Aircraft Detection Using HF Radar

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Abstract—High-frequency surface-wave over-the-horizon radar (HF SW-OTHR) systems have proven themselves to be a reliable tool for maritime surveillance. However, the surface-wave mode of propagation is closely bound to the surface of the sea, making it not suitable for detection and tracking of targets at greater altitudes, such as airplanes. This paper explores the possibility of using free-wave-propagating electromagnetic wave for aerial targets surveillance using radar in the HF band.

Keywords - High-frequency OTHR radar, aircraft detection.

I. INTRODUCTION

High frequency (HF) radar systems for aerial target detection is a well-known area, as some of the first radar systems in the world operated close to, or in this frequency band. Despite that, there is renewed interest in aerial target detection in this frequency band as high-frequency over-the-horizon radars (HF-OTHR) are becoming more common for ship detection and tracking. The possibility of extending the usability of HF-OTHR for airplane detection and tracking is explored in this paper.

II. NUMERICAL MODEL AND COVERAGE ZONE

The surface-wave mode of propagation generated by the HF-OTHR systems decays exponentially away from the air-sea boundary surface [1]. In the HF band, and for standard seawater electric parameters [2], the result is that the amplitude of the electromagnetic (EM) field will decay $e \approx 2.72$ times at heights of several tens of meters. As most aircraft fly at altitudes higher than that, this makes the surface-wave mode of propagation not suitable for the detection of aerial targets and free-wave mode should be used instead. For successful detection using free-wave mode, following conditions should be met: (i) Total distance between radar transmitter (Tx) and target, and between target and radar receiver (Rx) must satisfy the radar equation [3] for the signal-to-noise ratio (SNR) to be high enough for a target to be detectable. (ii) There must be a line of sight between the radar and the target. Refraction of EM field occurring in the atmosphere, altitudes of radar sites and the target must be taken into account [4]. The radar cross section (RCS) for the commercial airplane (Boeing 737) is estimated using 3-D EM modeling software WIPL-D Pro [5], as seen in Fig. 1. A frequency of 25 MHz was considered with a horizontal polarization to suppress the surface-wave mode of propagation.

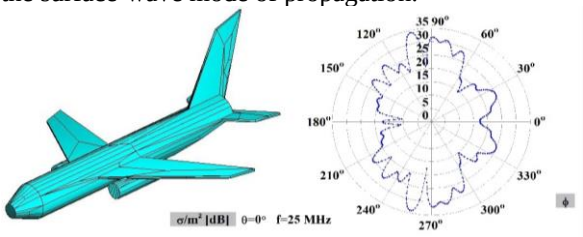

Figure 1. WIPL-D model and RCS for Boeing 737.

The zones of coverage are approximately calculated and shown in Fig. 2 for a hypothetical bistatic radar scenario for which existing Vlatacom HF radar [6] is used to detect Boeing 737 from Fig. 1. In Fig. 2 distances of possible detection are represented in different colors for different altitudes of flight. For the presented results it is estimated that for large targets (Boeing 737) detection is possible over 400 km, depending on the altitude of flying. In these results, the line of sight is the stricter limiting factor for detection (condition (ii)). For smaller targets, this is not the case, and condition (i) must be also considered. Elliptical arcs having constant mean distance between the radar and target are shown in white line (Tx and Rx are their focal points, shown in red dots).

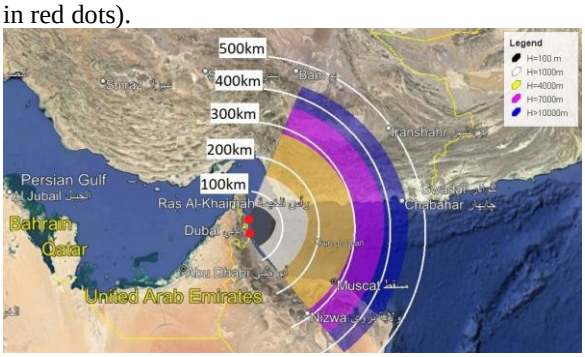

Figure 2. Coverage zone for a bistatic HF radar.

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