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MULTISTATIC SONAR OPERATOR VISUALIZATION DEVELOPMENT REQUIREMENTS

Mark A. Gammon †1, and Christopher Strode †2
1Defence R&D Canada Atlantic Research Centre, 9 Grove Street, Dartmouth, Nova Scotia, Canada.
2NATO Center for Marine Research and Experimentation, Viale San Bartolomeo 400, 19126, La Spezia, Italy

1 Introduction

Multistatic sonar presents unique challenges to the operational community due to a lack of experience with the technology and the unknowns regarding optimal sensor placement. Operations using multistatic sonar require close coordination between sources and receivers to maximize performance. One issue of effectively deploying these systems is related to the lack of operator visualizations aids to predict sensor performance.

Typically, effective deployment of legacy sonar systems required development and use of robust tactics. These tactics are almost always based on geographic or geometric applications using circular representations of sensor area coverage. For multistatic sonar operations, a transition is needed from the range of the day (RoD) calculation to the more complicated spatial extent of specular multistatic sonar coverage. When considering the employment of multistatic sonar, expected increases in detection ranges require that operators must be able to determine the probable sensor coverage and identify where gaps exist.

To deal with these issues, various multistatic sonar tactical aids have been developed. As one example, the Multistatic Tactical Planning Aid (MSTPA) was developed by the NATO Centre for Marine Research and Experimentation (CMRE) [1]. MSTPA was intended as an analysis tool for both scientists and operators. Defence R&D Canada also has experience with tactical decision aids to help operators visualize transmission loss (TL). One such tool was the development of an integrated sonar display aid to calculate TL known as the environmental modelling manager (EMM) [2]. This sonar display tool calculates a single monostatic TL range curve. These tools and aids have been exploited in the field, most recently during RIMPAC 2014 and Dynamic Mongoose 2015. These have been extremely useful for the analyst to provide support to these exercises. However, visualization is still required for the majority of the multistatic sonar operational community. The next section examines factors leading to operator uncertainty in sensor performance.

2 Operator Uncertainty

The use of EMM and MSTPA to visualize TL may help to mitigate environmental uncertainty and enhance operator confidence [3]. The confidence that operators have in acoustic performance predictions is based on experience gained while using current prediction tools. But such tools are typically applicable only for monostatic systems. MSTPA can be used to aid mission planners by providing a visualization of multistatic sonar performance. This was conducted at RIMPAC 2014. The example in Figure 1 shows a colour plot of sonar performance for a bistatic source and receiver combination against an imaginary target in yellow. This is a typical performance plot.

In the operational area, one of the first tasks for the sonar operator is to obtain a sound speed profile (SSP) which helps determine the actual acoustic conditions. Due to the fact that sensor positions vary, the sonar performance prediction will be different than the pre-mission plan. Using historical SSPs gives an idea of acoustic conditions, but analysis has shown differences in pre-mission and post-mission results. This is due to the different environmental conditions and the target’s actual manoeuvres from those assumed prior to the mission. The operator uncertainty is then compounded.

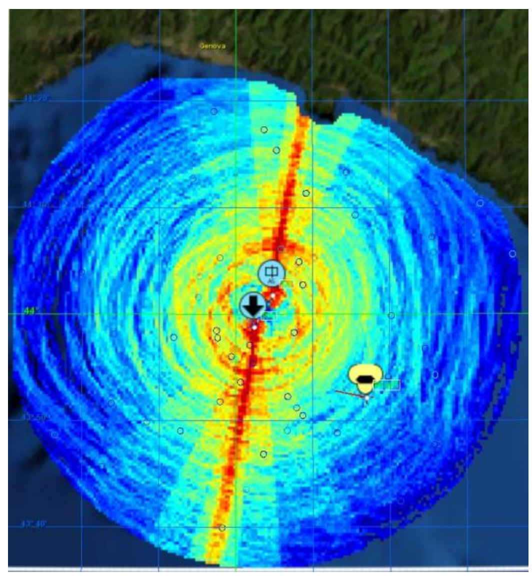

Figure 1: Bistatic Source and Receiver Example Plot.

Predicting the multistatic sonar performance in near-real time would be beneficial. A near-real-time prediction which is integrated with the sonar system would provide the required operator visualization of system performance. Robust tactics may still be required for optimal deployment of multistatic sensors. But most sonar tactics use the familiar RoD and sonar operators are trained in using this parameter as input for tactics.

Fewell examined monostatic and multistatic sonar performance based on an equivalent multistatic sonar RoD [4]. Multistatic sonar employment is not principally a RoD type of detection, but is largely based on specular detection [5]. This is because the target strength is typically greater on the beam and low at the bow and stern. Detections occur when favourable bistatic angles between source and receiver are found among the source-target-receiver configuration. In Figure 1, when the target crosses the line formed by the source ship and the down-arrow-icon receiving ship, a high specular detection line is shown in red. RoD based on circular "cookie-cutters" may then be impractical and misleading. A possible solution to support sonar tactical employment is discussed next.

3 Tactical Planning Requirements

The aim of tactical decision aids and tactics is to assist sonar operators. Traditional tactical development is often the result of modelling and simulation, followed by the drafting of experimental tactics, which are then tested during military exercises. This type of tactical development has been shown to provide operators and mission planners with good starting points for formulating their strategies.

Tactics are almost always based on a select number of input parameters, like RoD. Given an assessment of the sonar systems capabilities, a plan can be tabled for distribution and placement of platforms and sensors. In contrast, EMM, for example, provides operators with a near-real-time acoustic sonar transmission loss that can be used in a monostatic active sonar system to estimate sonar performance.

Alternatively, MSTPA has been used by operational analysts deployed as observers with the military to provide periodic in-situ reports. MSTPA was used in Dynamic Mongoose 2014 and Proud Manta 2013, two NATO exercises, as well as at RIMPAC 2014. Besides the sonar performance plots like that shown in Figure 1, the transmission-loss range/depth plot as shown in Figure 2 can also be generated.

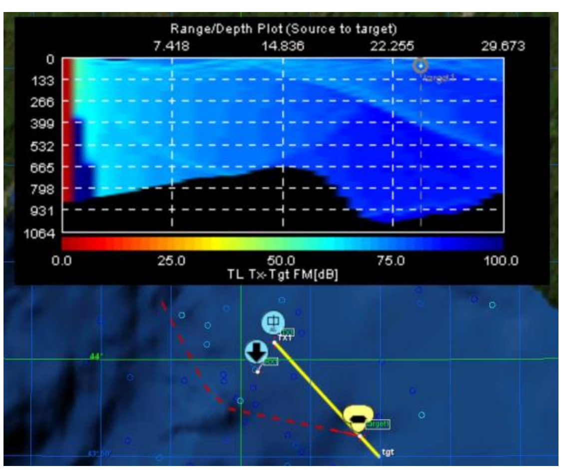

Figure 2: Transmission Loss Plot with Range/Depth from Source to Target.

At CMRE, work is ongoing to develop a true real time link for the MSTPA tool to include real-time platform positions. Such a link has been demonstrated during the CMRE COLLAB-NGAS14 at-sea experiment. MSTPA was connected in a manner that allowed the position of the ship NRV ALLIANCE and several autonomous underwater vehicles to be updated in real time. This direct link served to demonstrate the tool as a real time decision support aid. Fully range dependent and up-to-date temperature and salinity profiles were downloaded using a myOcean website.

The demonstration of MSTPA during COLLAB-NGAS14 was the closest yet to demonstrating the potential for a near-real-time multistatic sonar visualization tool. MSTPA operated with automatic platform positioning, which no longer required the user to manually pilot vehicles in real time (as in Dynamic Mongoose 2014). The experiment demonstrated a multistatic sonar system using autonomous vehicles operating as bistatic receivers. This represented a significant test of the acoustic prediction capability of MSTPA. Furthermore, the MSTPA Worldwind Graphical User Interface (GUI) was connected to an automatically refreshing KML file (Keyhole Mark-up Language file) containing the complete tactical picture available to the NRV Alliance platform, including the real time display of vehicle contacts and tracks together with the local Automatic Identification System (AIS) picture.

4 Conclusions

Proper visualisation of multistatic sonar is essential to allow mission planners for these operations to strategize. Operations may be enhanced if operators had a tool like MSTPA embedded in their sonar systems. As multistatic sonar capability improves but becomes more complex, the necessity for operational visualization of the sonar performance is becoming a requirement to facilitate its use. Further work at CMRE and DRDC Atlantic will determine ways in which this could be displayed on-board assets. Ideally a near-real-time multistatic sonar visualization aid integrated into the multistatic sonar system may enable operators to better estimate the actual sonar perfromance.

References

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