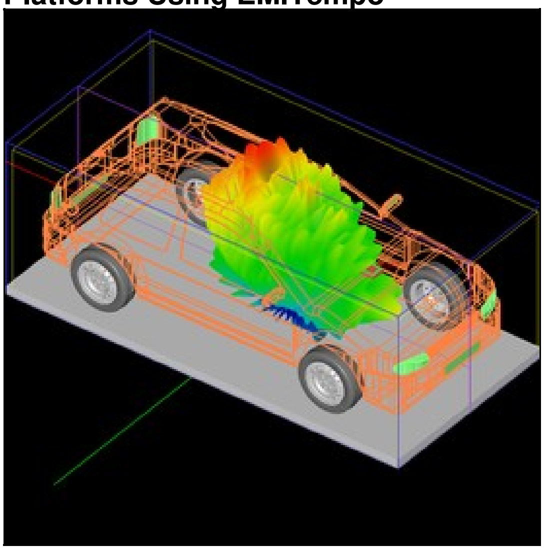
Application Note 5: Simulating The Performance Of Installed Antennas On Vehicular Platforms Using EM.Tempo

Application Project: Simulating The Performance Of Installed Antennas On Vehicular Platforms Using EM.Tempo



Objective: In this project, antennas mounted on a complex, real-sized, automobile platform are modeled and analyzed using EM.Tempo.

Concepts/Features:

- CubeCAD
- EM.Tempo
- CAD Model
- Patch Wizard
- Yee Mesh
- Field Distribution
- Radiation Pattern
- High Performance Computing

Minimum Version Required: All versions

Download Link: None

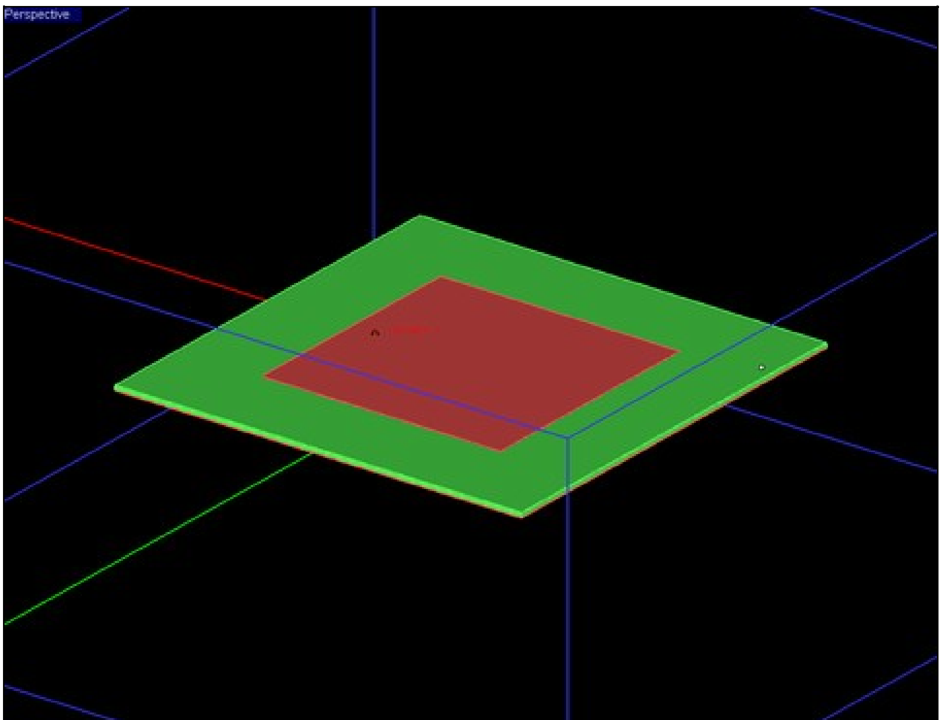
Contents

In this application note, we demonstrate how to use EM.Tempo to compute and analyze the radiation pattern of a patch antenna installed on a vehicular platform. Specifically, the CAD model of a Volkswagen Golf automobile is first imported to EM.Cube. Then, a microstrip patch antenna with a finite-sized substrate is placed at different locations of the automobile's chassis.

EM.Cube provides a number of wizards for quick construction of patch antennas with different feed mechanisms: a probe feed, an edge-connected microstrip feed with or without a recess, and a slot-coupled open-ended microstrip feed. For this project, we consider a probe-fed square patch antenna with the following specifications:

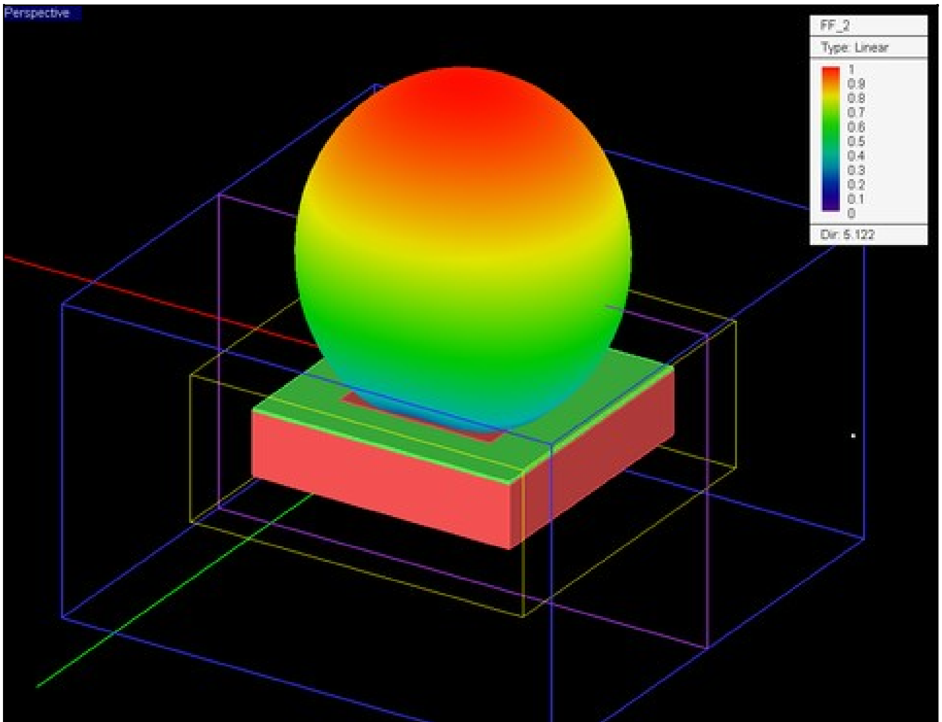
Parameter Name	Value
Substrate Height (h)	1.5mm
Substrate Relative Permittivity ($_{r}$)	2.2
Patch Length	88.20mm
Feed Offset (from Center)	35.28mm
Substrate Size	150mm

The geometry setup for the patch antenna in EM.Tempo is shown in the figure below. The dielectric substrate layer is backed by a perfect electric conductor (PEC) plate. The probe feed is modeled by a lumped source on a short vertical PEC line connecting the patch to the bottom ground plane.



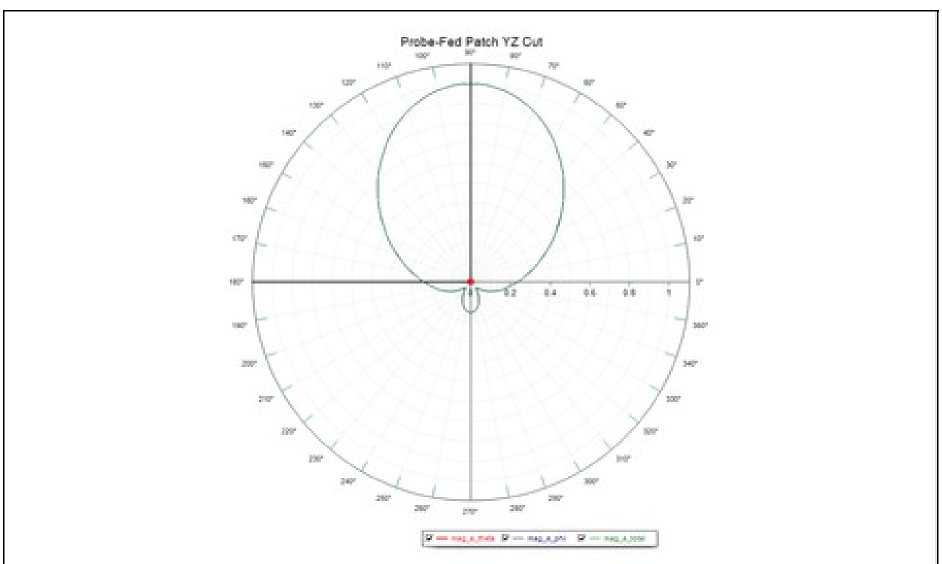
The geometry setup for a rectangular microstrip patch antenna on a finite-sized substrate in EM.Tempo.

The patch structure was simulated using EM.Tempo's FDTD solver on a thick metal ground. The 3D far-field radiation pattern of the isolated finite-substrate patch antenna is shown in the figure below. The directivity of the patch is computed to be 7.09dB.

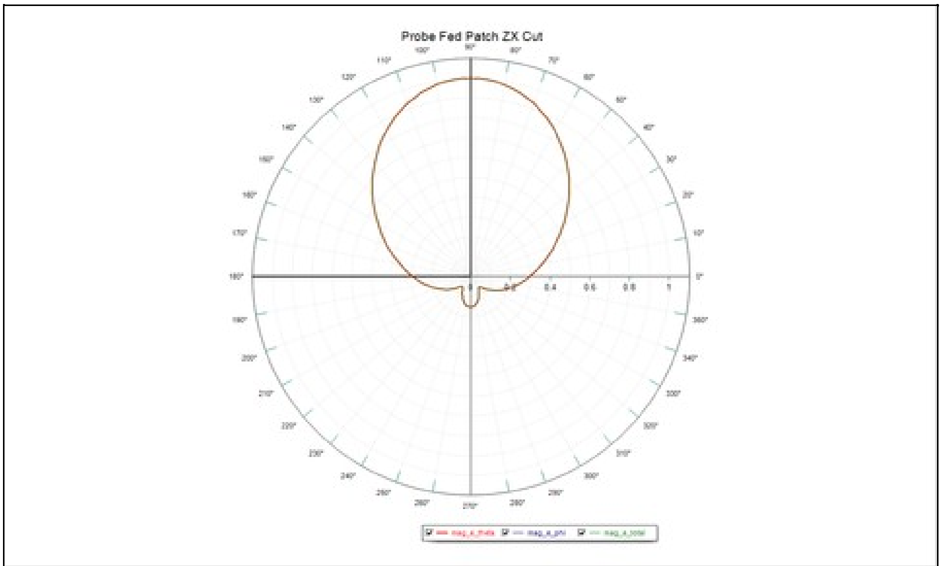


The 3D far-field radiation pattern of the isolated patch antenna computed by EM.Tempo.

The figures below show the 2D polar radiation patterns of the patch antenna in the principal YZ and ZX planes.

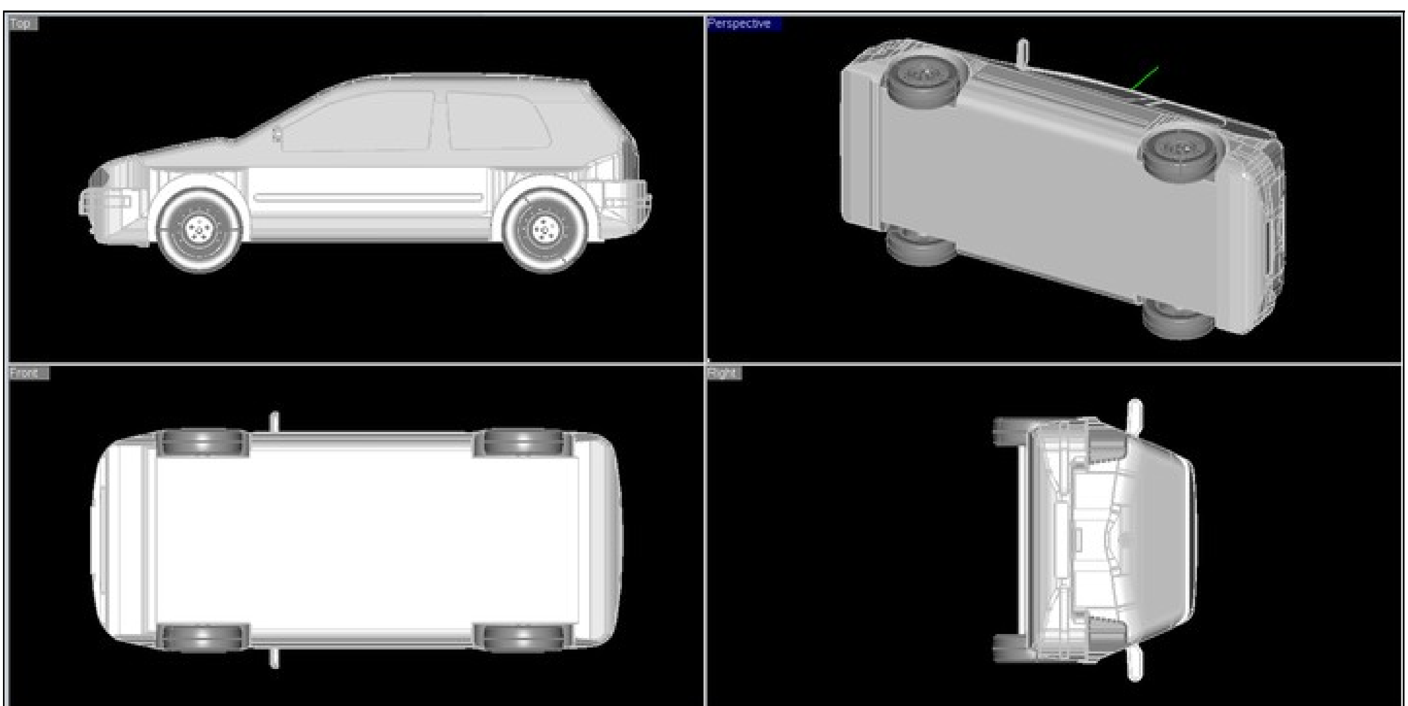


2D polar radiation pattern of the isolated patch antenna in the YZ plane.



2D polar radiation pattern of the isolated patch antenna in the ZX plane.

For this project, we use an IGES CAD model of a Volkswagen Golf automobile. The CAD model consists of 2019 different surface objects. They are originally grouped into a number of different object sets as shown in the figure below. The overall dimensions of the car are about 420cm × 200cm × 142cm.

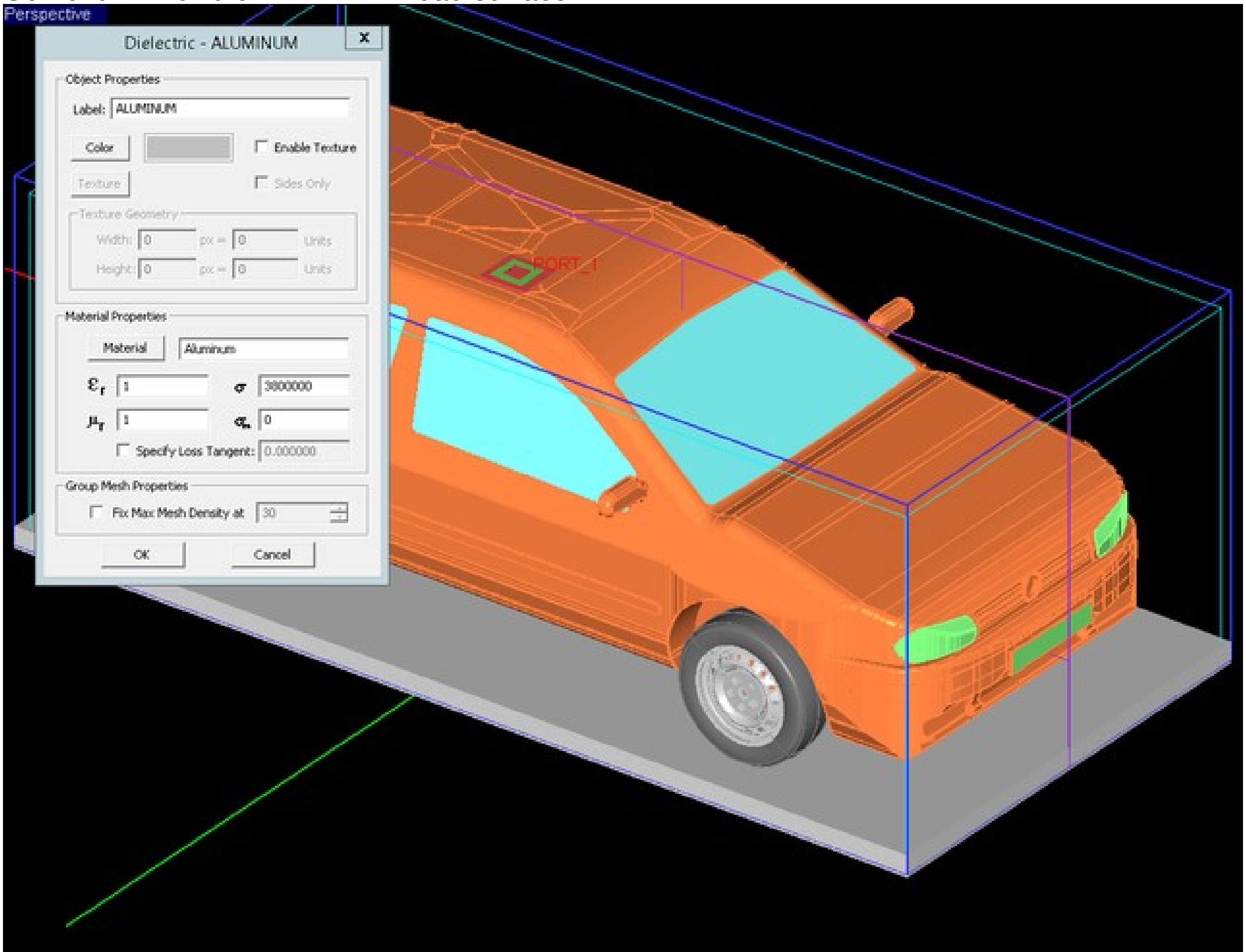


The four-port view of the imported CAD model of the vehicle before material assignments in CubeCAD.

The CAD model is initially imported to CubeCAD. From there we transfer all the parts to EM.Tempo, where the FDTD simulation is to take place. We also place a cement block underneath the automobile to model the road surface. A number of materials are defined and assigned to the various parts of the vehicle as listed in the table below.

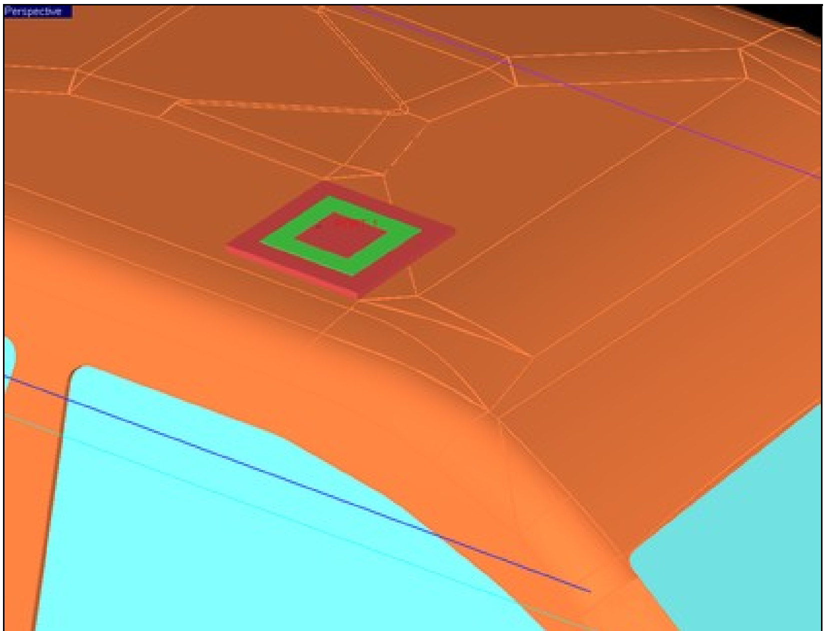
Material	$_r$		**Designated Model Parts**
PEC	1		Car body
Glass	6.5	0.005S/m	Car windows

Plastic	2.2	0.0	Head-light covers, brake-light covers, license plate mounts
Rubber	2.9	0.005S/m	Tires
Aluminum	1	3.8×10^6 S/m	Wheel rims
Cement	1.9	0.0	Road surface



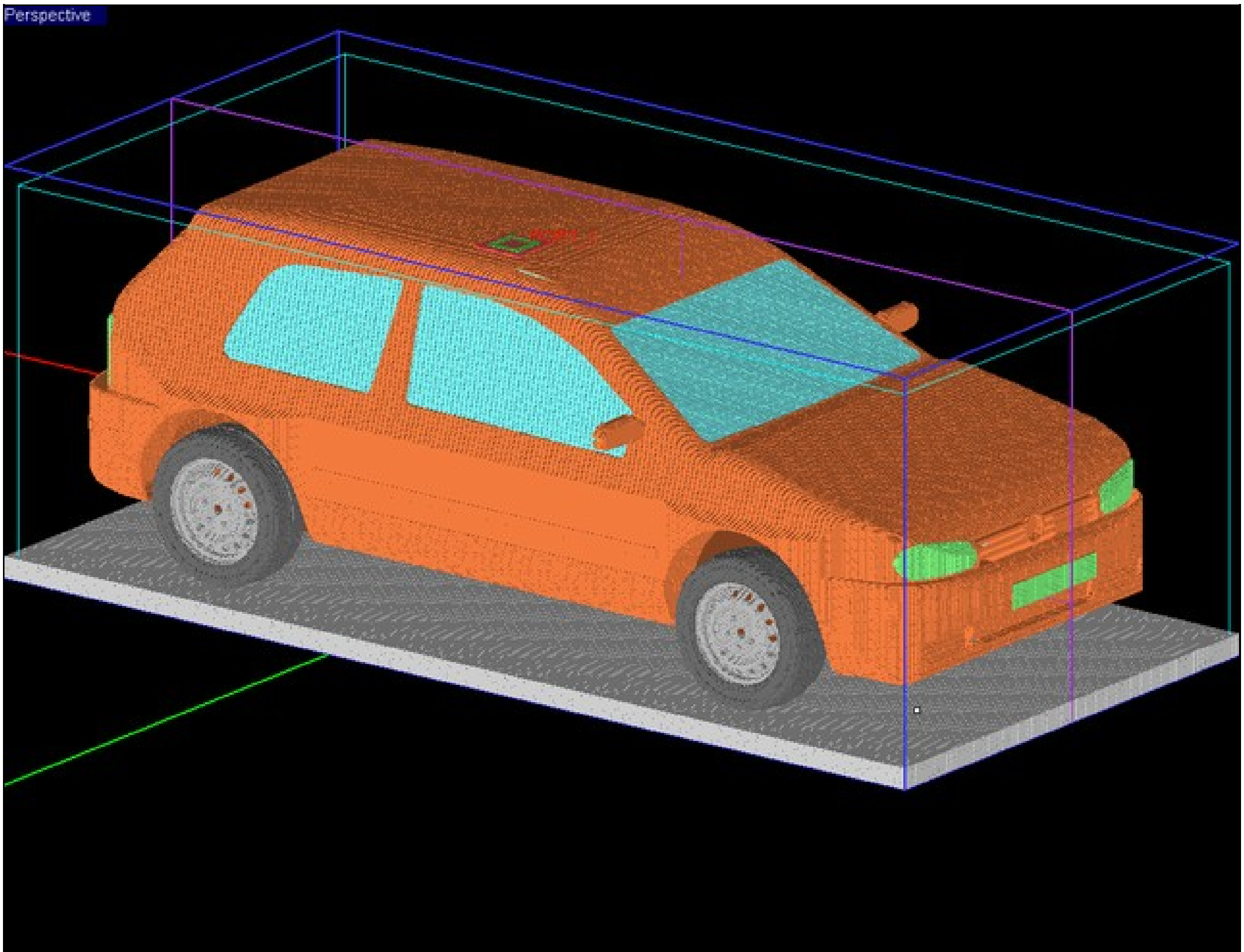
Assigning material composition to various vehicle parts in EM.Tempo.

First, we place the patch antenna on the roof of the Golf model as shown in the figure below.

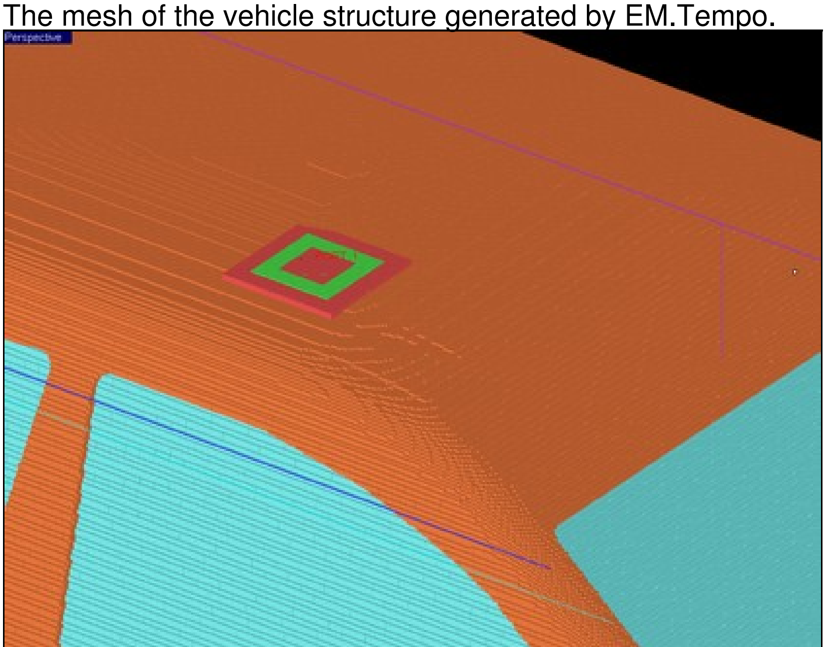


The location of the patch antenna on the vehicle's roof.

By default, EM.Tempo's mesh generator tries to place grid points at the corners of each graphic object's bounding box, and also at any internal boundaries any object may have. For models with a large number of complex geometric objects, this could drive the typical mesh cell size toward the "Absolute Minimum Grid Spacing", and would result in a much denser mesh than is required. Since the Golf model has more than 2000 distinct graphic objects, we will turn off some of these adaptive mesh options. A mesh density of 18 cells per effective wavelength is chosen for this structure with the absolute minimum grid spacing parameter set equal to 0.75mm. The figures below show the Yee mesh of the whole vehicle structure as well as the portion of the roof in the proximity of the installed patch antenna. The overall mesh involves **220 million** cells.



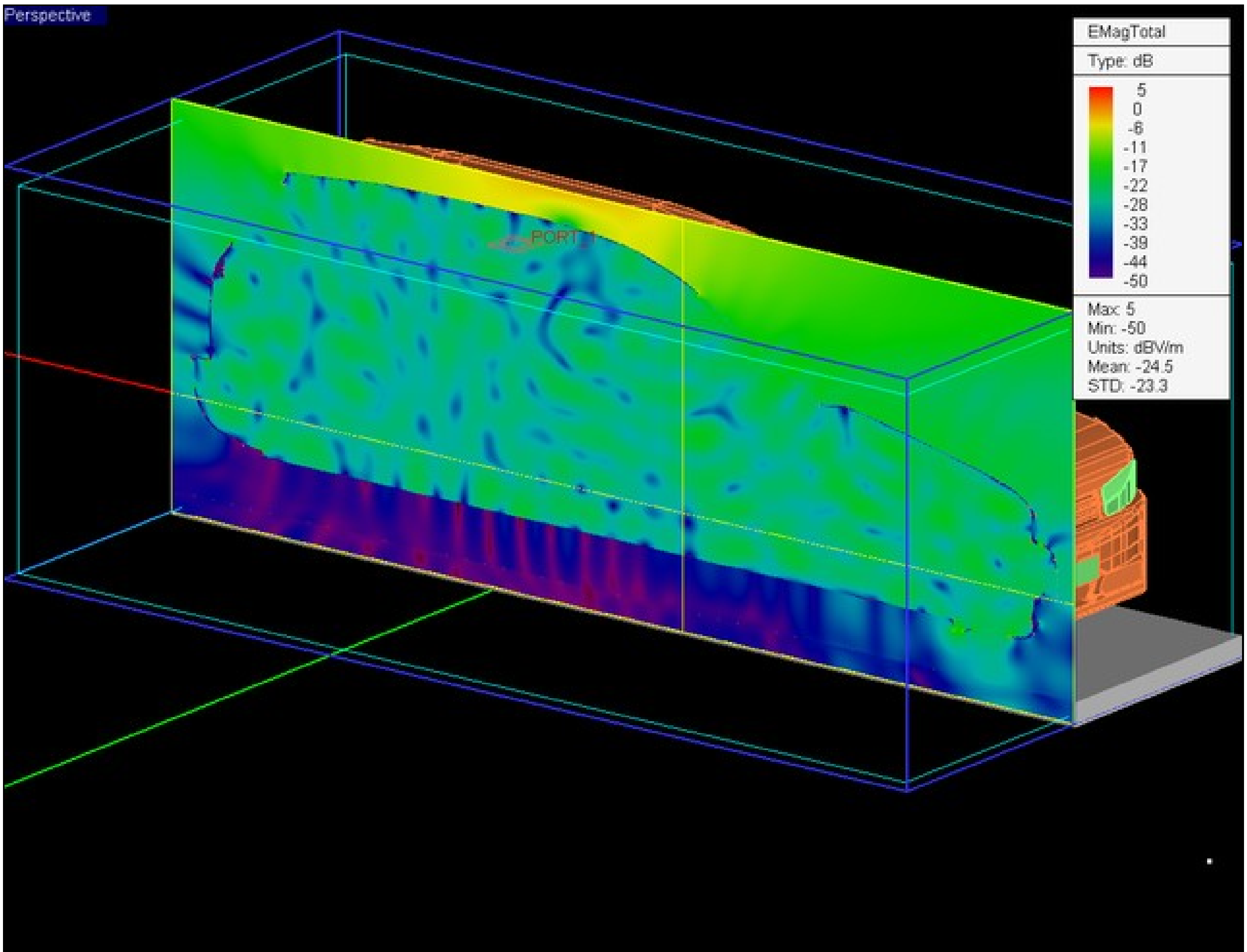
The mesh of the vehicle structure generated by EM.Tempo.



A close-up of the mesh of the patch antenna and its neighboring region of the vehicle's roof.

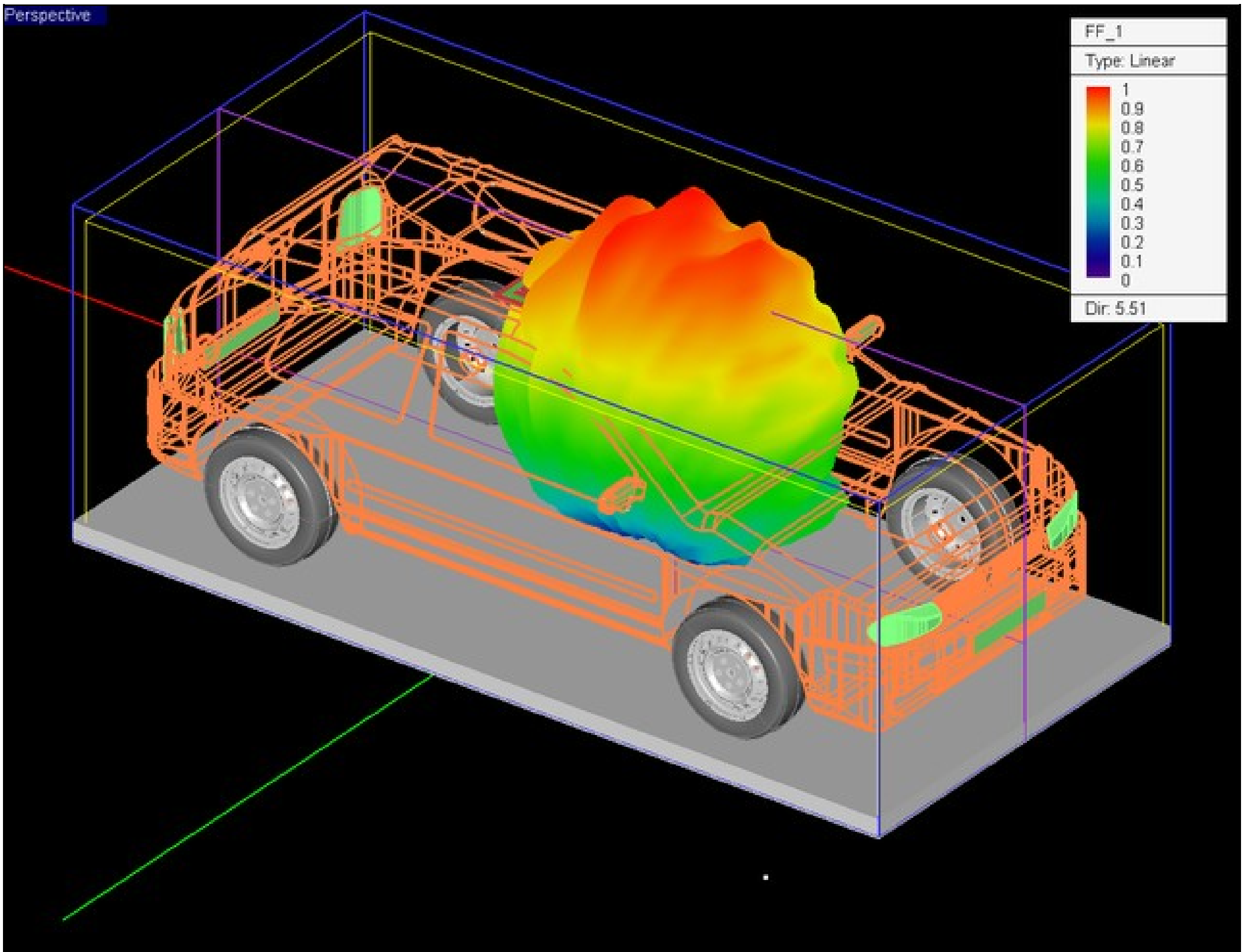
The FDTD simulation of the vehicle structure was run on Amazon Web Services. For the purpose of this project, we logged into an Amazon instance via Remote Desktop Protocol (RDP) and used a c4.4xlarge instance running Windows Server 2012. This instance had 30 GB of RAM memory, and 16 virtual CPU cores. The CPU for this instance was an Intel Xeon E5-2666 v3 (Haswell) processor. The thread factor setting essentially tells the FDTD engine how many CPU threads to use during EM.Tempo's time-marching loop. For a given system, some experimentation may be needed to determine the best number of threads to use. Eight thread factors were used for this simulation, with a total computation time of 285 minutes.

The figure below shows the electric field distribution of the vehicle-antenna combination structure in the vertical ZX plane that passes through the center of the vehicle.



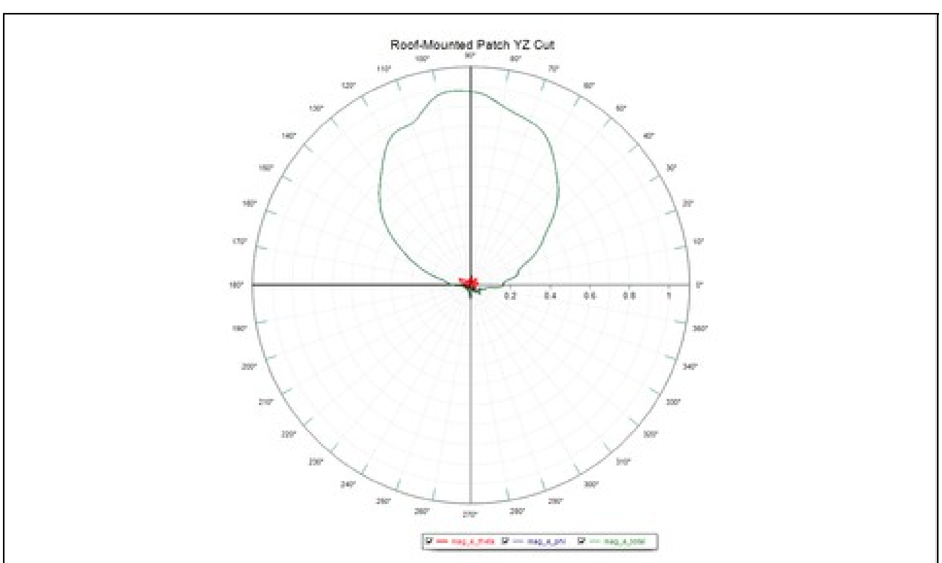
The dB-scale electric field distribution of the vehicle-antenna combination structure in the vertical ZX plane.

The figure below shows the 3D far-field radiation pattern of the installed patch antenna on the vehicle's roof. For this simulation, the far-field angular resolution was set to 2.5° along both azimuth and elevation directions.

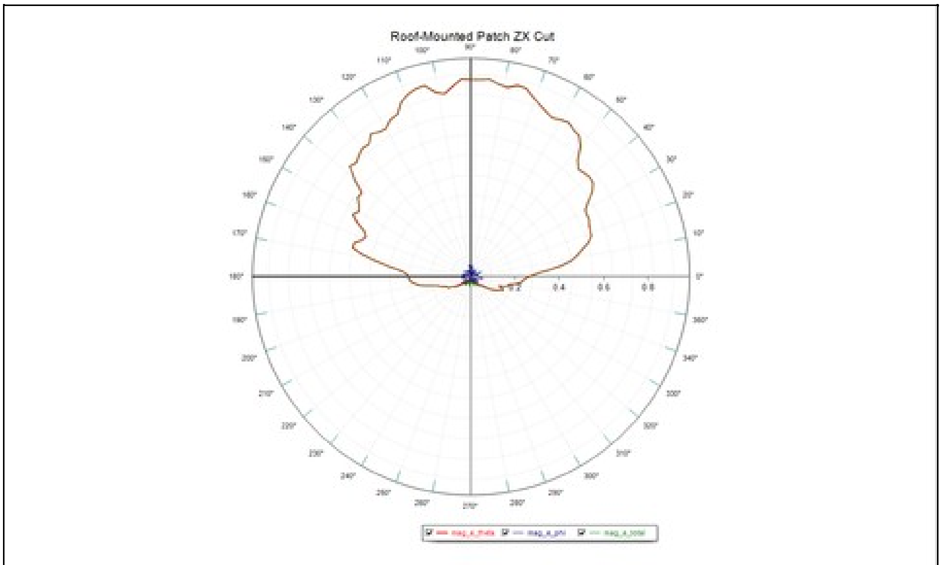


3D far-field radiation pattern of the vehicle-antenna combination structure, with the patch antenna installed on the vehicle's roof.

The figures below show the 2D polar radiation patterns of the roof-mounted patch antenna in the principal YZ and ZX planes. Comparing these graphs with those of the isolated patch antenna in the previous section reveals the impact of the mounting platform on the radiation characteristics of the installed antenna.

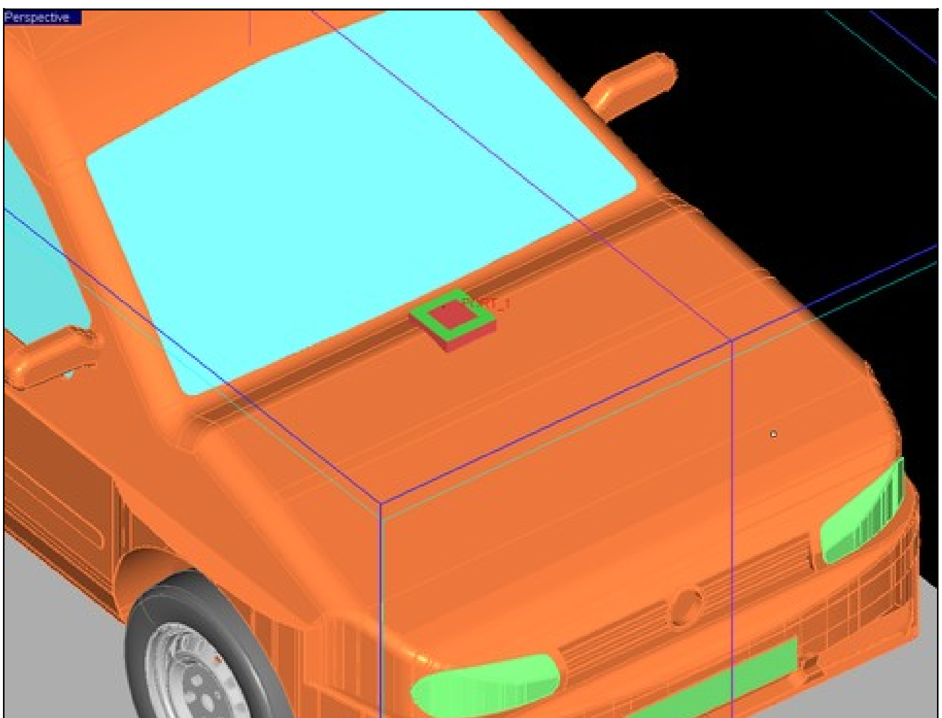


2D linear-scale polar radiation pattern of the roof-mounted patch antenna in the YZ plane..



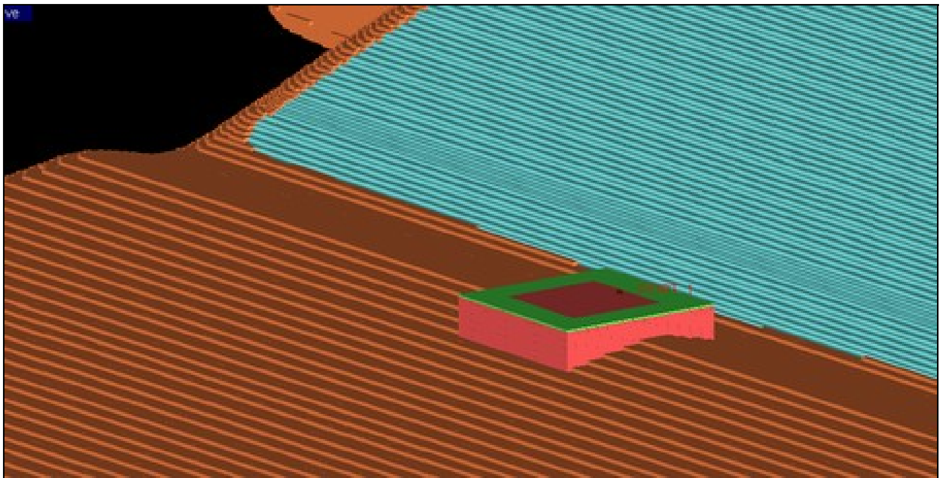
2D linear-scale polar radiation pattern of the roof-mounted patch antenna in the ZX plane..

Next, we move the patch antenna onto the front hood of the Golf model close to the front windshield as shown in the figure below.



The location of the patch antenna on the vehicle's hood.

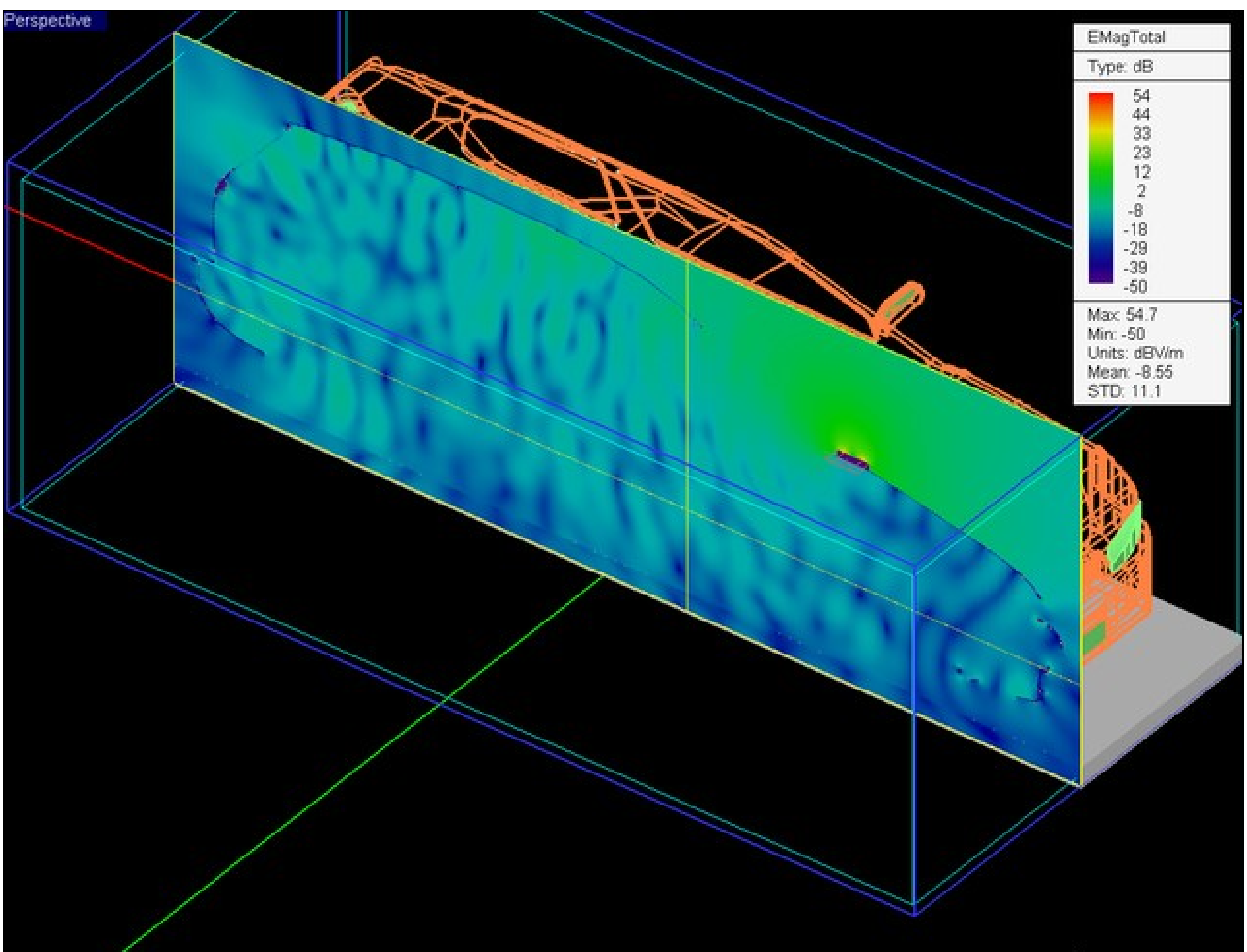
The figure below shows the details of the Yee mesh around the new location of the patch antenna. Due to the curvature of the surface of most parts in this area, the generated mesh has denser grid lines. This increases the total number of mesh cells to more than **230 million**.



The details of the Yee mesh of the vehicle structure generated by EM.Tempo around the location of the patch antenna on the hood.

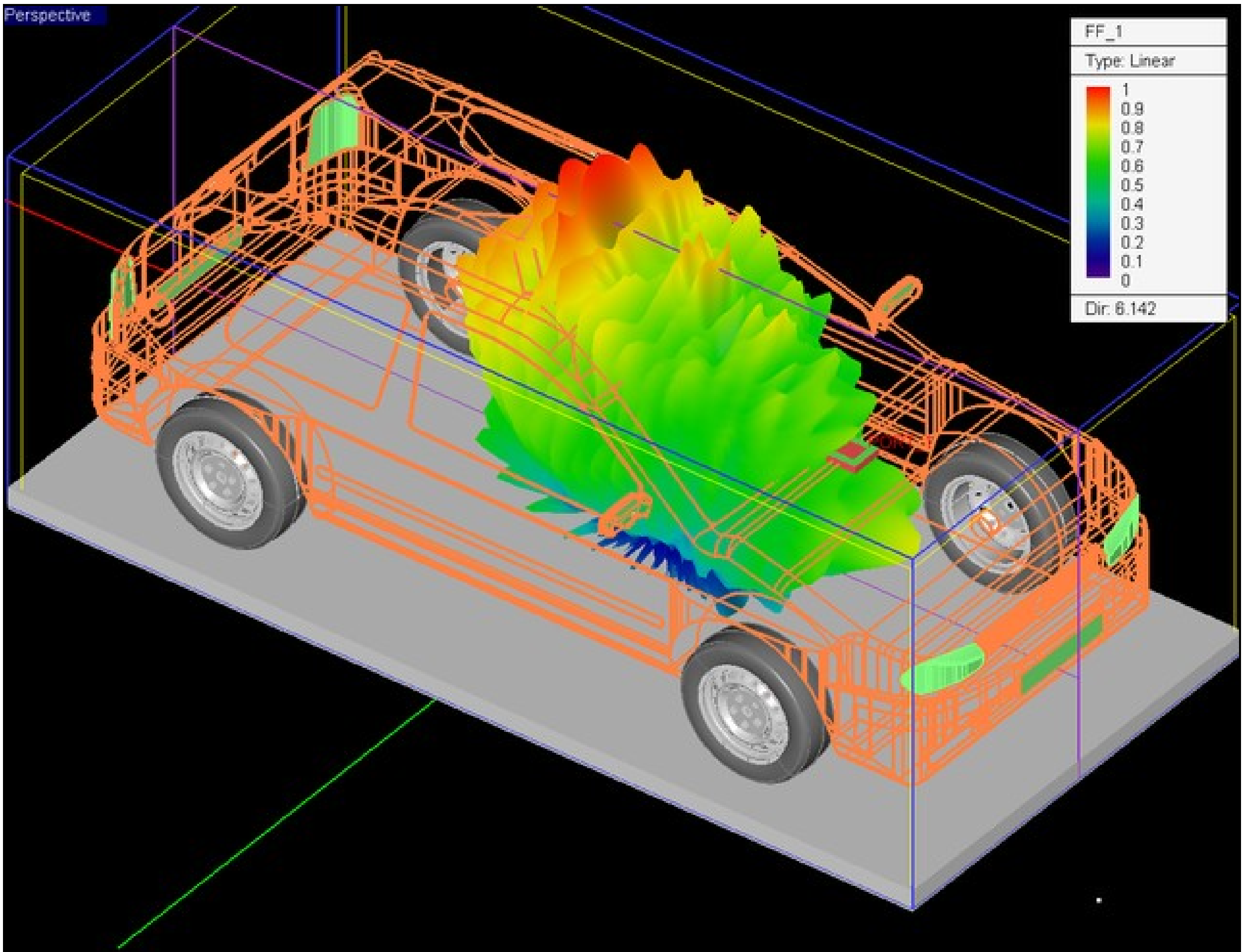
The FDTD simulation of the vehicle structure with its new antenna location is performed on the same computing platform using Amazon Web Services (AWS). The total computation time in this case increased to 325 minutes.

The figure below shows the electric field distribution of the vehicle-antenna combination structure in the vertical ZX plane that passes through the center of the vehicle.



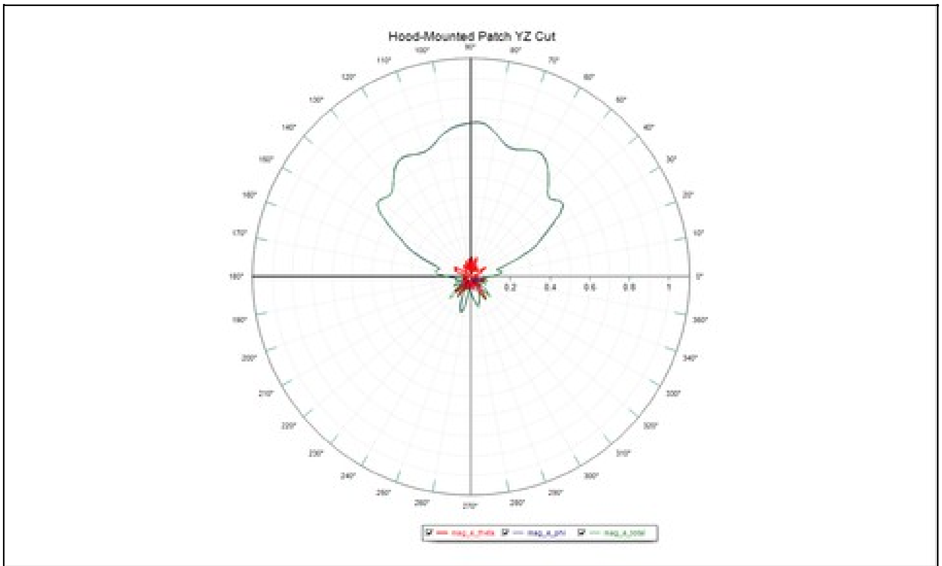
The dB-scale electric field distribution of the vehicle-antenna combination structure in the vertical ZX plane.

The figure below shows the 3D far-field radiation pattern of the installed patch antenna on the vehicle's hood. For this simulation, the far-field angular resolution was set to 2.5° along both azimuth and elevation directions.

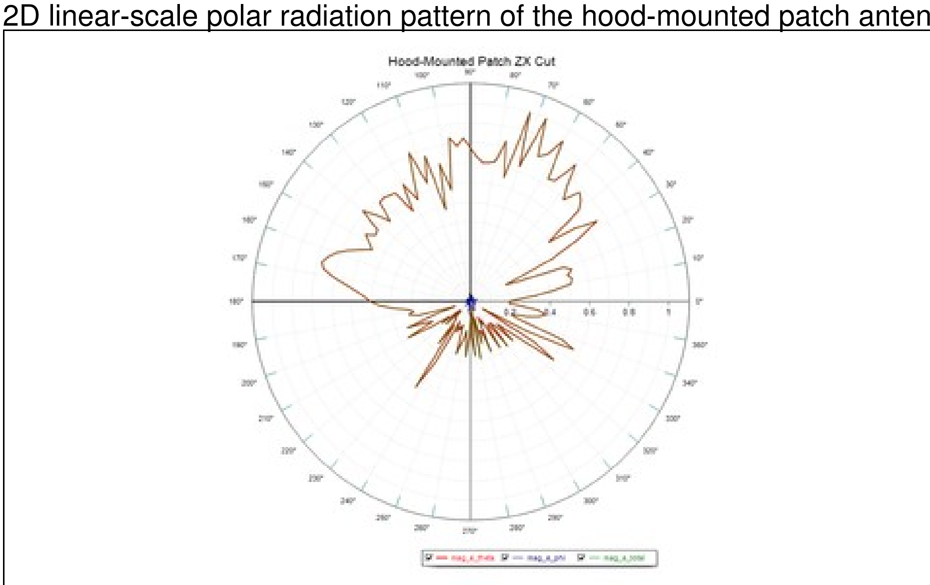


3D far-field radiation pattern of the vehicle-antenna combination structure, with the patch antenna installed on the vehicle's hood.

The figures below show the 2D polar radiation patterns of the hood-mounted patch antenna in the principal YZ and ZX planes. Comparing these graphs with those of the two previous cases shows significant reflection and diffraction effects at the new location of the patch antenna.



2D linear-scale polar radiation pattern of the hood-mounted patch antenna in the YZ plane.



2D linear-scale polar radiation pattern of the hood-mounted patch antenna in the ZX plane.

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