Conceptual Design of a Low Frequency Ultra-Wideband Synthetic Aperture Sonar

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Abstract

Most mine hunting missions rely on sonar imaging systems to detect and classify explosive ordnances. Traditionally, such missions employ side-looking sonar to produce acoustic images of the seabed. High frequency Synthetic Aperture Sonar (SAS) can generate range-independent, high-resolution images of the seafloor; however, these systems can suffer high false alarm rates when searching for stealthy targets in cluttered environments. In addition to masking by clutter, explosive ordnances can be concealed through acoustic cloaking, a technique which attempts to make a target invisible over a limited range of frequencies [1]. High frequency acoustics can only present the external or geometric shape of objects on the seafloor, making it difficult to discriminate between targets. Low Frequency Synthetic Aperture Sonar (LFSAS) has the potential to reduce false alarm rates and discriminate between man-made objects and naturally occurring seabed clutter by operating in the structural acoustics regime (1–50 kHz). At these frequencies sound waves penetrate objects of interest and excite resonant (elastic) modes of the target structure. Additionally, acoustic imaging with low frequencies allows for the ability to penetrate seabed sediment for buried target detection and 3D volume imaging of sub-bottom objects such as pipelines and communications cables [2].

This paper will present the conceptual design of Kraken's AquaPix® Multispectral SAS. The Multispectral SAS is a next-generation ultra-wideband acoustic sensor operating in the frequency range of 4–200 kHz. It will reduce false alarm rates in cluttered environments by presenting both geometric and elastic scattering, providing a rich set of classification features for target recognition. Operating over multiple frequency bands allows the Multispectral SAS to overcome acoustic cloaking techniques by ensuring the cloaked target is detectable in at least one of the frequency bands.

The Multispectral SAS is being developed as part of an R&D project with the Defence Research Development Canada Atlantic Research Centre. The Multispectral SAS is a fusion of several SAS systems operating concurrently at four distinct frequency bands: high frequency (140–180 kHz), mid frequency (50–90 kHz), low frequency (15–30 kHz), and very low-frequency (4–15 kHz). The system supports concurrent co-registration of all four frequency bands [3]. The low frequency and very low frequency bands will excite resonant modes on objects up to 0.9 and 2.8 m, respectively. In addition to imagery, the high frequency band will also provide high-resolution bathymetry derived from SAS interferometry. The multispectral SAS has been designed to fit on medium-sized towed and Autonomous Underwater Vehicles (AUVs) using a modular design which allows for long receiver apertures and high area coverage rates.

Designing and operating an ultra-wide bandwidth sonar presents a variety of challenges in terms of optimizing and predicting sonar performance, especially in strong multipath environments. The

Multispectral SAS consists of 4 different transmitters and one common ultra-wideband receive array. A hydrophone array that is multi-element in two dimensions has been selected to help achieve performance gains in multipath environments. In this paper, initial beampattern and frequency response tests of a prototype ultra-wideband receiver (Figure 1) will be demonstrated. Models of the Multispectral SAS performance in various mission scenarios will be presented. Mission scenarios will include seabed and buried target detection while operating in an environment supporting a variety of multipath interference mechanisms.

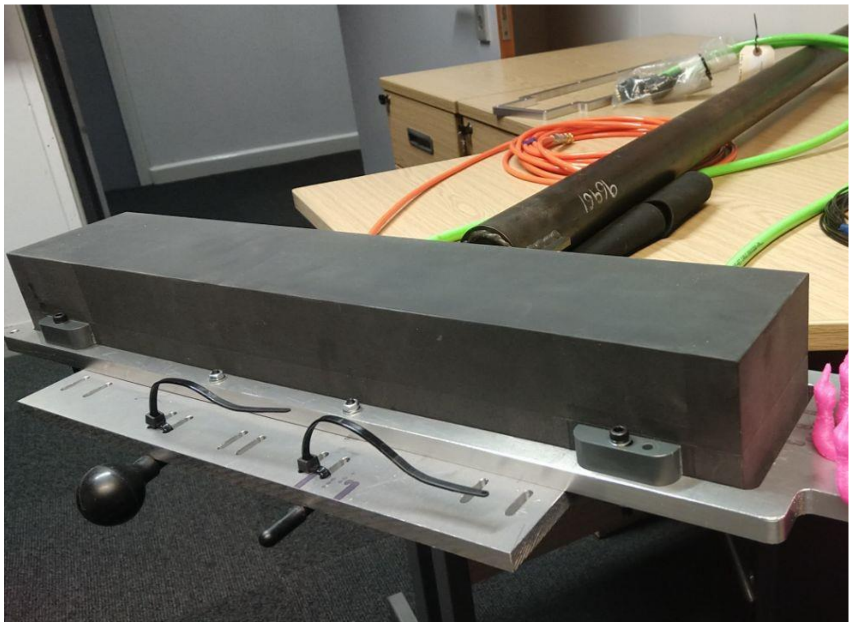

Figure 1: Prototype ultra-wideband receiver array (4–200 kHz).

References

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