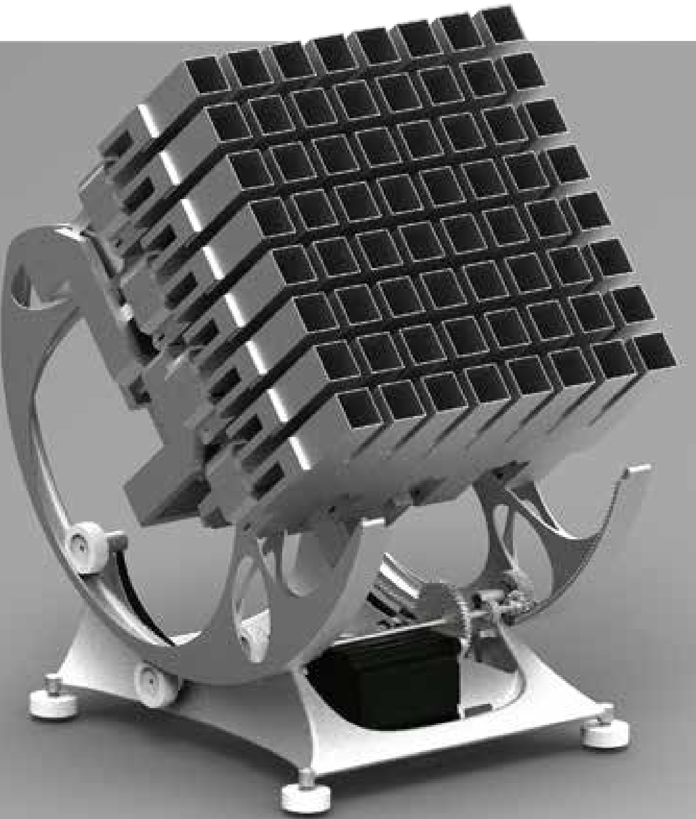
Tuning in to Antenna Design



By **Michael Hollenbeck**,
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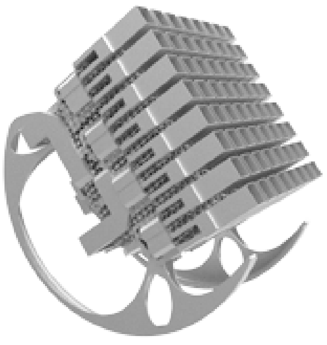
Using engineering simulation, big compute and 3-D printing, Optisys achieves orders-of-magnitude reduction in antenna size and weight while reducing development time. By leveraging ANSYS electromagnetic and structural simulation tools running on Rescale's big compute platform, this startup's engineers take full advantage of the design freedom offered by 3-D printing to meet radio frequency (RF) performance requirements for an integrated array antenna.

High-frequency antennas are traditionally built by fabricating and assembling dozens to a hundred or more individual components plus hardware to provide the required RF performance and structural integrity. The RF energy propagates from component to component through interfaces, seams and discontinuities, so the RF path length must be increased to compensate for these obstructions. Each component needs mounting surfaces and hardware, which add more unnecessary weight and space. In addition, part material thickness must be suitable to meet design-for-manufacturing constraints, and extra space is needed throughout for assembly clearances.

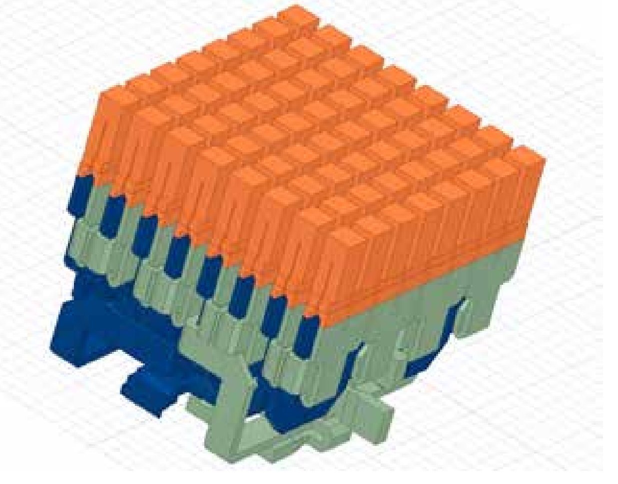


Array model

Advances in metal 3-D printing now make it possible to fabricate antennas and RF components at the scale required for wavelengths in the millimeter range. The entire antenna can be printed in one build as a single component. The elimination of interfaces, seams and discontinuities makes it possible to substantially reduce the length of the RF path, and absence of mounting surfaces and hardware provides further size and weight reductions. Further reductions can be achieved by decreasing material wall

"Using engineering simulation with Rescale's big compute platform provided Optisys with massive efficiency gains and the ability to reduce design cycles from months to weeks."

thicknesses. Because assembly clearances are not required, engineers can make further size reductions by packing features tightly into the entire 3-D volume. Optisys engineers used ANSYS simulation software to deliver order-of-magnitude reductions in size, weight and development time for the new 64-element X-band SATCOM integrated array antenna (XSITA). The amount of simulation required to perform such a feat is incredibly compute-intensive, and Optisys does the bulk of simulation on Rescale's cloud platform for high-performance computing (HPC), minimizing its on-premise IT footprint.

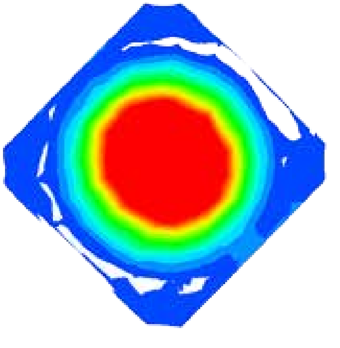


ANSYS HFSS model of radiating elements

Revolutionizing Antenna Design

Three-dimensional printing is revolutionizing high-frequency antenna design by realizing levels of integration and performance far above conventional fabricated antennas. To gain the full potential benefits of 3-D printing and other new manufacturing processes requires engineers to redesign the antennas from scratch. This is a long and laborious task using traditional RF design methods, which involve hand calculating an initial design, building a prototype, testing the prototype and then tuning manually. These steps are repeated over and over until the design meets all specifications, which can take a year or more.

To evaluate a broader range of alternative designs and iterate to an optimized design before building a prototype, Optisys uses simulation. By joining the ANSYS Startup Program, the company gained access to ANSYS HFSS electromagnetic simulation software and ANSYS Mechanical finite element analysis software to evaluate the RF and structural performance of the design. Engineers create simulation models locally and upload them to the Rescale cloud platform where they can run ANSYS software natively and access powerful HPC resources without having to maintain a computing infrastructure. Rescale complies with International Traffic in Arms Regulations (ITAR) so Optisys is able to use the platform even for antennas used in defense and homeland security applications.



E-field inside antenna horn

Optimizing the RF Design

Optisys engineers parameterized their initial concept design and used HFSS to calculate the S-parameters of each section of the antenna. They used the ANSYS Optimetrics electromagnetic optimizer to evaluate multiple design variables at a time based on the S-parameter results, primarily considering how much of the RF input was transmitted versus

Antenna Design and Platform Integration Analyses Using ANSYS HFSS
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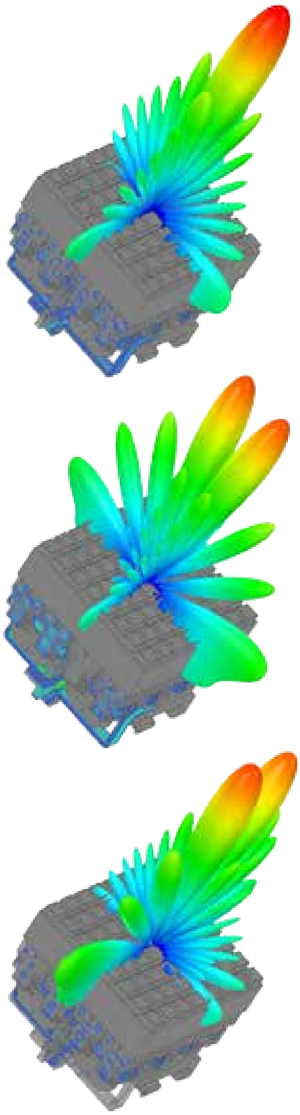


Radiation pattern for the antenna array is simulated in ANSYS HFSS for different elevations and rotations.

how much was reflected back. The optimizer stepped through the design space by following gradients toward an optimal design that minimized insertion losses and reflected energy. Engineers frequently generated e-field and surface current plots of the waveguide cavities for the designs generated by the optimizer to visualize performance and determine which areas are most in need of improvement.

The XSITA radiating elements consist of 64 square waveguide elements with chokes formed from the structural supports. Both left-hand circular polarization (LHCP) and right-hand circular polarization (RHCP) are generated, based on a classical 2-port septum design that transforms a single mode input to a circularly polarized output. The LHCP and RHCP networks were designed so that each quadrant of the full radiating element array is broken into four-element by four-element subsets. The polarizer outputs connect to a 16-to-1 corporate feed network that pulls down each quadrant into combiner networks that feed into monopulse comparators. The RHCP and LHCP outputs have separate monopulse comparators for tracking on both polarizations, resulting in eight total output ports. The monopulse comparator for each polarization is nested among the bottom sections of the corporate feed in a compact manner that adds as little extra additional volume as possible.

Due to the high levels of integration, with waveguide spacing approaching 0.020 inch in multiple regions, it is necessary to route the waveguide paths with all components of the model visible, but only simulate a subset of the geometry to improve simulation speed for optimization. HFSS makes it possible to include or exclude geometries from the simulation without removing them from the modeler window. This makes it possible for Optisys engineers to independently design the RHCP and LHCP networks while winding them around each other to minimize 3-D volume and waveguide length.

Designing the Structural Supports

Engineers used ANSYS Mechanical to analyze the lattice support structure to ensure sufficient mechanical strength to allow for reducing the thickness of the RF components to minimize the weight of the antenna. Engineers also designed a printed elevation axis that includes a rocking arm and gears and connects to an external motor.

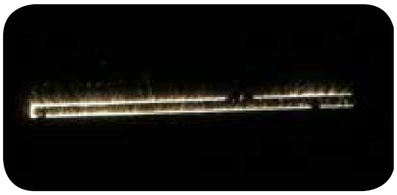
Cloud Computing for the Startup

Startups increasingly employ a cloud-based simulation platform because it is the only viable, cost-effective way to build digital prototypes for new products. Startups occasionally need increased compute capacity and often lack IT staff and/or the capital budget required to purchase, set up and maintain the appropriate hardware infrastructure. ANSYS actively works with cloud hosting partners such as Rescale to provide seamless turnkey access to ANSYS simulation and HPC resources. This approach provides ANSYS customers — from startups to large enterprise organizations — with an HPC cloud solution that is delivered by a partner who is an expert in HPC, remote hosting and data security.

— Wim Slagter, Director of HPC and Cloud Alliances, ANSYS

> “Optisys engineers used ANSYS simulation software to deliver order-of-magnitude reductions in size, weight and development time for a new array antenna.”

The design of the XSITA array showcases the level of integration that can be achieved with 3-D printing when engineers leverage ANSYS HFSS to optimize complex RF designs and the power of virtually unlimited scaling available on Rescale's cloud HPC platform. The success of startups like Optisys depends on delivering innovative solutions to the market faster than well-funded establishments. Using engineering simulation with the ability of Rescale's big compute platform to parallelize multiple projects provided Optisys with massive efficiency gains and the ability to reduce design cycles from months to weeks. While existing antennas in this space average 50 pounds and contain more than 100 components, the Optisys XSITA is only 8 pounds and consists of a single component. These capabilities allow a startup like Optisys to compete in this new field of 3-D printing, which is expanding exponentially and enabling unprecedented capabilities.



Antenna being built in 3-D printer

3-D printer used to build antenna

Rescale Cloud HPC Simulation Platform
rescale.com/ansys