# RF Antenna Placement on A320

WIPL-D software is full wave 3D EM Solver, based on **Method-of-Moments** (MoM) and empowered with **quadrilateral mesh** and **high-order basis functions (HOBFs)**. A unique combination of HOBFs and MoM allows accurately simulation of electrically large models. In the other words, HOBFs **decrease number of required unknowns** and **speed up simulations**. Also, WIPL-D enables very efficient **CPU** and **GPU** simulations on affordable hardware platforms. Finally, WIPL-D software interconnected products **WIPL-D Pro CAD** and **WIPL-D Pro** in such manner that solid modelling and wide support for transferring various models created in third-party tools into WIPL-D Pro are enabled.

Usage of modern software assumes that conversion from various CAD formats should be performed fast and easy. In addition, simulation of antennas mounted on electrically large platform should be completed in acceptable amount of time considering that **the requirement for highly accurate solution** still persists.

This application note is created to show various WIPL-D capabilities (for example, converting CAD format files to WIPL-D Pro native format, simulating electrically large antenna placement models, usage of *GPU Solver*…). Two antenna placement scenarios will be investigated. The first scenario encompasses a monopole antenna which is mounted on the model of Airbus A320 and simulated at 833 MHz. The second scenario encompasses three monopole antennas which are mounted in three different positions on the model of Airbus A320 and simulated at 1.53 GHz. All simulations will be carried out on a platform: Intel® Xeon® CPU E5-2650 v4 @ 2.20 GHz (2 processors) with 256 GB RAM and four GPU cards NVIDIA GeForce GTX 1080 Ti.

**Output results** (radiation pattern), information about various reductions applied, computer memory required and simulation times will be presented. Various **benefits** of using WIPL-D software, especially if combined with WIPL-D *GPU Solver* and *Smart reduction* will be highlighted.

## WIPL-D Features Suitable for Antenna Placement Problems

In order to solve an antenna placement problem, ***Smart reduction*** feature can be efficiently applied. It is based on **adaptive reduction of current expansion orders** over parts of the model which are distant from the antenna (e.g. *Antenna placement reduction*). On the other hand, very useful ***Unused Entities*** feature can exclude entities which influence to the output results is negligible. By applying the *Smart reduction* combined with *Unused Entities*, number of unknowns (thus, computer memory required and simulation time) can be dramatically reduced, preserving excellent accuracy. Furthermore, usage of the ***GPU Solver*** enables the user to perform extremely fast simulations of the models requiring a lot of unknowns. The *GPU Solver* **primarily accelerates system matrix solving** through **usage of graphical processing units (GPUs)**.

## Conversion to WIPL-D Native Format

WIPL-D Pro CAD GUI with the Airbus A320 model is shown in Figure 1. The model of the Airbus A320 was imported from an IGES file. The airplane length is 37.6 m, while the wing span is 33.5 m. The model contains details such as windows and jet engine parts. No model repair was required after import. Using *Direct* meshing algorithm, the all-quad mesh was created (Figure 2). The meshed model adequately represented all the details and yet created larger quads on the fuselage and wings (Figure 2) to enable the speed of higher order MoM.

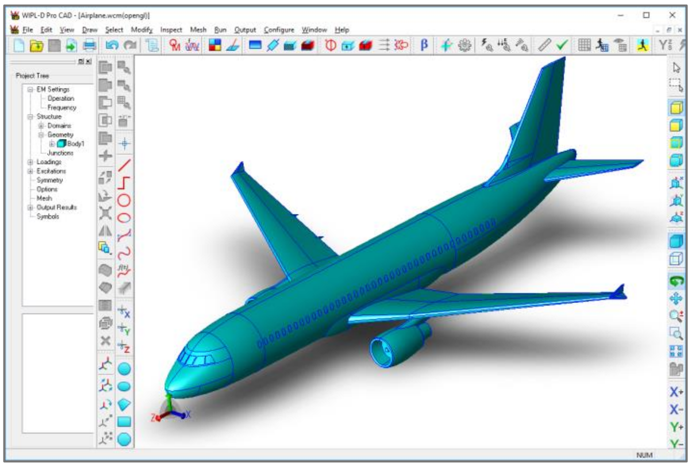

**Figure 1. Imported model of Airbus A320**

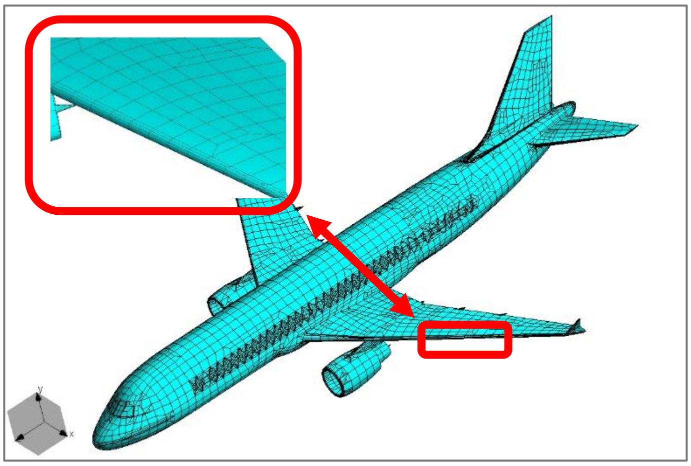

**Figure 2. Mesh of Airbus A320 with highlighted detail; full model; windows were not removed**

Using the cropping (*Crop by Plane*) and defeaturing (*Remove Feature*) techniques in WIPL D Pro CAD, the model was split in half and simplified by removing all windows (Figure 3). A monopole antenna was placed on the fuselage.

## Monopole Antenna at 833 MHz

The model (Figure 3) was simulated and the radiation pattern in the symmetry plane was calculated at 833 MHz (Figure 5), with the airplane being 104λ long at this frequency. Three cases, each with different reduction were simulated. In **the first case**, reduction was not applied. **The second case** involved *Antenna placement reduction* of 60%. **The third case** involved the same *Antenna placement reduction* supported with *Unused Entities.* Actually, the entities which are located on the bottom of the airplane are considered to be non-influential to the radiation pattern. Thus, these are defined as *Unused Entities* (Figure 4). Results after simulating three cases are shown in Figures 5-6.

Number of unknowns, computer memory required and CPU and GPU simulation times are presented in Table 1. Simulation time mainly consists of time required for performing **matrix fill-in, matrix inversion and calculation of radiation pattern**. **CPU simulation time** implies that all mentioned operations (matrix fill-in, matrix inversion and calculation of radiation pattern) were performed on CPU. **GPU simulation time** implies that matrix inversion was performed using GPU while the other operations are performed using CPU.

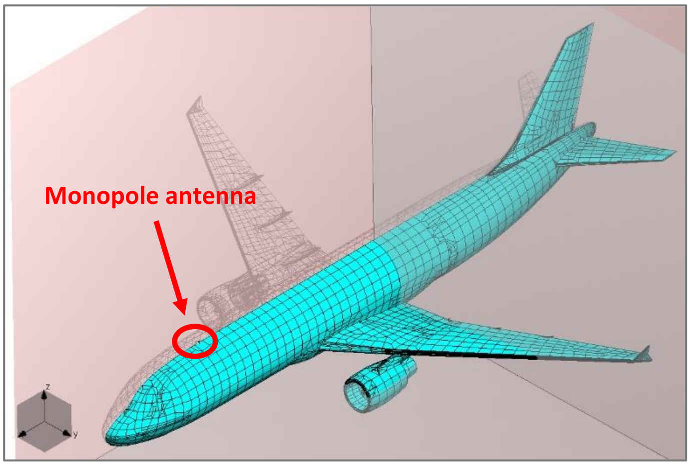


**Figure 3. Mesh of Airbus A320; half model; windows removed with *Remove Feature***

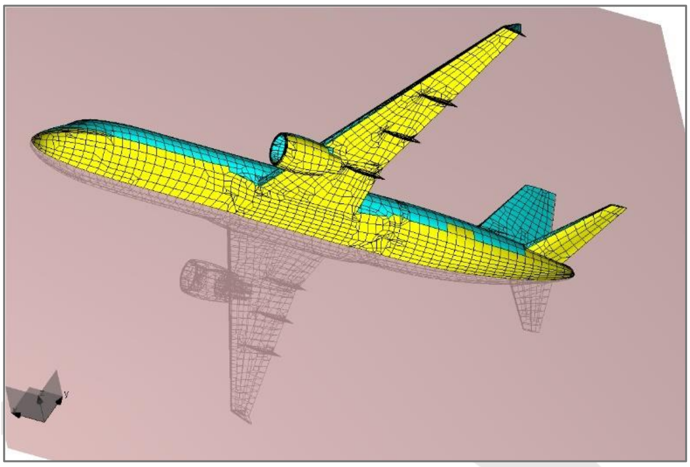

**Figure 4. Unused entities on the airplane model**

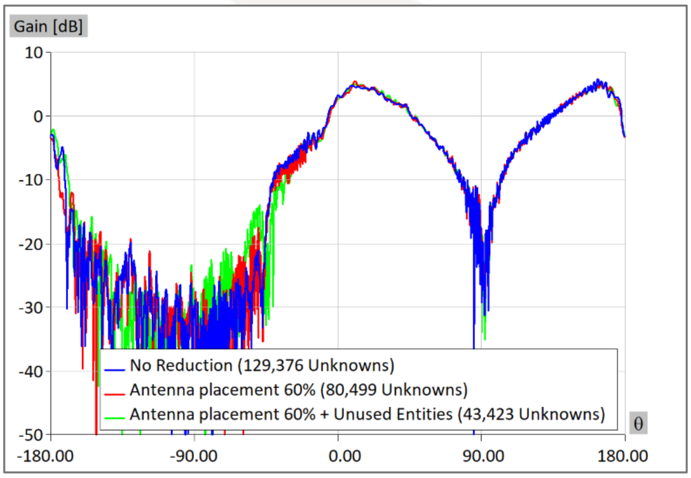


**Figure 5. Radiation patterns in the symmetry plane**

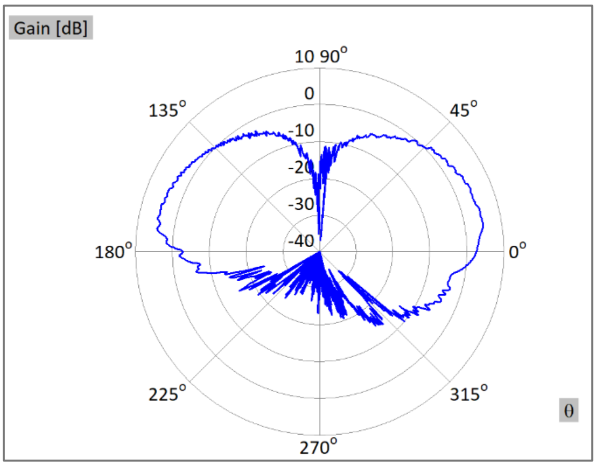


**Figure 6. Radiation pattern in the symmetry plane. *Antenna placement reduction* and *Unused Entities* applied.**

**Table 1. Number of unknowns, computer memory required and simulation times – airplane at 833 MHz**

| Model | Number of unknowns | Memory [GB] | CPU simulation time [min] | GPU simulation time [min] |
|---|---|---|---|---|
| No Reduction | 129,376 | 124.7 | 85.5 | 15.6 |
| Antenna Placement Reduction 60% | 80,499 | 48.3 | 21.6 | 6.5 |
| Antenna Placement Reduction 60% and Unused Entities | 43,423 | 14.0 | 4.0 | 1.9 |

## Monopole Antennas at 1.53 GHz

Placement of the monopole antennas on three different positions on the aircraft was investigated next. It was done in order to establish the **influence of the wings and the tail on the radiation pattern**. The monopole antennas were placed on the airplane fuselage: at midpoint between the wings and the nose, at wings, and at midpoint between the wings and the tail (Figure 7). The models were simulated and the radiation patterns in the symmetry plane were calculated at 1.53 GHz (Figure 9), with the airplane being 190λ long at this frequency. Numerical parameters are recalled from the 833 MHz simulation scenario. It was adopted that accurate results are obtained with *Antenna placement reduction* of 60% and with appropriately applied of *Unused Entities* feature (Figure 8). Number of unknowns, computer memory required and CPU and GPU simulation times are shown in Table 2. The radiation patterns in the symmetry plane for the monopole located in three different positions are shown in Figure 9.

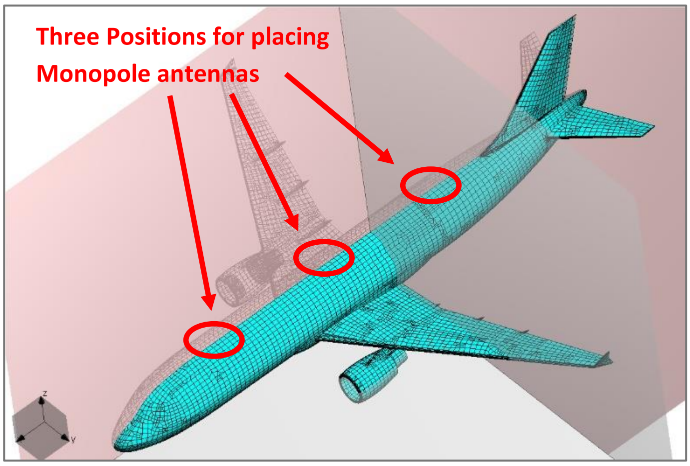


**Figure 7. Three positions for placing the monopoles**

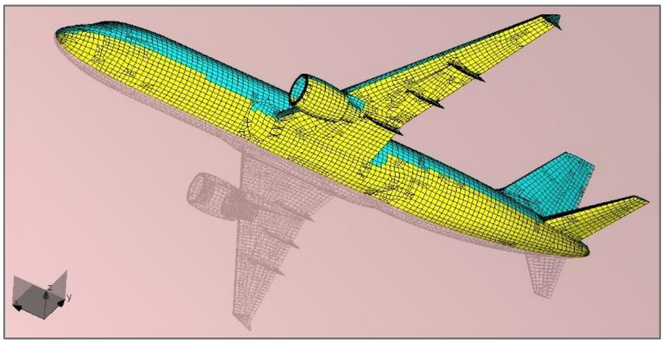

**Figure 8. Unused entities on the airplane model**

**Table 2. Number of unknowns, computer memory required and simulation times – airplane at 1.53 GHz**

| Model | Number of unknowns | Memory [GB] | GPU simulation time [min] |
|---|---|---|---|
| Antenna Placement Reduction 60% | 231,528 | 399.4 | 97.5 |
| Antenna Placement Reduction 60% and Unused Entities | 131,498 | 128.8 | 16.3 |

## Conclusion

This application note presented WIPL-D simulations of two electrically large scenarios. The first scenario encompassed a monopole antenna mounted on the model of the aircraft (simulated at 833 MHz). The second scenario encompassed three monopole antennas mounted in three different positions on the aircraft (simulated at 1.53 GHz). Output results mostly showed WIPL-D capabilities in antenna placement problems. In addition, it was shown that converting CAD format files to WIPL-D Pro native format can be performed easily. In addition, usage of WIPL-D features suitable for antenna placement problems such as *Antenna placement reduction,* or *Unused Entities* can tremendously decrease required computational resources. Finally, beside very efficient CPU simulation, the benefits of using *GPU Solver* in simulation of models requiring a lot of unknowns are displayed. Presented figures containing output results and tables containing various data prove that applying all mentioned reductions with GPU Solver can enable accurate results with decreased simulation time.

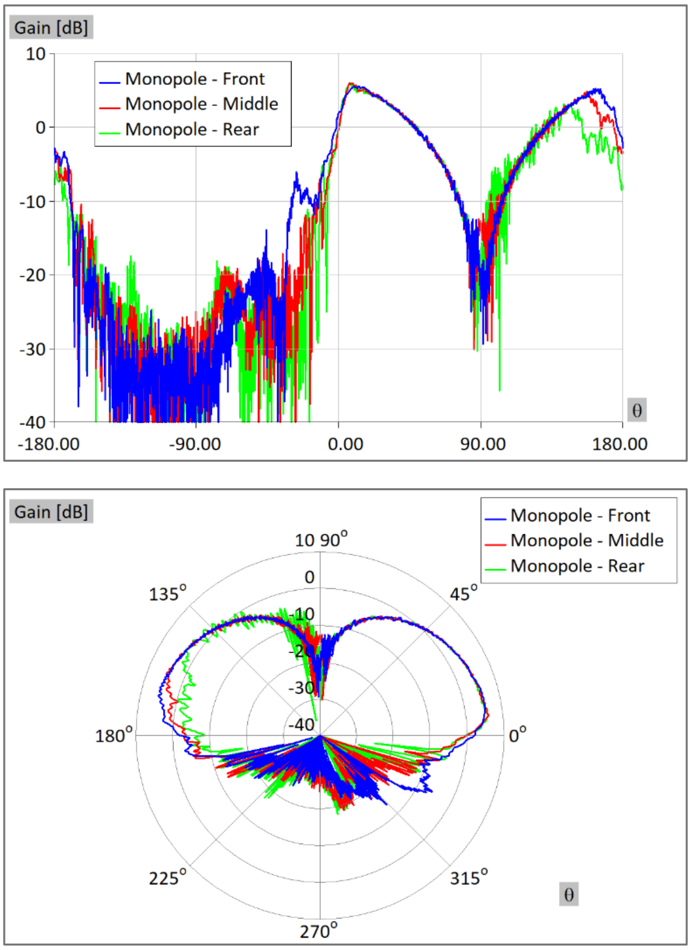


**Figure 9. Radiation patterns for 3 positions of the monopole**

All of this enables an antenna engineer to experiment with various antenna models in various environments. That way, for example, the influence of the surrounding objects to an antenna can be easily noticed. Particularly, in this application note the influence of the wings and the tail on the radiation pattern is shown. Especially, the influence of the tail is clearly visible in case the monopole is placed at the back. In the other words, after inspecting the results in Figure 9, one can see that the radiation pattern of the monopole at the third position is mostly affected by presence of the tail.