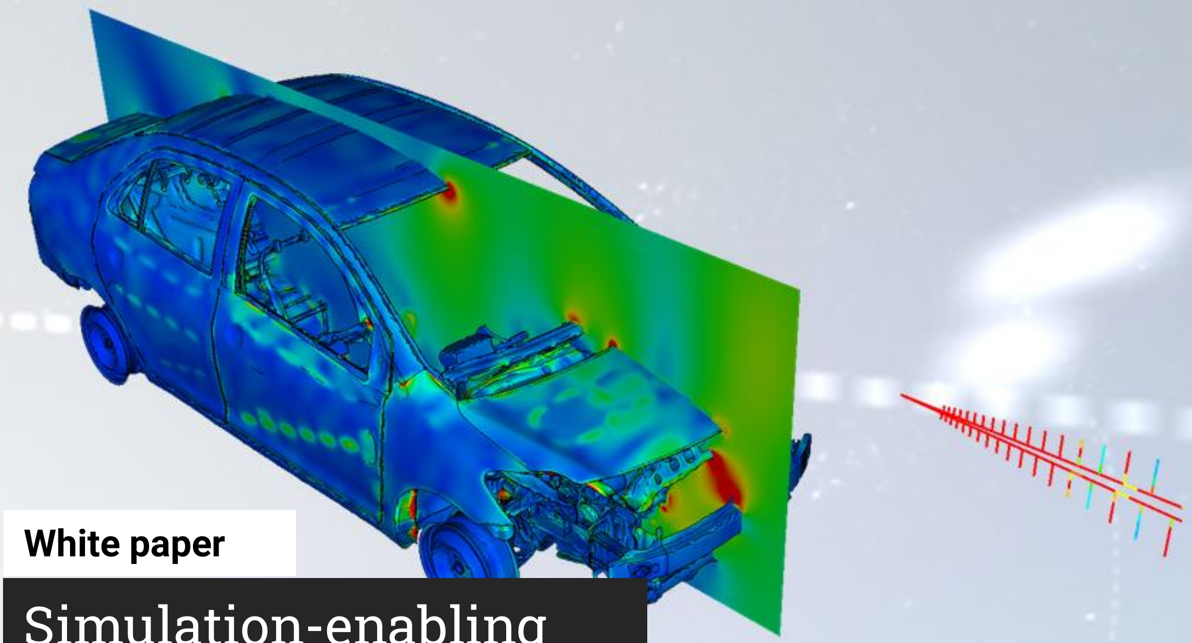
BETA SIMULATION SOLUTIONS

physics on screen



White paper

Simulation-enabling technologies

Electromagnetic compatibility simulations in the automotive sector

The communication of the vehicle with the surrounding environment, on-board automation, as well as navigational technologies are only a few amongst the recent capabilities enabled by the expanding use of electronic components in vehicles. This growing trend towards electric mobility and autonomous driving increases the demand for further electrification. To support this trend and to evaluate how all these components affect each other new simulation tools have been developed to enrich and support engineering simulation processes.

Introduction

To perform an electromagnetic (EM) simulation in an automotive scenario, several challenges need to be addressed. Such simulation models have significant differences compared to models used in contemporary structural simulations. Such a difference is the need to consider the conducting paths across the different metallic components. All metallic parts separated by a distance less than a threshold value need to be physically connected. As in most cases the parts are prepared in their mid-surface position, an extra gap between them is automatically created. This gap needs to be removed. All these gaps should be closed with FE elements. However, some elements are electrically isolated, and for this reason they should not be connected.

Another difference derives from the fact that the mesh length in an electromagnetic simulation need not be much finer than one tenth of the wavelength. Thus, a simplified model with a reduced mesh count adapted to the simulation frequency is required, something in contrast to the pre- processing aims in other CAE disciplines (structural, CFD, etc.), where finer meshes are needed for increased simulation accuracy.

The challenge that arises for the pre-processor is on the one hand to automatically detect and simplify the proximities in the model, and on the other hand to re-mesh the model to get the required mesh for the needed simulations, without generating intersections and avoiding over-simplification that might lead to unrealistic results.

Moreover, when running an electromagnetic simulation for Electromagnetic Compatibility (EMC), we need tools to help us evaluate the:

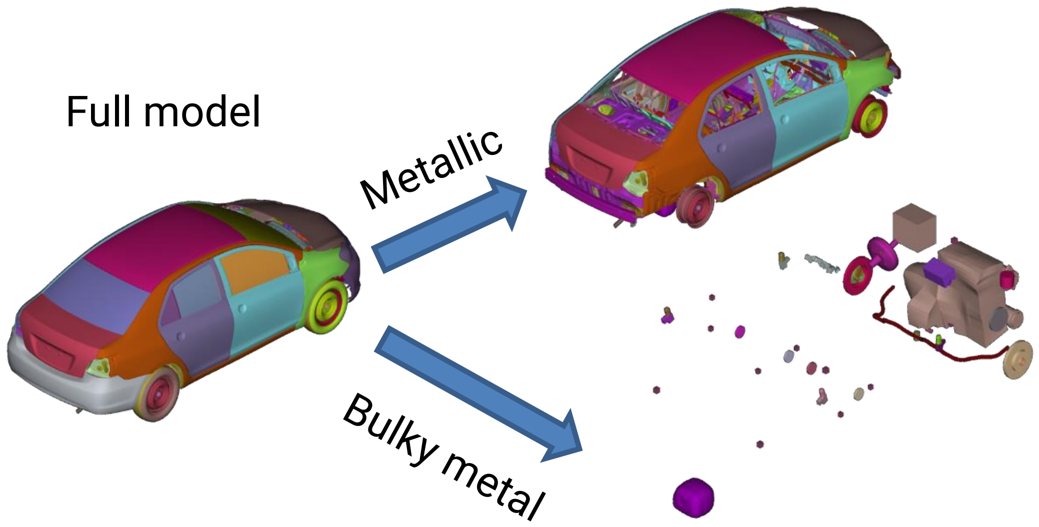
- Immunity, the effect of external radiation on car electronics
- Emissions, the radiation of car electronics into the environment
- Coupling, the cross-talk between different on-board electronic systems

What also needs to be addressed is that the use of different models for each simulation raises maintenance costs. This makes the application of the common model concept to convert an existing model to a ready-to-run electromagnetic model particularly important. In the context of the common model concept the FE-Model that has already been created for a structural analysis should be used as a basis for our electromagnetic simulation as well.

This white paper introduces the tools for the aforementioned issues, available in BETA CAE Systems software suite.

Isolation of Metal Parts

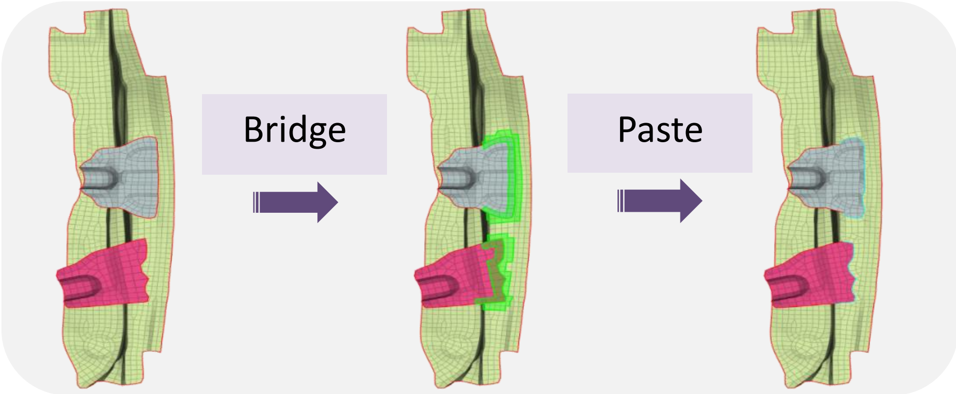
When converting an existing model to a ready-to-run electromagnetic model the engineer needs to identify the vehicle parts that contribute the main electromagnetic effects. For EMC simulations, mainly the conductive parts are considered. Such a tasks can be effortlessly performed in ANSA through the aid of various filtering options.



Connecting the model

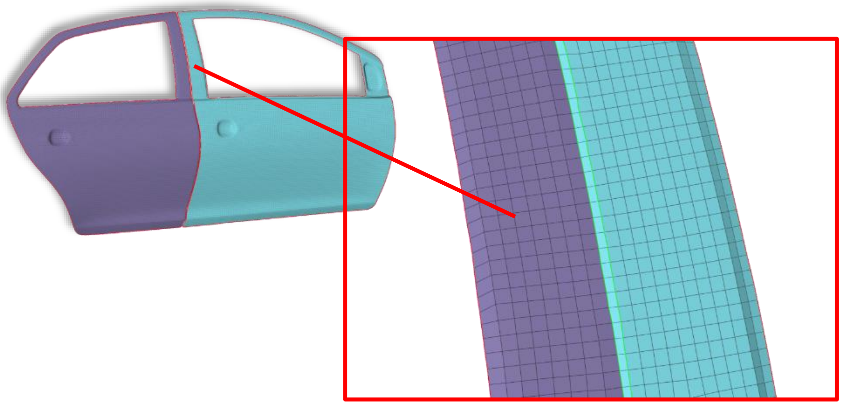
A main challenge during connecting the model is the identification of the proximities between different components of the model and the establishment of the electrical conductivity between these geometrical parts. In ANSA several tools exist to help with this procedure:

1. ***Bridge***
   Using the Bridge function the free edges that lie at a certain distance away from the neighboring components are automatically identified and projected on those parts. Consequently, these red edges are connected with the model using FE Elements.



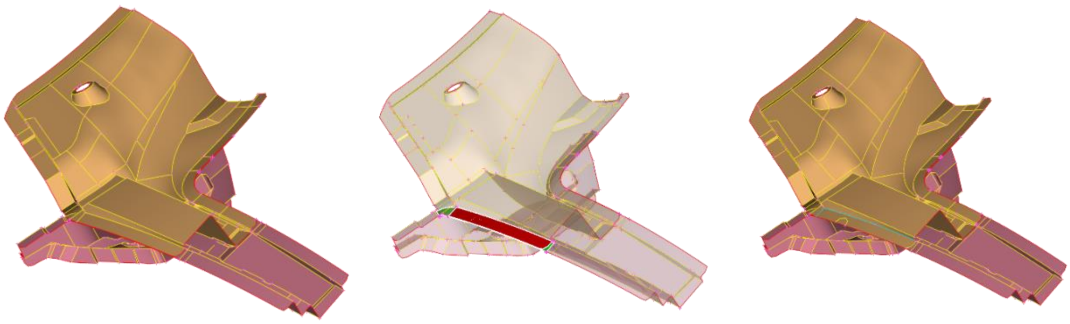
2. *Fill Gap*

When free edges do not have a projection to their neighboring components, openings cannot be closed using the Bridge function. For these areas the *Fill Gap* function can be used to connect the parts with ease.



3. *Connect Flange*

Models usually contain regions that act as connectivity areas (i.e. flanges). ANSA can automatically identify and connect them.



Remeshing the model

To use the model for the requested EM simulation an element length that corresponds to some fraction of the wavelength is required. Remeshing techniques in ANSA can create the needed model with ease. In most cases, we cannot use a coarse mesh on the whole model, since there are elements connecting parts with a smaller gap, and since geometry features might need smaller element lengths to be adequately captured. Using the Batch Mesh with different meshing scenarios we can assign different element sizes to different areas of the model.
Moreover, it is important to note that discontinuities in the element size can lead to penetration of neighboring parts. ANSA detects such regions and provides several ways to fix them automatically.

Electromagnetic compatibility in the automotive sector

The various Electromagnetic compatibility issues that a vehicle faces can be classified into one of the following categories:

1. ***Electromagnetic immunity***: How sensitive is the behavior of the onboard electronics to external EM radiation?
2. ***Electromagnetic emissions***: What is the intensity level of the EM radiation emitted by the onboard electronics into the environment?
3. ***Electromagnetic interference (EMI)***: How strong is the unintended wireless coupling (crosstalk) between different onboard electronic systems and communication channels?

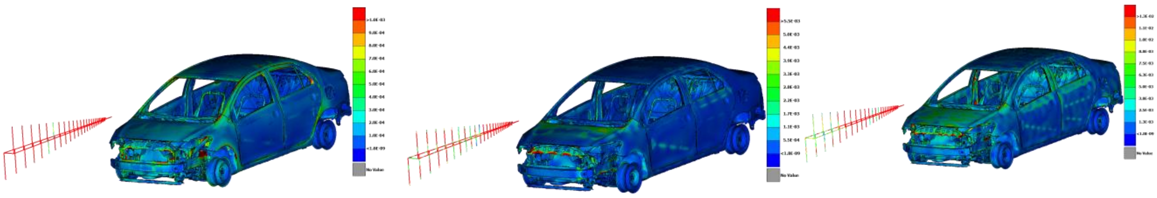
To answer these questions, electromagnetic simulations of the vehicle (or parts thereof) have to be performed. To prepare such analyses, a fully operational interface within ANSA for the ASERIS-BE™ solver has been created. Combined with the results display capabilities of the META post- processor Electromagnetic simulations are fully streamlined.

Examples of simulation cases that the ANSA, ASERIS-BE™, META toolchain enables are the following:

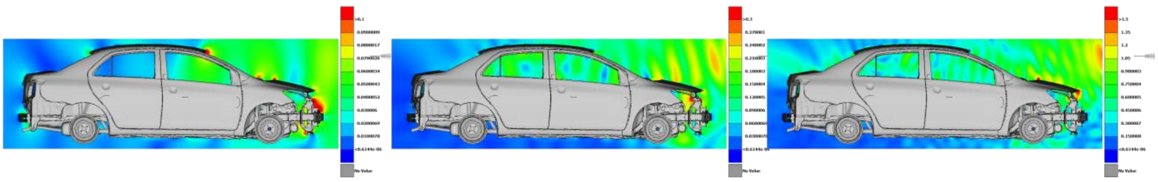
1. The EM immunity of a full vehicle in a realistic EMC testbed scenario.
2. The crosstalk (EMI) between an onboard Ethernet cable and the FM antennas of a vehicle.

EM immunity simulation

In this case a full vehicle model is irradiated by a broadband (log-periodic) antenna (outside the vehicle) in the frequency range 200MHz-1GHz. The boundary conditions of the simulation are set up to emulate an immunity test in an EMC chamber. The ground on which the vehicle rests is assigned to be a perfectly conducting infinite plane, while the radiation condition satisfied by the BEM method ensures that there are no reflections of the incoming and scattered radiation from the chamber's walls. Thus the chamber walls were not included in the simulation. The induced surface currents and the near fields inside and outside the vehicle were calculated by the post-processing modules of ASERIS-BE™ at three discrete frequencies (200MHz, 600MHz, 1GHz). The results are shown in the figures below:



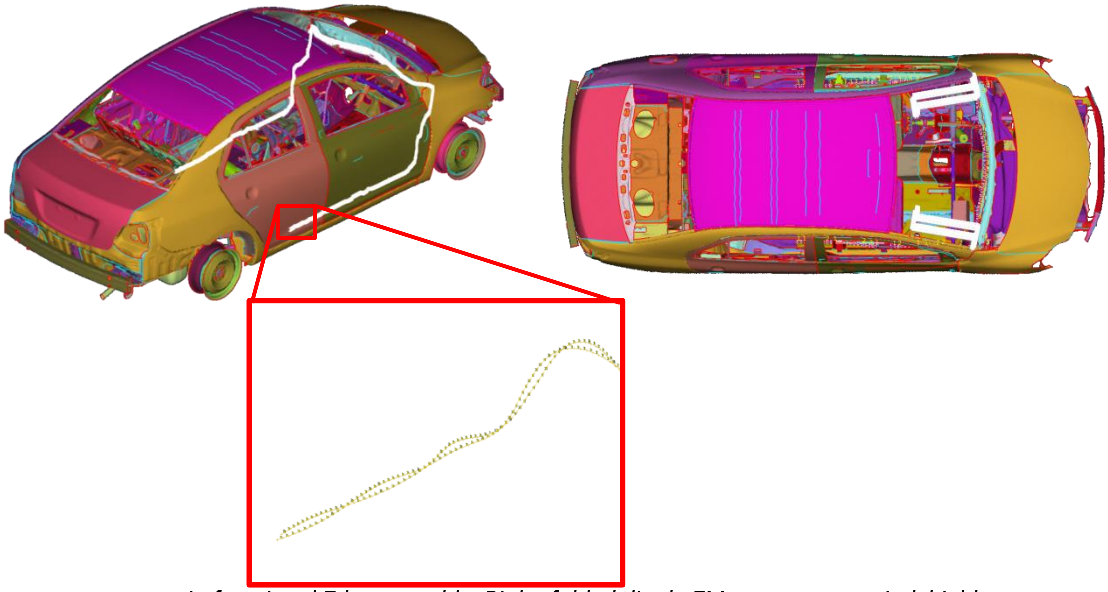
Surface currents induced by a log-periodic antenna on the metallic body of a car (left: 200MHz, middle: 600MHz, right: 1GHz)



Near electric fields induced by a log-periodic antenna inside and outside of a car(left: 200MHz, middle: 600MHz, right: 1GHz)

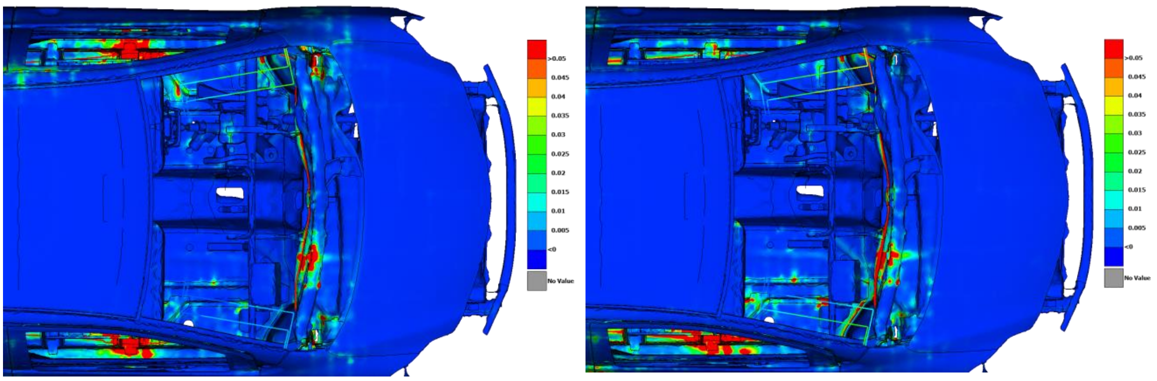
Crosstalk simulation

This case simulates the electromagnetic interference (EMI) of an Ethernet cable on the FM antennas of a car. The FE model of the car is identical to the one in the previous scenario (immunity) with two additions, namely a twisted-pair beam model for the Ethernet cable and a single-wire beam model for the two FM antennas. The Ethernet cable was routed from the left back door via the dashboard to the right back door of the car, while the FM antennas (folded half-wave dipoles) were placed on the windshield (see figure below):



Left: twisted Ethernet cable. Right: folded dipole FM antennas on windshield

The purpose of this simulation is to estimate the effect of the parasitic radiation of the Ethernet cable on the FM antennas. For this purpose the cable is excited at one of its endpoints, and the induced currents on the whole car model, including the antennas, are calculated. Two sub-cases were examined, namely the floating ground and the common ground. In the first case neither the antennas nor the Ethernet cable are grounded on the car chassis, while in the second case they are both connected to the metal car body. This simulation is conducted at 100MHz and the results can be seen in the picture below:



Left: induced currents for floating ground. Right: induced currents for common ground.

The results of this simulation show that in the case of floating ground the induced currents on the FM antenna are 44dB lower than on the active Ethernet cable. This is generally considered more than adequate isolation. In the case of common ground the isolation between the two systems decreases to 26dB. This is expected, as the common ground provides alternative conducting paths for the Ethernet signal to influence the antennas (conducted emissions).

Conclusion

The domain of EM simulations in the automotive sector presents significant modeling and computational challenges, while its importance is steadily increasing in the current technological landscape of advancing electrification and automation of vehicles. BETA CAE provides powerful and versatile tools to address these challenges. The ANSA pre-processor can be used to convert existing / legacy FE models from other physical disciplines, such as crash, into FE models suitable for electromagnetic simulations. This procedure can significantly cut down modeling costs and increase the interdisciplinary collaboration of CAE teams across the complete modeling workflow of a vehicle. The fact that ANSA is solver-agnostic is a great advantage, since the resulting FE model can be coupled to a wide variety of commercial EM solvers. In addition, BETA CAE also offers a fully streamlined EM simulation workflow with the seamless interfacing of the ASERIS-BE™ solver with ANSA and META.

About BETA CAE Systems International AG

BETA is a simulation solutions provider, dedicated to the development of state-of-the-art software systems for CAE. For almost 30 years, we have been developing tools and delivering services for the front-runners in numerous sectors by listening to their needs and taking up even the most demanding challenges. For more information on BETA CAE systems, our products, and our services, visit www.beta-cae.com

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