

Radar Cross Section (RCS) Benchmark on Simple Shapes

Introduction

This document presents simulation results from CAPITOLE-RCS on simple shapes. The monostatic RCS is calculated and compared to measured data publish in the following article : A.C. Woo, H.T.G. Wang, M.J. Schuh and M.L. Sanders « Benchmark Radar Targets for the Validation of Computational Electromagnetics Programs » IEEE Antennas and Propagation Magazine, Vol. 35, No. 1, February 1993. These models are intended for validation and benchmarking of Electromagnetic Simulation softwares. All simulations with CAPITOLE-RCS software was made on a Windows 10 laptop with Intel core i7 CPU and 16 Gb of RAM memory

1. NASA Metallic Almond

- **Model :**
The NASA almond is actually not a simple shape. It is defined by mathematical equations to form a surface with almond shape. This model is very interesting to study RCS because it highlights a large dynamic on RCS value. The mesh should be refined on the tip and the bottom to keep a good accuracy on the results.
The total length is 0.25 m (9.936 inches)
- **Simulation parameters :**
The Monostatic RCS is computed at 3 frequencies : 1.19, 7 and 9.92 GHz
For both Vertical and Horizontal polarization
The RCS is plotted in dBm² as function of azimuth angle from 0 to 180°. Zero degrees azimuth corresponds to incidence on the tip. The elevation angle is zero.
- **Solver :**
Method of Moment method was used with MSCBD solver and EFIE equations.

	1.19 GHz	7 GHz	9.92 GHz
Mesh size	Lambda/40	Lambda/15	Lambda/15
Number of unknowns	3 546	17 262	34 692
Total time	2 seconds	17 seconds	57 seconds

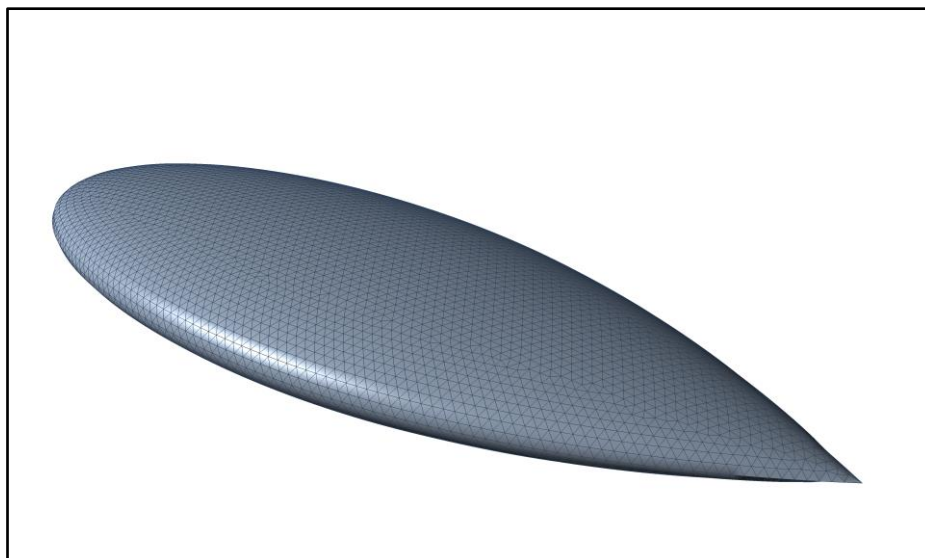


Figure 1 - NASA Almond mesh model

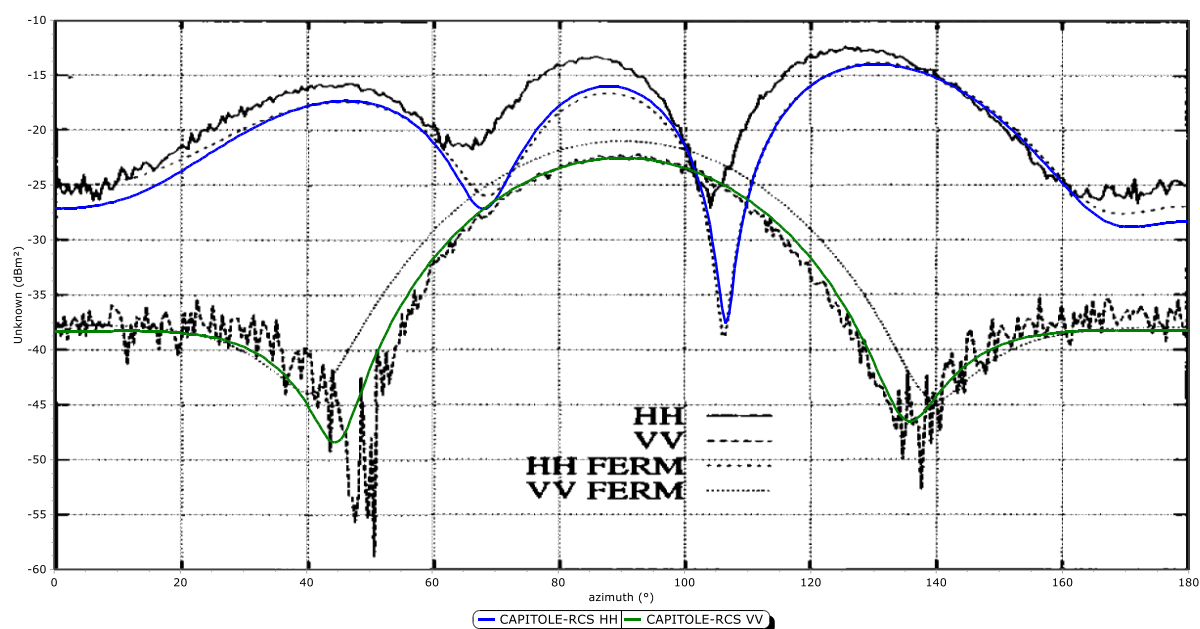


Figure 2 NASA Almond RCS @1.19GHz CAPITOLE-RCS vs measurement

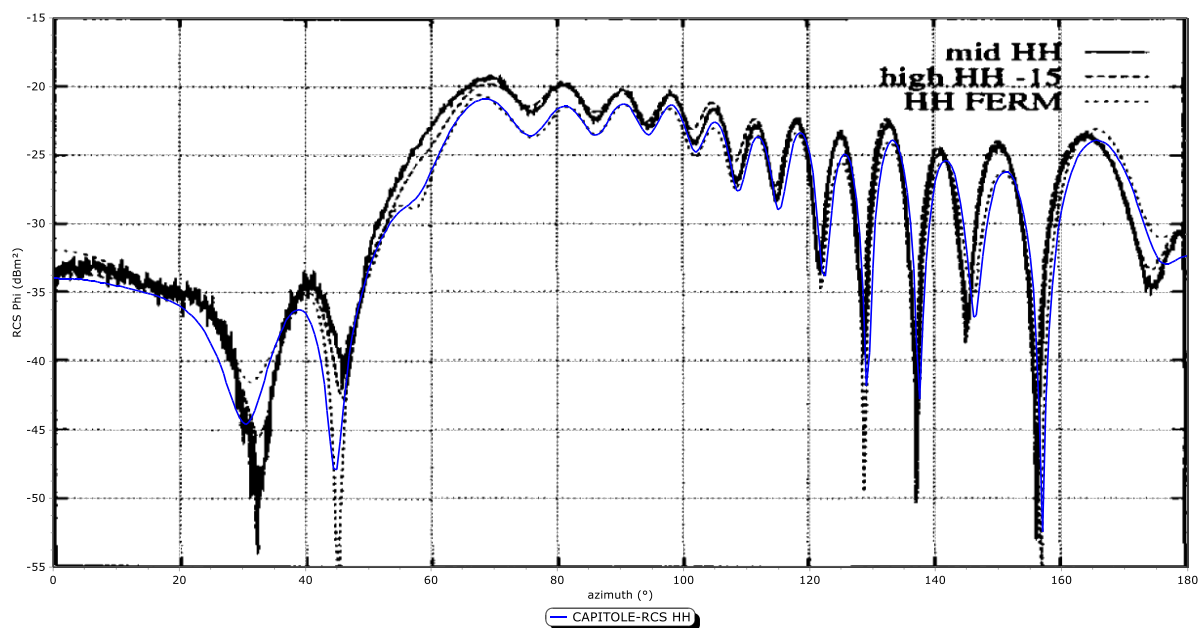


Figure 3 - NASA Almond RCS HH polarization @ 7GHz CAPITOLE-RCS vs measurement

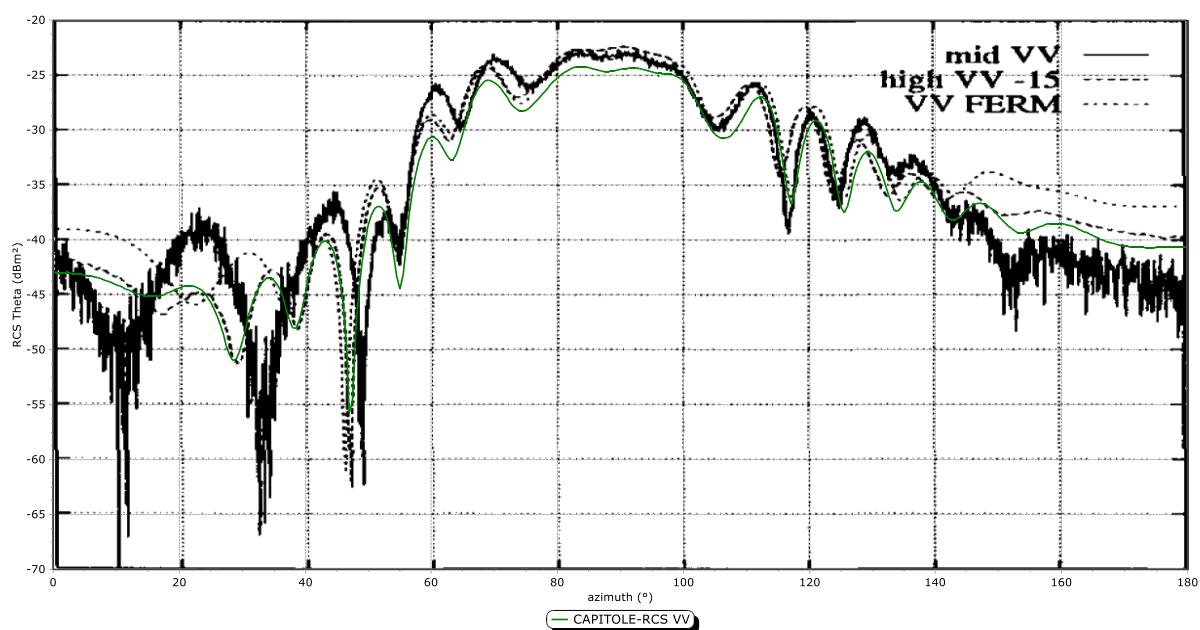


Figure 4 - NASA Almond RCS VV polarization @ 7GHz CAPITOLE-RCS vs measurement

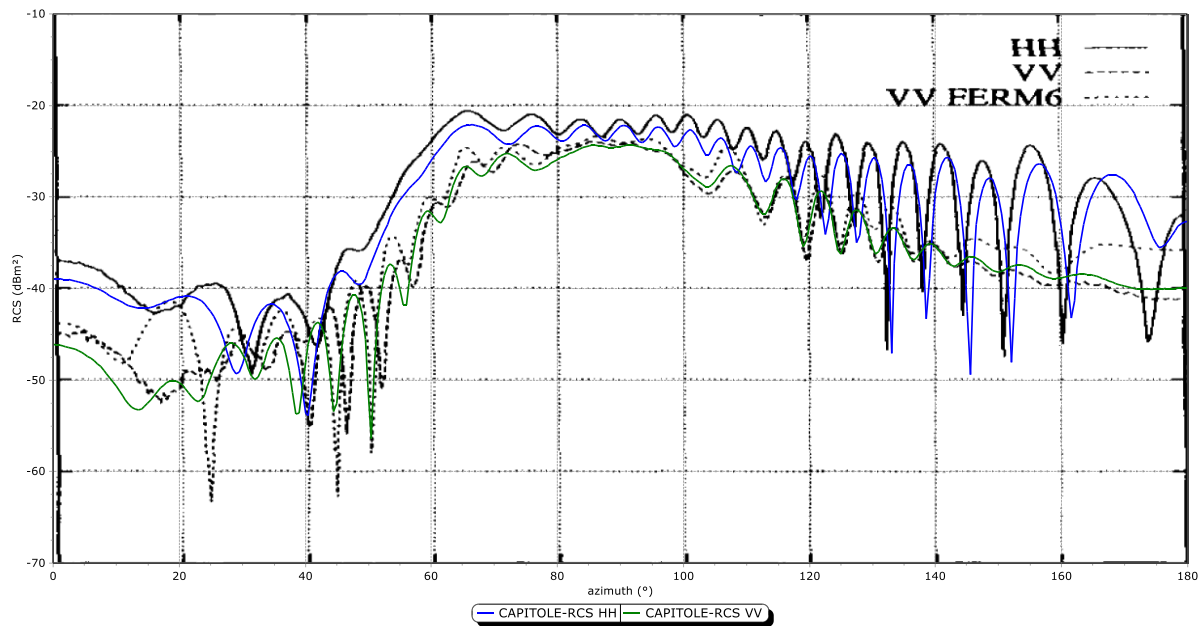


Figure 5 - NASA Almond RCS @9.92GHz CAPITOLE-RCS vs measurement

2. Metallic Simple Ogive

- Model :**
 The model was created from the analytic expression to create a curve and revolved to create a surface.
 The total length is 0.254 m (10 inches)
- Simulation parameters :**
 The Monostatic RCS is computed at 2 frequencies : 1.18 and 9 GHz
 For both Vertical and Horizontal polarization
 The RCS is plotted in dBm^2 as function of azimuth angle from 0 to 180°. Zero degrees azimuth corresponds to incidence on the tip. The elevation angle is zero.
- Solver :**
 Method of Moment method was used with MSCBD solver and EFIE equations.

	1.18 GHz	9 GHz
Mesh size	Lambda/50	Lambda/20
Number of unknowns	3 648	34 968
Total time	1 second	1 min 12 s

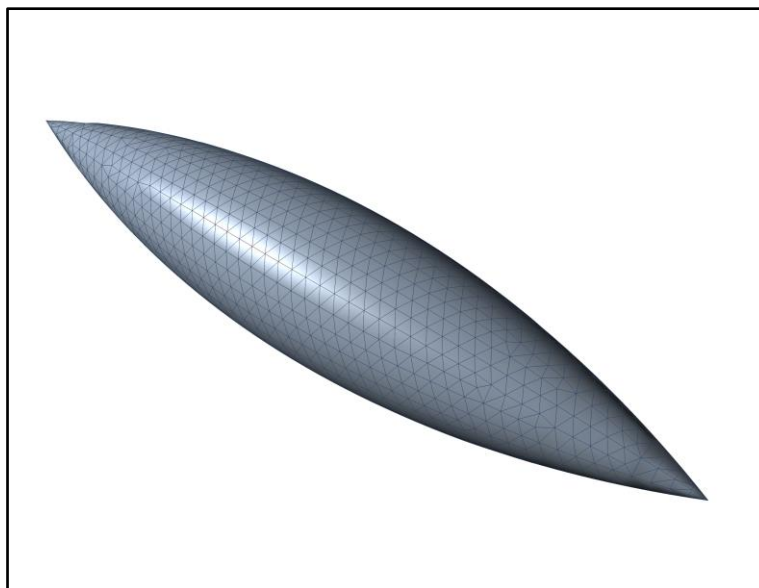


Figure 6 - Metallic Simple Ogive mesh model

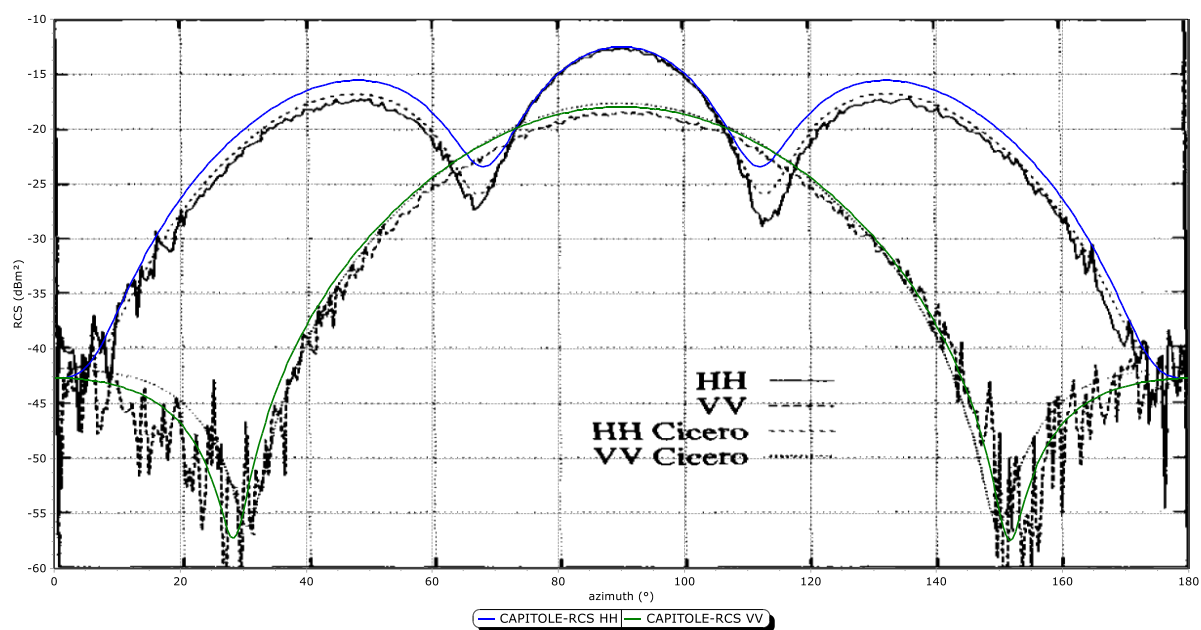


Figure 7 - Metallic Simple Ogive RCS @1.18GHz CAPITOLE-RCS vs measurement

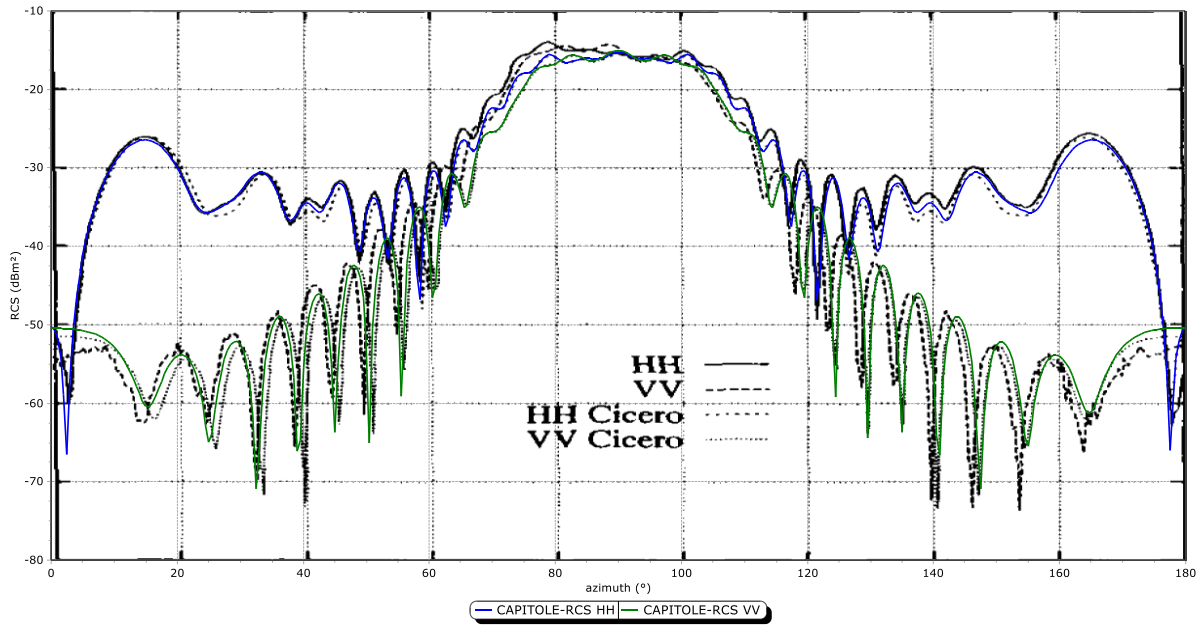


Figure 8 - Metallic Simple Ogive RCS @9GHz CAPITOLE-RCS vs measurement

3. Metallic Double Ogive

- **Model :**
The model was created from the analytic expression to create a curve and revolved to create a surface.
The total length is 0.191 m (7.5 inches)
- **Simulation parameters :**
The Monostatic RCS is computed at 2 frequencies : 1.57 and 9 GHz
For both Vertical and Horizontal polarization
The RCS is plotted in dBm^2 as function of azimuth angle from 0 to 180° . The elevation angle is zero.
- **Solver :**
Method of Moment method was used with MSCBD solver and EFIE equations.

	1.57 GHz	9 GHz
Mesh size	Lambda/40	Lambda/15
Number of unknowns	3 288	15 096
Total time	1 second	13 seconds

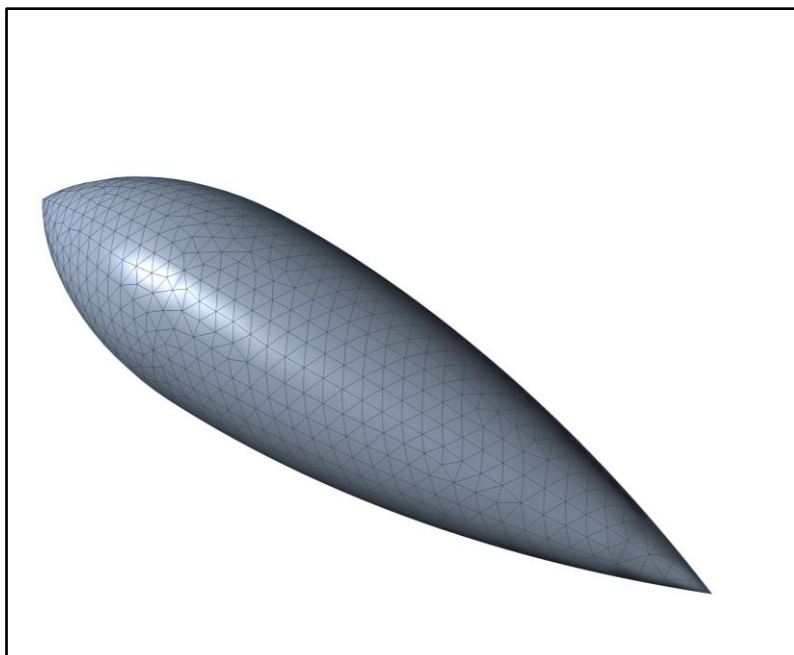


Figure 9 - Metallic Double Ogive mesh model

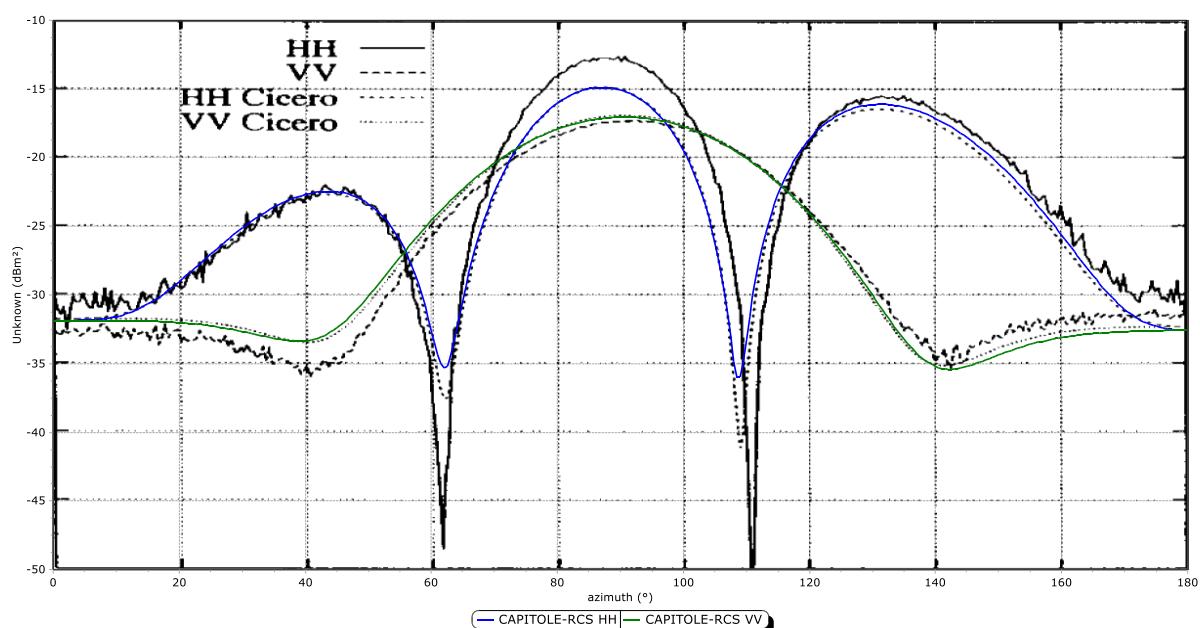


Figure 10 - Metallic Double Ogive RCS @1.57GHz CAPITOLE-RCS vs measurement

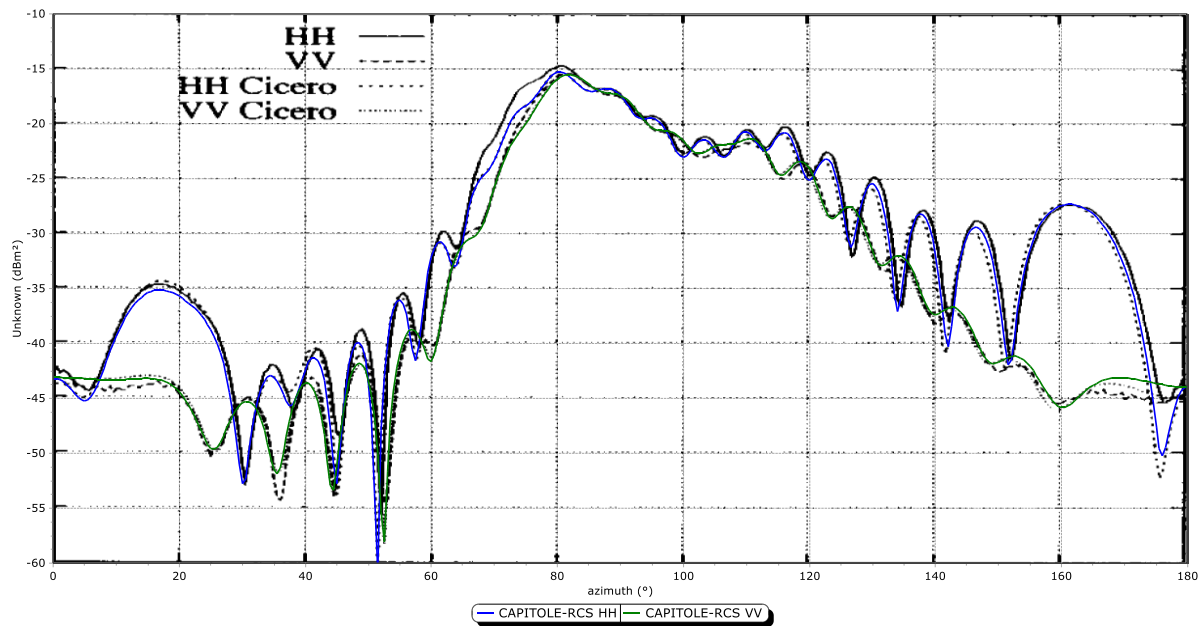


Figure 11 - Metallic Double Ogive RCS @9GHz CAPITOLE-RCS vs measurement

4. Metallic Cone-Sphere

- Model :**
 The model was created from the analytic expression to create a curve and revolved to create a surface.
 The total length is 0.689 m (27.127 inches)
- Simulation parameters :**
 The Monostatic RCS is computed at 2 frequencies : 869 MHz and 9 GHz
 For both Vertical and Horizontal polarization
 The RCS is plotted in dBm^2 as function of azimuth angle from -180 to 0°. -180 degrees azimuth corresponds to incidence on the tip. The elevation angle is zero.
- Solver :**
 Method of Moment method was used and EFIE equations.
 MSCBD solver for 869 MHz case and MLACA for 9 GHz case.
 The MLACA solver is more accurate for low level RCS, particularly for 9 GHz conesphere in HH polarization.

	869 MHz	9 GHz
Mesh size	Lambda/40	Lambda/20
Number of unknowns	8 664	227 793
Total time	12 seconds	3h 11min *on a 48 cores server

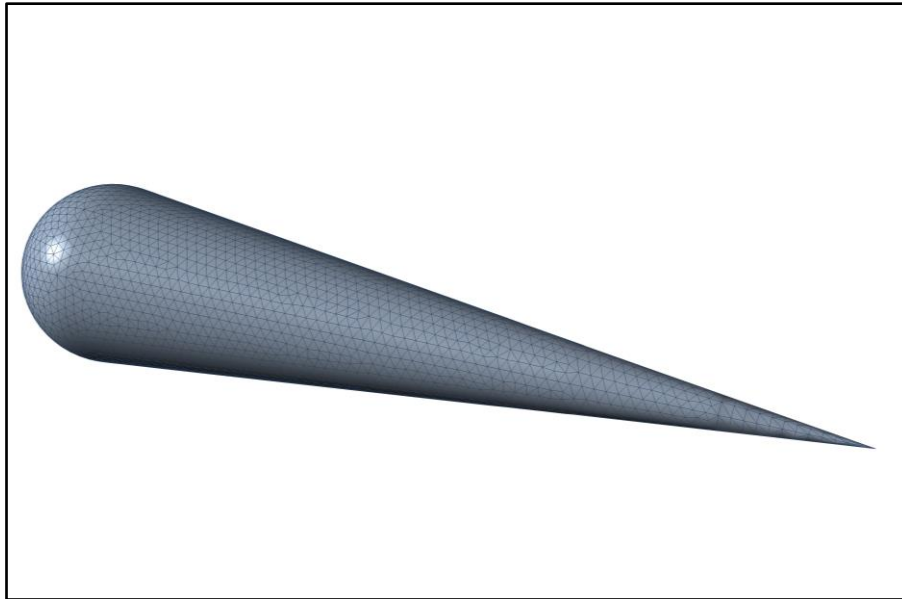


Figure 12 - Cone-Sphere mesh model

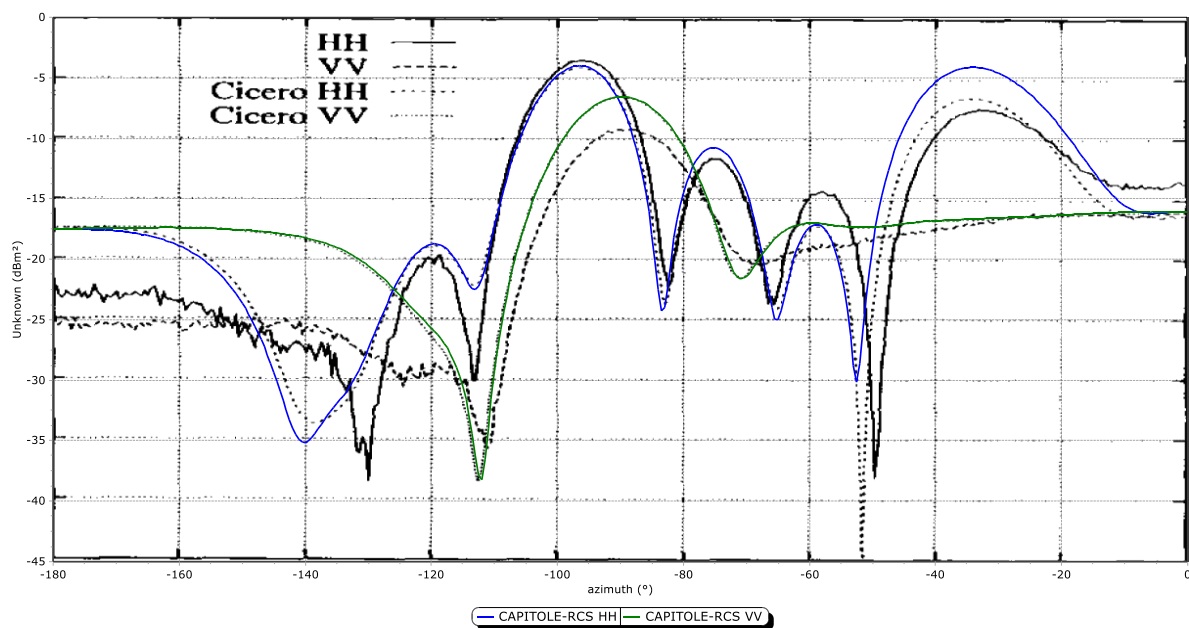


Figure 13 - Metallic Cone-Sphere RCS @869MHz CAPITOLE-RCS vs measurement

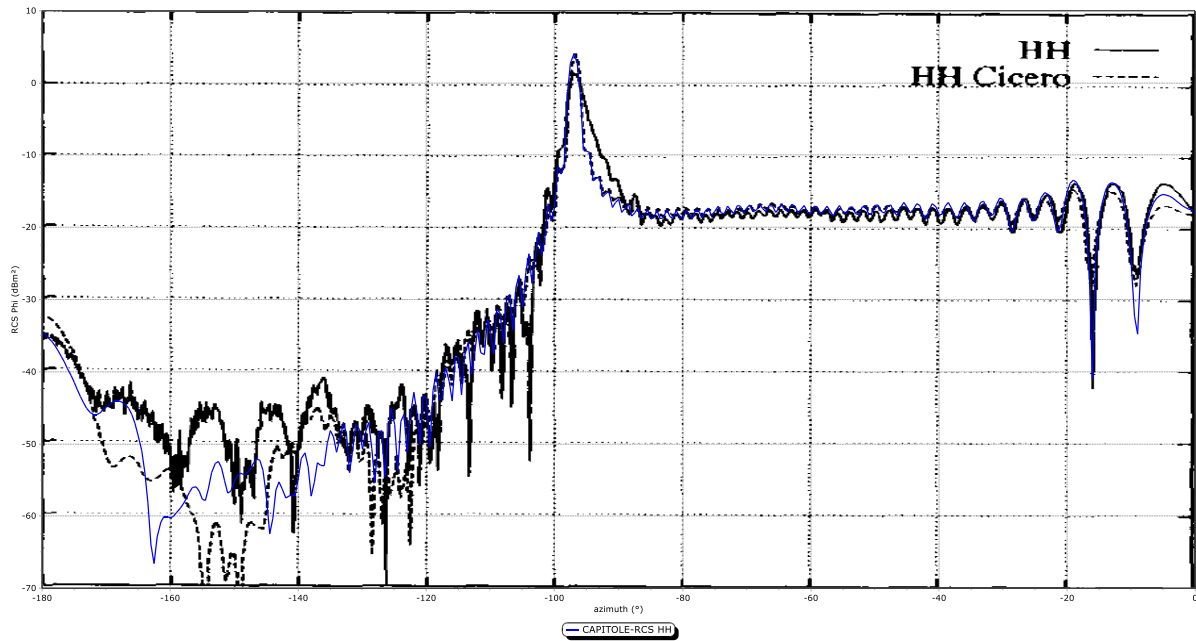


Figure 14 - Metallic Cone-Sphere RCS HH @9GHz CAPITOLE-RCS vs measurement

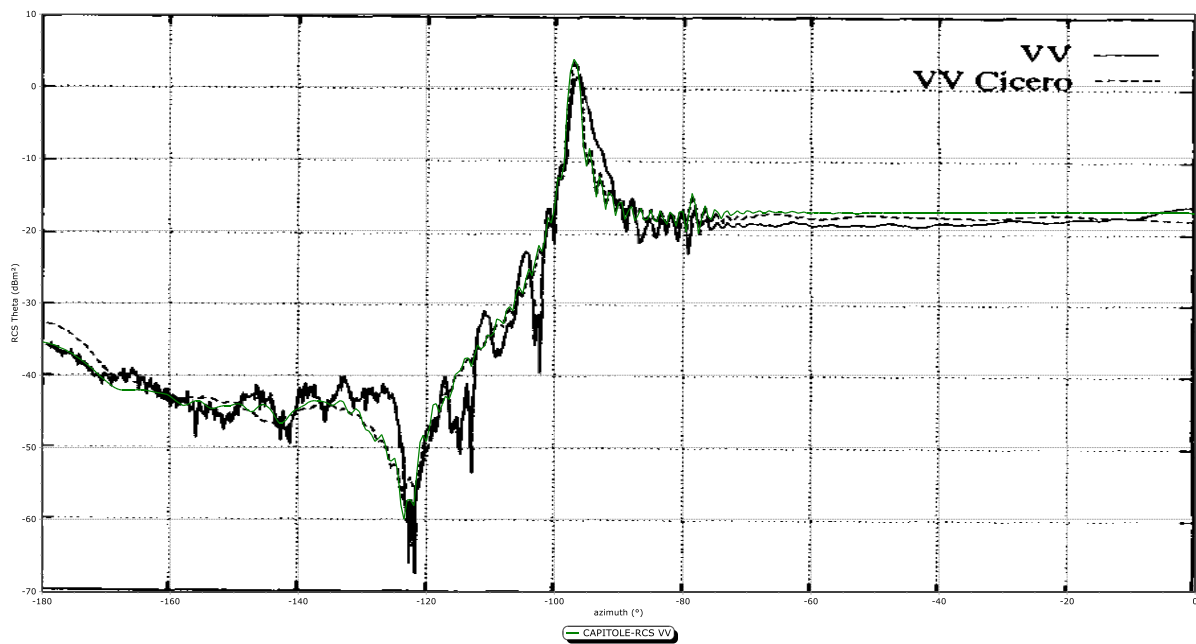


Figure 15 - Metallic Cone-Sphere RCS VV @9GHz CAPITOLE-RCS vs measurement

5. Metallic Cone-Sphere with Gap

- Model :
The model was created from the analytic expression to create a curve and revolved to create a surface.
The total length is 0.689 m (27.127 inches)
- Simulation parameters :
The Monostatic RCS is computed at 2 frequencies : 869 MHz and 9 GHz
For both Vertical and Horizontal polarization
The RCS is plotted in dBm² as function of azimuth angle from -180 to 0°. -180° degrees azimuth corresponds to incidence on the tip. The elevation angle is zero.
- Solver :
Method of Moment method was used with MSCBD solver and EFIE equations.

	869 MHz	9 GHz
Mesh size	Lambda/40	Lambda/15
Number of unknowns	8 952	131 508
Total time	13 seconds	7 min 26 s

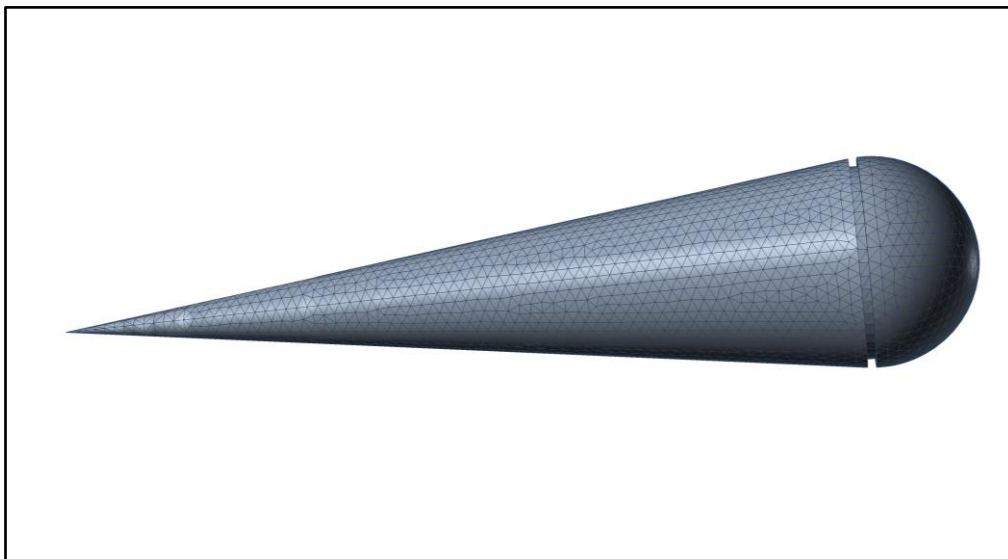


Figure 16 - Cone-Sphere with gap mesh model

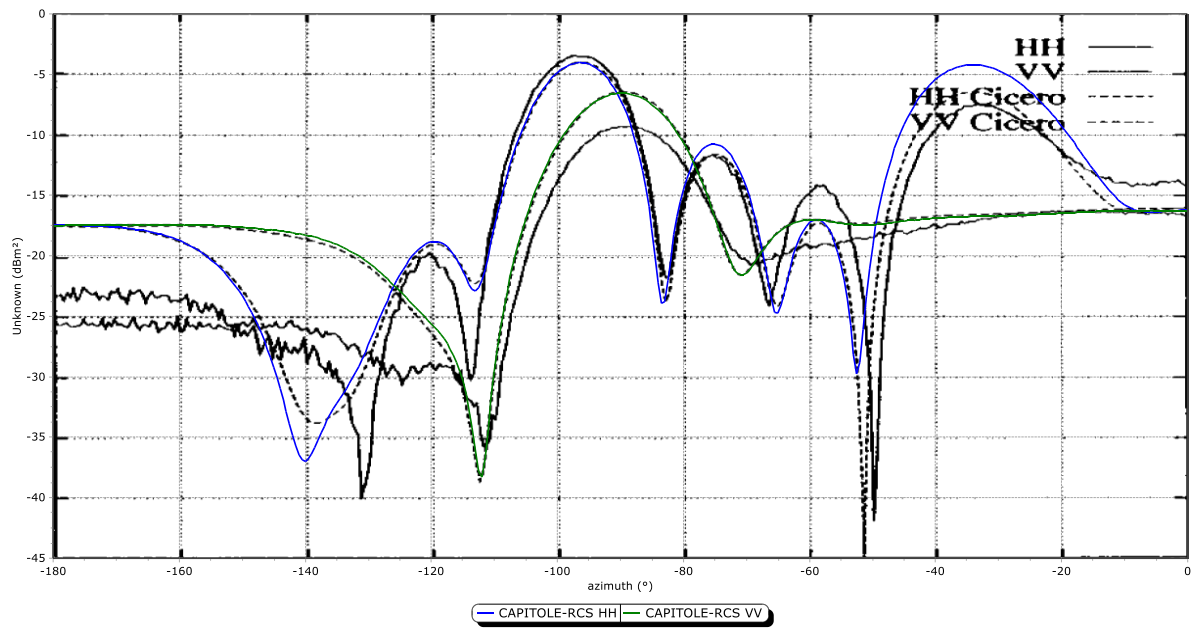


Figure 17 - Metallic Cone-Sphere with gap RCS @869MHz CAPITOLE-RCS vs measurement

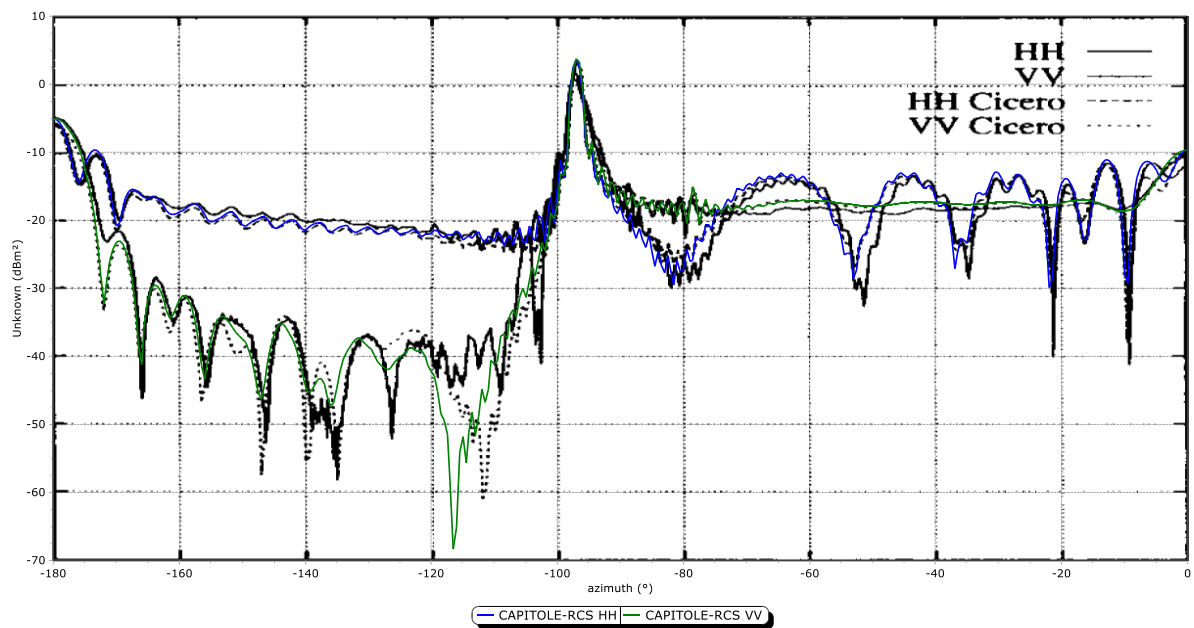


Figure 18 - Metallic Cone-Sphere with gap RCS @9GHz CAPITOLE-RCS vs measurement