

Specification for an Acoustic Projection System for Active Measurements

1.0 INTRODUCTION

This active sonar acoustic projection system, to be towed from oceanographic research vessels (University-National Oceanographic Laboratory System, North Atlantic Treaty Organization, The-Technical-Cooperation-Panel-nation, U.S. Navy, or commercial), must provide the high-power, broadband, directional source(s) of acoustic energy needed to perform scattering and reverberation measurements in ocean environments. The baseline system must include all components and equipment necessary to configure a system that is safely transportable, deployable, and retrievable by end-users aboard an oceanographic vessel.

The primary component of the baseline system is a sonar projection unit consisting of towable, high-power, broadband, directional source(s) of acoustic energy. Supporting components are: a power system to drive the source(s), electromechanical tow and deck cables connecting the source(s) and the power system, and an optional winch .

2.0 SCOPE

The contractor shall furnish a totally towed acoustic projection system that is a modular system consisting of a towable source projector unit, a power system to drive the source(s), and electromechanical tow and deck cables.

3.0 TECHNICAL REQUIREMENTS

The contractor shall provide an acoustic projection system that must meet or exceed the following specifications as described below:

3.1 General Requirements of the Sonar Projection System:

- a. **Construction:** The sonar projector(s) must be a unit ruggedized for use in the harsh marine environment.
- b. **Towability:** The sonar projection unit and power tow cable must be safely towable in a stable vertical configuration at depth at speeds of 0 to 4 knots **in sea states 0 to 3.**
- c. **Source Level Adjustment:** The sonar projection system must be capable of being ramped up in source level from experiment-specific minimum levels (a US Navy environmental compliance mitigation procedure).
- d. **Period of Use in Water:** The sonar projection unit and power tow cable must remain fully operational for continuous deployment periods of up to 20 days.
- e. **Operational Depth:** The sonar projection unit and power tow cable must function and meet all specifications when deployed in the ocean at any depth between 30 and 200 meters without cavitation or compensation.

- f. **Operating Temperature:** The sonar projection unit and power tow cable must function and meet all specifications in temperatures of 3 to +30 degrees Celsius.
- g. **Storage Temperature:** The sonar projection unit and power tow cable must function and meet all specifications in operation after being stored indefinitely in temperatures of 0 to +50 degrees Celsius.

3.2 Sonar Projectors. The acoustic projectors must be constructed as a unit and capable of being operational in a vertical configuration at tow speeds of 0-4 knots **in sea states 0 to 3** (Fig. 1).

The sonar projection unit must have the following characteristics:

- a. **Useable Frequency Range:** The sources must be useable over a minimum 70% of the band covering 1.5 to 5 kilohertz.
- b. **Source Level:** The total source level (**band level, i.e., integral of the source intensity spectral density over the band**) of the sonar projection unit must be at a minimum 210 decibels re 1 micropascal @ 1 meter over a minimum 70% of the 1.5-5 kilohertz frequency band, and at a minimum 200 decibels re 1 micropascal @ 1 meter over a minimum 85% of the 1.5-5 kilohertz frequency band.
- c. **Beam Pattern:**
 - 1. Omnidirectional in azimuth to ± 1 decibels over the useable frequency range specified in **3.2.a**.
 - 2. Directional in vertical planes, with only one main lobe in the directivity pattern when steered horizontally, whose 3-decibel beamwidth must be 40 degrees or less, and with sidelobes at a minimum 13 decibels down in level from the main lobe, over the useable frequency range specified in **3.2.a**.
 - 3. The source projection unit must be steerable, allowing look directions for the maximum response axis to be user selectable in the range of at least ± 30 degrees over the useable frequency range specified in **3.2.a**. If directionality is accomplished by a linear array of source elements, then each element must be individually controllable with individual power leads. In this case, the end user will provide the signals required to the electrically steer the array.
- d. **Signals and Duty Cycle:** The source projection unit must be capable of transmitting coded waveforms (such as continuous wave and frequency-modulated signals) of pulse lengths of 10 milliseconds (or less) to 30 seconds (or greater) with **duty cycles up to and including 10%**.
- e. **Construction:** The sonar projection system must be a unit ruggedized for operation in the harsh marine environment. The sonar projection unit must have minimal cross-section to maximize towability in a stable vertical configuration. The sonar projection unit must have the additional following characteristics:
 - 1. This mounting must not be greater than 10 feet in any dimension.

2. If an array of source elements is used, each projector must be mounted so that it is field replaceable (and for the purposes of testing and repair).
3. Electrical attachment to the tow cable must be made using waterproof connectors that have strain-relief caps. These strain-relief caps must withstand a force of at least 100 pounds without disconnecting or compromising the electrical integrity of the attachment.
4. An attachment point must be provided at the tail of the sonar projection unit's mounting to support a minimum tensioning weight of 1000 pounds (to maintain maximum verticality when either towed at speeds up to 4 knots or in the presence of ocean currents when operating in a stationary mode). The mounting scheme must be able to take the strain of the armored cable, the sonar projection unit, and the anchor weight, i.e. the mounting must be able to support a minimum static load of 2000 pounds.

3.3 Power System. The shipboard-based power system (amplifier(s)) must provide all power for the sonar projection unit meeting the specifications of **3.2**, plus any specifications of Options **8.1** and **8.2** if exercised.

General requirements include:

- a. Each amplifier must function and meet all specifications in ambient temperatures of 0 to + 40 degrees Celsius.
- b. Each amplifier must have protection such that no combination of passive loads, input signals or switch settings causes amplifier failure.
- c. Each amplifier must have current and voltage monitors.
- d. The frequency range (-3 decibels) must be 500 hertz (or less) to 15 kilohertz (or greater).
- e. The maximum total harmonic distortion of each amplifier must be 3% (or less).
- f. Each power amplifier must be ruggedized for operation at sea.

3.4 Electromechanical Tow Cable. The electromechanical tow cable connects the sonar projection unit and the deck cable, providing both power and a communications link between these two modules, and it mechanically supports both the towable sonar projection unit and an anchor weight during deployments.

The tow cable must be a faired, watertight, double-armored, **steel**, electromechanical submarine cable 250 meters in length.

The tow cable must be capable of safely providing power to the acoustic projectors. If a linear array of sources is used to form the sonar projection unit then the tow cable must have individual pairs of power lines for each element of the array specified in **3.2** and, if exercised, in Options **8.1** and **8.2**, plus 4 spare pairs of power lines. The tow cable must further include at the time of manufacture **a sufficient number of wires to carry the**

non-acoustic data from two engineering sensor modules matching the requirements specified in Option **8.6**.

Additional requirements include:

- a. Strength:** The tow cable must have a minimum working strength of 4000 pounds and a minimum breaking strength of 8000 pounds.
- b. Mechanical Terminations:** Separate electrical and mechanical terminations must be used to provide strain relief for the electrical connector(s) and to enable the electrical connector(s) to be connected and disconnected while maintaining a working strength tension on the assembled mechanical terminations. Mechanical terminations must be provided at both ends of the cable.
- c. Electrical Terminations:** The tow cable must be capable of connection to the sources via one or more waterproof electrical connectors. This connector must have a screw-on or twist-lock strain relief cap to prevent disconnection of the connector(s) due to a tension of 250 pounds when the unit is assembled.
- d. Fairing:** The tow cable must be faired along its entire length with a haired fairing. The minimum length of the fairing strands must be 4 times the cable diameter. The linear density of the fairing must conform to customary industry practice for effective reduction of current-induced strum.

3.5 Deck Cable. A deck cable (deck leader) of length 50 meters must be provided with one end terminated to connect to the power amplifiers and the other end terminated with a connector which mates with the electromechanical tow cable. The deck cable and its connectors must be waterproof for use in the harsh marine ship-deck environment. The deck cable must include at the time of manufacture **a sufficient number of wires to carry the non-acoustic data from two engineering sensor modules** matching the requirements specified in Option **8.6**.

4.0 DOCUMENTATION

4.1 Test Plan: The contractor shall furnish a test plan for system performance and acceptance testing. The plan must detail how the manufacturer intends to prove that the system meets the specifications as defined in the solicitation. The plan must cover all areas in the basic Sections **3.2-3.5** and any options exercised at the date of contract award. The test plan must be delivered to the Technical Manager for approval no later than 45 days prior to the start of the factory test. Delivery of the test data will take place with the delivery of the system.

4.2 Deployment and Recovery Plan: The contractor shall furnish a deployment and recovery plan for the baseline system. The plan must detail all hardware, procedures, and specifications for any equipment identified as required to safely deploy, operate (at speeds at up to 4 knots), and recover a system in up to 200 meters of water **in sea states of 0 to 3**. The manual must specify a minimum sheave diameter to be used that will allow multiple deployments without damage to the electrical and mechanical characteristics of the cable. Delivery of the plan will take place with the delivery of the system.

4.3 Operation Manual: The contractor shall furnish operation manual(s) that describe in detail how to operate all contractor-supplied components of the system. It must contain the procedures to be used for pre-deployment checkout, hardware and system preparation, and provide a system checklist for all mechanical and electrical connections required for a successful deployment, operation, and recovery. Delivery of the operation manual(s) will take place with the delivery of the system.

4.4 Technical Manual: Technical manual(s) must be provided which describe in detail the design of each contractor-supplied system component, including its hardware/parts. A detailed list of all contractor-supplied parts/components used in the system must be provided. The list must identify all vendors, vendor part numbers, vendor addresses, telephone/fax numbers, and web sites. The manual must provide detailed drawings for all contractor-supplied custom hardware required by the system. Delivery of the technical manual(s) will take place with the delivery of the system.

5.0 TECHNICAL SUPPORT

The contractor shall provide telephone/fax/e-mail technical support for a period starting with the delivery of the system and extending for 6 months after the delivery and training is completed.

6.0 TRAINING

The contractor shall provide training on the assembly, disassembly, configuration, and operation of the system. The training of 6 NRL personnel for a period of 8 hours will take place at the Naval Research Laboratory within 30 days after delivery of the system. The operator manuals must be used in the training.

7.0 WARRANTY

The contractor shall provide a standard commercial warranty for the amplifiers.

8.0 OPTION REQUIREMENTS

OPTION 4: DIRECTIONALITY ENHANCEMENT

8.1 Increasing Directionality: While maintaining the requirements of 3.2, modifying at the time of manufacture the baseline system to provide increased directionality (such as by increasing the number of source elements if a linear array of projectors is used to form the baseline sonar projection unit).

OPTION 1: FREQUENCY- RANGE EXTENSION

8.2 Increasing the Upper Frequency Range: While maintaining the requirements of 3.2, modifying at the time of manufacture the baseline system to extend the upper frequency range to 10 kilohertz, with a total source level (**band level, i.e., integral of the source intensity spectral density over the band**) of at least 200 decibels re 1 micropascal @ 1 meter over a minimum 70% of the frequency range 5 to 10 kilohertz.

OPTION 2: WINCH

8.3 Winch : A winch to hoist and deploy/recover the tow cable must be provided. It must be sized to match the baseline system's cable specifications (for a minimum cable length of 350 meters) and be capable of providing better than a 2000-pound line pull when fully loaded, with pay-in/pay-out speeds variable from 0 to 50 feet per minute. The inner core of the winch must be such that the bending radius of the tow cable is not exceeded. The winch must be ruggedized for the harsh marine operating environment. It must be operable and storable in temperatures between -20 degrees Celsius and +55 degrees Celsius.

OPTION 5: POWER AMPLIFIERS

8.4 Additional Power Amplifiers: Additional power amplifiers matching the specifications of 3.3.

OPTION 6: CALIBRATION OF PROJECTION ELEMENTS

8.5 Projector Calibration: Each projector element is to be calibrated in water at depth (e.g., at Lake Seneca, NY) prior to delivery. Delivery of the calibration test results will take place with the delivery of the system.

OPTION 3: ENGINEERING SENSOR MODULES

8.6 Engineering Sensor Modules: Two identical engineering sensor modules (ESM) must be provided for optional attachment to the head and tail of the sonar projection unit. Each engineering module must be housed in a pressure vessel meeting the same operational depth requirements as the sonar projection unit. Each engineering module must have a single connector providing both signal and power connections; the pin-out of this connector must be identical on both ESMs to facilitate troubleshooting and module swapping. Connector end-caps at appropriate pressure ratings must be provided to allow the sonar projection unit to be deployed with zero, one or two ESMs attached.

Each basic ESM must consist of four sensors: a depth sensor, a two-axis tilt sensor, and a heading sensor. All ESM sensor signals must be relayable to shipboard electronics in analog form. Any sensor-specific calibration factors must be provided in the documentation. Required sensor accuracies are:

- a. **Depth Sensor:** Depth sensor resolution must be 1 meter or smaller with an accuracy of 3 meters over the full operating depth of the sonar projector unit.
- b. **Tilt Sensor:** A two-axis tilt sensor must be provided for each engineering module. Minimum tilt measurement accuracy in each axis must be ± 0.5 degrees with an operating angle of ± 45 degrees.
- c. **Heading Sensor:** A heading sensor must be provided that measures heading to an accuracy of ± 2 degrees minimum through a tilt angle of ± 45 degrees.

CONTRACT DATA REQUIREMENTS LIST

(2 Data Items)

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Public reporting burden for this collection of information is estimated to average 220 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503. Please DO NOT RETURN your form to either of these addresses. Send completed form to the Government Issuing Contracting Officer for the Contract/PR No. listed in Block E.

A. CONTRACT LINE ITEM NO. 0003		B. EXHIBIT A		C. CATEGORY: TDP _____ TM _____ OTHER _____			
D. SYSTEM / ITEM 0001AA,0001AB,0001AC,0001AD			E. CONTRACT / PR NO. 71-4078-00		F. CONTRACTOR		
1. DATA ITEM NO. A001	2. TITLE OF DATA ITEM Test Plan			3. SUBTITLE			
4. AUTHORITY (Data Acquisition Document No.) N/A			5. CONTRACT REFERENCE Paragraph 4.1		6. REQUIRING OFFICE NRL Code 7140		
7. DD 250 REQ No	9. DIST STATEMENT REQUIRED N/A	10. FREQUENCY 1 Time	12. DATE OF FIRST SUBMISSION 45DPTT	14. DISTRIBUTION			
8. APP CODE N/A	11. AS OF DATE N/A	13. DATE OF SUBSEQUENT SUBMISSION	a. ADDRESSEE			b. COPIES	
16. REMARKS Test Plan: The contractor shall furnish a test plan for system performance and acceptance testing. The plan must detail how the manufacturer intends to prove that the system meets the specifications as defined in the solicitation. The plan must cover all areas in the basic Sections 3.2-3.5 and any options exercised at the date of contract award. The test plan must be delivered to the Technical Manager for approval no later than 45 days prior to the start of the factory test. Delivery of the test data will take place with the delivery of the system.				TM	Draft	Final	
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1. DATA ITEM NO. A002		2. TITLE OF DATA ITEM Deployment and Recovery Plan		3. SUBTITLE						
4. AUTHORITY (Data Acquisition Document No.) N/A			5. CONTRACT REFERENCE Paragraph 4.2		6. REQUIRING OFFICE NRL Code 7140					
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D. SYSTEM / ITEM 0001AA,0001AB,0001AC,0001AD			E. CONTRACT / PR NO. 71-4078-00		F. CONTRACTOR
1. DATA ITEM NO. A003	2. TITLE OF DATA ITEM Operation Manual.			3. SUBTITLE	
4. AUTHORITY (Data Acquisition Document No.) N/A			5. CONTRACT REFERENCE Paragraph 4.3		6. REQUIRING OFFICE NRL Code 7140
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