Influence of mast positioning on ship RCS in HF band

Nemanja R. Grbić[1,2], *Member*, *IEEE*, Pavle Z. Petrović[1,2], *Member*, *IEEE*, Nikola Lekić[2], *Member*, *IEEE*, Miroslav Perić[2], *Senior Member*, *IEEE*, and Slobodan V. Savić[1], *Member*, *IEEE*
[1]University of Belgrade, School of Electrical Engineering, Belgrade, Serbia
[2]Vlatacom Institute of High Technologies, Belgrade, Serbia
nemanja.grbic@vlatacom.com, pavle.petrovic@vlatacom.com, nikola.lekic@vlatacom.com, miroslav.peric@vlatacom.com, ssavic@etf.bg.ac.rs

Abstract—In this paper effects of the position of a ship's mast on its radar cross section (RCS) are examined in the high frequency (HF) band. Depending on the relative placement of masts it is shown that the monostatic RCS of a ship will change considerably. Hull, command bridge, and other objects will influence the RCS also. Results of electromagnetic simulations indicate that mast placement and bridge positioning allow for an increase or decrease of monostatic RCS for a particular direction.

Keywords – radar cross section (RCS), high frequency over the horizon radars (HF OTHR), mast placement, monopole antenna.

I. INTRODUCTION

Over the horizon radar (OTHR) is a system used for long-range maritime surveillance, which employs the high frequency (HF) surface wave which is vertically polarized [1]. It was shown that in this system a significant contribution to RCS can come from vertical structures such as masts, antennas, and towers [2]. This is even more pronounced when the height of vertical structures is near resonant. With certain arrangements of vertical structures, monostatic radar cross section (RCS) can be canceled in specific directions. In this paper, we will examine some of these effects through numerical simulations.

II. NUMERICAL MODELS AND RESULTS

To investigate the mechanism of RCS cancelation, a simple model of two monopoles separated by λ/4 is simulated (λ being the free space wavelength). Monopoles are placed above an infinite ground plane and illuminated with transverse electromagnetic (TEM) waves traveling in the horizontal plane. The results for monostatic RCS in the horizontal plane are calculated by the WIPL-D Pro [3] and shown in Fig. 1. A clear null in monostatic RCS is seen for directions in the horizontal plane containing the plane of both monopoles, as expected.

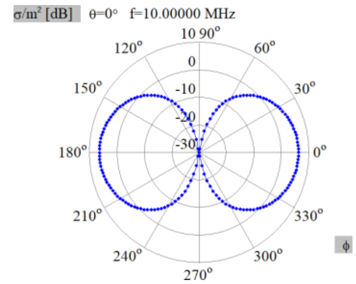

Figure 1. Monostatic RCS of two monopoles separated by λ/4.

On the other hand, for ships with two masts separated by λ/2, there are some effects not present in the previous model. Ships have multiple masts and a command bridge with different electromagnetic surroundings and the ship's hull could not be seen as an infinite ground plane. A simplified realistic model of an oil tanker with two masts and a bridge is presented in the inset of Fig. 2. The ship is illuminated with vertically polarized TEM waves traveling in the horizontal plane. Monostatic RCS for three situations, two λ/2 separated masts and a command bridge separated by λ/4 (blue line), front mast excluded (red line), and both masts excluded (green line) are shown in Fig 2.

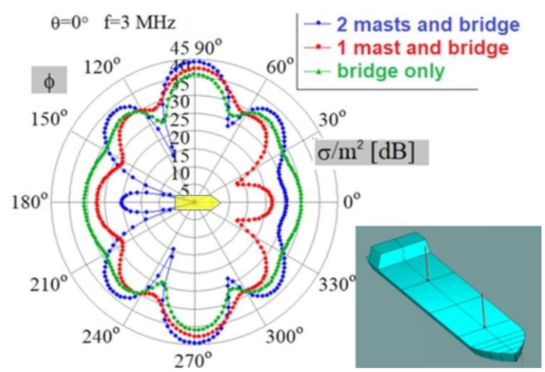

Figure 2. Ship RCS for two masts (blue line), 1 mast (red line) and bridge only (green line). The illustration of ship orientation is shown with yellow object in the center of the diagram.

From Fig. 2 it is observed that monostatic RCS in the direction of ship's axis is reduced when 1 or 2 masts are added compared to the command bridge. Results are generally are dependent on the number of masts and angle of monostatic RCS.

REFERENCES

[1] D. Nikolic, N. Stojkovic, P. Petrovic, N. Tosic, N. Lekic, Z. Stankovic, N. Doncov, "The High Frequency Surface Wave Radar Solution for Vessel Tracking Beyond the Horizon," *Facta Universitatis*, vol. 33, no. 1, pp. 37-59, March 2020.
[2] D. Trizna and L. Xu, "Target Classification and Remote Sensing of Ocean Current Shear Using a Dual-Use Multifrequency HF Radar," *IEEE Journal of Oceanic Engineering*, vol. 31, no. 4, pp. 904-918, October 2006.
[3] WIPL-D Pro v18, WIPL-D, 2022, https://wipl-d.com/.

This research was funded by Vlatacom Institute.