Success Story

Surrogate Models for Antenna Placement on Large Platforms

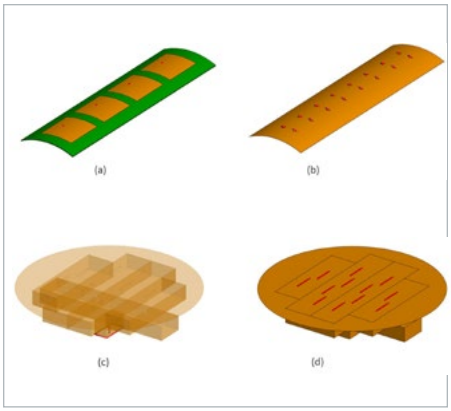

Figure 1: (a) A conformal patch antenna array and (c) a slotted waveguide antenna and their respective surrogate models in (b) and (d) built with FEKO.

Institute of High Performance Computing
A*STAR

Key Highlights

Industry

Aerospace, Defense

Challenge

Antenna placement for electrically large platforms.

Altair Solution

FEKO

Benefits

- Efficient electromagnetic solvers, combined with optimization
- Surrogate antenna model approach
- True hybridization of solvers offers accurate, efficient solution for antenna placement on electrically large platforms.

Background

Established in 1998, the Institute of High Performance Computing (IHPC) is a Research Institute under the Agency for Science, Technology and Research (A*STAR). IHPC seeks to power discoveries through advanced methodologies, techniques and new tools in modelling, simulation and visualization. The RF engineering group develops advanced computational electromagnetics and multiphysics algorithms and tools, leverages vast know-how in electromagnetic compatibility (EMC) for a wide range of applications covering both small-scale and large scale problems, such as high-speed electronics, urban and space EMC.

Numerous impactful projects have been delivered in collaboration with companies and government agencies both local and overseas, such as with MNCs on the mitigation of electromagnetic interference, and with consortium members on efficient EMC tools for aerospace applications. The Institute provides solutions and customized designs for customers, where both in-house tools and commercial software are used.

The Challenge

IHPC is driven by the ever-increasingly complex electromagnetic (EM) system and environment to develop cost-effective and innovative approaches for modelling, diagnosing and finally solving EMC problems. Typical challenges include, but are not limited to

- Electrically-large and multi-scale EM problems such as the antenna placement on large platforms
- Multiphysics problems such as the electrical-thermal-mechanical analysis of composite materials

Complementary to the measurement, simulation is playing an ever-increasing instrumental role in product development. At the Institute, simulation is adopted in every respect from pre-study, through design optimization and final validation. In solving above-mentioned electrically large radiation problems, besides developing in-house simulation tools, the institute also uses software like FEKO.

Keywords: Antenna design, surrogate, antenna placement, electrically large platform, hybridization, FEKO

Antenna Research Group Success Story

"Simulation is playing an instrumental role in product development. At our Institute, simulation is adopted in every respect from pre-study, through design optimization and final validation."

Si-Ping Gao
Scientist II, IHPC, A*STAR

For example, in a project that dealt with electrically large platforms, an efficient modelling tool was required to identify optimum antenna positions and minimize interference between various antennas

There were basically two challenges:

1. The geometric model of a proprietary antenna was difficult to obtain from the vendor, so a surrogate model had to be developed [1 - 4] to represent it in the antenna placement simulations on the platform
2. The antenna-on-platform problem is both electrically-large and multi-scale, and can no longer be practically solved with a full-wave only method. A hybrid approach that combines full-wave and asymptotic methods is ideal for simulation of such scenarios

The Solution

The team successfully developed surrogate models to represent a patch array and slotted waveguide antenna (see Figure 1) based on the phaseless radiation pattern information, usually available in the antenna data sheet. The surrogate models represent the radiation and scattering performance of the original antennas. During the development, the accurate full-wave simulation of FEKO was used to reveal the current distribution on the antenna, which is crucial to identifying the currents that have been the main contribution to the radiation. The design parameters of the surrogate models were determined by exploiting FEKO's powerful optimization function.

Once an accurate surrogate model is available, it is mounted on platforms at various locations to compute and compare the installed radiation pattern. For electrically large platforms, FEKO's hybridized solvers are essential. For example, an area around (and including) the antenna can be solved with MoM/MLFMM, while the remaining platform geometry is solved simultaneously with PO, LE-PO or RL-GO. This true hybridization approach implies that coupling of currents between the antenna region and the platform is inherently captured, ensuring both an accurate and an efficient solution.

The constructed surrogate model is mounted on an aerial vehicle (Figure 2) to validate its capability of representing the original patch antenna array. Figure 3 shows the radiation patterns of the patch antenna array and its surrogate model computed. The good agreement proves the surrogate model's capability.

Figure 4 shows another example of an antenna mounted on an airframe platform, using the surrogate antenna approach. The FEKO simulation results are validated with an in-house code that was developed at IHPC.

Reference

- [1] S.-P. Gao, B. Wang, H. Zhao, W.-J. Zhao, and C. Png, "Installed radiation pattern of patch antennas: Prediction based on a novel equivalent model," IEEE Antennas Propag. Mag., vol. 57, pp. 81–94, June 2015.
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- [3] S.-P. Gao, H. Zhao, B. Wang, W.-J. Zhao, "Analysis of slotted waveguide antenna on large platforms using an equivalent model," Proc. of URSI GASS, Beijing, China, Aug 16-23, 2014.
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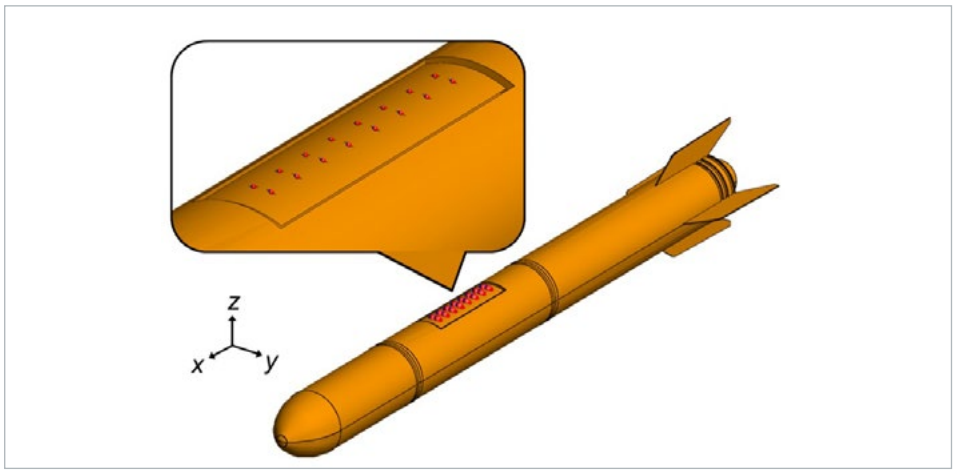

Figure 2: Deployment of the surrogate model on an aerial vehicle, 15.5 wavelengths long.

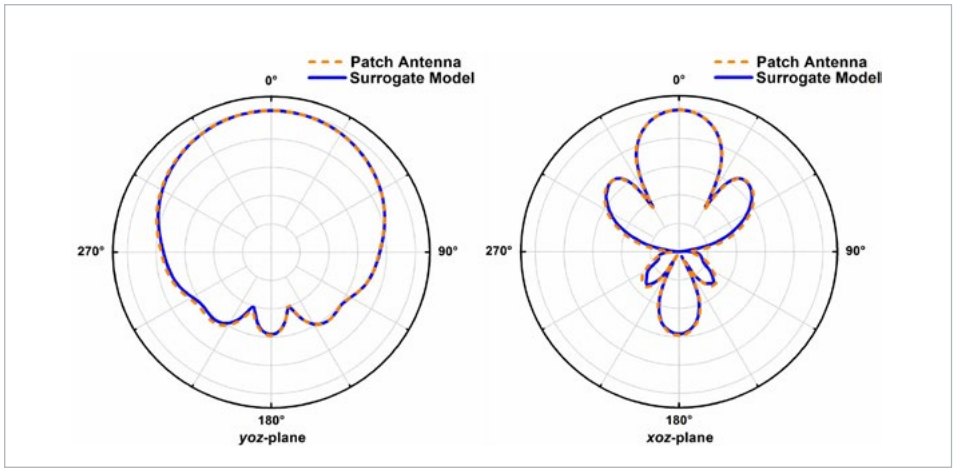

Figure 3: Installed radiation patterns of the patch antenna array and its surrogate model on an aerial vehicle.

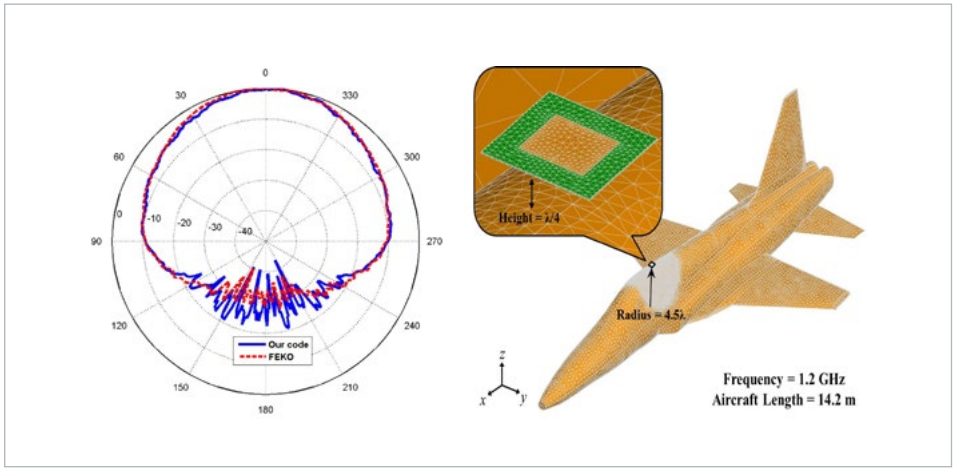

Figure 4: The radiation of a patch antenna above an aircraft, where FEKO's hybrid MoM and LEPO solver were used to solve the structure. Great agreement between iHPC code and the FEKO results was obtained

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