Radar Cross Section (RCS) Measurement and Simulation of Generic Simple Shapes

RCS targets including the NASA almond, ogive, double-ogive, cone-sphere and cone-sphere with gap were constructed and the RCS was simulated. Simulation data is compared to measured data in open literature.

Introduction

Woo et. al. published measured and simulated results for a range of simple RCS benchmark targets in 1993, [1]:

- The NASA almond
- Simple ogive
- Double ogive
- Cone-sphere
- Cone-sphere with a gap between cone and sphere

These targets are defined mathematically to ensure that the correct shape is simulated during RCS benchmarking. These targets were simulated in CADFEKO to achieve two goals:

- To show that CADFEKO can generate simple and complex mathematical shapes (such as the NASA almond)
- To benchmark FEKO's RCS abilities against accurately measured data

All five targets that were presented in [1] are simulated and the FEKO results are compared with the measured results. In all cases the FEKO result closely matches the measured result.

A Note on Model Construction

For all of the models that will be described, the following steps are taken in addition to the geometry construction:

- All internal faces of the shape is deleted
- All face normals were set to point outward
- All faces were set to be solved using combined field integral equation (CFIE)
- All models were solved using multilevel fast multipole methods (MLFMM)

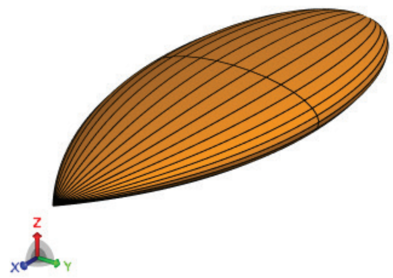
The CFIE setting helps the MLFMM to obtain convergence more quickly, which results in a reduction in runtime.

NASA Almond

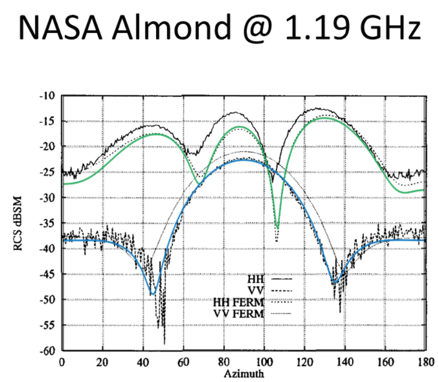
Constructing the model

The NASA almond is not a simple body-of-revolution (BOR) shape as it is essentially flattened in the z-axis. The mathematical definition of the curves were used to define curves analytically in CADFEKO that represent the curves of the model. The shape is formed by lofting two adjacent lines to form surfaces; this is repeated for all of the defined curves until a quadrant of the almond has been formed. The faces are stitched together to account for any mathematical inaccuracies and to ensure a closed surface. The resulting shape is then mirrored to form a half-almond and the surfaces stitched together. The half-almond is then mirrored again to form the complete model. In this way a precisely defined shape can be created in CADFEKO to almost arbitrary levels of accuracy.

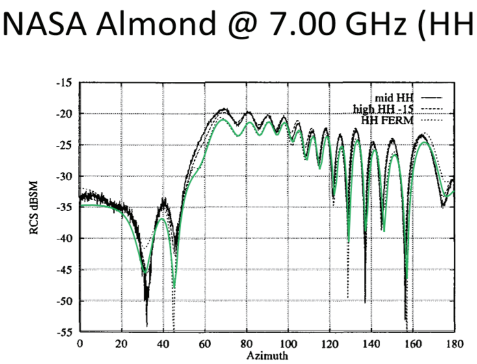
Results



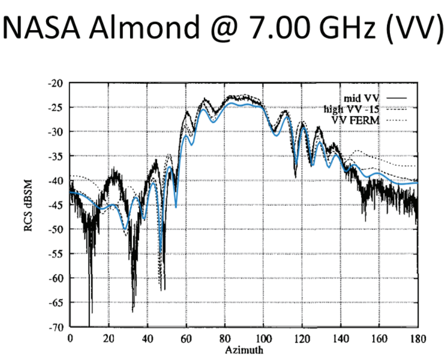
(a) Geometry



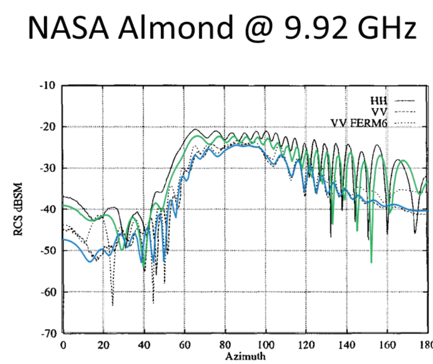
(b) 1.19 GHz (both polarizations)



(b) 7 GHz (HH polarizations)



(d) 7 GHz (VV-polarization)



(e) 9.92 GHz (both polarizations)

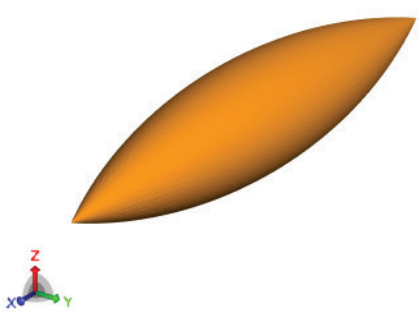
Figure 1: NASA Almond RCS Comparisons with [1]

Simple Ogive

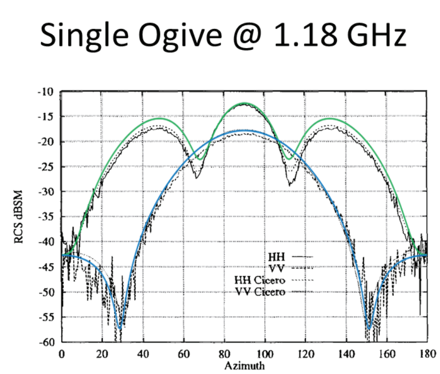
Constructing the model

The simple ogive was constructed using a single analytic curve in CADFEKO that was rotated to form the surface. This can be done since the ogive is a BOR shape.

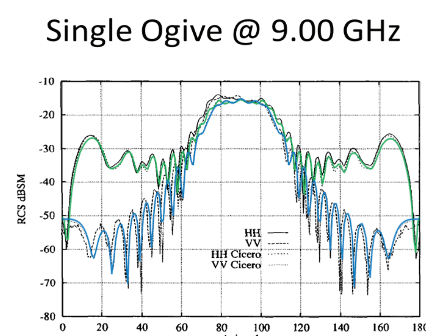
Results



(a) Geometry



(b) 1.18 GHz (both polarizations)



(c) 9 GHz (both polarizations)

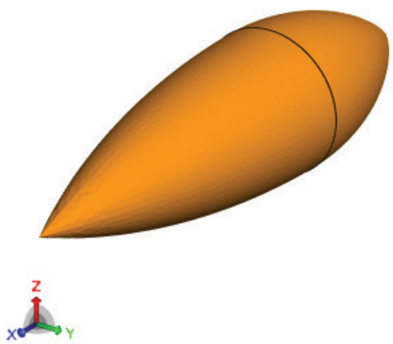
Figure 2: Metallic Ogive RCS Comparisons with [1]

Double-Ogive

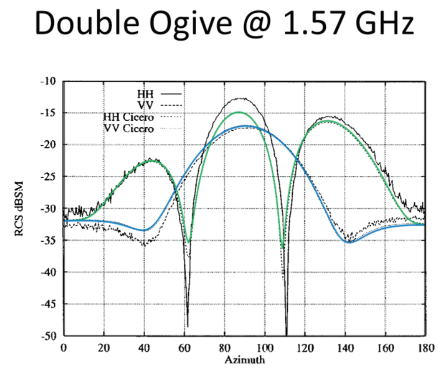
Constructing the model

The double ogive was constructed in the same way as the simple ogive. The only exception is that two analytic curves were required to describe the front and rear points of the shape.

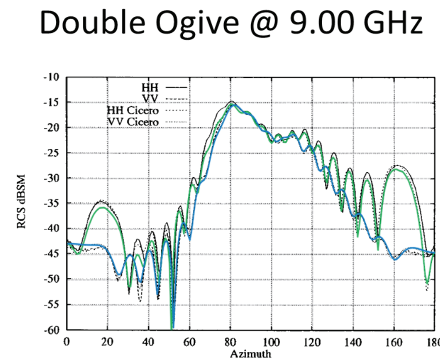
Results



(a) Geometry



(b) 1.57 GHz (both polarizations)



(c) 9 GHz (both polarizations)

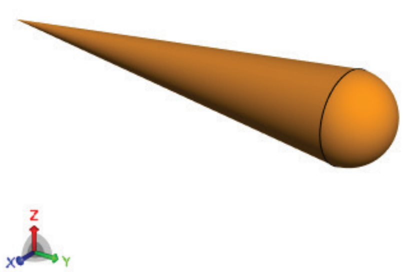
Figure 3: Metallic Double Ogive RCS Comparisons with [1]

Cone-Sphere

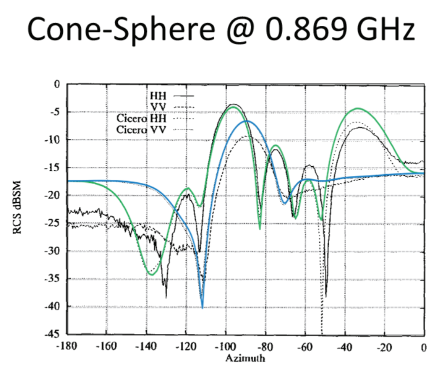
Constructing the model

The cone-sphere was created by using the sphere and cone primitives in CADFEKO.

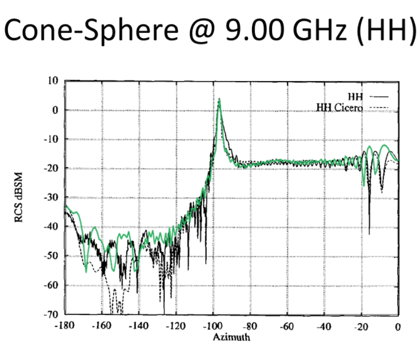
Results



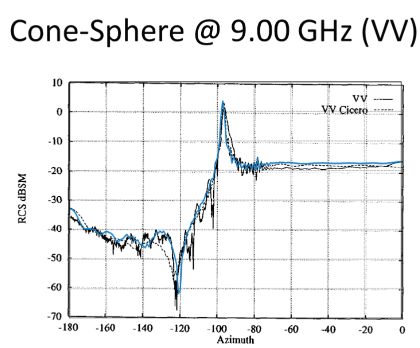
(a) Geometry



(b) 869 MHz (both polarizations)



(c) 9 GHz (HH-polarization)



(d) 9 GHz (VV-polarization)

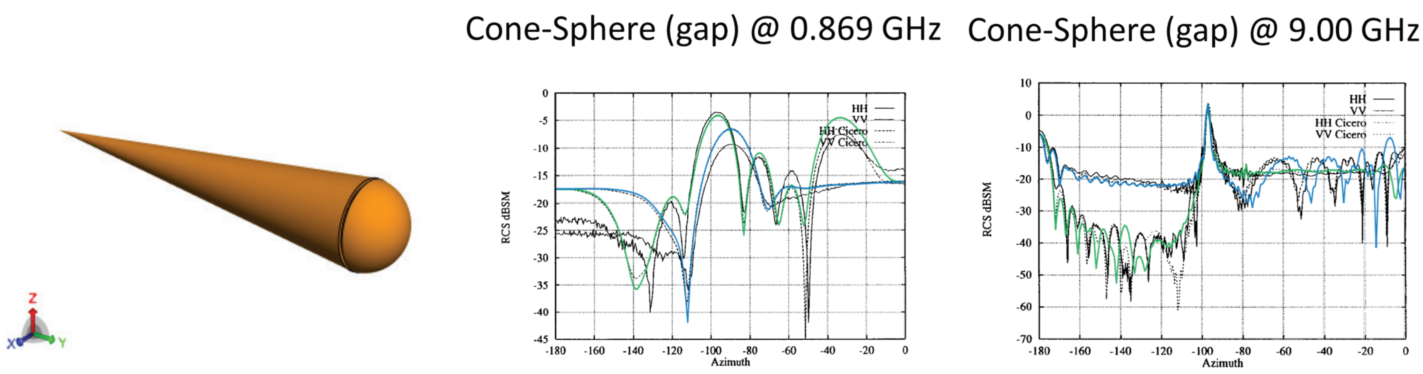
Figure 4: Cone-Sphere RCS Comparisons with [1]

Cone-Sphere with Gap

Constructing the model

The gap that is inserted between the conical and spherical components of the shape is represented by a cylinder.

Results



(a) Geometry (b) 869 MHz (both polarizations) (c) 9 GHz (both polarizations)

Figure 5: Metallic Cone-Sphere with Gap RCS Comparisons with [1]

References

[1] A. C. Woo, H. T. G. Wang, and M. J. Schuh, „Benchmark Radar Targets for the Validation of Computational Electromagnetics Programs," IEEE Antennas and Propagation Magazine, vol. 35, no. 1, February 1993, pp. 84 - 89.