TECHNICAL DOCUMENT
for MFG Galileo

MFG Galileo

As an industry leader in composite radomes, MFG Galileo has extensive expertise in the design, and analysis of radomes. We also have RF measurement capabilities to 40 GHz.

Advanced Analysis and Measurement Capabilities

MFG Galileo has several tools developed specifically for the design and analysis of radomes and radome seams. These tools include:

CRD - A suite of analysis codes for analyzing, designing, and optimizing composite radomes
LARA - A multipurpose tool for calculating radome far field impact on antenna systems
FDTD - Used for calculating seam Induced Field Ratio (IFR)
Noise Temperature Analysis
Measurement Capabilities

Composite Radome Designer (CRD)

CRD allows us to custom design each radome we build thus providing our customers with the best possible performance. CRD has several modules for calculating key radome parameters.

CRD Analysis Capabilities

- Flat Panel Loss
  (Loss and Axial Ratio Impact)
- Radome Transmission Loss
- Absorption Loss (a.k.a. Ohmic Loss)
- Phase Non-Linearity

Design Features

- Genetic Algorithm Optimization
- Local Optimizers
- Comparison of design and measurement data for iterative improvements

Examples of CRD include the ability to analyze the transmission of a plane wave on a homogenous flat panel and the insertion loss through a spherical radome as shown in Figure 1 and Figure 2.

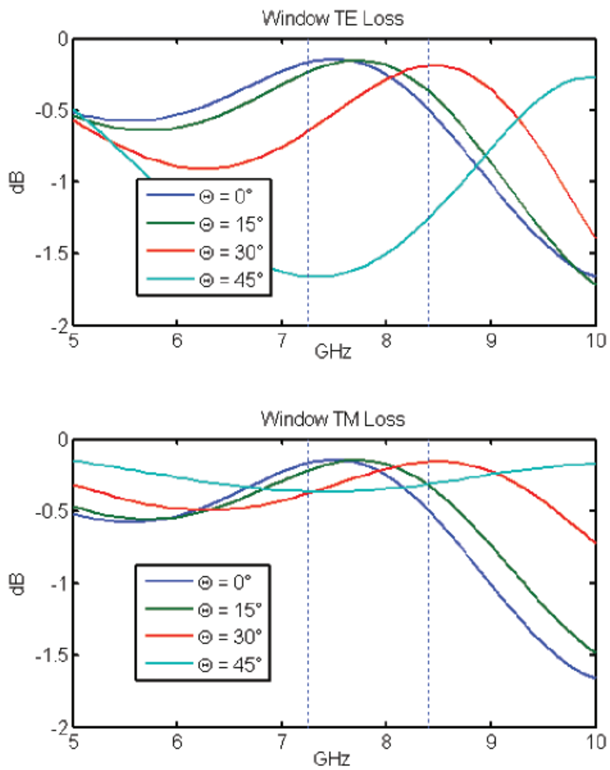

Figure 1 Flat panel analysis of radome panel designed for X band satcom for both Transverse Electric (TE) modes and Transverse Magnetic (TM) modes.

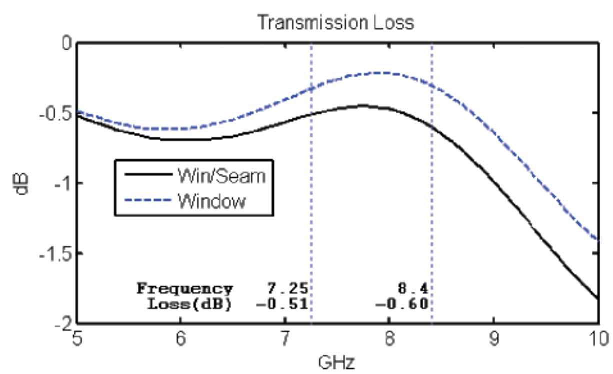

Figure 2 Analyzed transmission loss of 30 ft radome accounting for antenna dimensions, radome curvature, and seam scattering.

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Large Aperture Radome Analysis (LARA)

LARA is a very powerful and versatile analysis tool. Using LARA, we can analyze many radome parameters using complex models that include geometry and seam placement as shown in Figure 3.

Design parameters that can be analyzed include:

- Radome sandwich design
    - A-Sandwich, C-Sandwich and Multilayer Construction
    - Non-homogeneous construction
- Radome Geometry
- Seams
    - Construction
    - Location and Orientation
- Antenna Parameters
    - GRASP Output Files
    - Aperture Distribution
    - Antenna Location
    - Frequency of Operation

Performance parameters that can be analyzed include:

- Seam Scattering
- Sidelobes and Sidelobe degradation
- Boresight Error
- Change in Beamwidth
- Null Depth
- Transmission Loss vs. Frequency
- Transmission loss vs. Pointing Angle
- Axial Ratio Degradation

For example, Figure 3 shows MFG Galileo's 30 ft radome model. LARA analyses the seam scattering and the impact on sidelobes as shown in Figure 4 and Figure 5.

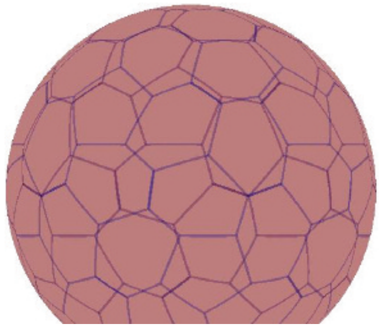

Figure 3 Model of 30 ft radome used in LARA analysis.

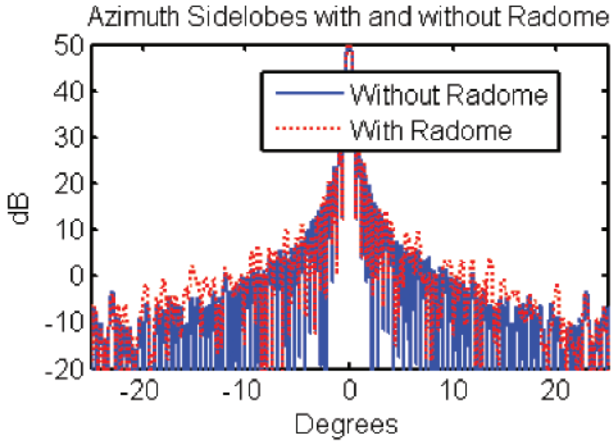

Figure 4 Azimuth sidelobes of 30 ft radome at C Band.

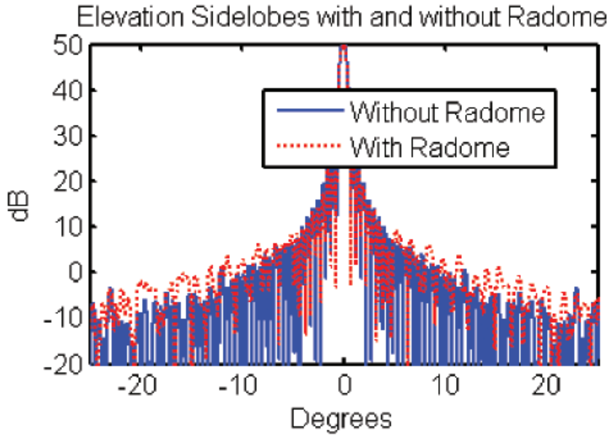

Figure 5 Elevation sidelobes of 30 ft radome at C band.

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LARA can also be used to calculate other far field parameters impacted by the radome including axial ratio. Figure 6 shows a non-spherical radome configuration. Because the radome is non-spherical, some axial ratio degradation will occur in circularly polarized antenna systems. Figure 7 shows computed axial ratio degradation when the radome is optimized for X band.

Figure 6 Non-spherical 8.3 ft radome model used to calculate axial ratio degradation.

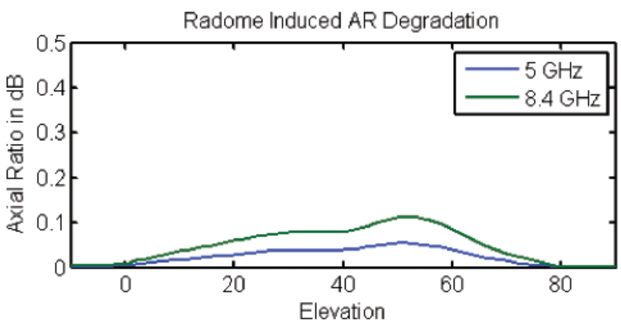

Figure 7 Radome induced axial ratio degradation of radome shown in Figure 6.

Finite Difference Time Domain Analysis (FDTD)

MFG Galileo uses the FDTD technique to analyze the Induced Field Ratio (IFR) of seam construction. In addition to CRD which computes seam impact, FDTD is a proven method for analyzing radome strut/seam IFR. Figure 3 shows the e-field of a plane wave impacted by a radome joint.

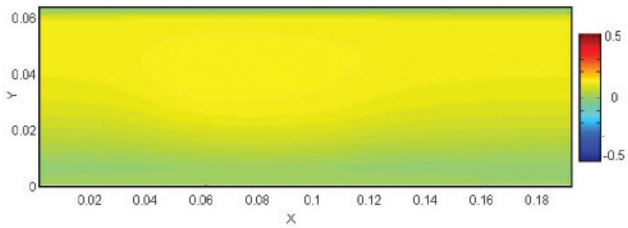

Figure 8 FDTD analysis showing electric field amplitude shift and phase delay caused by radome seam.

Impedance matching is a technique commonly used to reduce reflections between microwave components. In the vernacular of the radome community, impedance matching has come to mean using metal strips to reduce the IFR of dielectric space frames. Rather than using narrow band metal strips, MFG Galileo uses broadband impedance matching techniques using dielectric materials to reduce seam IFR.

Noise Temperature and G/T Analysis

MFG Galileo considers reflective, ohmic, and scattering losses to determine the radomes noise temperature. Calculations use Temp = 290 C, which is the standard value utilized for noise temperature calculations.

G/T is the ratio of the antenna gain divided by the antenna noise temperature. The radome will increase the system temperature while reducing system gain. Parameters used to calculate G/T impact include:

Parameters Supplied by Antenna Vendor

- Sky Temperature at Frequency of Interest
- Antenna Parameters
    - Feed Loss
    - LNA Noise Figure
- Ambient Temperature
- Radome Temperature

Parameters Supplied by MFG Galileo

- Radome
    - Absorption Loss
    - Reflection Loss
    - Scattering Loss

Using these parameters, MFG Galileo provides our customers with accurate estimates of radome impact to G/T.

Measurement Capabilities

All radomes produced by MFG Galileo are custom designed for each application. To ensure accurate design parameters, we do extensive testing of materials electrical parameters including dielectric constant and loss tangent. We have in house test equipment to accurately characterize dielectric properties. In house test results have also been verified by outside test labs to validate in house results.

Using the dielectric properties, of skin and core materials, each MFG Galileo radome is optimized for the frequency of operation. At the customer's request, we build a flat panel test coupon using the same construction as the final radome. This flat panel is then tested for transmission loss in a free space test range. Measured results and analytical results are then compared and provided to the customer.