Ultra-Wide Band Radome CAE Optimization

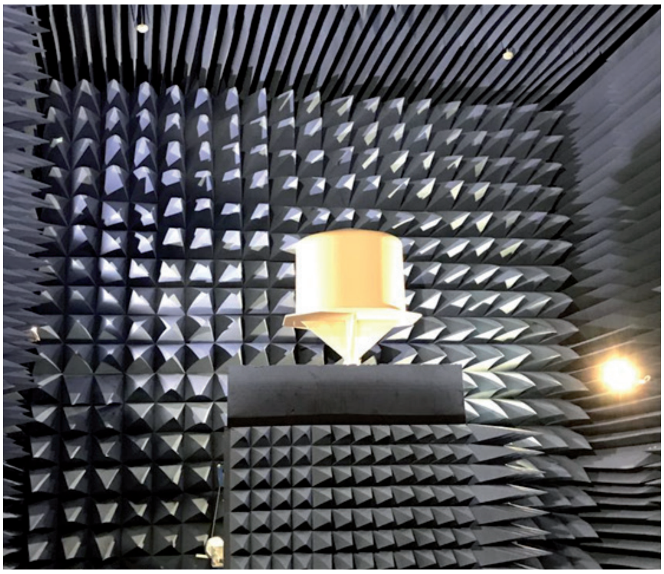

Fig. 1 - Radome in Elettronica SpA anechoic chamber

We show here the design of a radome for electronic warfare covering an entire signal intelligence system. The radome design was very challenging from both an electromagnetic (EM) and a mechanical point of view because of its size and bandwidth.
In particular, we want to show how the choice of the correct simulation environment can prevent simulation artifacts, leading to a successful design.

Introduction

A radome is a cover placed above an antenna to protect it from the external environment. An ideal radome would protect the antenna from any physical damage and be electromagnetically transparent in its operational frequency band. Nowadays, radomes are widely used on ground, airborne and maritime application.
The growth in the use of the electromagnetic spectrum lead to an improvement in the radome performance. In particular, during the last decades composite materials became the preferred choice for antenna radome due to their low thickness and high mechanical strength.
A radome can be designed in a monolithic or sandwich fashion. The monolithic radome is made of a single solid layer, while the sandwich radome alternates high-density (aramid fiber, fiberglass) and low-density materials (honeycomb, foam). In this work, we focus on sandwich radomes.
A sandwich stratification can be electromagnetically modeled using an equivalent transmission line: each layer is represented by a shunt impedance, defined through the thickness of the layer and its characteristic impedance. Eventually, one can predict the transparency of the whole stratification knowing the electric behavior of each layer. It is worth noting that a larger number of layer does not necessarily mean higher reflectivity. In fact, the sandwich stratification can be viewed as a shunt-inductance-coupled filter, where the goal is to insert a pole in the operational band.

Radome scenario

In Elettronica SpA we design and produce system for electronic warfare (EW). Each system has to meet different requirements, depending on the platform and the purpose (jamming, support measurement).
In this case, we consider a terrestrial system for signal intelligence, using more than 40 ultra-wide band (UWB) antennas to detect the threats. The peculiarity of this system is that a single radome has to protect all the antennas. In this scenario, the radome design represents a great challenge from both a mechanical and an electromagnetic (EM) point of view. In fact, the shape of the radome is, approximately, a cylinder with a diameter of 1 m and a height of 0.8 m, as shown in Fig. 1. It has to be strong to withstand difficult environmental conditions. At the same time, it has to be electromagnetically transparent from DC to 40 GHz.

Radome design

The first step for the EM design consists in the maximization of the transmission coefficient of the sandwich stratification, given the mechanical constraints. In our case, the constraints are related to the total thickness of the radome and the thickness of the inner and outer layers of prepreg.

First Prototype

A numerical optimization of the stratification has been performed. The chosen stratification alternates aramid fiber and honeycomb. The total thickness, after the optimization is 8 mm.
EM full wave simulations have been performed on the antennas behind the radome to evaluate the perturbations introduced on the radiation pattern. The radome dramatically increases the simulation spatial domain and, for some of the antennas, the problem was too complex with the available computational resources. On these antennas, approximations in the simulation setup have been introduced. In particular, a sinuous antenna working in a band 1-18 GHz has been substituted by a field source radiating behind the radome. The simulation results show that the level of perturbation on the radiation patterns was considered acceptable and a first prototype has been manufactured.
The radome has been measured, but the result was unexpected: the radiation pattern of the sinuous antenna was deeply deformed, exhibiting a minimum at the boresight for some frequencies.

Solution identification

The perturbation of the radiation pattern is particularly strong in the higher part of the band, where the radiating surface of the antenna is small compared to its physical size. This destructive

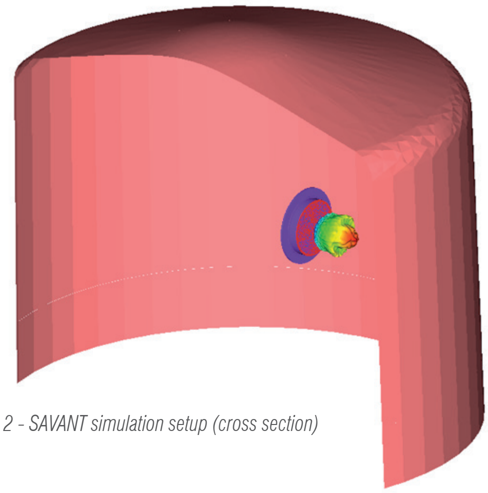

Fig. 2 - SAVANT simulation setup (cross section)

phenomenon is related to the reflected field contributions bouncing on the inactive part of antenna itself, radiating with opposite phase.
A smart simulation environment had to be tailored to reproduce the pattern perturbation, giving confidence for a successful redesign. The solution has been found in cooperation with EnginSoft, making use of ANSYS Savant. The software is based on a ray-tracing method. The setup is shown in Fig. 2: the equivalent field source is placed inside the radome. In order to reproduce the perturbation effect, the structure of the antenna has been placed in its position (without being fed). This expedient allows the antenna structure to reflect without overcomplicate the simulation.

The simulated radiation pattern at 17 GHz is shown in Fig. 3. This frequency has been chosen to clearly show the described phenomenon. The simulation is in line with the measurement results.

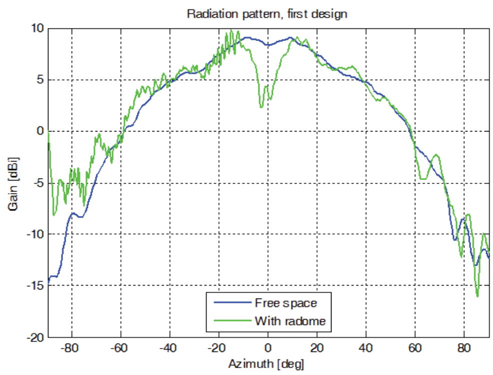

Fig. 3 - First design, simulated radiation pattern @ 17 GHz

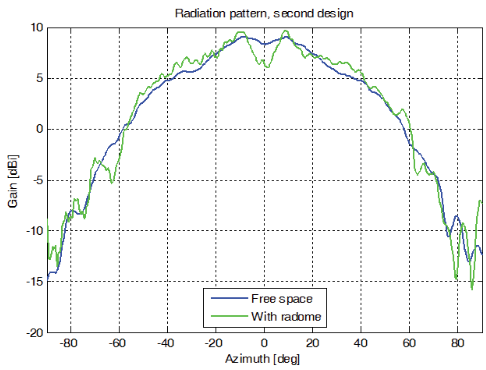

Fig. 4 - Second design, simulated radiation pattern @ 17 GHz

Second Prototype

With a greater confidence on the simulation results, a second stratification has been designed. The design of the stratification favors the transparency in the higher portion of the band of the sinuous antenna. The simulation results are shown in Fig. 4. The prototype of this new stratification has been manufactured and measured. The measurement results are in line with the simulations.

Conclusions

In this paper, we showed the design of a challenging radome. The operational band is from DC to 40 GHz and it cover an entire system for signal intelligence. The approximations introduced during the design lead to a strong perturbation in the radiation pattern of an UWB sinuous antenna, discovered in the measurement stage. Identifying a more effective simulation setup, a second version of the radome has been successfully designed and manufactured, with an agreement between simulations and measurements

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ANSYS HFSS SBR+ Solver Option

The ANSYS HFSS SBR+ Solver Option - formerly Delcross Savant can be added to the ANSYS Electronics Desktop or any of the ANSYS products that utilize the ANSYS Electronics Desktop. This solver-only option does not include a GUI. With this option, you can add the HFSS SBR+ solver to your existing ANSYS Electronics Desktop cost-effectively and maximize your investment in ANSYS technology.

HFSS SBR+ is an advanced antenna performance simulation software that provides fast and accurate prediction of installed antenna patterns, near-fields and antenna-to-antenna coupling on electrically large platforms. HFSS SBR+ analyzes installed antenna performance on platforms that are tens to thousands of wavelengths in size. It leverages the asymptotic Shooting and Bouncing Ray Plus (SBR+) technique to efficiently compute accurate solutions with incredible speed and scalability.
The state-of-the-art technology in HFSS SBR+ includes advanced physics models such as creeping waves, UTD diffraction rays and surface curvature extraction not available in other commercial electromagnetic solvers.

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