Optimizing Antenna Safety and Performance During Platform Integration

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Simulation-based assessments are fast, cost-effective, and ensure success.

Introduction

Successful integration of an antenna onto a vehicle platform poses many challenges. Vehicle features impact antenna performance by blocking, reflecting or reradiating energy, and co-site interference can impair the effectiveness of multi-antenna configurations. Platform motion and environmental factors such as terrain and buildings may reduce system effectiveness in actual operational conditions. Furthermore, radiation hazards may pose risks to nearby personnel. Modeling and simulation provides a powerful tool to aid in understanding these issues and developing solutions.

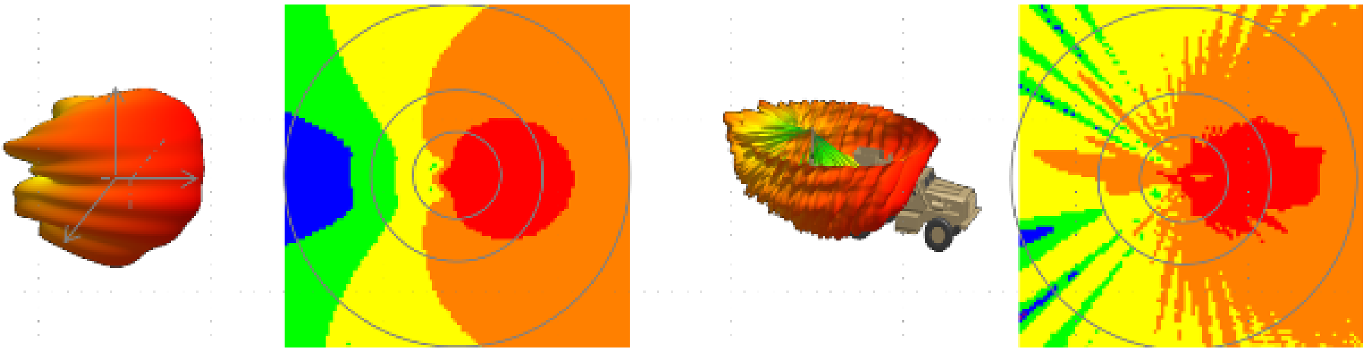
The key benefit of simulation-based assessment is that it is relatively fast and cost-effective compared to physical system modification and measurement. Modeling and simulation can assess options and tradeoffs in order to select a small number of planned approaches well before any physical testing occurs. This approach reduces the risk of encountering problems that require retesting, costly redesign or introduce dangerous in-theater behavior.

A comprehensive modeling and simulation toolset allows an organization to overcome these challenges by being able to simulate any number of conditions, identify and resolve key issues, and reserve the use of physical measurements to confirm successful pre-test, simulation-based assessments. This article provides a variety of examples of simulation-based assessments used to analyze antenna performance, identify problems, and evaluate potential solutions.

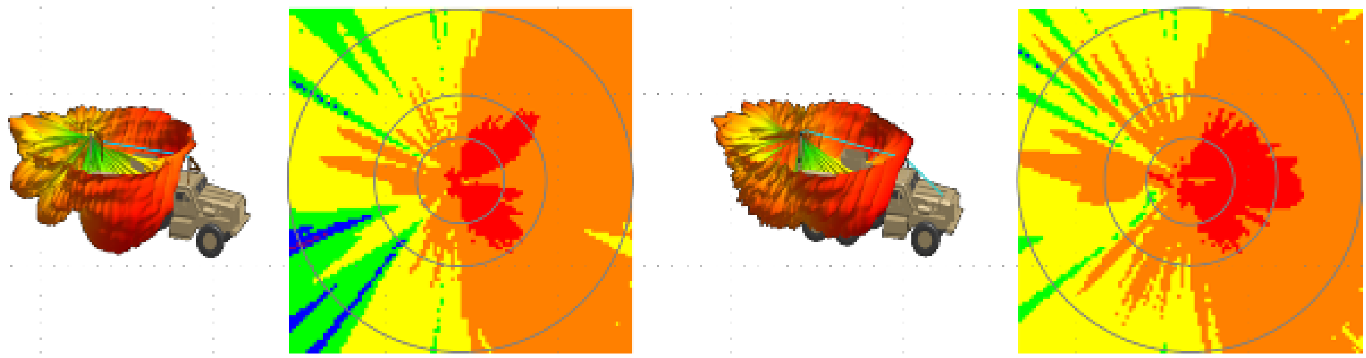
Assessing Performance of Antennas When Integrated on Vehicle Platforms

High-fidelity electromagnetic solvers predict the performance of an antenna, including effects introduced by the features of a vehicle on which it is mounted. Figure 1 shows a series of results from simulations that were performed by the U.S. Army Communications-Electronics Research, Development, and Engineering Center (CERDEC) using Remcom’s XFdtd® software and an in-house ray-tracing tool. Figure 1(a) depicts the radiation pattern simulated in free space without any vehicle or other obstruction to perturb the pattern. Figure 1(b) shows the radiation pattern once the antenna has been mounted on a vehicle.

The next two images illustrate how in-theater modifications complicate antenna performance. Figure 1(c) displays the pattern after modifying the vehicle with the addition of an Overhead Wire Mitigation kit (OWM) using a metallic post. The impact is significant. A null forms in the main lobe reducing antenna gain forward of the vehicle. Replacing the metal post with a fiberglass rod, as shown in Figure 1(d), significantly improves performance with the return of strong gain in the forward direction.



(a) Antenna radiation in free space (no vehicle) and **(b)** Antenna radiation, mounted on vehicle

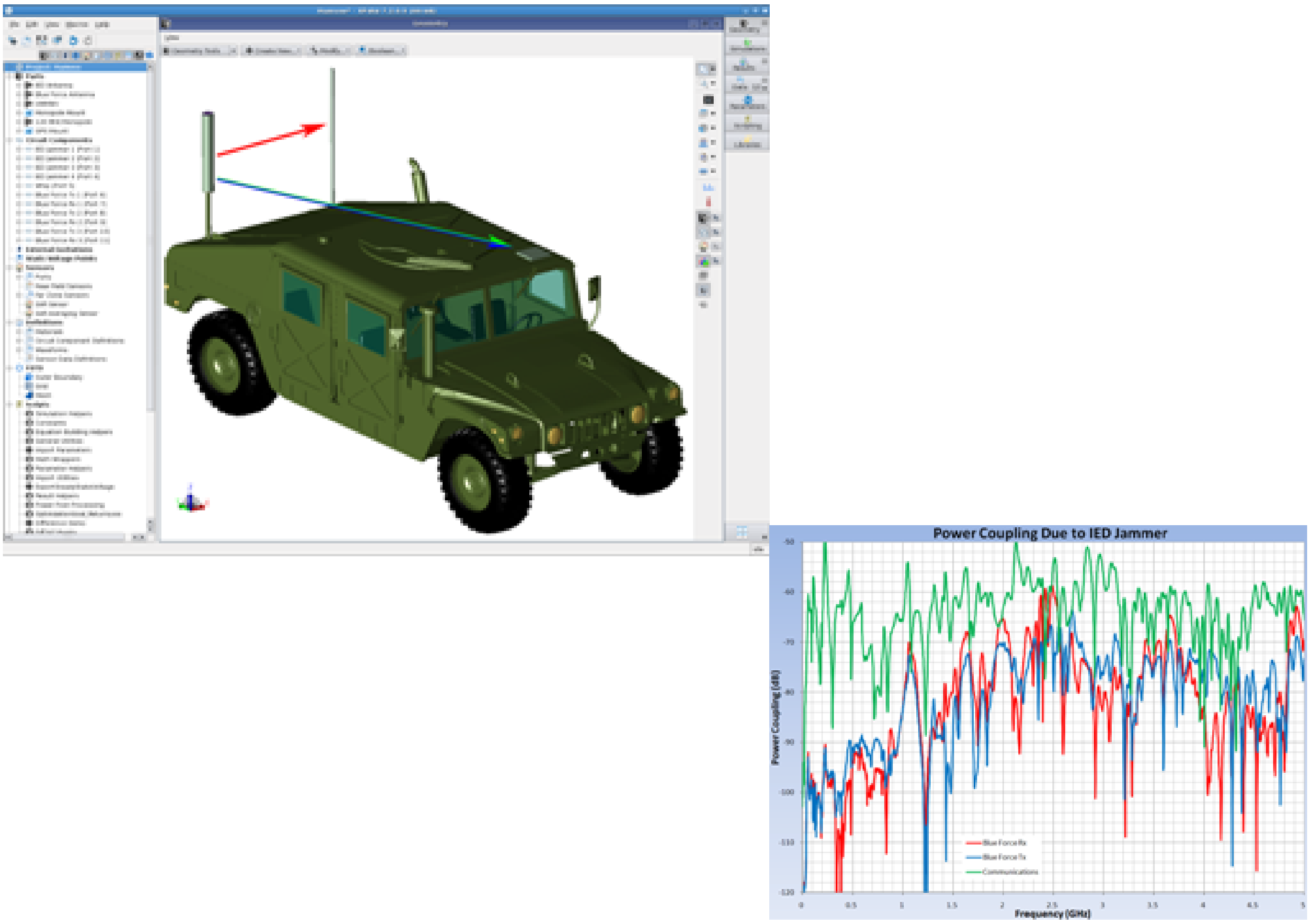


(c) Antenna radiation with metallic post OWM and **(d)** Antenna radiation with fiberglass rod OWM
Content Courtesy of US ARMY CERDEC

Assessing Co-Site Interference Between Multiple Antennas

Military vehicles commonly incorporate several antenna systems in close proximity. Interference between these systems can cause problems with simultaneous operation. As a first step in understanding the impact, the power coupling between each transmitting and receiving antenna must be assessed. This is typically done by simulating or measuring the power received at each installed antenna from every transmitting antenna. In the case of arrays, these transmitted and received powers must be summed appropriately in order to represent the real signals observed at the array's input port.

Figure 2 presents the results of an XFdtd simulation assessing power coupling between three conceptual antennas mounted on a HMMWV, as shown in Figure 2(a). A directional jammer antenna is modeled as an array mounted on the rear right of the vehicle. Power coupling is simulated from this antenna to three other antennas: a monopole communications antenna mounted on the rear left of the vehicle and a flat patch array on the front left roof that includes transmit and receive antenna arrays for satellite communication. Figure 2(b) shows the broadband power coupling from the jammer to each of the other antennas, with plot colors matching the arrows in the vehicle display.

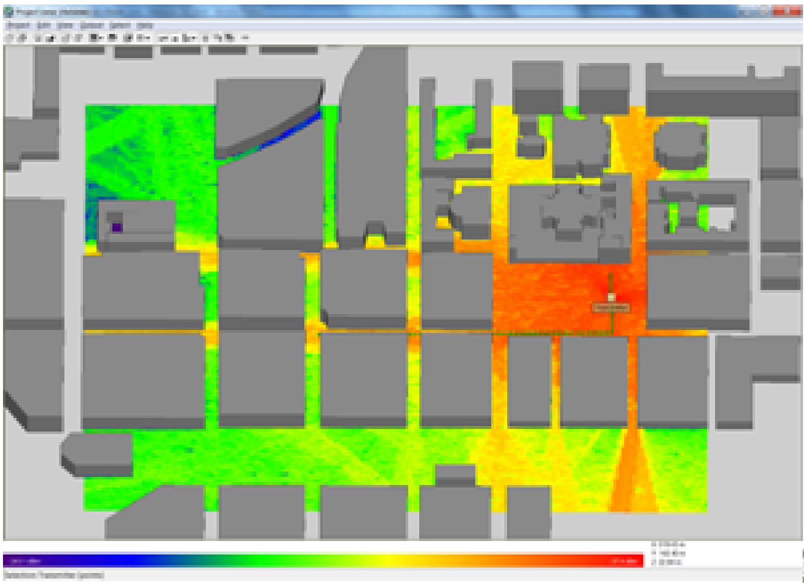


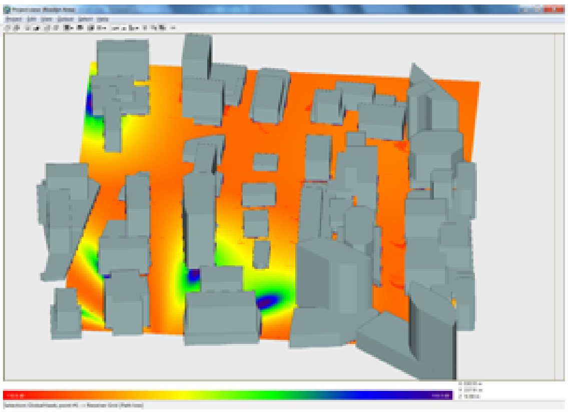
(a) Antenna locations and **(b)** Power coupling between antennas

Assessing the Impact of the Environment on Antenna Performance

The environment plays an important role in antenna performance. The presence of a dielectric ground plane in the near field of the antenna will alter radiation performance. As fields propagate to the far zone, interactions with the ground and structures cause interference due to multipath, which leads to constructive or destructive interference and shadowing. Nowhere is this interference more evident than in dense urban scenarios, where the specific layouts of buildings can become the single most dominant factor in the propagation of fields within the environment.

Figure 3 demonstrates the multipath effects of buildings in an urban environment for two different scenarios, modeled within Remcom's Wireless InSite®. Figure 3(a) shows received power from a transmitting antenna mounted on a HMMWV as it drives along a route through a city. Figure 3(b) presents the path loss for the array antenna on a Global Hawk as it flies high above the lower-left corner of the urban scene in the image. Both images assist in planning the operational use of the systems.





(a) Received power from antenna mounted on HMMWV at one position along a street route and **(b)** Path loss from system on Global Hawk to urban area below

Assessing Potential Radiation Hazards to Personnel

When alternative systems and locations for mounting system antennas are being considered, one key factor must include consideration of the potential risk of radiation exposure to personnel. Figure 4 displays the magnitude of the electric fields that XFdtd predicts will enter the cabin of a HMMWV, mostly through its windows, from an antenna mounted on the roof. At a more detailed level, it is also possible to use the FDTD method to estimate specific absorption rate (SAR) for a person modeled as sitting within the vehicle or standing nearby; however, field levels over time (as shown in the figure) are the usual metric for a radiation hazard assessment within the DOD.

Figure 4: Assessment of fields and potential radiation hazard to driver and passengers using XFdtd

Simulations can quickly determine the potential for an on-platform system to exceed the MPE. Any identified risks can then be addressed with alternative configurations or approaches for limiting exposure to personnel.

Conclusion

There are a number of critical issues to consider when integrating an antenna onto a vehicle platform, particularly when the intended use is for military operations. This article provides a number of examples, including assessment of the impact of vehicle features on radiation, co-site interference from multi-antenna systems, and environmental obstructions to propagation, as well as analysis of potential radiation hazards. A variety of electromagnetic modeling solutions exist for analyzing various parts of the problem; by using these tools for simulation-based assessment prior to final antenna integration and field testing, an organization can identify key issues and develop mitigation approaches cost-effectively. In this sense, modeling and simulation becomes one more tool to help ensure success when the system is finally deployed in the field.

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