UNDERWATER COMMUNICATIONS TESTING OF THE MULTI-MODE PIPE PROJECTOR

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1. INTRODUCTION

A method for providing undersea navigation was sought in order to provide autonomous undersea vehicles with absolute navigation data while submerged. Floating buoys based on the earlier LAND buoy were developed at DRDC Atlantic to permit transmission of real-time GPS NMEA embedded acoustic signals via underwater sonar transducers.

An experiment, carried out in February 2006 as part of CFAV Quest cruise Q294 in the Gulf of Mexico, was conducted to evaluate the accuracy, range and robustness of the GPS encoding and transmission system. This was also an opportunity to test the multi-mode pipe projector (MMPP) as an underwater communications source. For the purposes of this paper, range and decoding success will be discussed.

1.1 GPS (LAND) Buoy

The floating GPS retransmission buoy was developed using the casing of the earlier Lagrangian (Ambient Noise) drifter (LAND) buoy. The buoy's casing is composed of a water-tight aluminum cylinder with removable end bulkheads and a expanded polystyrene floatation collar.

These buoy are equipped with a GPS receiver and antenna from which time-stamped NMEA-formatted data is stripped. This data is fed to a PC-style microprocessor for translation into a hyperbolic frequency modulated (HFM) coded audio signal with 200 Hz bandwidth. Each of the three constructed buoys had its center frequency set for a particular projector. The audio signal is amplified by a 400-watt commercial car audio unit. A matching inductor in series with the sonar projector keeps the power factor above 0.8. Each buoy is powered with 5-12 VDC deep cycle batteries.

Two MMPP's and one barrel-stave projector were selected as transmitting elements. Each transducer was tethered to its GPS buoy with a strength member and conducting cables to operate at a depth of 30 m.

1.2. Multi-Mode Pipe Projector

The Multi-Mode Pipe Projector is a wideband, inexpensive, and depth insensitive sonar projector that has been under development at Defence Research and Development Canada (DRDC) -Atlantic over the past 3 years.

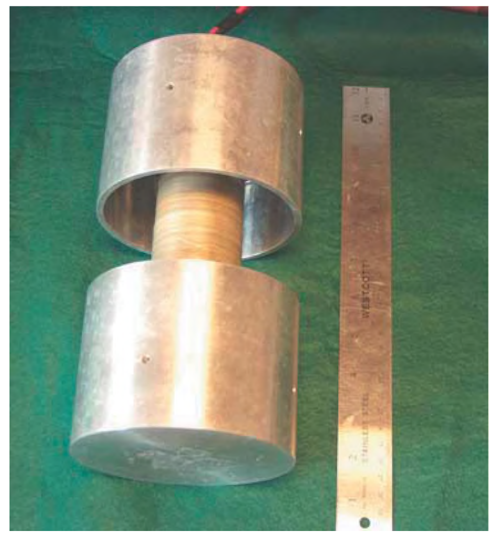

Figure 1. 30X40 MMPP.

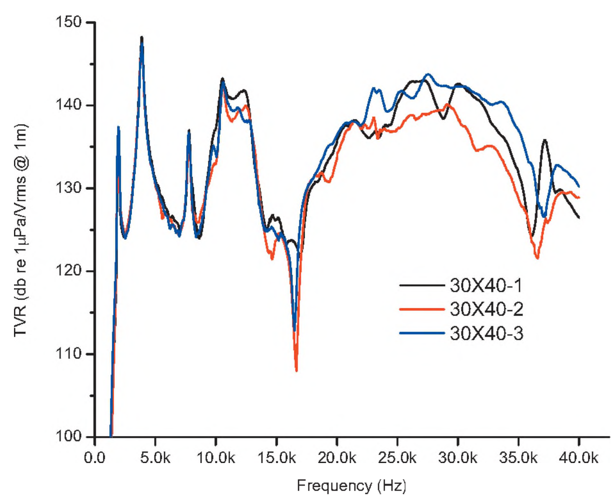

Figure 2. 30X40 MMPP slot-direction transmitting voltage response.

The MMPP's wide bandwidth is achieved through juxtaposition of resonant mode frequencies by optimization of various projector dimensions and materials. The low frequency modes are generated by cavity and flexural modes of the cup-shaped endcaps while high frequencies are generated from drive motor breathing modes.

The 30X40 version of the MMPP has a useable band from 1.8 to 34 kHz from its slot-fire direction. This projector (see Figure 1) is 0.232 m long, 0.119 m in diameter and has a mass of 3.4 kg in air. For this trial the first and second resonance frequencies centered at 1950 Hz and 3850 Hz (see Figure 2) for 30X40 MMPP's were selected. As well, a barrel-stave projector was employed at its 1500 Hz first resonance.

2. EXPERIMENT DESCRIPTION

The three transducer-equipped GPS buoys were deployed at a test site off the west coast of Florida in the Gulf of Mexico (see Fig. 3). The GPS buoys were assigned labels L1, L2 and L4 which corresponded to the barrel-stave projector at 1500 Hz, MMPP at 1950 Hz and MMPP at 3850 Hz respectively. Source levels were kept low so that acoustic emissions did not exceed the maxima stated in the cruise plan. GPS NMEA data was encoded on HFM sweeps at a rate of 8 symbols per second. A group of type SSQ-53F(GPS) sonobuoys were laid out to receive the GPS encoded acoustic signal and subsequently retransmit the data via RF link to CFAV Quest. The GPS coordinates of the type 53F buoys were also tracked for later comparison of computed position to actual position.

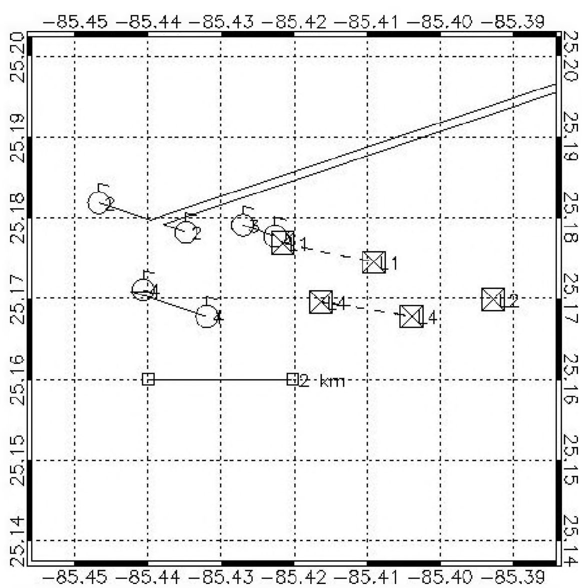

Fig 3. L1, L2 and L4 Acoustic GPS buoys (square icons) transmitting to a field of 53F sonobuoys (circle icons).

3. RESULTS

GPS Buoy labeled L2 provided no usable GPS decodes likely due to its 3km distance from the sonobuoys. The signals were received with high enough signal to noise ratio, but the time variance between symbol arrivals was too high to be decoded consistently enough to produce usable data. Ignoring L2, 70% clear and another 26% highly usable transmissions were decoded. With L2, useable decoded transmissions decreased to 47% and 18% respectively.

4. DISCUSSION

Preliminary results in this and related experiments during Q294 indicate that the MMPP is a good candidate for use in underwater communications. MMPP performance was minimally impacted by multi-path distortion at ranges of less than 2 km given the geometry of this experiment and water conditions. Further analysis of the data is planned to assess acoustic GPS positioning accuracy using this method of acoustic GPS data transmission.