# RCS Estimation of Generic Airplane Scale Model

This paper presents modeling and simulation results of monostatic RCS for scaled model of generic airplane in WIPL-D software. We present simulation times, memory requirements and hardware used for two types of solvers: CPU and GPU. The result validates results shown in [1].

## Modeling and Simulation

The airplane is modeled from the sketch in WIPL-D Pro CAD which provides simple and fast solid modeling of complex geometries using built-in primitives, Boolean operations and other features. Rather simple geometry of this model enables easy creation by using built-in basic shapes and operations by using the advantages of local coordinate system and its easy adjustment. Due to symmetry of the structure, we have modeled only half of the plane. The airplane model is shown in Figure 1 (the image of the model is taken from WIPL-D Pro CAD before the mesh phase).

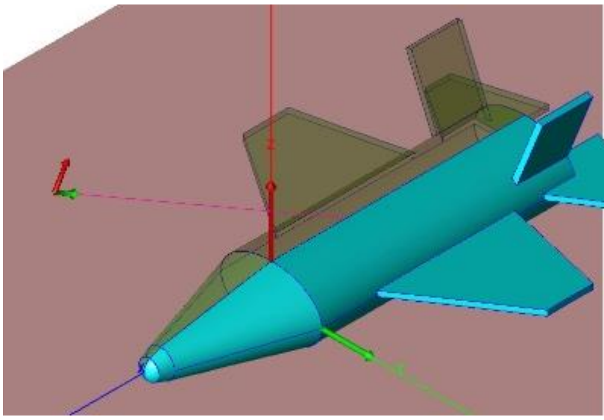

**Figure 1. CAD model of the airplane.**

Length of the model is 310 mm. The model is meshed in WIPL-D Pro CAD by using automatic mesher which allows mesh size of two wavelengths. The mesh consists of bilinear surfaces or shorter quadrilaterals, where usage of built in WIPL-D HOBFs allows maximum quad size of 2 wavelengths for each side. The simulation was performed in WIPL-D Pro at frequency of 30 GHz. The final mesh is presented in Figure 2.

The results in horizontal and vertical planes are obtained. The polarization of the incident wave, also presented in Figure 1, is parallel to the vertical plane and the wave is set to 30 degrees shifted from the horizontal plane. Two different types of simulation are conducted. In order to obtain results in vertical plane, due to the symmetry of the excitation, we have simulated half of the structure using one symmetry plane. In case of a horizontal plane the excitation is asymmetric and can be presented as a sum of symmetric and anti-symmetric excitation. So, two simulations, one for symmetric and the other for anti-symmetric excitation are conducted. According to this, time needed for calculating results in horizontal plane is two times larger than the time needed for getting results in vertical plane. Simulations for both planes decreases number of unknowns two times than in case when the whole model is simulated (when we don't use symmetry of the problem).

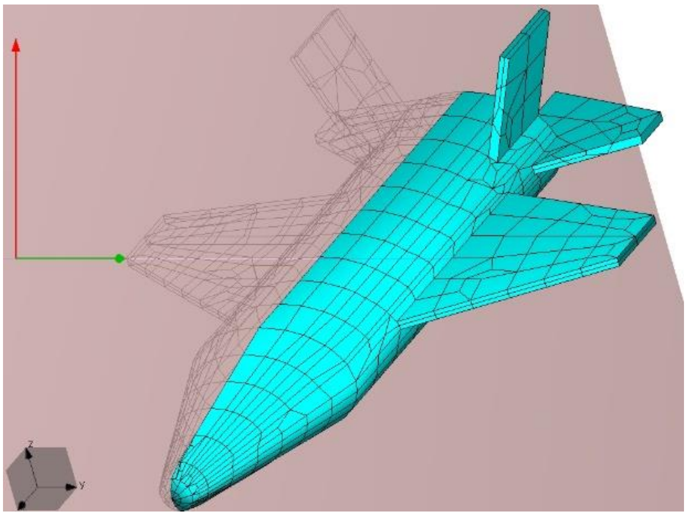

**Figure 2. Final mesh used for simulation.**

The model is simulated using both CPU and GPU solvers. CPU solution has been prominent feature of WIPL-D software for many years, but last several years the GPU technology has been flagship product for large scale examples. This problem can be treated as an example of small to moderate size. Thus, we present simulation times for both GPU and CPU simulation. Simulation conditions are presented in Table 1.

**Table 1. Simulation details**

| parameter | Description |
|---|---|
| CPU specification | Intel® Core™ i7-7700 CPU @ 3.60 GHz (4 physical cores) |
| GPU specification | 1x Nvidia GeForce GTX 1080 |
| Modeling and simulation tool | WIPL-D Pro CAD with WIPL-D Pro |
| Simulation method | MoM (HoBF) |
| Frequency | 30 GHz |

The PC used for simulation is a regular configuration, rather than an expensive workstation. Effective usage of symmetry and higher order basis functions yields a total memory requirement of only around 2 GB (Table 2). The hardware configuration only differs from regular configurations since it is equipped with inexpensive CUDA enabled GPU, with medium performances and price in the market of GPU graphic adapters.

Simulation times, number of unknowns and memory requirement are presented in Table 2. In order to obtain completely smooth curves we have estimated minimum number of directions at 1441. The overall shape of curve can be obtained when results are calculated for only 541 directions. They are also of satisfying quality, so simulation times in this case are as well listed in Table 2. Number of directions used is essential data for monostatic calculation. Figure 5 indicates that a completely smooth result is obtained for 1441 directions, which was tested by comparing results where larger number of directions was used. The results with larger number of directions can be obtained by built-in interpolation of both RCS or current coefficients. But tremendously small simulation times allow that merely running the simulation is far easier.

**Table 2. Simulation times**

| Number of directions | Solver | Simulation time [sec] | Memory in GB and number of unknowns |
|---|---|---|---|
| 541 | CPU | 93 | 2.24 GB and 17,227 unknowns |
| | GPU | 52 | |
| 1441 | CPU | 145 | |
| | GPU | 85 | |

Because of the different simulation conditions for horizontal and vertical plane, the time needed for simulation in vertical plane is presented in Table 2. As mentioned above, the time needed for simulation in horizontal plane is two times larger.

## Results

Monostatic RCS (1441 directions) is presented in Figs 3 and 4, for horizontal and vertical planes respectively.

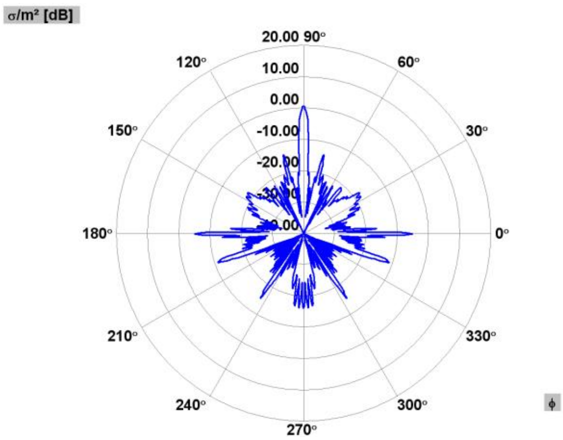


**Figure 3. Monostatic RCS - horizontal plane.**

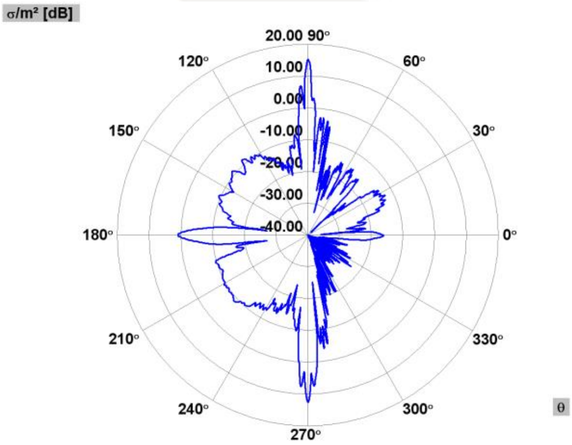


**Figure 4. Monostatic RCS - vertical plane.**

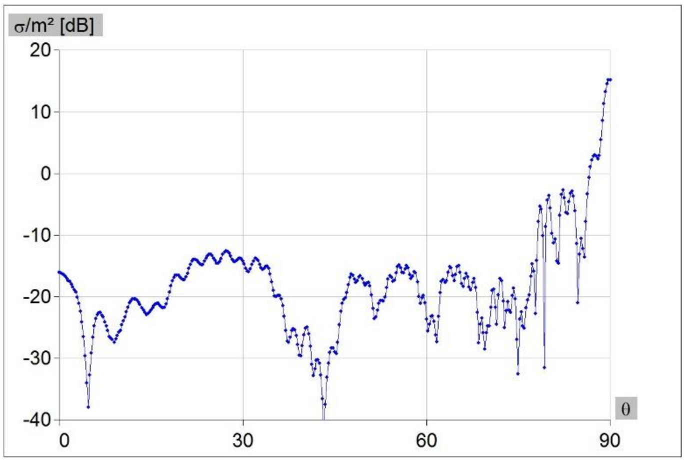


**Figure 5. Monostatic RCS – segment of vertical plane, indicating the curve is smooth.**

## Reference

[1] https://www.rev-jec.org/index.php/rev-jec/article/download/93/86