

La simulation numérique RF comme outil d'aide à la décision dans l'automobile

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Outline

- Radiofrequency band
- Antennas in Automobile
- Numerical methods
- Examples
 - Antenna placement
 - Multi-antenna Device

Radiofrequency band

Radiofrequency band in automotive system

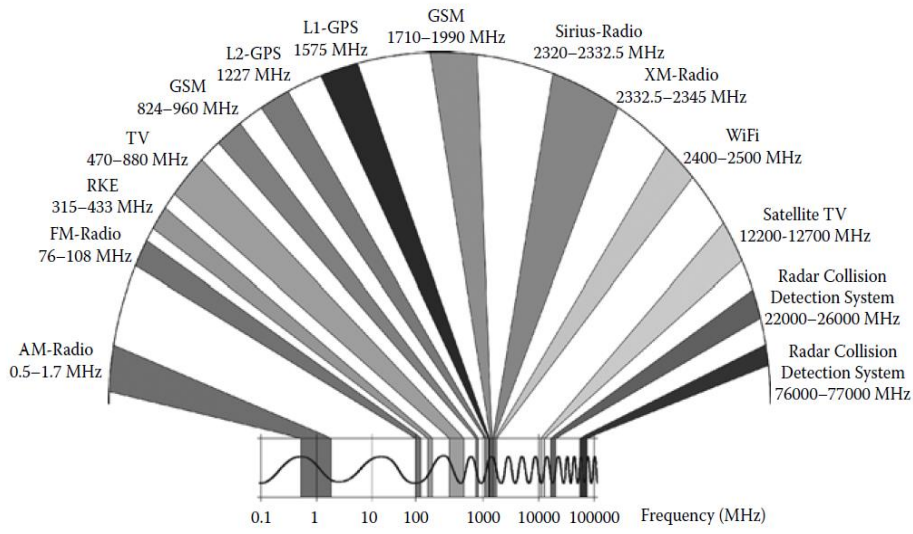


FIGURE 1.1
Frequency spectrum used in RF equipment for automotive industry.

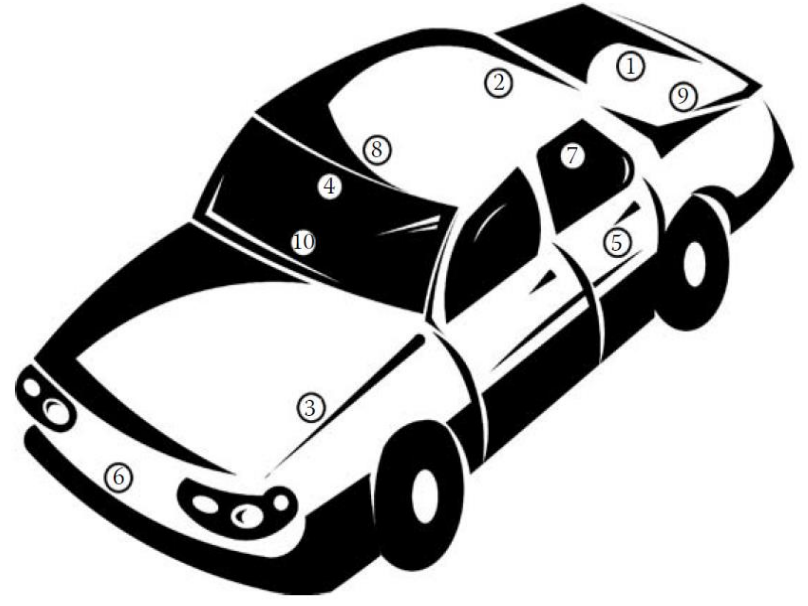


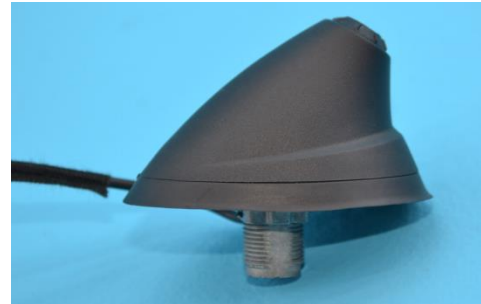
FIGURE 1.2
Locations of car antennas for different applications.

Victor Rabinovich, Nikolai Alexandrov, Basim Alkhateeb
Automotive Antenna Design and Applications, CRC Press



Antennas in Automotive

Radio Antenna



GPS Antenna



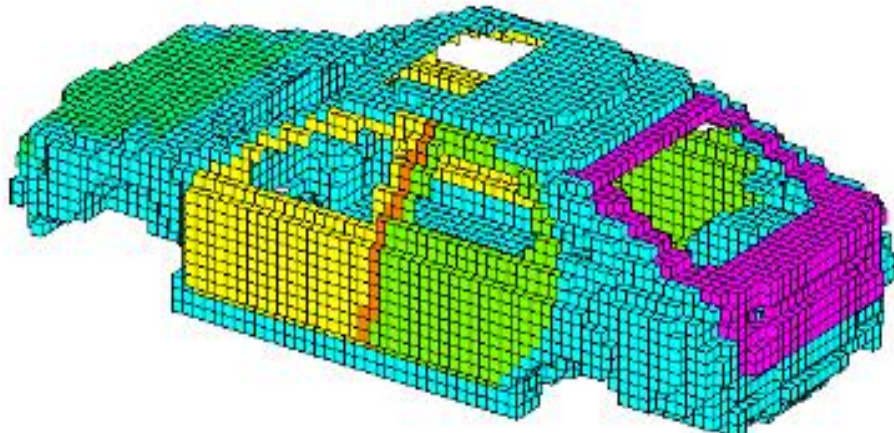
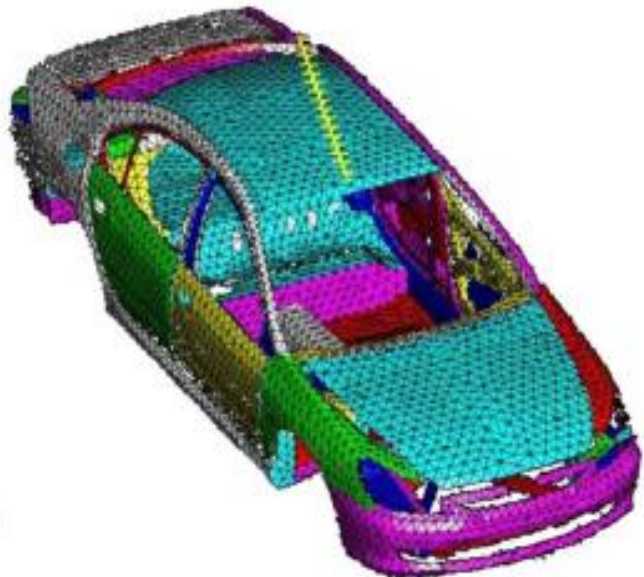
Tire pressure sensor antenna





Numerical methods

Time domain methods/Frequency domain methods



Frequency-domain

Time-domain

3D electromagnetic codes

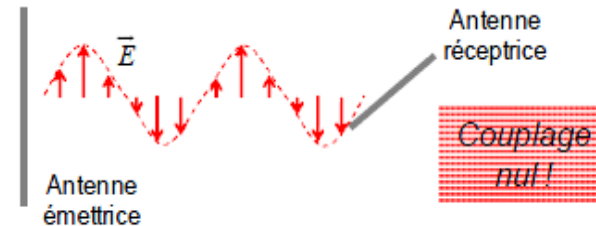
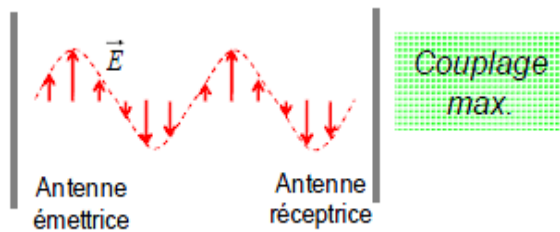
FEKO

CST

Example of application 1
Antenna placement

Antenna placement (1/2)

Problematic : communication between two antennas inner a vehicle

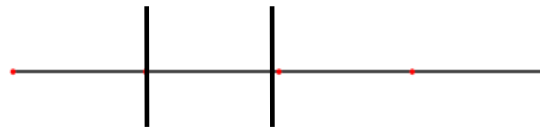
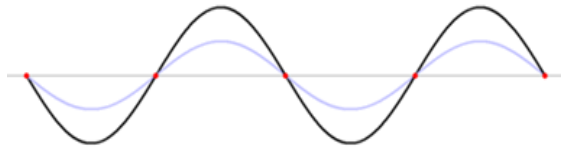
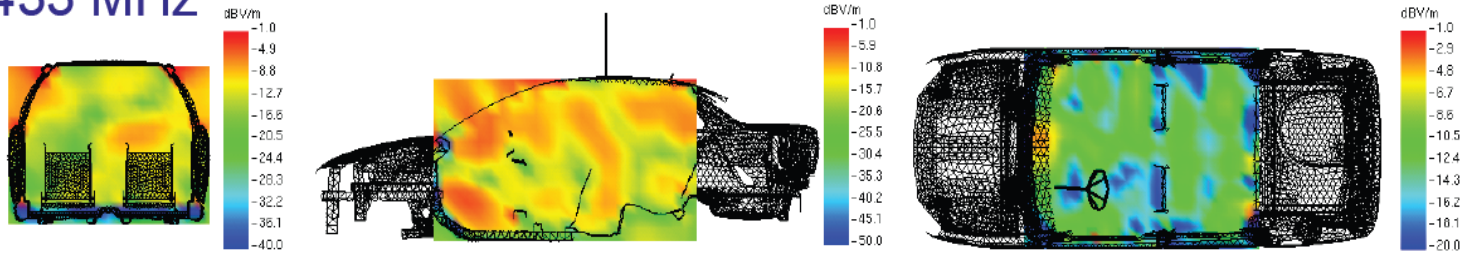


=> Requirement : Antennas has to be place in the same direction of the filed

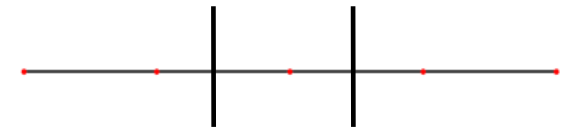
Antenna placement (2/2)

- inner a vehicle : presence of minima field and extrema field

433 MHz



No coupling



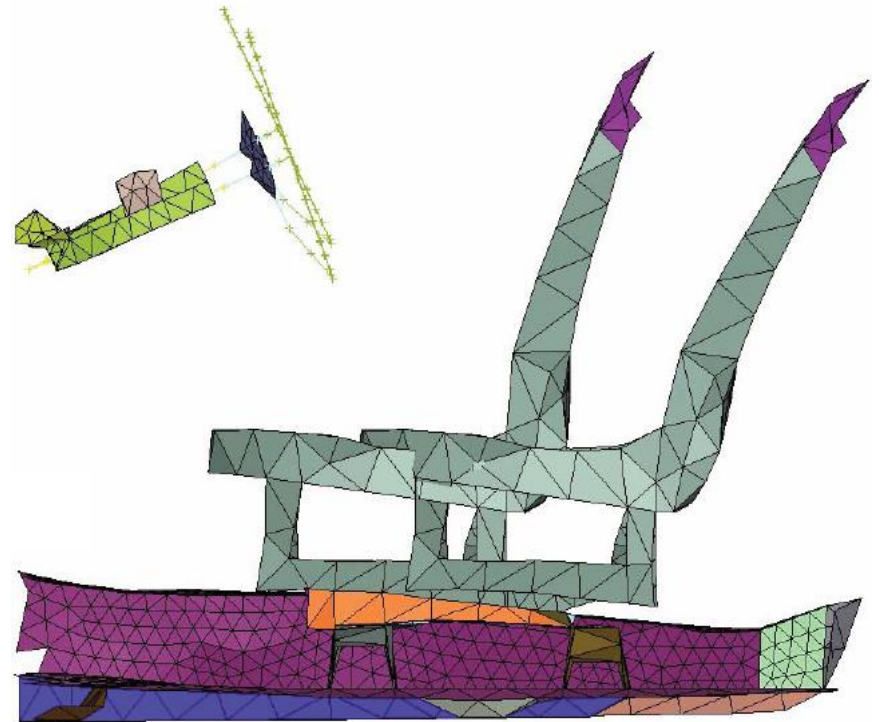
Maximum coupling

=> Identify the locations where the field is maximum

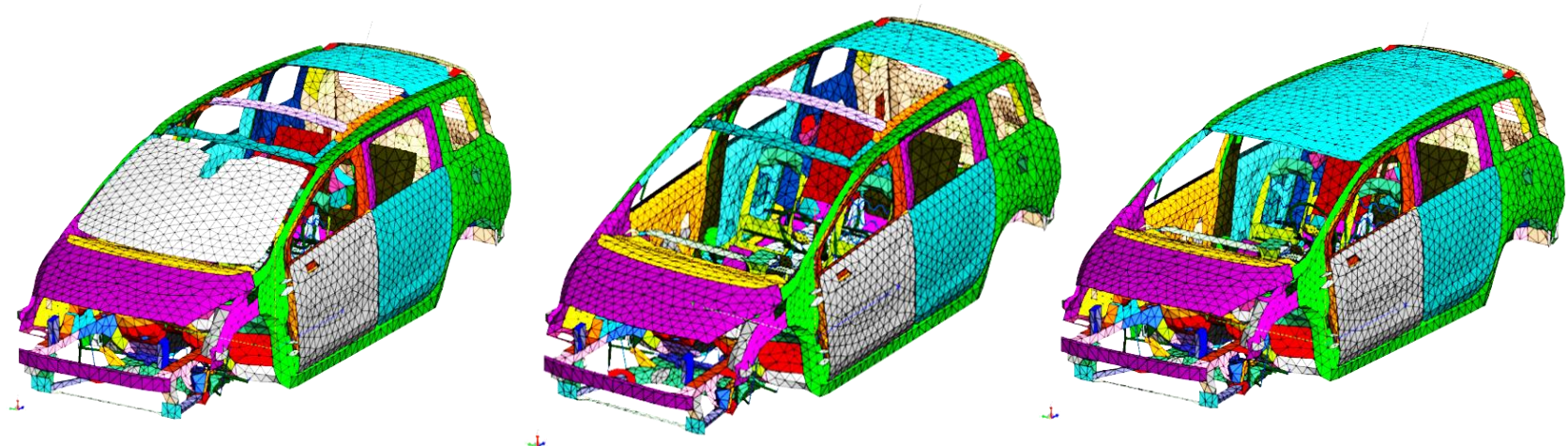
Validation plan for metallic part of the car

- 2 steering-wheel positions
- 2 drive seat positions
- 2 front passenger set positions

=> Overall, 8 cases covered



Validation plan for body car



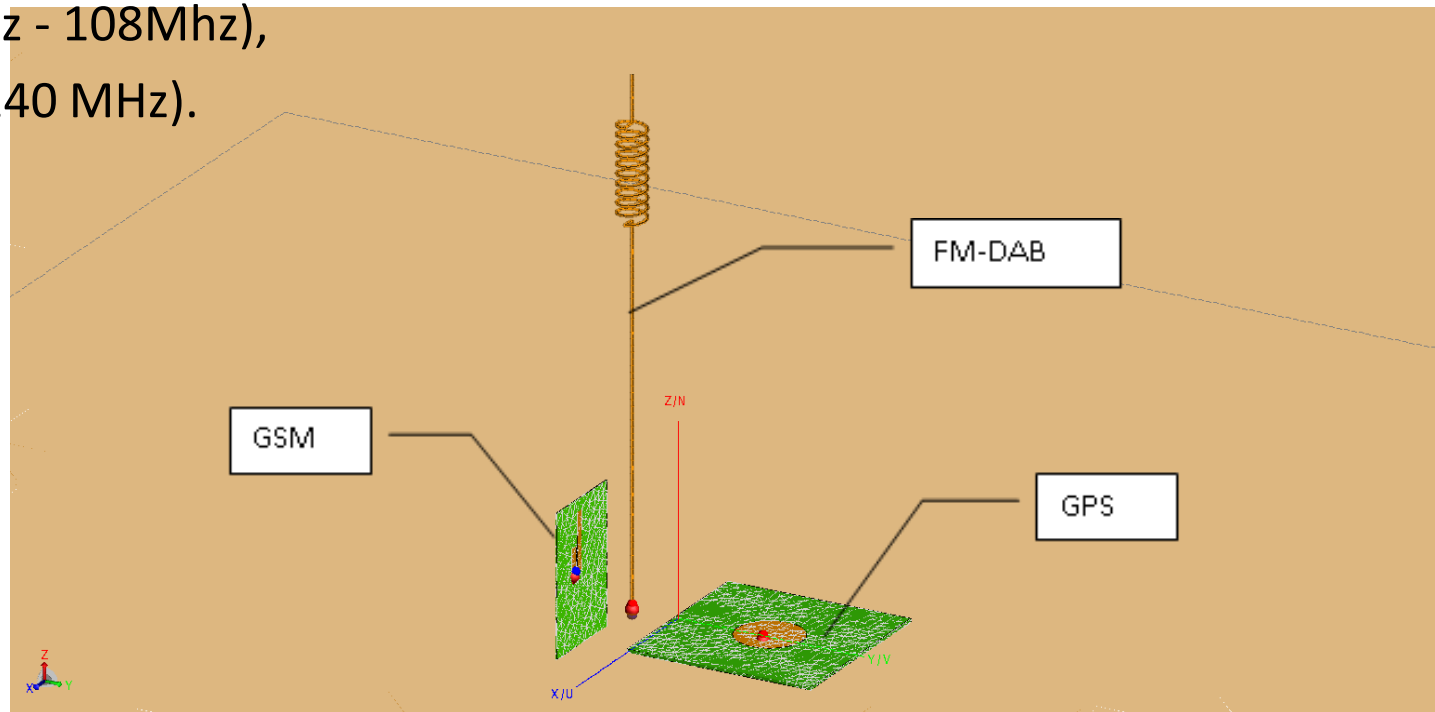
Conclusion

- Simulation are used
 - To predicate the performance of the antenna
 - As a decision support
 - To perform validation plan

**Example of application 2
multiband antenna**

Multiband antenna

- Problematic : Studying the performance of an antenna without knowing the CAO of the antenna.
- The different frequency range tested :
 - GPS (1575 MHz),
 - GSM (880-960, 1710-1880 MHz),
 - FM (88 MHz - 108MHz),
 - DAB (174-240 MHz).

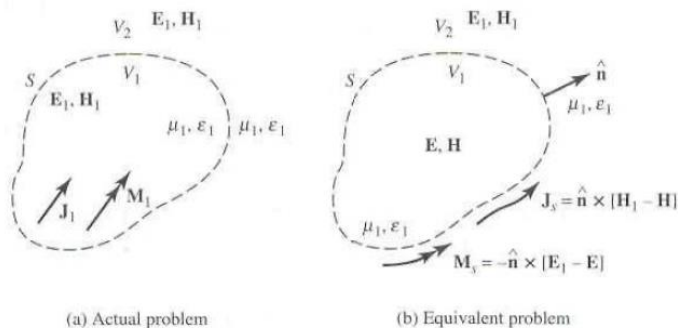


Configuration of tested antennas

Huygen's principle

“each point on a primary wavefront can be considered to be a new source of a secondary spherical wave and that a secondary wavefront can be constructed as the envelope of these secondary spherical waves”

a field in a lossy region is uniquely specified by the sources within the region plus the tangential components of the electric field over the boundary, or the former over part of the boundary and the latter over the rest of the boundary



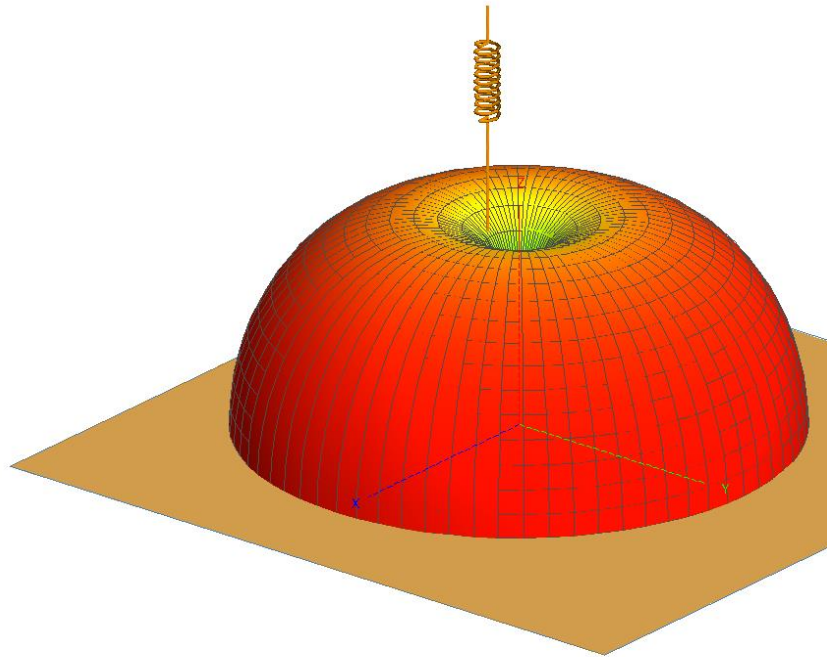
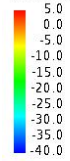
(a) J_1 and M_1 : radiation sources.
 E_1 and H_1 radiated field
 S : imaginary surface

(b) J_s and M_s : current electric and magnetic density on surface S

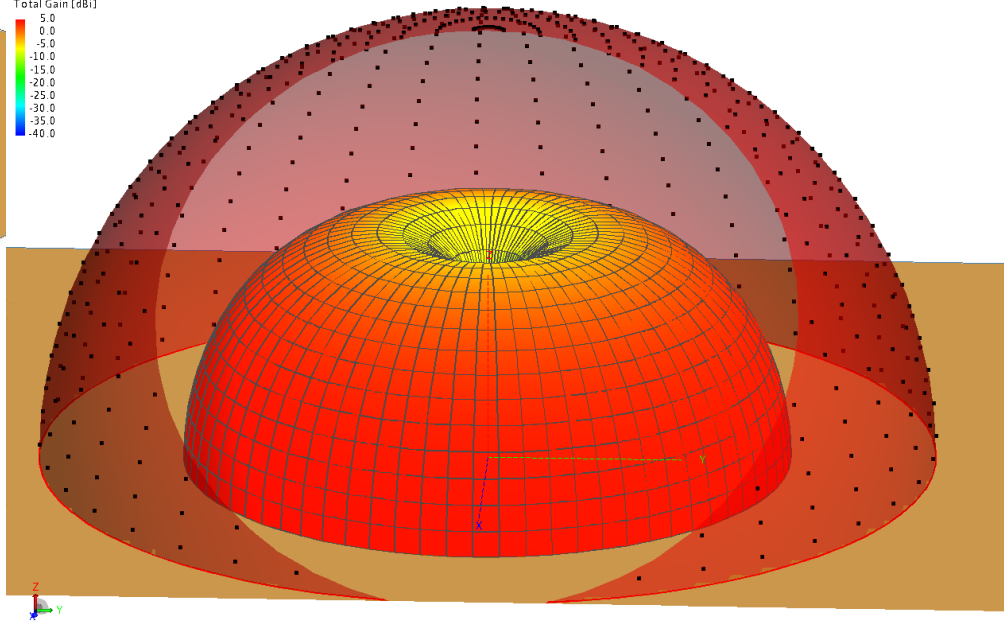
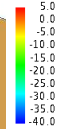
E_1 and H_1 can be calculated

Comparison of Radiation pattern at 90 MHz

Total Gain [dBi]

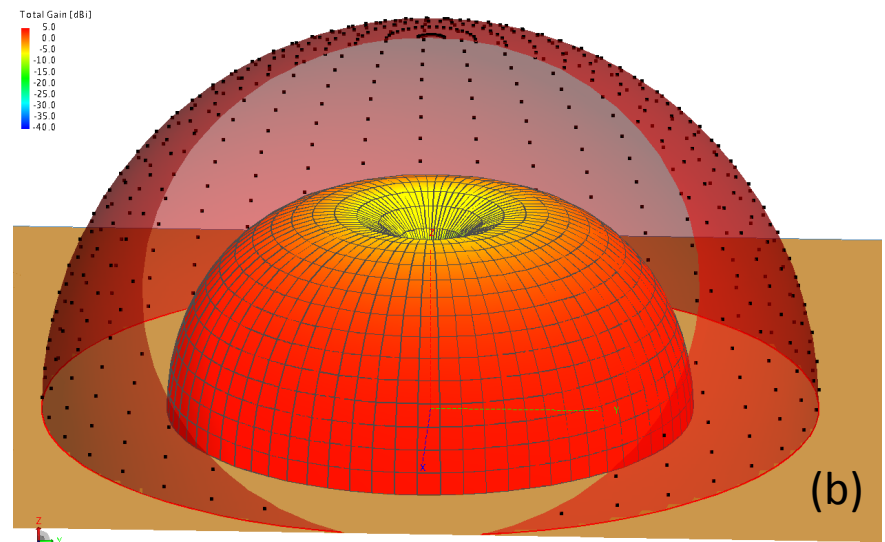
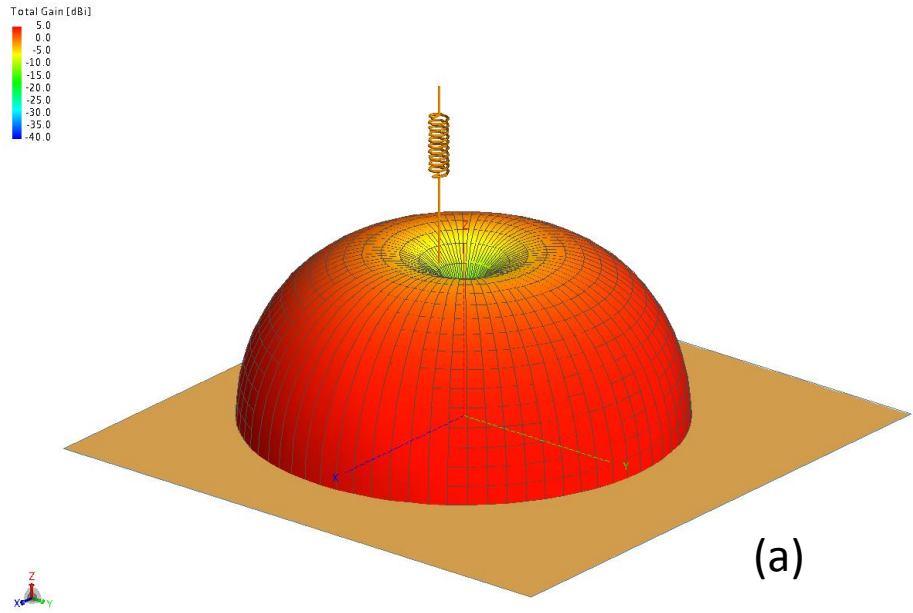


Total Gain [dBi]



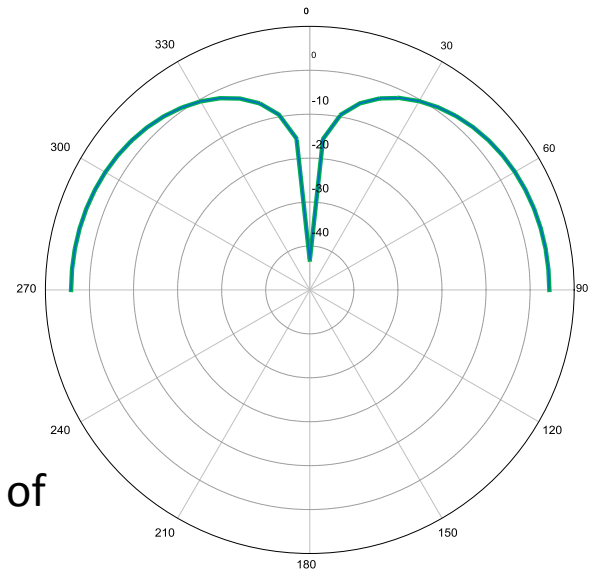
Radiation pattern of the model of the antennas at 90 MHz with the complete structure (a), and with the equivalent sources (b).

Comparison of Radiation pattern at 250 MHz



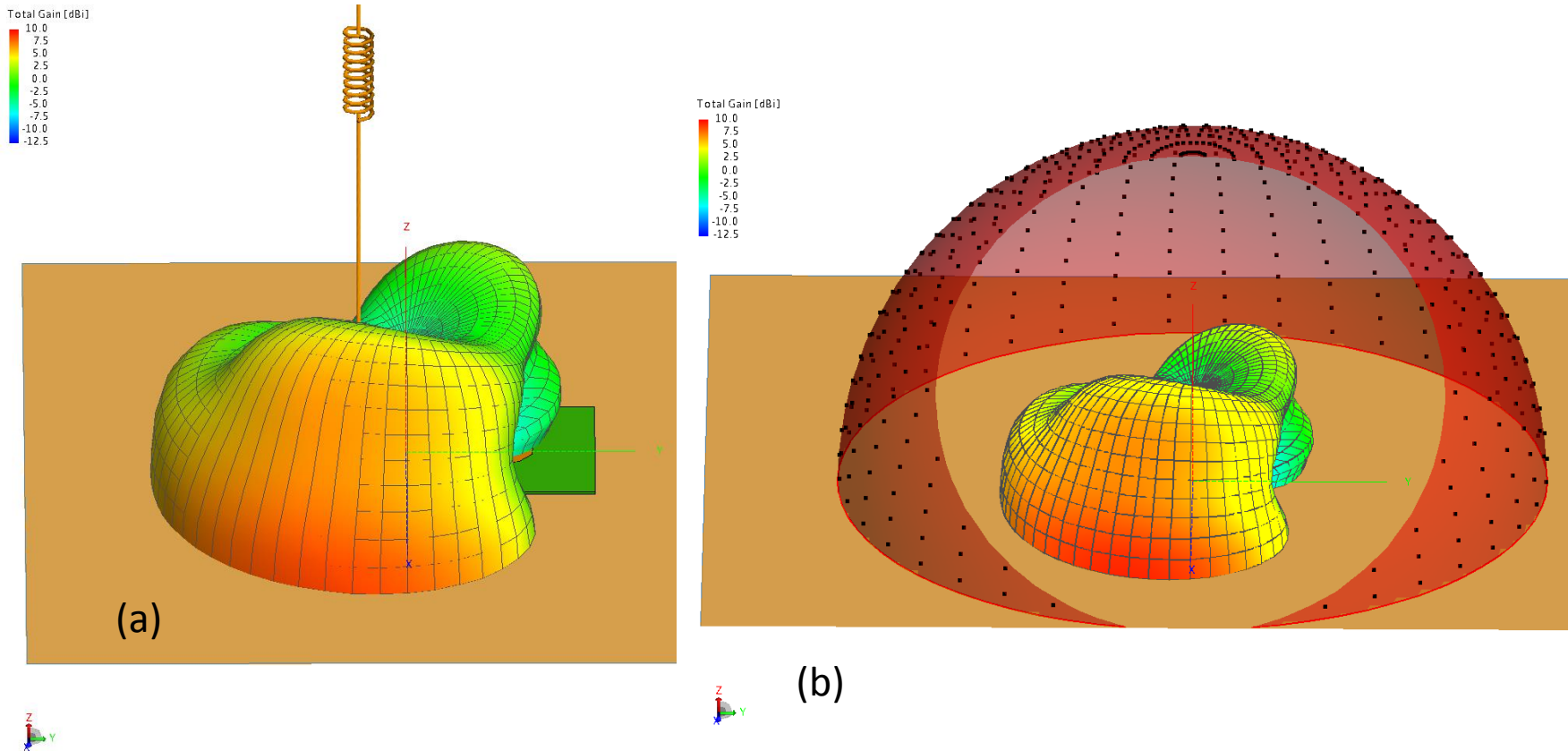
Radiation pattern of the model of the antennas at 205 MHz with the complete structure (a), and with the equivalent sources (b).

— FM_modele_equivalent_205_MHz — FM_extraction_donnee_205_MHz



Radiation pattern in 2D of the both models of the antennas at 205 MHz

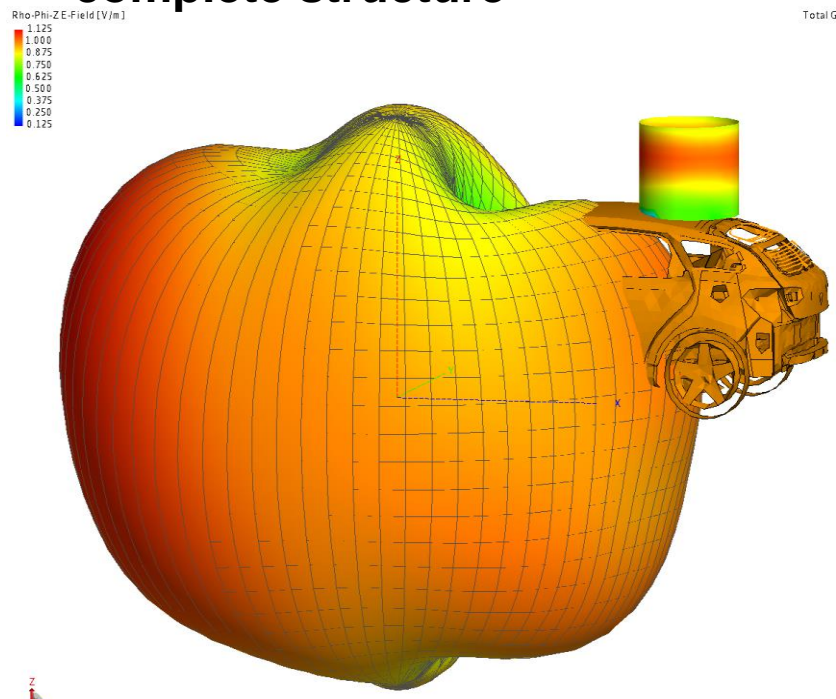
Radiation pattern at 800 MHz



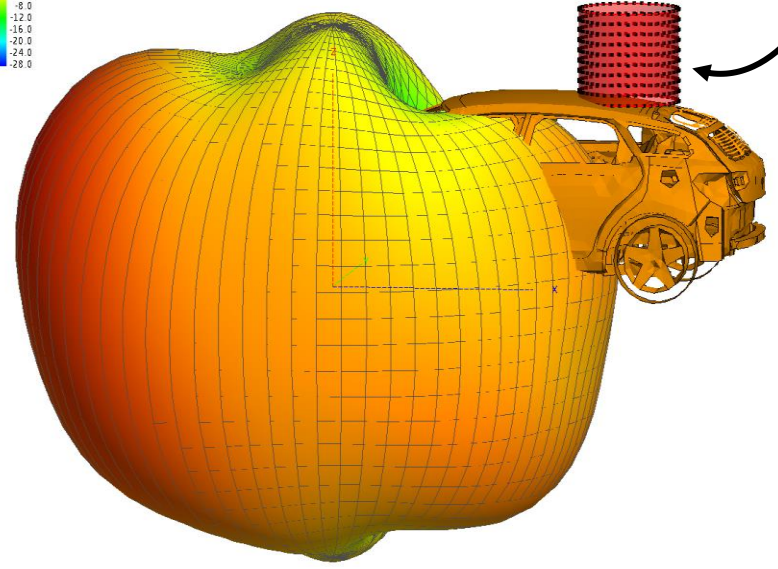
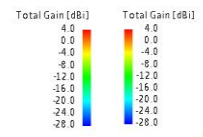
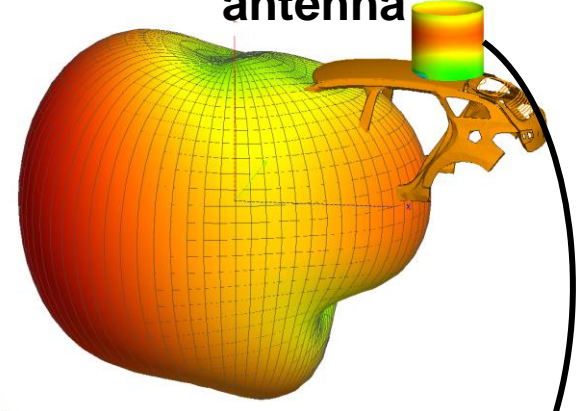
Radiation pattern of the model of the antennas at 800 MHz with the complete structure (a), and with the equivalent sources (b).

Simulation on vehicle

Radiation pattern of the model of the antennas at 80 MHz with the complete structure



Extraction of Field radiated by the antenna



Radiation pattern with equivalent sources

Conclusion

- Simulation with equivalent sources are used
 - To predicate the performance of the antenna without knowing the CAO of the antennas
 - To solve the multi-scale problems in a numerical simulation.
- Limits
 - antenna mismatch is unknown
 - Valid for specific cases