Automotive Applications

EM simulations have a significant role in automotive industry. WIPL-D software continuously improves its variety of tools which allow various applications in this growing industry. The range of EM simulations has been extended with introduction of CAD tools (allowing easy import of CAD files, as well as modeling and positioning of devices in conjunction to complex CAD geometries) and GPU simulation module (which extended the range of frequencies where applications can be designed and simulated). Furthermore, WIPL-D introduced Domain Decomposition Solver (DDS), a product, which is intended for simulations of electrically very large problems.

The simulations presented in this application note under the titles: *GPS Antenna Mounted on Car Roof, Bluetooth and GSM Interference*, and *FM Antenna Immersed into Glass Window* were performed on a desktop computer, Intel® Xeon® CPU E5-2650 v4 @2.20 GHz, 2 processors, 256 GB RAM and 4 GPUs Nvidia GeForce GTX 1080 Ti (matrix inversion was performed on GPU cards).

GPS Antenna Mounted to Car Roof

This EM simulation demonstrates a basic use where a simple patch antenna is mounted to the Citroen shell.

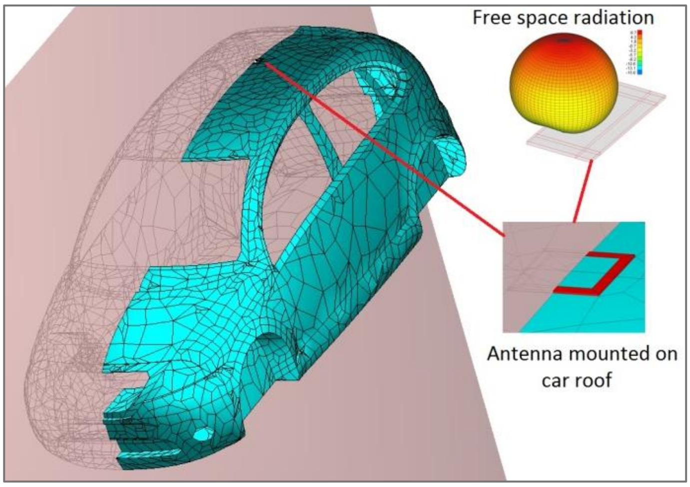

Figure 1. Citroen car shell simulation scenario

The antenna is placed on roof, symmetrically so that number of unknown coefficients is halved and simulation time is reduced. The car shell and magnified area where patch antenna is positioned are presented in Figure 1. Linearly polarized patch is 65 mm wide, on 2 mm thick dielectric plate (Er = 2.2). Radiation pattern of standalone antenna is shown in Figure 1 (1.59 GHz operating frequency), while mounted pattern is presented in Figure 2.

The EM simulation requires only **about 25,000 unknown** coefficient (it corresponds to 4.5 GB of RAM or hard disc space). The **run time per frequency is about 45 seconds**.

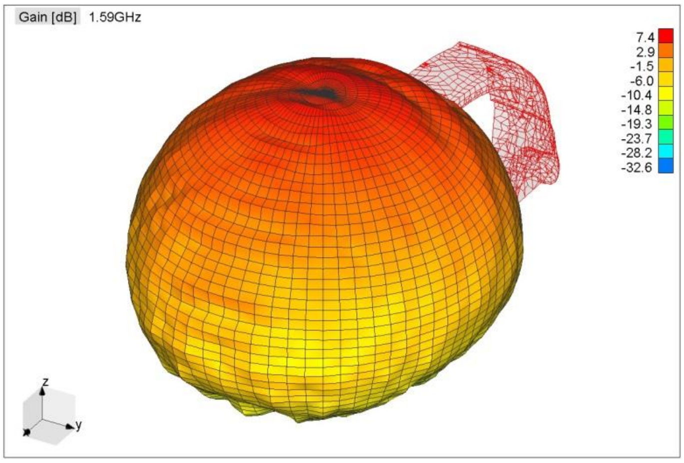

Figure 2. Mounted patch antenna pattern

The next step is to extend the simulation by using circularly polarized patch and full shell model, since the patch antenna is no longer symmetrical. The dimension of the slit is 6.4 mm (Figure 3).

Full model of car shell now requires **approximately 45,000 unknowns**, almost two times more than in previous simulation. Simulation lasts **about 100 seconds per frequency**. However, WIPL-D suite offer features to reduce number of unknown coefficients on models parts which are far away from the antenna itself - antenna placement reduction. When **reduction** is set to maximum, EM simulation requires only **about 17,500 unknowns** which yields in about **48.5 seconds run time per simulated frequency**. Figure 3 demonstrates that antenna placement reduction almost has no effect to result and compares return loss of the antenna in free space and mounted to car roof.

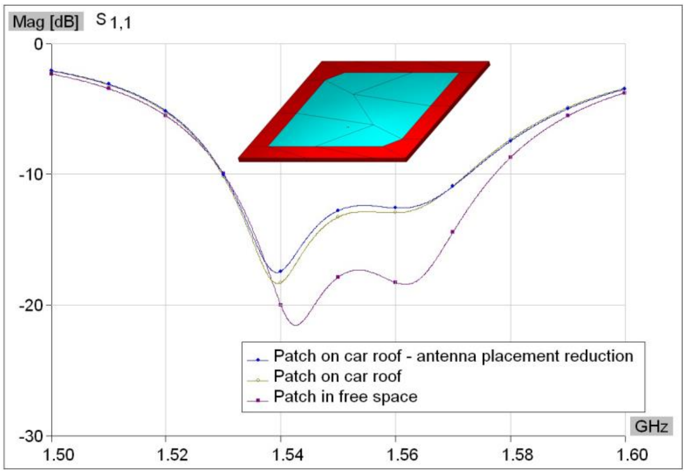

Figure 3. Patch return loss, free space and mounted

Bluetooth and GSM Interference

The following example demonstrates that interference within car shell of devices working with various wireless technologies can be efficiently simulated. The scenario includes Citroen car shell with added car seats, GSM mobile device on front seat and Bluetooth devices on the command board.

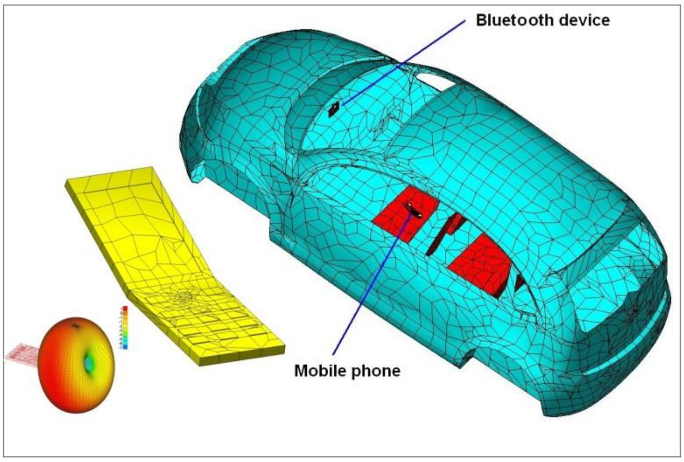

Figure 4. Complex multiple antenna scenario

Mobile has two antennas, GSM and Bluetooth. Radiation pattern of the GSM antenna in free space and inside car is shown in Figures 4-5 (1.8 GHz).

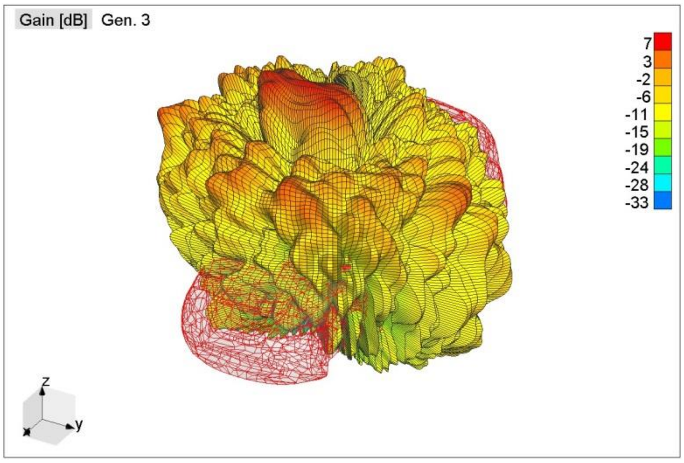

Figure 5. GSM antenna pattern inside car shell

Figure 6 presents coupling between Bluetooth antennas on Bluetooth device on command board and Bluetooth antenna inside mobile phone.

At 1.8 GHz (GSM) simulation that includes car shell with seats and control board added, as well as two generic devices, requires **approximatelly 93,000 unknowns**. The simulations carried out at the previously mentioned configuration lasts **7.5 minutes**. At 2.4 GHz EM simulation requires **about 157,000 unknowns** and simulation time is **around 22 minutes, per simulated frequency**.

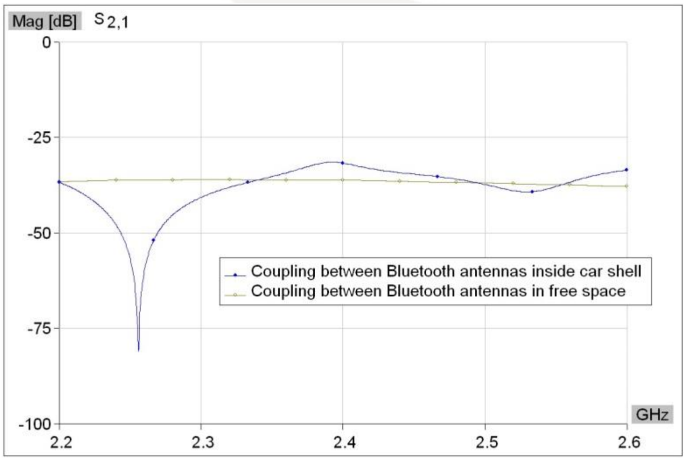

Figure 6. Coupling among devices (free space, in car)

FM Antenna Immersed into Glass Window

The next example demonstrates how FM receiving wire antenna (108 MHz) can be immersed into car window. The window glass is modeled as dielectric (Er=3.5). The wire is immersed into window along with the heating wires.

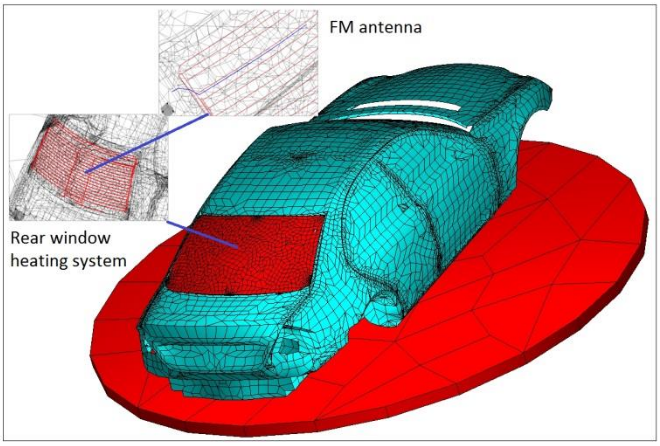

Figure 7. Mercedes shell with rear window included

EM simulation requires almost **39,000 unknowns** and lasts **5 minutes** on the above mentioned configuration. Radiation pattern of the FM antenna is illustrated in the Figure 8.

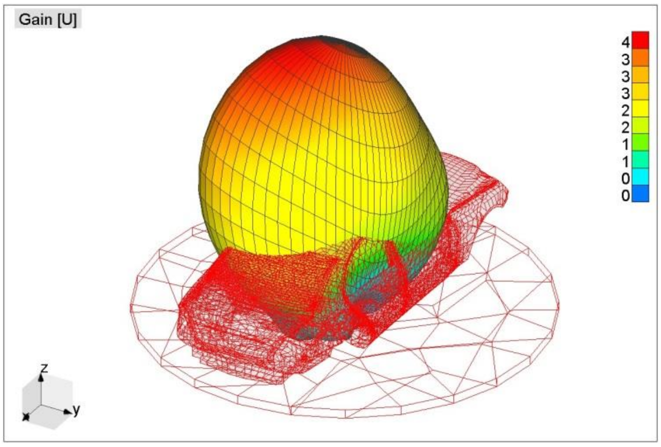

Figure 8. FM antenna radiation pattern