BBN Technical Memorandum W-2008

Hydroacoustic Studies Using HydroCAM – Station-centric Integration of Models and Observations

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1. Summary of Activities

BBN's work during the third quarter of 2003 was focused on preparations for and participation in the 2003 Seismic Research Review Meeting, unit testing and bug fixes to HydroCAM 4.1, data collection and analysis, and procuring high-resolution bathymetric data. In an attempt to save money, BBN scaled back its labor in the third quarter, delaying some deliverables but saving contract funding in case our next increment is delayed.

We have succeeded in finding the correct Naval contact that can help us procure high-resolution bathymetry data. Although these data may require the release of a classified version of HydroCAM, we are optimistic that we will be able to acquire and integrate high-resolution bathymetric data near the Indian Ocean IMS stations.

HydroCAM 4.1, which includes the ability to make blockage predictions using varying resolution bathymetric data, has completed unit testing and is now under integration (release) testing. We hope to deliver that functionality to DOE and AFTAC in November.

BBN improved its database of hydroacoustic events in the Indian Ocean by including meta-data for associated arrivals. For each earthquake event, BBN is now picking the direct arrival at each station (Diego Garcia North and South, and Cape Leeuwin) and associating that arrival with the origin information that we are compiling. The data for 2001, 2002 and 2003 (to date) will be delivered to LLNL for integration into the Knowledge Base during the fourth quarter of 2003.

2. Introduction

The current contract's period of performance began on September 4, 2002. BBN is now on its second increment of funding which is intended to cover BBN's work through fiscal year 2003.

This contract's research is intended to extend the capability of BBN's Hydroacoustic Coverage Assessment Model (HydroCAM). Specifically, the effort is designed to improve HydroCAM's database and modeling capabilities with respect to hydroacoustic blockage. In this phase BBN is undertaking three tasks. First, BBN is investigating blockage by analyzing events in the Indian Ocean that are recorded at the International Monitoring System (IMS) stations at Diego Garcia and Cape Leeuwin. Second, BBN will attempt to improve HydroCAM's blockage modeling capability by integrating high-resolution bathymetry into HydroCAM near IMS stations.

The third task in this contract is a support-oriented one. BBN is tasked to support the HydroCAM and modeling needs of DOE and AFTAC. Lawrence Livermore National Laboratory (LLNL) and AFTAC are the two primary users of HydroCAM. In the past BBN has also supported them by performing event-driven data analysis and modeling tasks. Therefore, BBN expends significant effort maintaining the HydroCAM software and addressing any issues/needs that our contacts at DOE and AFTAC might have.

What follows is a complete summary of BBN activities on these tasks from July 2003 – September 2003.

3. 2003 Seismic Research Review

The 2003 Seismic Research Review meeting was held in Tucson, Arizona from September 23-25. BBN collaborated with Phil Harben and Eric Matzel of Lawrence Livermore Labs to present our complete program in a single paper/poster entitled, "Hydroacoustic Blockage Calibration for Discrimination." This poster was one of only two presented in the area of hydroacoustics. The abstract of the paper is included here for reference.

Hydroacoustic Blockage Calibration for Discrimination

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ABSTRACT

The core focus of this hydroacoustic research is to develop a better understanding of hydroacoustic blockage to better predict those stations that can be used in discrimination analysis for any particular event. The research involves two approaches: 1) model-based assessment of blockage and 2) ground truth data-based assessment of blockage. The goal is to reliably determine all hydroacoustic stations that can be brought to bear on a discrimination analysis from any event location in the world's oceans. An important aspect of this capability is to include reflected T-phases where they reliably occur since reflected T-phases can allow station utilization when the direct path is otherwise completely blocked. We have conceptually designed an approach to automated assessment that will allow both model-based and data-based methodologies to be utilized and in the future, integrated. We have modified the HydroCAM model-based network assessment code to include variable density bathymetry grids. This will improve the reliability of model-based blockage assessment as dense bathymetry grids are added to the bathymetry database where available and needed. We are also running the HydroCAM code to produce blockage grids in the Indian Ocean for many different blockage criteria. We have been building the database necessary to begin the data-based assessment of blockage. At present, the database is accumulating earthquake events within the Indian Ocean basin as recorded at Diego Garcia and Cape Leeuwin. Over 130 events from 2001 and 2002 have been loaded in the past. Now earthquake event data is automatically loaded into the LLNL database at 1-hour record lengths to accommodate future reflection phase analysis. Future work will focus on the utilization of reflected T-phases, the automated use of model-based blockage grids, and the enhancement and use of the data-based method for blockage assessment in the Indian Ocean. The analysis methodology will then be applied to other ocean basins to eventually include all ocean basins for a full worldwide blockage assessment capability.

4. LLNL visit

Following the Seismic Research Review meeting, Zachary Upton traveled to Livermore, CA to spend a few days meeting and working with Phil Harben and Eric Matzel at Lawrence Livermore National Laboratory. The objectives of this visit were very similar to those of our visit to AFTAC in 2002: to meet with HydroCAM's users on site, address their questions and problems, look for areas of potential collaboration, etc.

In addition to the goals stated above, this face-to-face meeting allowed BBN and LLNL to collaborate on the many topics, including:

- ?? Ideas for modeling diffraction and scattering around seamounts and islands.
- ?? Implementation of the variable resolution bathymetry in HydroCAM
- ?? Ideas for using hydroacoustic reflections to aid the AFTAC analyst
- ?? Plans for Eric Matzel's Java-based hydroacoustic model/data tool
- ?? The BBN SOW for FY04
- ?? Ideas for the forthcoming NNSA/AFRL BAA.

This was a very productive visit. BBN came away with a few actions/issues regarding the HydroCAM code, a number of ideas for improvements and future business, and a positive relationship with the newest member of the BBN/LLNL hydroacoustics team, Dr. Eric Matzel.

5. Software Development and Support

5.1. High-Resolution Bathymetry Search

BBN has had some preliminary success in our search for high-resolution bathymetry near the Indian Ocean stations of the International Monitoring System (IMS). We were able to leverage our U.S. Navy sponsors to find a useful contact at the Warfighter Support Center of the Naval Oceanographic Office. This contact has agreed to help us to acquire the bathymetry, where available, pending a formal request from DOE/NNSA. BBN has drafted the request and is currently working on finalizing it with Leslie Casey. We hope to acquire high-resolution bathymetry around the Diego Garcia, Cape Leeuwin, and Crozet stations. The only caveat to this search is that such bathymetry is likely to be classified. We are hoping to get bathymetry classified at a level of SECRET or below. In this case, we will release a classified version of HydroCAM.

5.2.HydroCAM 4.1

As stated in previous reports, HydroCAM 4.1 will include the ability to calculate paths using very high-resolution bathymetry near a receiving station while using lower resolution global bathymetry for the rest of the ocean. We hope that this will improve our ability to predict hydroacoustic blockage.

BBN has integrated a high-resolution bathymetry dataset at Wake Island into HydroCAM's GlobeRay model. HydroCAM can use this dataset in conjunction with a larger, lower-resolution, global dataset (i.e., ETOPO5) to calculate acoustic propagation and blockage at the future Wake Island hydrophone installation. The models and interfaces have been revised to handle two bathymetry datasets of different resolution, so integration of new data near other hydrophone stations should be simple. However, since we have no acoustic data at Wake to use to validate our model improvements, it is difficult to assess the value of these improvements with respect to hydroacoustic blockage prediction.

At the suggestion of Phil Harben at LLNL, BBN will release HydroCAM 4.1 to DOE and AFTAC. This version is currently under final testing and we hope to deliver it in November 2003.

6. Data Collection and Analysis

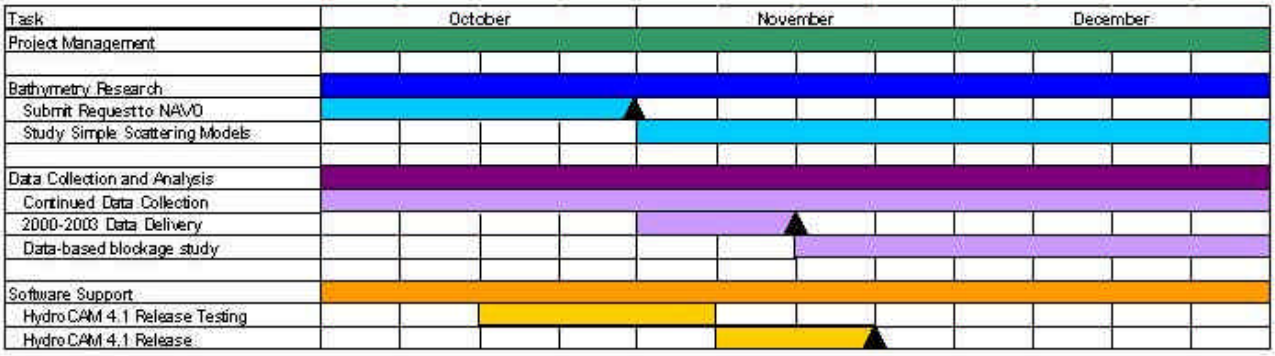
Data collection efforts continued in the second quarter. BBN monitors the Indian Ocean for earthquakes and other events of interest that might be recorded at the IMS stations at Diego Garcia and Cape Leeuwin. There was an uncharacteristic lack of earthquakes in the Indian Ocean during the third quarter. However, there was a series of interesting events along the Carlsberg Ridge that have been added to the database and are being analyzed at this time.

Database development continued in the third quarter. BBN added useful meta-data to the earthquake database including the CSS Version 3.0 association and arrival files (.assoc and .arrival extensions). For each station, the direct arrival is picked using HydroCAM travel time grids. This additional development work has delayed the delivery of the complete database, but we feel that the end product has greatly improved. We anticipate that we will be able to make a database delivery to DOE for integration into the Knowledge Base in November.

7. POA&M for Q4 2003

BBN's POA&M for the fourth quarter of 2004 is very conservative due to the uncertainty of our next round of funding. We will catch up on the deliverables that were put off in the third quarter and begin some of the important bathymetry research and data analysis that will allow us to improve our understanding of blockage, scattering/diffraction and reflection. This quarter's Key milestones are:

- ?? Submission of the request for high-resolution bathymetry data to the Naval Oceanographic Office
- ?? Delivery of the 2001-2003 Hydroacoustic Event Database to DOE
- ?? Delivery of HydroCAM 4.1 to DOE and AFTAC



7.1. Labor Budget

Currently, BBN has about $16K of its current increment of funding remaining. We will work the level necessary to complete the three conservative milestones set for October and November.

7.2. Risks

Obviously, the biggest risk during this quarter is that we will run into complications either finalizing the 2001-present Hydroacoustic Event Database or finalizing the HydroCAM 4.1 release before our next increment of funding is available. It is difficult to mitigate this risk, but BBN plans to keep regular communication with our contacts at DOE headquarters and LLNL to stay on top of the funding issue.