI's goal is to procure a Modified Commercial-off-the-Shelf (COTS) MBES that meets requirements specified herein. Specifically, this specification assumes that the sonar is a modified SeaBat® Model 7100 purchased from RESON, Inc., Goleta, CA. This specification is submitted in partial compliance with contract milestone D.

2 APPLICABLE DOCUMENTS

The following documents form a part of this specification to the extent specified herein.

2.1 Military Specifications

Military specifications referenced in this document include those identified in Table 2.1-1.

TABLE 2.1-1: MILITARY SPECIFICATIONS

DOCUMENT NO.	TITLE
MIL STD 167-1	Mechanical Vibrations of Shipboard Equipment, 1 May 1974

2.2 Other Specifications

Other specifications referenced in this document include those identified in Table 2.2-1.

TABLE 2.2-1: OTHER SPECIFICATIONS

DOCUMENT NO.	TITLE
ABS	Rules for Building and Classing Underwater Vehicles, Systems, and Hyperbaric Facilities, 1990 American Bureau of Shipping
11560	6046 Payload Controller Specification, RESON, Inc.
11559	6046 Data Validation Utility Specification, RESON, Inc
11542	7K Data Format and Network Protocol Definition Document, RESON, Inc.

3 REQUIREMENTS

3.1 Configuration Item Description

3.1.1 Overview and Identification of LRUs

The MBES will be mounted on an Autonomous Undersea Vehicle (AUV) and used to conduct surveys of the sea floor. Figure 3.1-1 describes the major MBES components and their interfaces to other system components. The MBES projector unit will repetitively transmit an acoustic signal ensonifying a specified Field of View (FOV) below the sonar and the MBES Receiver and Integrated Control and Processor Units will receive, beam form, and process returning acoustic echoes to produce a record of the sea floor. Table 3.1-1 identifies the Lowest Replaceable Units (LRUs) of the MBES which are identified as components in the block diagram, Figure 3.1-1.

TABLE 3.1-1: MBES COMPONENTS

COMPONENT	RESON PART NO.	COMMENT
TC 2158 PROJECTOR UNIT	7C2158	
EM 7204 RECEIVER UNIT	EM 7204	
7-I INTEGRATED CONTROL & PROCESSOR UNIT (ICPU)	850000995	Subass'y, Electronic Boards Contained in mounting Rack.
CABLE, PROJECTOR UNIT TO ICPU	11393-X	X specifies cable length in meters.
CABLE, RECEIVER TO ICPU	11392-X	X specifies cable length in meters.
CABLE, ICPU TO MBARI HOUSING	TBD -1	MBARI-Provided Interface Cable
CABLE, POWER	N/A	Standard power cable. Provided by MBARI
CABLE, PROCESSOR TO ETHERNET	N/A	10/100 BaseT Ethernet Cable. Provided by MBARI.

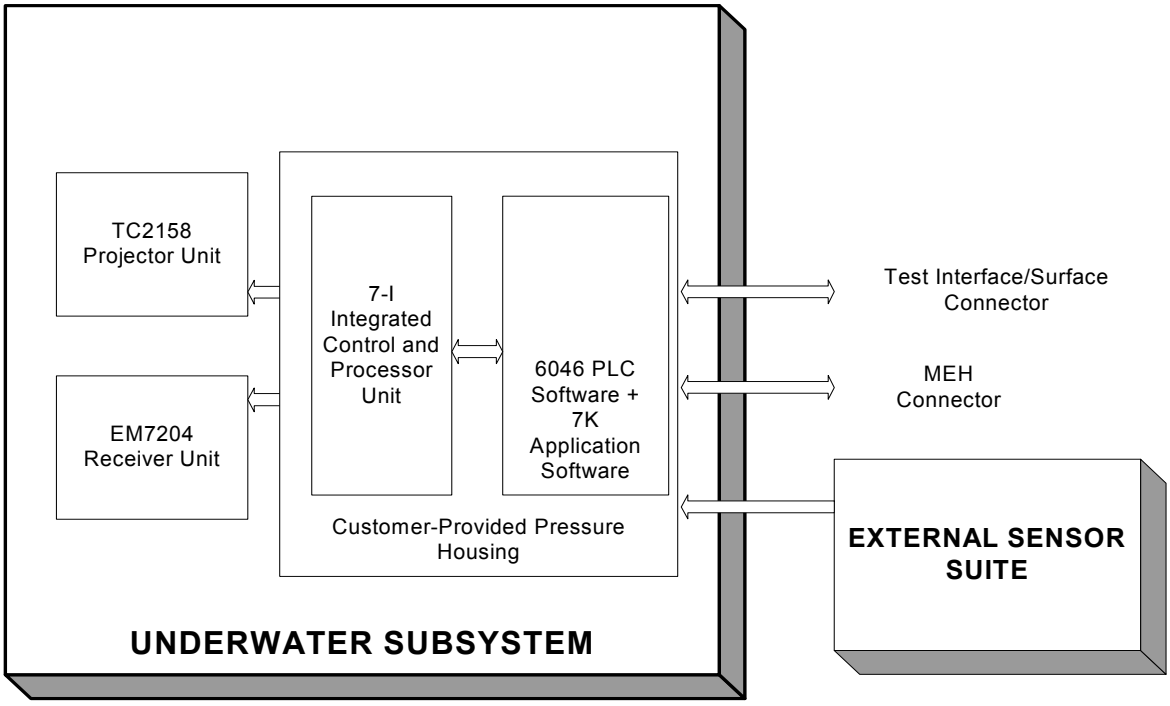

FIGURE 3.1-1: MBES BLOCK DIAGRAM

3.1.2 Interfaces

3.1.2.1 Electrical Interfaces

MBES LRUs are electrically connected to other components in the AUV. The ICPU is interconnected to the MBES Projector and Receiver Units via RESON cables which will be constructed to lengths specified by MBARI. The ICPU is also electrically connected to a separate MBARI-provided housing (known as the MEH) on the AUV which accepts sonar data, and provides power, digital commands, and a synchronization signal to the ICPU. Power is provided to the Acoustic Projector unit and Acoustic Receiver via the ICPU.

3.1.2.2 Data Interface

The ICPU shall incorporate a 10/100 BaseT Ethernet link to support communication between the ICPU, the MEH electronics, and a shipboard data docking system. RESON-supplied software (6046 and 7K Applications Software), shall support MBES Sonar control and data logging. Data output format shall conform to "7K Data Format and Network Protocol Definition Document".

3.1.2.3 Mechanical Interfaces

The Acoustic Projector unit, Receiver Unit, and ICPU will be mechanically mounted to the AUV structure. The Projector unit and Receiver will be positioned to direct their acoustic apertures downward. Dimensions, mounting interfaces and weights shall be as specified in the following Interface Control Documents.

- TC2158 Projector Unit Interface Control Document
- EM7204 Receiver Unit Interface Control Document
- 7-I Integrated Control and Processor Unit Interface Control Document

3.1.2.4 Acoustic Interfaces

The Acoustic Projector and Receiver Units interface to the ocean acoustic environment. This environment is defined as any ocean with water temperatures, pressures (depths), salinity, and noise characteristics specified herein. During deck check, the Projector and Receiver Units will also be exposed to non-ocean environment as well, but not required to meet operational requirements. Because of heating limitations, operation in the non-ocean environment shall be limited to 5 minutes.

3.2 Characteristics

3.2.1 Sonar Acoustic Performance

3.2.1.1 Operating Frequency.

The sonar shall operate a nominal frequency of 200 kHz.

3.2.1.2 Acoustic Performance Parameters

Sonar acoustic performance parameters are described in Table 3.2.1-1

TABLE 3.2.1-1: SONAR ACOUSTIC PERFORMANCE

PERFORMANCE PARAMETER	NOM.	TOL.	COMMENT
RECEIVER CROSS-TRACK BEAM WIDTH	1 deg	± 0.2 deg	Center Beam, 3 dB Points
RECEIVER VERTICAL BEAM WIDTH	27 deg	± 2.0 deg	
NUMBER OF RECEIVER BEAMS	349	N/A	
PROJECTOR UNIT VERTICAL BEAM WIDTH	1 deg	± 0.2 deg	

PROJECTOR UNIT CROSS-TRACK BEAM WIDTH	>140 deg	N/A	
MAX. PROJECTOR UNIT ON-AXIS SOUND PRESSURE LEVEL	220 dB//µPa//1m	Min.	
MINIMUM RANGE	5 meters	Min.	
MINIMUM PULSE LENGTH	30 µ sec	N/A	.

3.2.1.3 Swath Coverage

Swath coverage depends on many environmental conditions in addition to the sonar performance. These include bottom composition, salinity, ocean ambient noise and vehicle radiated noise. With an across-track subtended angle of over 140º, and a hard bottom, the SeaBat 7100 measures a swath as great as 6 times the altitude above the seafloor at ranges between 5 and 500 meters. At altitudes greater than 100 meters, the ratio of altitude to swath width decreases, approximately as noted in Table 3.2.1-2.

TABLE 3.2.1-2: TYPICAL SEAFLOOR COVERAGE

AUV ALTITUDE ABOVE SEAFLOOR	COVERAGE (WATER DEPTH MULTIPLE)
5 - 100 meters	6
200 meters	5
300 meters	3

3.2.2 1 PPS Synchronization Signal

3.2.2.1 Signal Description

The sonar shall accept a 1 Pulse per Second (1PPS) signal from MBARI-provided electronics. The input shall be opto-isolated. The sonar shall utilize this signal to synchronize and time tag all data.

The 1PPS signal shall be a TTL Level digital pulse with characteristics defined in Table 3.2.2-1 and figure 3.2.2-1. The leading edge shall be synchronized to GPS time

TABLE 3.2.2-1: 1PPS SIGNAL CHARACTERISTICS

CHARACTERISTIC	VALUE	TOL.	COMMENT
Minimum Input Impedance	1 K ohm // 50 pf	N/A	// = in parallel with
Voltage Digital High Digital Low	 + 5.0 VDC 0.0 VDC	 + 0.1, - 0.5 VDC + 0.5, - 0.0 VDC	Driving minimum load impedance.
Maximum Rise Time	1 μsec	N/A	Driving minimum load impedance.
Maximum Fall Time	1 μsec	N/A	Driving minimum load impedance.
Pulse Width	1.5 msec	±0.5 msec	

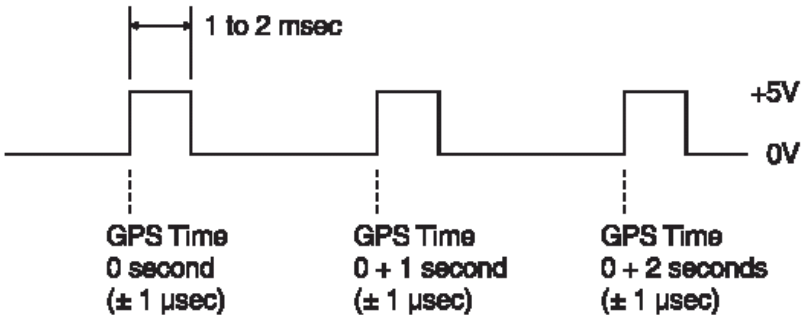

FIGURE 3.2.2-1: 1 PPS SIGNAL DEFINITION

3.2.3 Power Requirements

3.2.3.1 ICPU, Projector unit, and Receiver Power

The Projector unit and Receiver units derive electrical power from the ICPU, as shown in Figure 3.1-1. The ICPU, in turn, derives its power from the vehicle. Power requirement is as follows:

- Voltage Range: + 20 to 36 VDC
- Nominal Voltage: + 28 VDC

- Maximum Average Power: 260 watts

The maximum average power, specified above, occurs at maximum transmit duty cycle in combination with maximum power settings. Maximum current and maximum average power are significantly reduced at lower duty cycle and/or power level settings.

Required average power will be less than 260 watts, determined by selected range and source level, as shown on Figure 3.2.3-1.

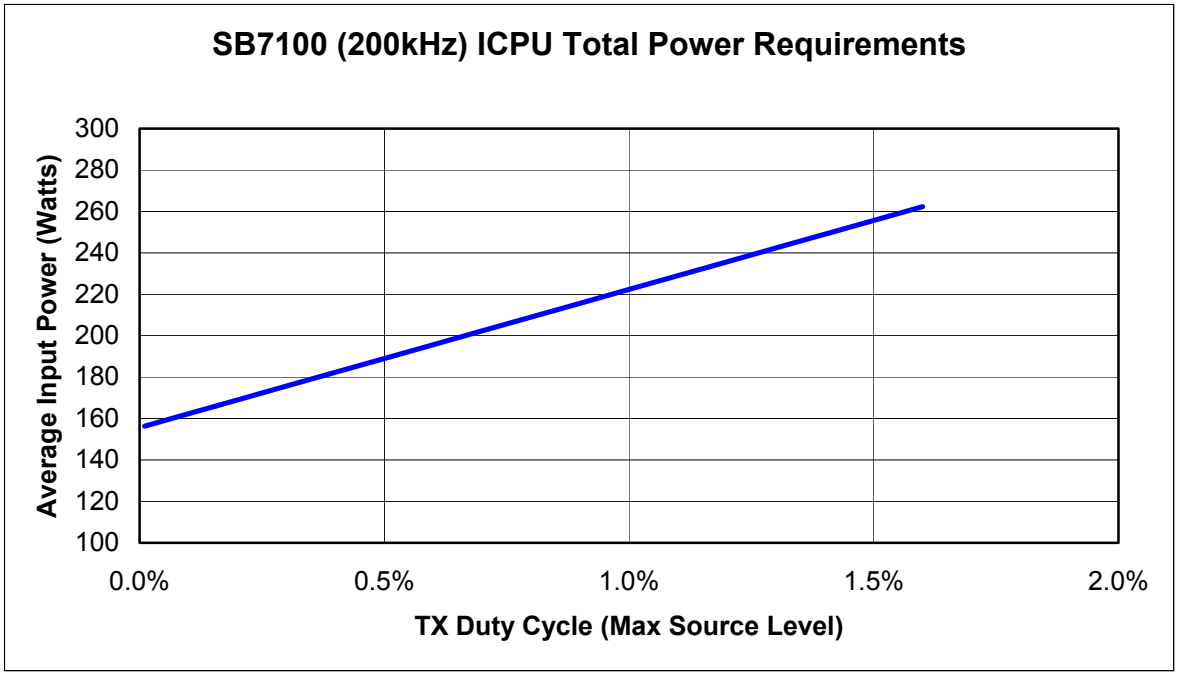

FIGURE 3.2.3-1 POWER REQUIRED AS TRANSMIT DUTY CYCLE VARIES

3.2.4 Physical Requirements

The physical requirements for MBES components are shown in tables 3.2.4-1, 3.2.4-2.

TABLE 3.2.4-1: MBES COMPONENT WEIGHT

MBES COMPONENT	WET WT.	DRY WT.	DIMENSION REFERENCE
TC 2158 ACOUSTIC PROJECTOR UNIT	8.0± 0.5 Kg	13.0± 0.5 Kg	See TC2158 ICD, Figure 2
EM7204 ACOUSTIC RECEIVER UNIT	14.0± 2 Kg	28.0± 2 Kg	See EM7204 ICD, Figure 3
7-I INTEGRATED CONTROL & PROCESSOR UNIT (ICPU)	Not Applicable	7.8 ± 0.4 lbs	See Figures 1 through 4 of 7-I Interface Control Document

TABLE 3.2.4-2: MBES CABLE PHYSICAL CHARACTERISTICS

CABLE ID	FROM	TO	LENGTH	RESON P/N	DESCRIPTION
1	ACSTC XMTR	ICPU	TBD m)	11393-TBD	8-wire Projector unit Cable. Same physical specifications as Receiver Cable.
2	ACSTC RCVR	ICPU	TBD m	11392-TBD	8-wire Receiver Cable. Same physical specifications as Projector unit Cable.
6	MEH	ICPU	TBD m	N/A	MBARI Provided.

3.2.5 Environmental Characteristics

3.2.5.1 Overall System Environmental Characteristics

The following environmental characteristics shall apply to all MBES LRUs.

3.2.5.1.1 Non-operational Temperature

The MBES, as packaged for shipment, shall be capable of meeting performance requirements after exposure to external temperatures between -30 ºC and 55 ºC.

3.2.5.1.2 Handling and Transportation Vibration

The MBES, as packaged for shipment, shall be capable of meeting performance requirements after being subjected to vibration resulting from transportation in a common carrier environment described in MIL-STD-810F, Method 514.4, Category 1, Figures 514.4-1 through 514.4-3. Duration of exposure to vibration shall be commensurate with transportation with common carrier over a distance of 3300 miles.

3.2.5.2 In-Water Component Environmental Characteristics

The Projector unit, Receiver Unit, and Integrated Control and Processor Unit (ICPU), with associated cables, shall meet the following requirements.

3.2.5.2.1 Depth

The MBES shall meet all performance requirements at depths between 10 and 6,000 meters, and shall survive exposure to a depth of 6,500 meters.

3.2.5.2.2 Operational Speed – Doppler Performance

The MBES shall meet all performance requirements at AUV speeds between 0 and 5 knots.

3.2.5.2.3 Non-Operating Speed

The MBES shall survive transit speeds of 10 knots and meet all performance requirements when speed is reduced to the range specified in paragraph 3.2.5.2.2.

3.2.5.2.4 Operational Temperature

The MBES shall meet all performance requirements with in-water components exposed to sea water at temperatures in the range of 0 ºC to 40 ºC. Non-acoustic functions, such as Built-In-Test functions, and in-air check-out, shall operate correctly at temperatures between -2 ºC and 40 ºC. Operation during in-air checkout shall be limited to 5 minutes.

3.2.6 Reliability

The MBES components shall be designed for an operational life of 5 years. Mean Time Before Failure (MTBF) requirements for each of the major components are identified in Table 3.2.7-1.

TABLE 3.2.7-1: MBES MTBF REQUIREMENTS

MBES COMPONENT	REQUIRED MTBF
PROJECTOR UNIT	8376 hours
RECEIVER UNIT	8376 hrs
INTEGRATED CONTROL & PROCESSOR UNIT (ICPU)	8376 hrs

3.2.7 Maintainability

The MBES Lowest Replaceable Units (LRUs) are identified in Table 3.1-1. The maintenance philosophy shall be:

- Field Maintenance
    - LRU replacement
- Depot Maintenance
    - LRU replacement
- Factory Maintenance
    - LRU repair

3.2.7.1 Built-In Test

The MBES shall incorporate a built-in test (BIT) function to localize faults to the LRU level.

3.2.7.2 Pressure Vessel Leak Detector

The ICPU shall contain a leak detect sensor to alert the operator when there is seawater intrusion.

3.3 Design and Construction

3.3.1 Materials Selection

RESON shall verify that no hazardous materials are used in the manufacture of the MBES. In particular, the MBES shall not include mercury or mercury compounds.

Projector and Receiver Unit materials shall be selected in accordance with commercial standards and American Bureau of Shipping (ABS) “Rules for Building and Classing Underwater Vehicles, systems, and Hyperbaric Facilities, 1990”.

3.3.2 Identification and Marking

The MBES Subsystem assemblies, subassemblies and components shall be identified, at the lowest replaceable unit level, in a permanent manner by markings traceable to applicable maintenance manuals and parts lists.

The MBES Subsystem components (down to the lowest replaceable unit level) shall be permanently marked with an individual serial number.

3.3.3 Workmanship

The MBES Subsystem workmanship for mechanical assemblies shall be in accordance with best practices necessary to meet the reliability, maintainability and availability requirements of the MBES Subsystem equipment when transported, installed, and used in the specified environments. External surfaces shall be free of burs and sharp edges and corners except where sharp edges and corners are functional.

3.3.4 Interchangeability

All parts having the same part number shall be functionally and dimensionally interchangeable.

4 Quality Assurance Provisions

4.1 General

4.1.1 Responsibility for Inspection

Responsibility for performing all specified tests/verifications identified in Section 4.2.3 shall rest with RESON. Test data will be available for customer inspection.

4.2 Verification

4.2.1 Definition of System Verification Process

The MBES Subsystem performance requirement compliance shall be verified by employing the methods defined in paragraph 4.2.2 and delineated in Table 4.2.3.3-1 at the pertinent facility using the appropriate operational configuration.

4.2.2 Verification Methods

The methods for verifying each requirement are test, demonstration, analysis and inspection and are defined in paragraphs 4.2.2.1 through 4.2.2.4.

4.2.2.1 Test

Test is the exercise of hardware, firmware, software, or operations to measure quantitatively specified performance.

4.2.2.2 Demonstration

Demonstration is the exercise of hardware, firmware, software, or operations to assure that qualitatively specified functions can be performed.

4.2.2.3 Analysis

Analysis is the quantitative treatment, including logical and mathematical processes (which may include computer modeling or simulation), to determine compliance with specifications where test, demonstration, or inspection is not feasible or adequate. Analysis may be combined with test results to provide verification that a requirement has been satisfied.

4.2.2.4 Inspection

Inspection is the examination or measurement of system characteristics and features or the review of design, production, or test documentation to determine satisfactory compliance with the requirements.

4.2.3 MBES Verification Requirements

4.2.3.1 Verification Program

Compliance with the MBES requirements as identified in Table 4.2.3.3-1, “MBES Subsystem Requirements Verification Matrix”, shall be the objective of the verification program.

4.2.3.2 Factory Verification

For the MBES Subsystem, factory verification encompasses all of the testing performed at contractor facilities. All requirements specified in this document shall be verified through Inspection, Analysis, Demonstration, or Test.

RESON shall record and maintain results of the factory verification activities that confirm compliance with the applicable requirement listed in Table 4.2.3.3-1. This table shall be provided to the Buyer, in the shipment of the product, with the RESON's Quality Assurance stamp to the right of each requirement in the Requirements Description column.

4.2.3.3 Verification Matrix

Table 4.2.3.3-1 presents the Verification Matrix for the MBES Subsystem. Methods of verification include:

- I: Inspection
- A: Analysis
- D: Demonstration
- T: Test

Appropriate verification method for each specified parameter is included in Table 4.2.3.3-1.

TABLE 4.2.3.3-1
MBES REQUIREMENTS VERIFICATION MATRIX

		METHOD			
SPEC. PARAGRAPH	**REQUIREMENT DESCRIPTION**	**I**	**A**	**D**	**T**
3.1	Configuration Item Description				
3.1.1	Overview and Identification of LRUs	X			
3.1.2	Interfaces				
3.1.2.1	Electrical Interfaces	X			
3.1.2.2	Data Interface			X	
3.1.2.3	Mechanical Interfaces	X			
3.1.2.4	Acoustic Interfaces	X			
3.2	Characteristics				
3.2.1	Sonar Acoustic Performance				
3.2.1.1	Operating Frequency				X
3.2.1.2	Acoustic Performance Parameters				
	Receiver Cross-Track Beam Width		X		
	Receiver Along Track Beam Width				X
	Number of Receiver Beams	X			
	Projector unit Cross-Track Beam Width				X
	Projector unit Along Track Beam Width		X		
	Projector unit On-Axis Sound Pressure Level				X
	Minimum Sonar Range		X		
	Minimum Pulse Length				X
3.2.1.3	Swath Coverage		X		
3.2.2	1 PPS Synchronization Signal				
3.2.2.1	Signal Description			X	
3.2.3	Power Requirements				
3.2.3.1	ICPU, Projector unit, and Receiver Power				X
3.2.4	Physical Requirements				

		METHOD			
SPEC. PARAGRAPH	**REQUIREMENT DESCRIPTION**	**I**	**A**	**D**	**T**
	MBES Component Weight (Table 3.2.4-1)	X			
	MBES Component Dimensions	X			
	MBES Cable Physical Characteristics	X			
3.2.5	Environmental Characteristics				
3.2.5.1	Overall System Environmental Characteristics				
3.2.5.1.1	Non-operational Temperature				X
3.2.5.1.2	Handling and Transportation Vibration				X
3.2.5.2	In-Water Component Environmental Characteristics				
3.2.5.2.1	Depth				X
3.2.5.2.2	Operational Speed – Doppler Performance		X		
3.2.5.2.3	Non-Operational Speed		X		
3.2.5.2.4	Operational Temperature		X		
3.2.6	Reliability		X		
3.2.7	Maintainability		X		
3.2.7.1	Built-In Test (BIT)			X	
3.2.7.2	Leak Detector	X			
3.3	Design and Construction				
3.3.1	Materials Selection	X			
3.3.2	Identification and Marking	X			
3.3.3	Workmanship	X			
3.3.4	Interchangeability	X			