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# Simulation of Scattering Characteristics of Aerial Resonant-Size Objects in the VHF Band

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**Abstract**—A method based on solving the surface integral equations of second kind is proposed for calculating the scattering characteristics of aerial resonant-size objects. The calculation results are presented for a model of the reentry vehicle of the LGM–30G Minuteman III intercontinental ballistic missile and the AGM86C cruise missile.

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## 1. STATEMENT OF THE PROBLEM

VHF radars (with wavelength $\lambda = 1\ldots10$ m) feature a number of advantages as compared with UHF (decimeter-wave) and SHF (centimeter-wave) radars. Their main advantages include the efficiency of application for the detection of stealth targets (the targets having a small electrical size such as light aircraft, dummy targets, and different purpose missiles) and the long-range targets. In designing radars and developing algorithms for processing of signals reflected by the specified aerial objects it is important to have the most complete and reliable information possible on their scattering characteristics (backward secondary radiation pattern (BSRP), reflected signals in the frequency and time domains). In other words, we need a mathematical model of signals that is adequate to physical processes observed during sensing of targets in the VHF band.

The paper investigates characteristics of the secondary radiation of cruise missile (CM) AGM86C, the reentry vehicle, and the warhead of intercontinental ballistic missile (IBM) LGM–30G Minuteman III. The typical linear dimensions of the specified objects, as applied to the very high frequency (VHF) band, are commensurable with the length of the sensing wave. Therefore, it is reasonable to expect that the scattering of electromagnetic waves by such targets will feature the resonant behavior. It should be also noted that the numerical computer simulation using the well-known classical high-frequency methods of diffraction [1–4] does not ensure acceptable accuracy of calculating the scattering characteristics of resonant objects.

The method based on solving the surface integral equations (IE) was applied for solving the problem under consideration. The developed algorithm was used to simulate the scattering characteristics of CM, IBM reentry vehicle and warhead.

This paper includes a brief discussion of the method for developing a digital model of the surface of the aerial object. The main attention is devoted to the analysis of the obtained BSRP of CM AGM86C and the reentry vehicle of IBM LGM–30G Minuteman III at the length of sensing wave $\lambda = 1.5$ m (carrier frequency $f = 200$ MHz) and also the signals reflected by the ICM warhead at different aspect angles of irradiation by a pulsed signal having the average wavelength $\lambda = 0.86$ m (with spectrum occupying the band from 200 to 500 MHz at level 0.707 of the maximum that corresponds to wavelengths from 1.5 to 0.6 m lying in the VHF band and on the lower boundary of the UHV band).

## 2. BASIC CALCULATION RELATIONSHIPS AND FEATURES OF COMPUTING THE ELECTROMAGNETIC FIELD SCATTERED BY RESONANT-SIZE AERIAL OBJECTS

The initially designed algorithm was applied for simulating the scattering characteristics of objects having a relatively small electrical size such as mortar shells of different types. The basic calculation relationships, calculation results and their application examples were presented in papers [4–6]. The method