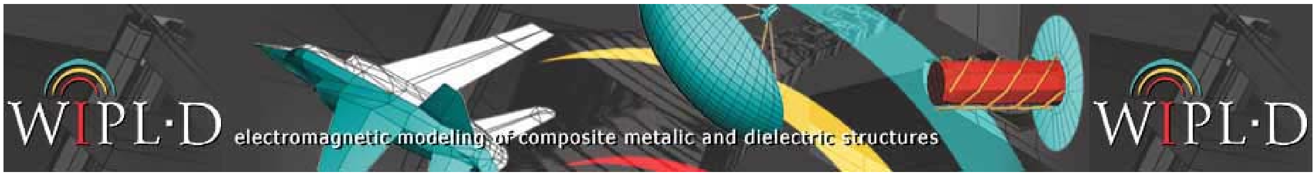
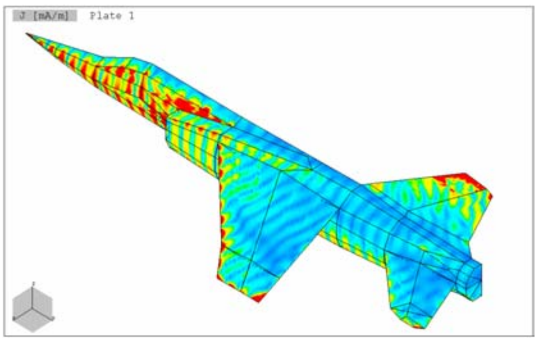


Simulation of Electrically Large Structures

WIPL-D Pro is a Method of Moments (MoM) based code which enables very accurate EM simulation of arbitrary 3D structures. Owing to application of sophisticated techniques, very large structures are simulated on PC computers or inexpesive workstations.

MoM Efficiency

MoM is one of the full-wave simulation techniques (MoM, FEM, FDTD,...). Unlike field based techniques (FEM, FDTD) it requires source-domain discretization instead of field discretization. Therefore, it is not prone to error accumulation due to wave propagation through meshed field-domain. Also, it is more suitable for open-region problems, because the discretized domain doesn't need to be artificially confined, and it demands far less memory and time resources in these cases. For example, in case of coupling between two distant antennas, FEM and FDTD would demand a large number of cells (more memory and time resources) in order to calculate the fields in the region between the antennas. When using MoM, the distance between the antennas doesn't influence neither the resources nor accuracy.



After source-domain discretization, source current distribution is approximated by known mathematical functions defined over mesh cells. These functions are called basis functions. By calculating coefficients which multiply basis functions, we obtain approximated current distribution over structure surfaces. The efficiency of MoM is directly dependent on the type of basis functions applied.

WIPL-D software applies a very sophisticated formulation of MoM which involves Higher Order Basis Functions (HOBFs). This means that basis functions are higher order polynomials instead of simple linear (rooftop) functions. Hence, in case of equal number of HOBFs and rooftops defined over a surface, HOBFs are capable of expressing more dynamic current distribution. As a result of this efficiency, significantly larger structures are quickly simulated on cheap PCs than by using other methods/solvers.

Meshing and basis functions	**Unknowns/λ^2 - metal**	**Unkowns/λ^2 - dielectric**
Triangular meshing, rooftops	125	250
Quadrilateral meshing, HOBFs (WIPL-D Pro)	32	64

Application of HOBFs is entirely automatic, although the user has the freedom to increase the precision of approximation if required.

Structure	**Number of unknowns**	**Memory requirement**
Parabolic reflector with 40 λ aperture	10000	0.8 GB
Military helicopter at 520 MHz – 25 λ long	20000	3.2 GB
Fighter plane at 1.39 GHz – 55 λ long (1 sym. plane)	30000	8 GB

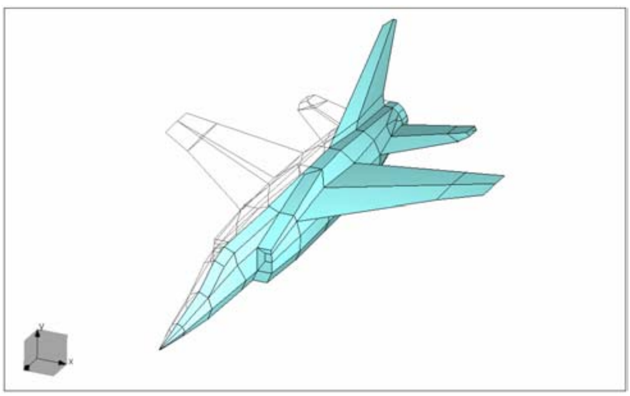
Direct Solution & Out-of-core Solver

Direct solution based on LU decomposition is the most accurate solution technique used in WIPL-D Pro 3D Electromagnetic Solver. When there is not enough RAM memory for the incore direct solution, out-of-core solution can be used instead. The out-of-core solver employs the hard drive of a PC so it stores the system matrix in RAM block-by-block, during calculations. This causes a small increase in simulation time (up to 20% of the incore time), but erases the RAM limit problems. Thus, the fighter from the previous table (30000 unknowns) can be simulated on an ordinary, cheap, 32-bit PC with 1 GB of RAM.

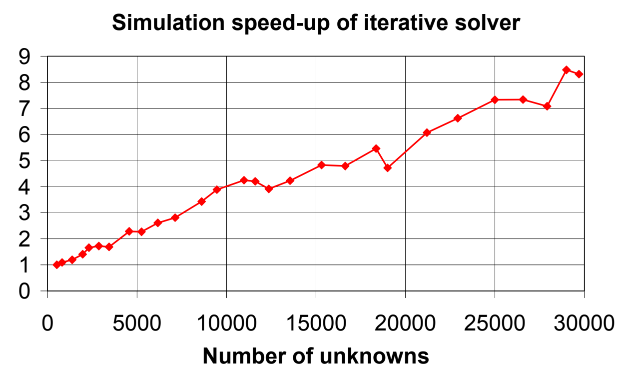
Iterative Solution

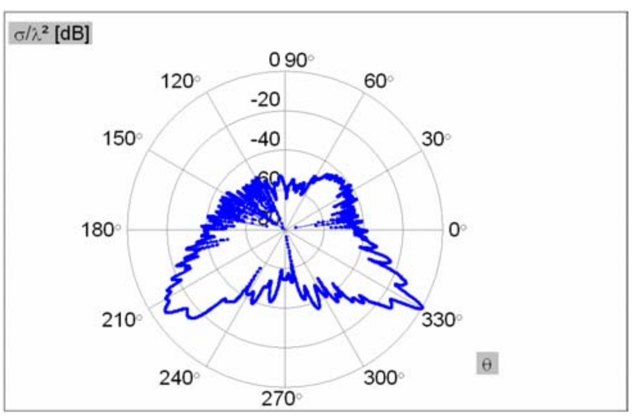
The idea of the iterative solution technique is to achieve a good solution in a relatively small number of iterations, using less time than the direct solution. Maximally orthogonalized HOBFs have been launched with WIPL-D Pro v6.1 with the intention of creating a good way of solving electrically large structures in an acceptable time frame. As a result, the simulation speed-up for electrically large scatterers is significant. Thus, a lot of structures that took days to be simulated, now can be simulated in hours. This facilitates and speeds-up the design process while not sacrificing the accuracy expected from a MoM code.

Case Study



Fighter model (one symmetry plane)





RCS in symmetry plane

Project: Scattering of a fighter plane (12 m length, 7m wingspan) calculated at 1 GHz in 25 minutes with the iterative solver. One symmetry plane was applied.

Machine: 3.2 GHz Intel Pentium 4 with 2GB of RAM.

Comments: Speed comparison of the iterative and the direct solver was done on another machine, AMD Opteron system with 8 GB of RAM. Number of unknowns of the model was incresed by increasing the working frequency. Speed-up of simulation of this project compared to direct solver was about 6 times at 1.15 GHz and 8.3 times at 1.39 GHz.