electromagnetic modeling of composite metallic and dielectric structures

Simulation of Antenna Mounted on F16 Aircraft

Simulation of real-life antennas mounted on electrical large platforms is often very demanding problem. In such cases, comparing to overall dimensions of the structure, antenna is electrically small. In the model of the antenna, one can find details several dozens times, or even several hundred times smaller than wavelength. The whole structure can be several hundred times larger than wavelength. Although such simulations are complex, there is always requirement for highly accurate and fast solution.

WIPL-D uses higher order basis functions (HOBFs) instead of low-order basis functions, in order to operate with relatively large meshing elements (meshing elements are with size up to 2 wavelengths by 2 wavelengths). It is also possible to combine different orders of current approximation along two axes of quadrilateral mesh element. In this way, the number of unknowns is minimized, even with very elongated mesh elements.

The number of unknowns can be also dramatically reduced by using quadrilateral mesh (comparing to triangular mesh).

In order to fully exploit capabilities of WIPL-D software, it is desirable to have relatively very large mesh elements (up to 2 wavelengths by 2 wavelengths) in flat or smooth parts of the model. At the same time, an accurate representation of model details is obtained by using fine mesh elements on which low-order basis functions are defined (as a subset of HOBFs). Also, on model parts which are flat or smooth along one dimension, and curved along the other, elongated mesh elements are the optimal choice.

In addition, if GPU accelerated kernel is used, WIPL-D can perform extremely time efficient solving of electrically large antenna placement problems.

Air Platform and the Antenna

In order to show capabilities of WIPL-D Method of Moment (MoM) solver, we will perform full 3D EM analysis of the antenna as a part of the IFF system, operating at frequency of 1.9 GHz. The antenna will be mounted on the lower part of fuselage of the F16 aircraft.

Model of the aircraft is imported from a CAD file, while the antenna is modeled from the scratch using WIPL-D Pro CAD built in primitives and placed on the appropriate position on the aircraft fuselage (Figure 1).

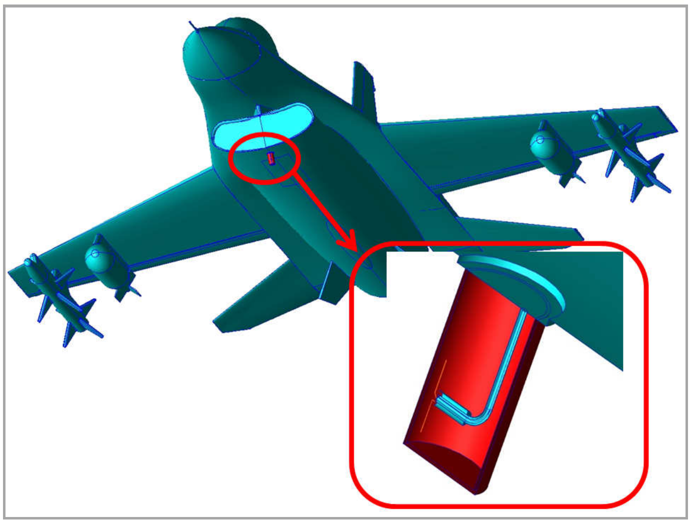

Figure 1. Antenna mounted on air platform – WIPL-D Pro CAD model

Symmetry of the structure was used to half the number of unknowns. We used one symmetry plane and simulate just half of the model shown in Figure 1.

After creating final CAD model, model of antenna and air platform was meshed by using in-house developed mesher (Fig. 2). Size of meshing elements on flat and smooth parts of the structure is slightly lower than 2 by 2 wavelengths. Meshing elements over the small details of the structure are smaller. Cylindrical parts over the antenna are meshed using thin, long plates. These meshing element sizes enabled us minimization of number of unknowns over the whole model.

The special feature intended for antenna placement problems is "smart reduction". It is based on adaptive reduction of current expansion orders over parts of the model which are distant from the antenna or in shadow. By applying both reductions, number of unknowns is dramatically reduced, preserving excellent accuracy (Table 1, Fig 3).

Table 1. Number of unknowns depending on reduction

Reduction	Number of unknowns
No reduction	196 752
Smart reduction	94 215

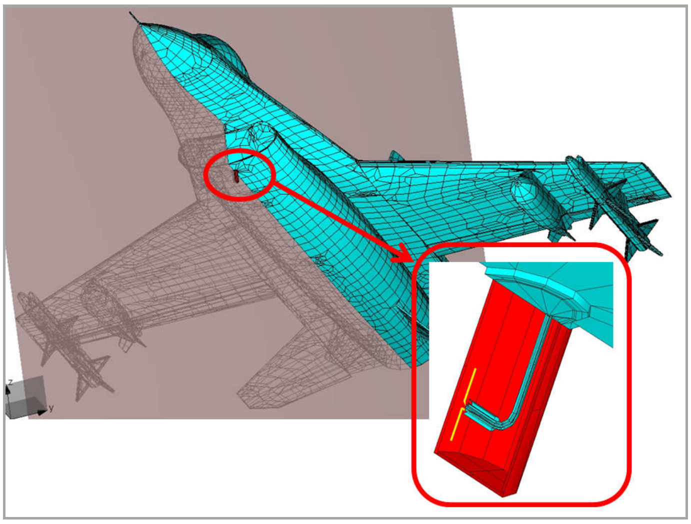

Figure 2. Half model of the antenna mounted on air platform obtained using direct mesh - WIPL-D Pro

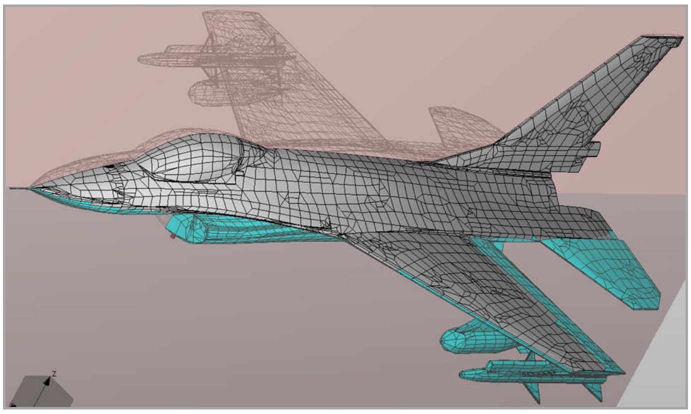

Figure 3. Antenna mounted on air platform – shadow reduction in WIPL-D Pro model

Results

The whole model was analyzed from 1.7 GHz to 2.1 GHz in 7 frequency points. Results of interest are s11 parameter and 3D radiation pattern at 1.9 GHz.

Parameter s11 is presented in Figure 4.

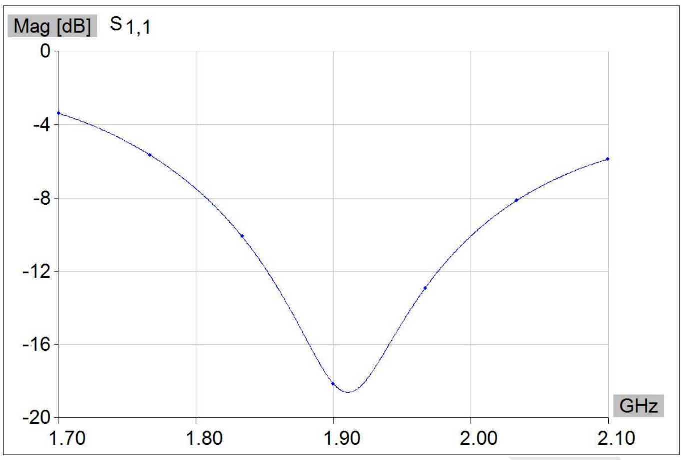

Figure 4. Parameter s11 of IFF system antenna

3D radiation pattern is presented in Figure 5.

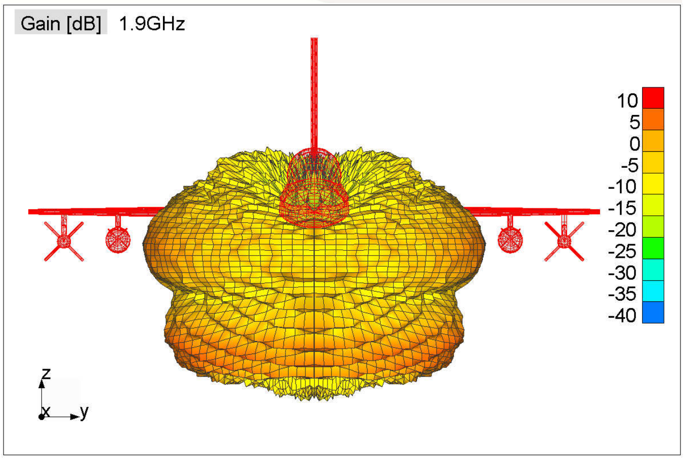

Figure 5. 3D Radiation pattern of IFF system antenna

Computational Platform and Simulation Time

Model of the antenna mounted on aircraft platform was simulated on computational platform Intel® Core™ i7-3820 CPU @ 3.60 GHz (4 cores) with 64 GB RAM and GPU card NVIDIA GeForce GTX 590.

Simulation was performed in 7 frequencies. Simulation time of one frequency is about 1.2 hours.

Conclusion

Results presented in this application show us that WIPL-D can successfully analyze electrically large platforms (approximately 105 wavelengths length) with dielectric involved, especially if methods of reducing number of unknowns were properly applied.

Also, WIPL-D can successfully handle discrepancy between size of model details and size of the whole structure. Length of the aircraft is about 15 meters (105 wavelengths), while diameter of inner coaxial conductor of antenna feeder is 3.16 mm (approximately 45 times smaller than wavelength).