

Environmental Acoustic Support Plan for Distant Thunder Program

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LONG-TERM GOAL

The long term goal is to contribute to the understanding of the dynamic environmental conditions in the littoral region off the east coast of Korea where the Navy is tasked to implement multistatic Distant Thunder (DT) program technologies and transition this capability to the Navy. Of particular importance is the extrapolation of critical environmental factors to sonar performance in other geographic regions.

OBJECTIVE

We wish to ensure that test planning for the Distant Thunder engineering test and planning for participation in the SHAREM 126 is completed utilizing historical environmental data with numerical and geoacoustic model predictive capability. This gives the experiment planner advanced knowledge of possible critical environmental factors that might affect the outcome of system testing within planned source, target and receiver geometries. Because of the phenomenal success of previous Distant Thunder tests in less harsh environments, it is imperative that planners be forewarned of possible variances in performance due to this very extreme environment.

We also wish to collect as complete an environmental data set as is possible within the framework of a systems test in order to document and examine any environmental effects during the test. Included in this is the objective of working with the U.S. Naval Oceanographic Office (Navoceano) in planning their environmental acoustic data collection for their participation in SHAREM 126.

The third objective is to process the environmental data and evaluate the impact of the environment on the Distant Thunder multistatic performance.

APPROACH

Our approach is to combine the expertise and knowledge of NRL, Ocean Acoustical Services and Instrumentation Systems (OASIS) and NAVOCEANO to obtain historical data from data bases, literature and other institutions to develop geoacoustic models for bottom loss and water column

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climatic provinces. This information is applied to state-of-the-art propagation models to predict performance envelopes within expected environments. This process is repeated with measured data and compared to selected system results to determine the impact of the environment.

WORK COMPLETED

Historical environmental data for the May (DT II) and September (DT III) time frame were assembled. Specific data for the May test were distributed to modelers at Applied Research Laboratory/ University of Texas, BBN laboratories, and Naval Undersea Warfare Center to support them in their Tactical Decision Aid development process. Propagation models using Navy Standard Parabolic Equation (PE), Finite Element PE and OASES were run using the predicted environmental data. The geoacoustic model developed from geologic data sets was used in the REFLECT model to obtain grazing angle vs. bottom loss. Modeled propagation loss was then compared to previous Distant Thunder results to estimate performance, making assumptions of similar noise and source levels. The complete set was presented in an environmental data package for test planners and program managers. Propagation modeling was also completed for use in obtaining environmental compliance approval prior to DT II.

Cruise preparations for the May test were completed with instrumentation shipped to the USNS Narragansett. Participation in the May test presail set up the successful data collection of expendable bathythermograph (XBT) profiles from the Navy ships participating in this exercise. An extensive set of XBT and Conductivity/Temperature/Depth (CTD) measurements were made within limited time frames at both May-Test sites.

Environmental data from the May test has been processed and propagation models run to evaluate performance. Predicted performance agreed reasonably well with actual results due to bottom loss conditions, sound speed gradients and the presence of a strong oceanic shelf-break front.

Planning efforts for the SHAREM 126 test were completed with Navoceano for bottom sampling, chirp sonar runs and Transmission Loss measurements. Historical water column data were processed, provisioned and delivered to Navoceano for use in their modeling efforts and inclusion in the data package presented to the fleet prior to SHAREM 126. Personnel participated aboard the USNS Sumner and the USNS Narragansett in the environmental data collection effort during SHAREM 126. Processing of these data is currently underway.

RESULTS

The impact due to very high sound speed gradients along with high bottom-loss regions off the shelf break was demonstrated during the May engineering test. While previous tests indicated harsh shallow water environments, this test had significantly higher levels of variability impacting system performance (fig.1). The large sound speed gradients present during this time of the year also produce higher grazing angles with the bottom, moving them into the range where bottom loss is seen to increase to higher levels. In addition, test tracks in site 2 were shown to straddle the East Korea Coastal Front between the North Korea Cold Current and the East Korea Warm Current (fig.2).

Conclusions are that over low loss bottoms, the sound speed difference have a small effect on transmission loss and little frequency dependence; however, when operating over a high loss bottom, large differences in TL are evident due to sound speed differences and the variations in grazing angles.

When operating on the warm side of the front, which was over higher loss bottoms, grazing angles of about 15° produced significantly higher propagation loss. Positioning the source and receiver below the thermocline will result in less propagation loss.

IMPACT/APPLICATIONS

Operations in shallow water shelf regions are sensitive to primarily sound speed gradients and bottom type. The effects of bottom roughness and off-axis scattering and shelf break internal waves were not investigated due to limited data collection; however, these may further impact the degree of propagation loss experienced in this type of environment. It is known that bottom type changes rapidly from one location to the next over horizontal scales on the order of less than several kilometers. Most databases do not contain data of sufficiently high granularity or resolution to permit tacticians to adjust geometries for this scale of variability.

TRANSITIONS

The Distant Thunder system is currently being transitioned to the U.S. Navy. Recognition of the impact of bottom type, sound speed gradient, spatial and temporal variability, and upslope vs. downslope vs. cross-slope directions on propagation is important for Tactical Decision Aid (TDA) development and the need for fast, range dependent predictive models.

RELATED PROJECTS

1 - Littoral Warfare Advanced Development (ONR CODE 321 US) CDR Scott Tilden, program manager is supporting system development with a comprehensive set of environmental and environmental acoustic measurements to document and quantify environmental impact and variability.

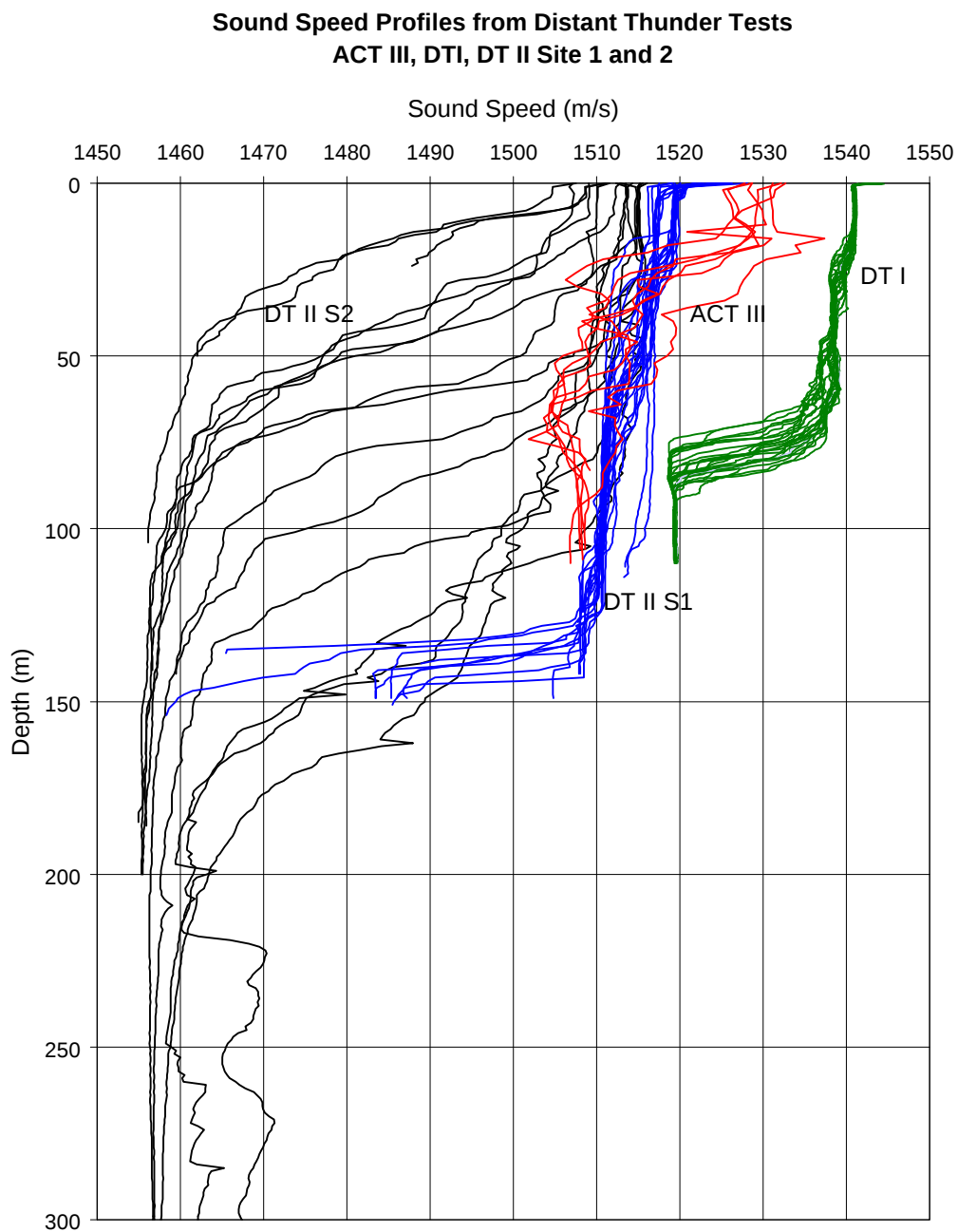


Figure 1. Sound speed profiles from different DT tests indicating high degree of variability at site 2, DT II of the May engineering test.

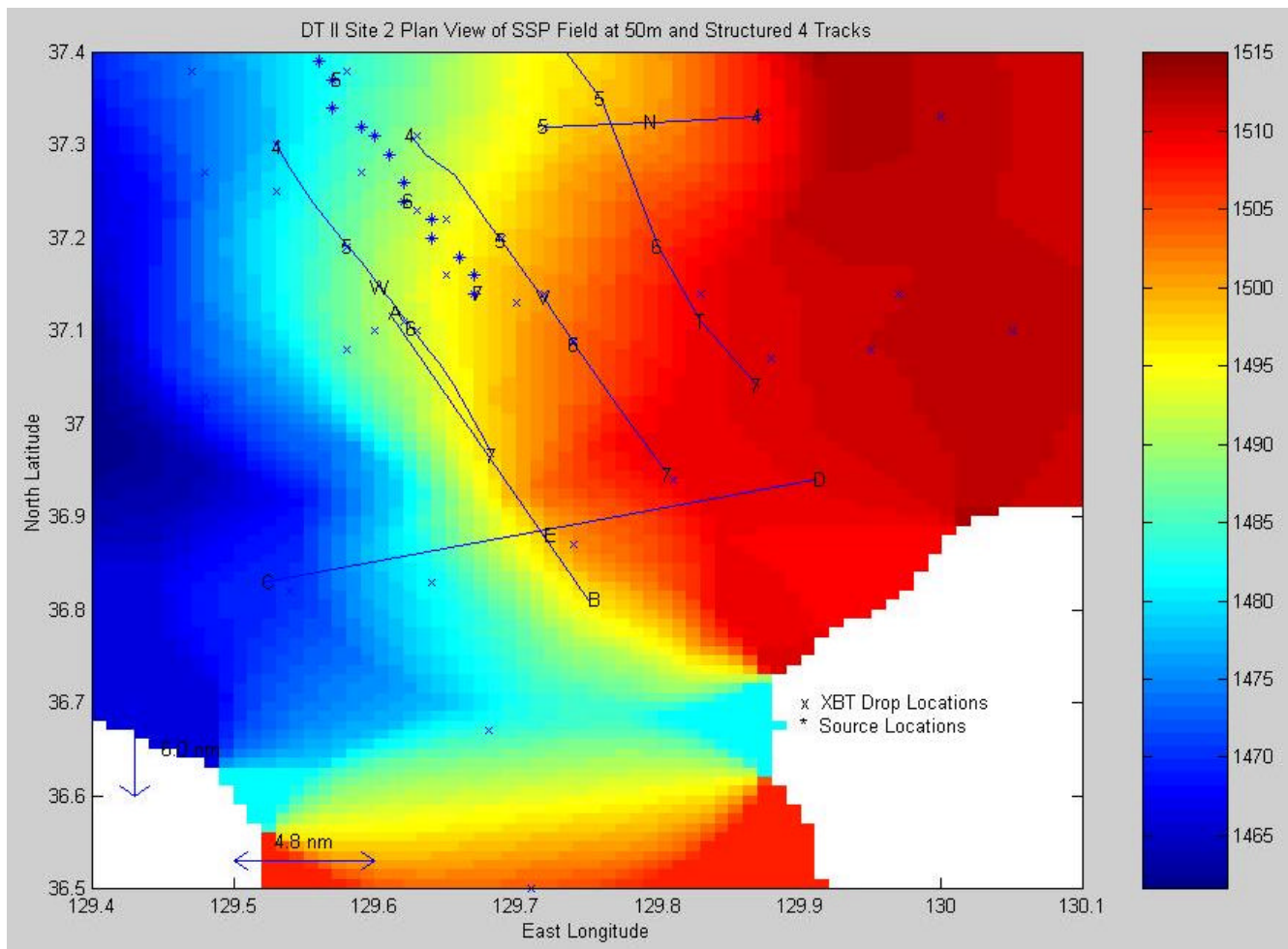


Figure 2. Tracks of the USS Vandegrift (V), the USS Curtis Wilbur (W), the target (T), Narragansett (N) and TL runs AB and CD. The USS Curtis Wilbur track runs along the front at 50 m depth.