Enclosure (1)

Draft SHDAS Specifications

1. The system shall consist of a shore station including a data acquisition system, cable and sensor packages. The sensor packages shall include co-located seismic and hydro-acoustic sensors. These sensor packages shall have an operational availability (A_0) of 0.995 with a 20-year mean time between failure (MTBF). The anticipated environment includes water depths up to 2,650 m with an ambient temperature range of +3°C to +25°C.

2. The system shall be capable of providing long term detection, localization, and identification of nuclear explosions above and below the floor of broad open ocean areas at local and regional distances. The design target shall be a 1 kiloton explosive device detonated at a range of 1,000 kilometers from the sensors.

3. The Sensor Package (SP) shall be a weighted watertight enclosure that is installed on the ocean floor. Each SP shall be powered and networked to the Data Acquisition and Storage System (DASS) via a Seafloor Trunk Cable (STC). Where multiple SPs are installed in an array configuration, each inline SP shall pass shore power and optical network communications to the next SP. Each SP shall contain a three axis broadband seismometer, seismometer leveling mechanism for centering in the vertical plane, omni-directional hydrophone, power management circuitry, splice assembly to continue power and communications to the next SP, a digital waveform recorder, and local data storage.

4. Acoustic sensing capability shall include the sensing of acoustic pressure fluctuations and conversion to electrical signals. This shall also include the amplification and filtering of the electrical signals. Requirements for this capability are as follows:

- Operating Band: 1 – 100 Hz
- Frequency Response of the Electronics: 3 dB down at 6.5 Hz and 100 Hz but otherwise flat in the passband; ±1 dB from calibrated value
- Acoustic Directionality: Omnidirectional to within ±1 dB
- Dynamic Range: 126 dB
- Quantization: 24-bit analog-to-digital conversion
- Sampling Rate: 250 samples per second
- Maximum Operational Acoustic Pressure Level: The acoustic sensor(s) shall be capable of measuring acoustic signals with a received level of up to 185 dB re 1 μPa without clipping.

The Design Minimum Ambient (DMA) is taken to be: max [88.5-33.5 log (f), 70-8 log (f)] where f is frequency in Hz. Spectrum equalization may be applied to optimize the dynamic range of the acoustic sensing capabilities. However, the shape of the pressure signal in the time domain is one attribute used to identify the signal as originating from a nuclear explosion. Therefore, the channel amplitude and phase response shall be

provided to NFESC so that appropriate corrections to the data may be made. The amplitude and phase response must be sufficiently precise so that the corrected output signal of the system shall match the original input sound pressure signal to within a factor of ±1 dB as measured by the peak of the cross-correlation between input and output as compared to the peak of the auto-correlation of the input signal.

All acoustic sensors shall be characterized at the operational temperature across the frequency band of interest for the minimum, nominal, and maximum signal levels; and also at the depth each acoustic sensor will be installed. The poles-zeros shall be determined through this verification process.

5. Seismic Sensing Capability shall include the sensing of seismic fluctuations and conversion to electrical signals. Specific requirements are:

- Operating Band: 1 – 40 Hz
- Frequency Response of the Electronics: 3 dB down at 1 Hz and 40 Hz but otherwise flat in the velocity or acceleration passband; ±0.5 dB in amplitude and 5-degrees in phase from calibrated value.
- Seismic Directionality: Three single axis seismic sensors installed orthogonally to within ±0.5 degrees. Following installation, the three axis sensor assembly shall self-adjust to the vertical plane within ±0.5 degrees.
- Dynamic Range: 132 dB
- Quantization: 24-bit analog-to-digital conversion
- Sampling Rate: 100 samples per second

All seismic sensors shall be characterized at the operational temperature across the frequency band of interest for the minimum, nominal, and maximum signal levels. The poles-zeros shall be determined through this verification process.

6.0 A Digital Waveform Recorder (DWR) shall be used to digitize acoustic and seismic sensor signals, time tag and format each sensor signal into CD-1.1 channel subframes, provide at least 30 minutes of data storage, and push when commanded or have pulled the CD-1.1 channel subframes to the DASS. The DWR shall also provide a calibration function to calibrate the digitize channels in loopback mode and each of the seismic sensors, and a webpage for viewing SP status of health and for command and controlling the SP. Command and control webpage function shall be limited to an administrator. Other requirements include:

- Low power circuitry,
- Separate linear 24-bit digitizer for each sensor,
- Appropriate preamplifier to ensure full dynamic range usage,
- Calibrator with the ability to generate sine and pseudo-random binary sequences at select amplitudes and duration,
- Circuitry to connect and disconnect the sensor sense lines from the applicable digitizer when commanded,
- Circuitry to connect the calibrator to any of the seismometer sensors,

- Circuitry to loop back the calibrator to any digitizer input when commanded,
- Logic to control the sequence of events to perform any type of calibration whether connected to a sensor or loopback,
- Accurate clock that is phase loaded to the DASS Network Time Server with an accuracy of ±1 microsecond,
- Processor to generate 10-second time tagged CD-1.1 channel subframe data for each digitized sensor channel,
- Memory to store 30-minutes of CD-1.1 channel subframe data,
- Non-volatile memory to store permanent and temporary parameters,
- Highly reliable redundant high intensity 1550 nanometer laser diodes that can traverse the 210 kilometers of STC without a repeater. Both diodes shall carry identical data to the terrestrial cable interface.
- Highly reliable redundant 1550 nanometer low noise optic sensors,
- Webpage for viewing the status-of-health, programming of network parameters, programming the CD-1.1 parameters, flushing the CD-1.1 memory, resetting the DWR, locking and unlocking the seismic sensors, and control over the seismic leveling mechanism.
- Digitizing Capability
    - A digitizing capability shall include the digitization of each seismic and acoustic sensor at their defined rates; install appropriate impedance to mitigate sensor damping and changing the sensor's transfer function; apply appropriate amplification so that the sensor's operational amplitude range is within the operational range of the digitizer; and appropriate application of filters so that impulsive signals are not altered in the operational frequency band. The filter coefficients shall be provided to NFESC.
- Time Synchronization
    - Time tag accuracy of the sensor data shall be within ±1 milliseconds, with synchronization of the DWR's internal clock to the UTC time provided by the DASS Network Timing Server. Time tagging of the sensor data shall be on the whole second with a new 10-second CD-1.1 channel subframe generated on the 00, 10, 20, 30, 40, and 50 whole second.
- Calibration
    - In an acoustic calibration, the acoustic sensor output signal is disconnected from the digitizer, and the calibrator's output stimulus looped back to the digitizer's hydrophone input for the duration programmed, and then returns the connection to the nominal state.
    - In a loopback calibration, the sensor output signal is disconnect from the digitizer, and the calibrator's output stimulus looped back to the digitizer's sensor input for the duration programmed, and then returns the connection to the nominal state.
    - In a seismic sensor calibration, the calibrator connects to the desired sensor's calibration stimulus lines, applies the selected signal for the duration programmed, and then returns the connection to the nominal state.