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Radar Cross Section Modelling of Lossy Dielectrics

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Abstract : Radar cross section (RCS) of dielectric objects play an important role in many applications, such as low observability technology development, drone detection, and monitoring as well as coastal surveillance. Various materials are used to construct the targets of interest such as metal, wood, composite materials, radar absorbent materials, and other dielectrics. Since simulated datasets are increasingly being used to supplement infield measurements, as it is more cost effective and a larger variety of targets can be simulated, it is important to have a high level of confidence in the predicted results. Confidence can be attained through validation. Various computational electromagnetic (CEM) methods are capable of predicting the RCS of dielectric targets. This study will extend previous studies by validating full-wave and asymptotic RCS simulations of dielectric targets with measured data. The paper will provide measured RCS data of a number of canonical dielectric targets exhibiting different material properties. As stated previously, these measurements are used to validate numerous CEM methods. The dielectric properties are accurately characterized to reduce the uncertainties in the simulations. Finally, an analysis of the sensitivity of oblique and normal incidence scattering predictions to material characteristics is also presented. In this paper, the ability of several CEM methods, including method of moments (MoM), and physical optics (PO), to calculate the RCS of dielectrics were validated with measured data. A few dielectrics, exhibiting different material properties, were selected and several canonical targets, such as flat plates and cylinders, were manufactured. The RCS of these dielectric targets were measured in a compact range at the University of Pretoria, South Africa, over a frequency range of 2 to 18 GHz and a 360° azimuth angle sweep. This study also investigated the effect of slight variations in the material properties on the calculated RCS results, by varying the material properties within a realistic tolerance range and comparing the calculated RCS results. Interesting measured and simulated results have been obtained. Large discrepancies were observed between the different methods as well as the measured data. It was also observed that the accuracy of the RCS data of the dielectrics can be frequency and angle dependent. The simulated RCS for some of these materials also exhibit high sensitivity to variations in the material properties. Comparison graphs between the measured and simulation RCS datasets will be presented and the validation thereof will be discussed. Finally, the effect that small tolerances in the material properties have on the calculated RCS results will be shown. Thus the importance of accurate dielectric material properties for validation purposes will be discussed.

Keywords : asymptotic, CEM, dielectric scattering, full-wave, measurements, radar cross section, validation
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