T-72 RCS on Amazon Cloud Server

In this paper, bistatic and monostatic RCS simulations of complex and electrically very large structures are presented.

WIPL-D Pro CAD enables import of extremely complex geometries from all commonly used CAD, validation of models, and easy simplification of details obsolete for EM simulation itself. This product also includes in-house developed mesher which performs subdivision of complex geometries into generalized quadrilaterals which serve as input for numerical kernel. The meshing is automated and extremely efficient to allow precise modeling of details, curvatures and small features while the requirements for EM simulation are kept as minimal as possible.

After a proper quad mesh is created, WIPL-D Pro allows EM simulation in most efficient manner available among commercial tools. Quite large mesh elements (quads) of size 2 wavelengths by 2 wavelengths are allowed due to unique Higher Order Basis Functions (HOBFs) for current approximation. Owing to this unique combination, the number of unknown coefficients to be stored in Method of Moments (MoM) matrix is minimal and it can be estimated as 30 unknown coefficients per lambda square for metallic surfaces.

Instead of local desktop or server, Amazon cloud server with the following specifications is used:

- CPU: Intel Xeon E5-2686 v4 @ 2.3 GHz (2 processors). (Total number of cores/threads is 32 cores/64 threads)
- RAM: 488 GB
- HDD: 3 Hard disks, which I\O speed is about 1,000 MB/s
- GPU: 8 x Tesla V100
- OS: Window Server 2016

The software package is successfully installed on the machine, and no problems with its working is noticed during the work

T72 Tank Example

One of the most complex applications of EM codes for RCS are military vehicles, such as tanks, because of their size, complexity and high frequencies used for manufacturing of devices in this field.

Bistatic and monostatic RCS of the tank T-72, at 3.6 GHz, are results of interest in this application note. Length of the tank is 7.4 m. At this frequency, tank is 89 wavelengths electrically long.

Because of pure metallic structure, MoM matrix is symmetric, and the matrix inversion was run accounting that.

Both, bistatic and monostatic RCS simulations are performed.

Bistatic RCS

The problem is solved without applying symmetry as bistatic RCS in 1801 directions in the horizontal plane, as shown in Fig. 1. The model originates from a CAD file and all details were kept during the mesh and simulation. The incident RCS wave arrives backside in the horizontal plane. Vertical polarization is observed.

At operation frequency of 3.6 GHz and without any reduction technique for decreasing number of unknowns for current approximation, it requires 834k number of unknowns for current approximation.

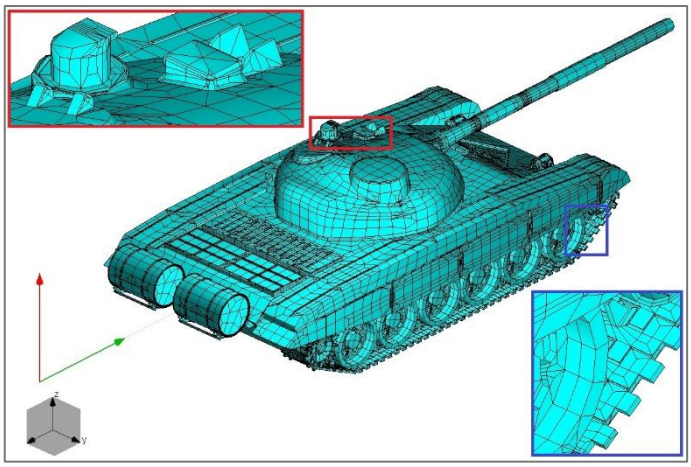

Figure 1. Meshed model of T-72 tank for Bistatic RCS simulation.

Monostatic RCS

As well as in bistatic, we did not apply symmetry neither in monostatic RCS simulation, as shown in Fig. 2.

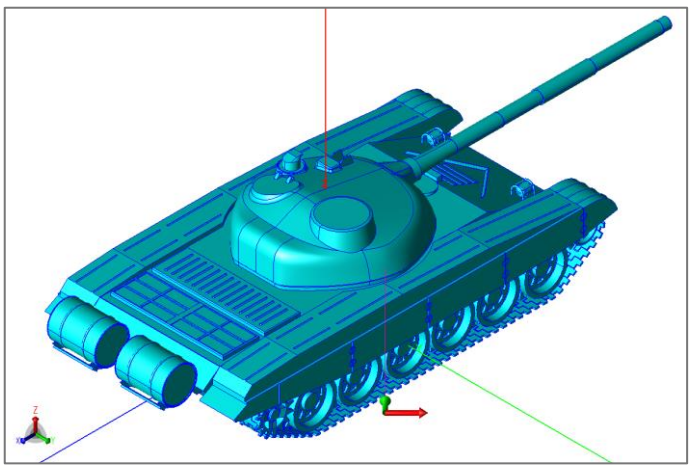

Figure 2. CAD model of T-72 tank Monostatic RCS simulation.

In monostatic mode, RCS is calculated in 70 directions, for 15 degree elevation angle and azimuth angle from 42.75 to 47.25 degrees. Polarization is horizontal.

In case without any of reduction techniques for decreasing number of unknowns for current approximation, this monostatic simulation requires the same amount of unknowns as bistatic simulation.

With applied reduction of reference frequency and "total shadow" reduction of 30%, required number of unknowns is decreased to 507k.

RCS Simulations and Results

Matrix fill-in and calculation of output results are performed on CPU, while matrix inversion is performed on GPU.

Required number of unknowns and simulation times are listed in Table 1. Simulation times are very similar for bistatic and monostatic without reduction simulations. This is expected, as number of unknowns are the same, then matrix inversion times (precisely the LU decomposition times) should be the same for these two models. Furthermore, as number of excitations in monostatic simulation is not very large, difference in time for Forward and Backward substitutions for 70 excitations and only 1 excitation is negligible.

Table 1. Simulations details

Model	No. of unknowns	Total Simulation Time [hours]	Matrix Inversion Time [hours]
Bistatic/Monostatic without Reduction	833,323	20.8	16.38
Monostatic with Reduction	507,000	6.9	4.7

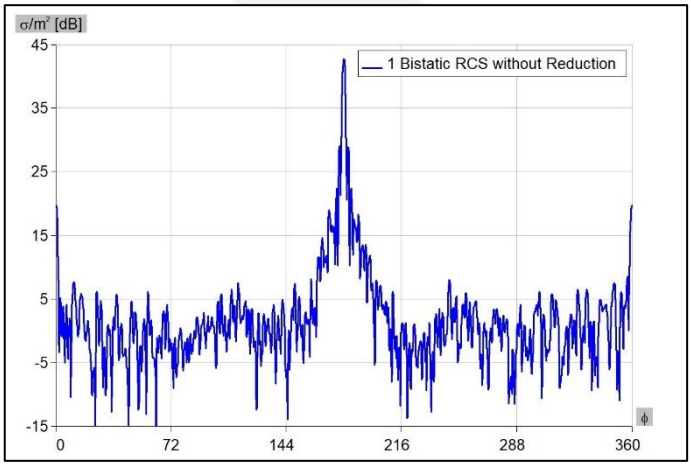

Figure 3. Result for bistatic RCS simulation of T-72 tank.

Result for bistatic RCS without reduction is shown in Fig. 3. There is slight asymmetric in results, but that is expected because the model of tank dome is not symmetric.

Results for monostatic RCS without and with reduction overlaid are shown in Fig. 4. One can see that accuracy of simulation is mostly preserved, but simulation time is significantly decreased.

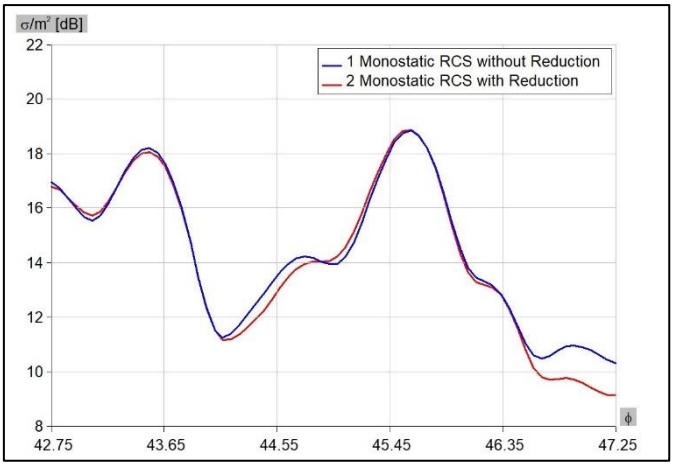

Figure 4. Overlaid monostatic RCS simulation of T-72 tank without and with reduction.