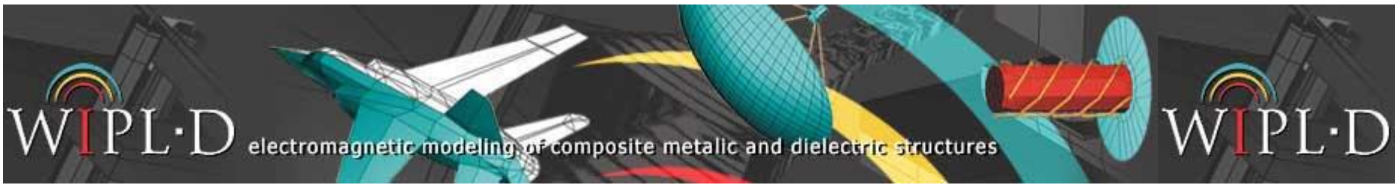

Radar Cross-Section Calculation of Aircraft

Application of higher order basis functions (HOBFs) on a quad mesh is the foundation of WIPL-D Pro EM solver efficiency. As a result, very large structures are simulated on inexpensive computers.

WIPL-D Pro models a large structure with about ten times less unknowns than MoM codes using triangular mesh and Rao-Wilton-Glisson (RWG) basis functions [1]. However, demands for simulation of ever larger structures (e.g. in car, aircraft or ship industries), are going beyond the capabilities of higher order MoM.

Hence, Multilevel Fast Multipole Method (MLFMM) has been applied to the higher order MoM setup to extend these limits. MLFMM is applied to the same models previously treated by MoM, with no changes to the mesh. Maximally orthogonalized HOBFs [2] and system preconditioning enhance the convergence of the iterative solution algorithm, making it applicable to scatterers, antennas, metallic-dielectric structures, etc.

In MoM, interactions between all basis functions in the model are calculated independently. The MLFMM groups basis functions. In case when groups are far-apart in the model, it calculates interactions between groups, rather than between individual basis functions. This way, the MLFMM algorithm provides dramatic memory savings compared to the MoM.

The fighter airplane (Fig 1) is excited with a plane wave, coming in from 30° under the horizon. Fuselage is 12 m long, wing span is about 7 m. The airplane is simulated at 3 GHz (it is 120 λ long) and 4 GHz (it is 160 λ long). The simulation report is given in Table 1. Higher order MoM models requiring 152,601 and 307,118 unknowns are equivalent to around 1.5 million and 3 million RWG unknowns, respectively. By applying the MLFMM, memory requirements are reduced to just 3.2 GB and 7.2 GB respectively. The calculated RCS in the incident plane, at 4 GHz, is shown in Fig 2.

In both cases the simulation was done on a PC with Intel Core(TM) i7 CPU 950 @3.07 GHz, 24 GB RAM.

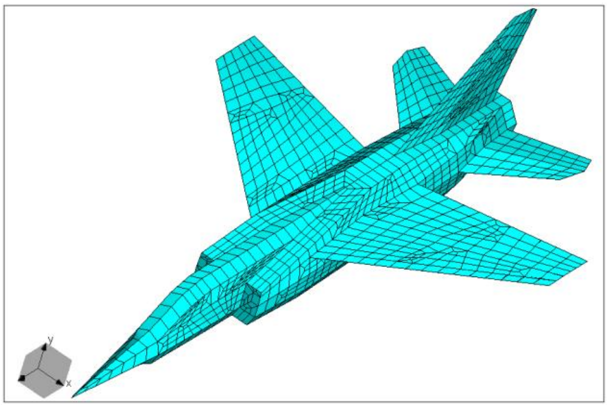

Figure 1. 160 λ long fighter airplane model

Table 1. Simulation reports

Higher Order MoM		MLFMM		
No. of unknowns	RAM [GB]	Iterations	RAM [GB]	Simulation time
152,601	173.5	100	3.2	47 min
307,118	702.8	102	7.2	173 min

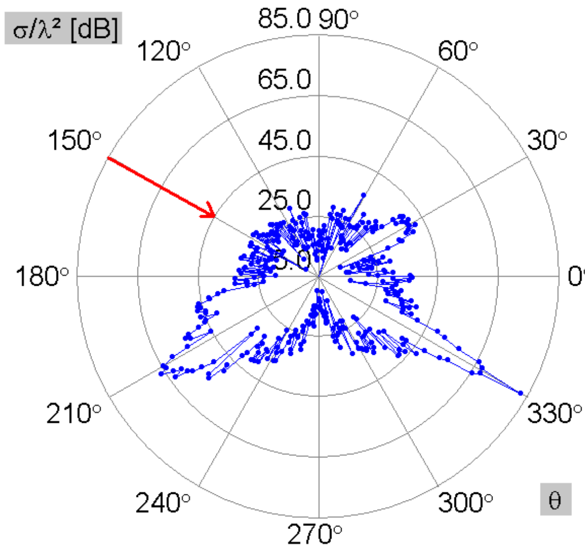

Figure 2. Radiation pattern, incident plane, at 4 GHz

Conclusion

WIPL-D Pro offers several sophisticated techniques for solving challenging radar cross-section computation problems, such as MLFMM. In addition, the out-of-core solver can be used in case when there is not enough RAM to perform simulation, at a cost of slight decrease in simulation speed.

It is often not necessary to turn to asymptotic methods to solve RCS of electrically large aircraft. Using the advanced algorithms of WIPL-D Pro instead, both accurate and reliable results are acquired in reasonable time.

References

[1] B. M. Kolundzija and A. M. Djordjevic, *Electromagnetic modeling of composite metallic and dielectric structures*, Artech House, Norwood, MA, USA, 2002.

[2] D. S. Sumic and B. M. Kolundzija: "Efficient Iterative Solution of Surface Integral Equations Based on Maximally Orthogonalized Higher Order Basis Functions", *Proceedings of the 2005 international IEEE AP-S Symposium*, session #116, paper #5, July 2005.