

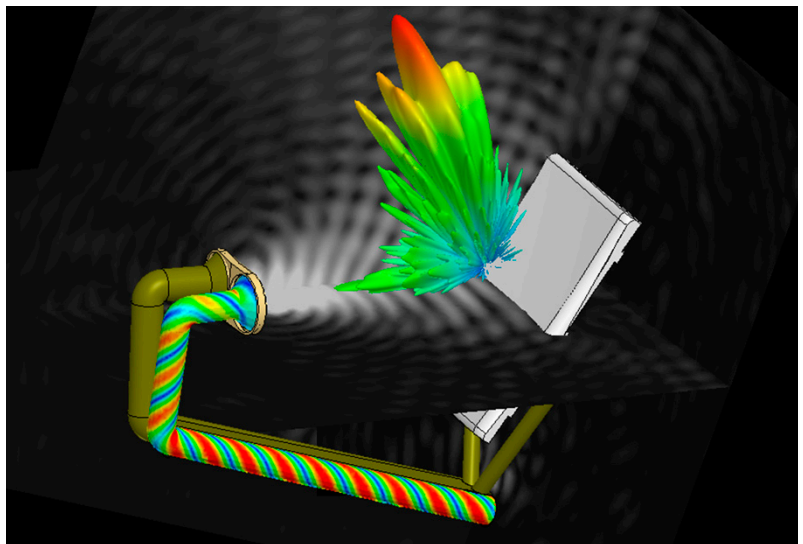
# HFSS 12.0

This industry-standard RF and microwave simulation solution delivers significant new domain decomposition technology for high-performance computing as well as other key performance-related updates.

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The High Frequency Structure Simulator (HFSS) is the industry-standard software tool for 3-D full-wave electromagnetic field simulation. HFSS technology provides E- and H-fields, currents, S-parameters and near- and far-radiated field results. Intrinsic to the success of HFSS as an engineering design tool is its automated solution process in which users are required only to specify geometry, material properties and the desired output. HFSS software automatically generates an appropriate, efficient and accurate mesh for solving the problem using the proven finite element method. With HFSS, the physics define the mesh; the mesh does not define the physics.

The power of HFSS software comes from many research and development innovations, which have made it the most widely used software for solving 3-D full-wave electromagnetic field simulations. The invention of tangential vector basis functions enabled the highly accurate finite element method for electromagnetic field solution. The transfinite element method allowed the 3-D finite element solution to couple to port solutions for fast and accurate multi-mode S-parameter extractions. Finally, the development of automatic mesh generation and adaptive refinement was a key innovation for reliable, repeatable and efficient results.



HFSS 12.0 software has numerous plotting and user interface advances, illustrated by this waveguide-fed reflector antenna with 3-D near- and far-field plot overlay.

## New in HFSS 12.0

The HFSS 12.0 release is a major step forward for three-dimensional full-wave electromagnetic field simulation with new innovations for engineering simulation and design. The software includes key updates in mesh generation, solver technologies, and enhancements to the user interface and modeler. The most significant solver technology enhancement is domain decomposition, a technique that allows HFSS to exploit high-performance computing (HPC) capabilities to solve electromagnetic field problems of unprecedented size and scope. With domain decomposition, a single HFSS job can be divided into smaller pieces and then

distributed across a network of computers. Leveraging this available memory allows for truly giant simulations that combine the rigor, accuracy and reliability of HFSS software.

A faster and more robust meshing algorithm generates higher-quality, more efficient tetrahedral meshes. This technology is particularly effective on complex geometries, especially those imported from external 3-D CAD tools. Other important enhancements include mixed element orders, curvilinear elements and adjoint derivative computation. Ease of use and automation in the user interface have been improved and include additional

modeler capabilities, such as sheet wrapping and imprinting. Advanced integration with load-sharing utilities and a native Remote Solve Manager (RSM) provide integration within popular computing environments. These advances in HFSS 12.0 software enable electrical engineers to expand their solution capability, exploit HPC hardware and fully integrate electromagnetics analysis into their design processes.

### HFSS HPC Option

The HPC option in HFSS 12.0 enables new solver technology using breakthrough implementation of the domain decomposition method (DDM). With the HPC option, large-scale simulations can be solved across a network of machines using all the available memory.

HFSS 12.0 technology has seamless, out-of-the-box integration with industry-standard schedulers (computing queuing systems) to allow engineering organizations to combine the power of HFSS with Platform LSF®, Windows HPC Server 2008 Job Scheduler from Microsoft, PBS Professional® from Altair Engineering, and Sun Grid Engine.

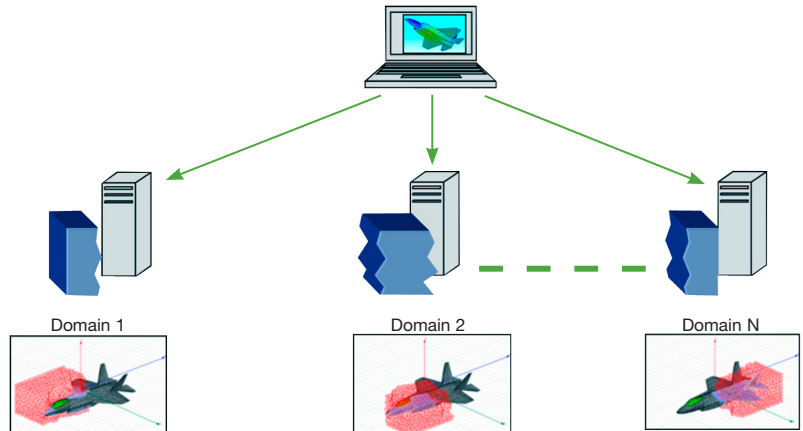
The combined HPC enhancements allow engineers to simulate and design at a scale and speed never before possible. Users of this latest version of HFSS software can achieve a dramatic reduction in development time and costs while at the same time realizing increased reliability and design optimization.

### High-Performance Computing Technologies

The HFSS high-performance computing options provide for intra- and inter-machine parallel solving and processing that distribute and speed the solution.

#### Domain Decomposition Method

DDM enables the simulation of very large models by accessing the

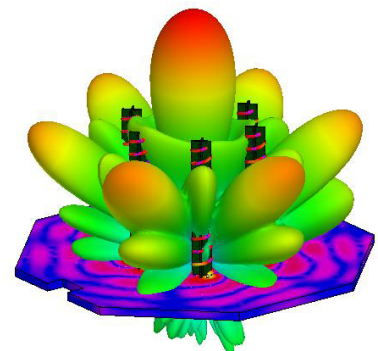
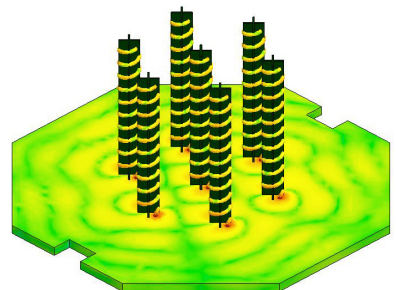


The domain decomposition method enables the simulation of very large models by automatically splitting the finite element mesh of the geometry into a number of smaller mesh sub-domains.

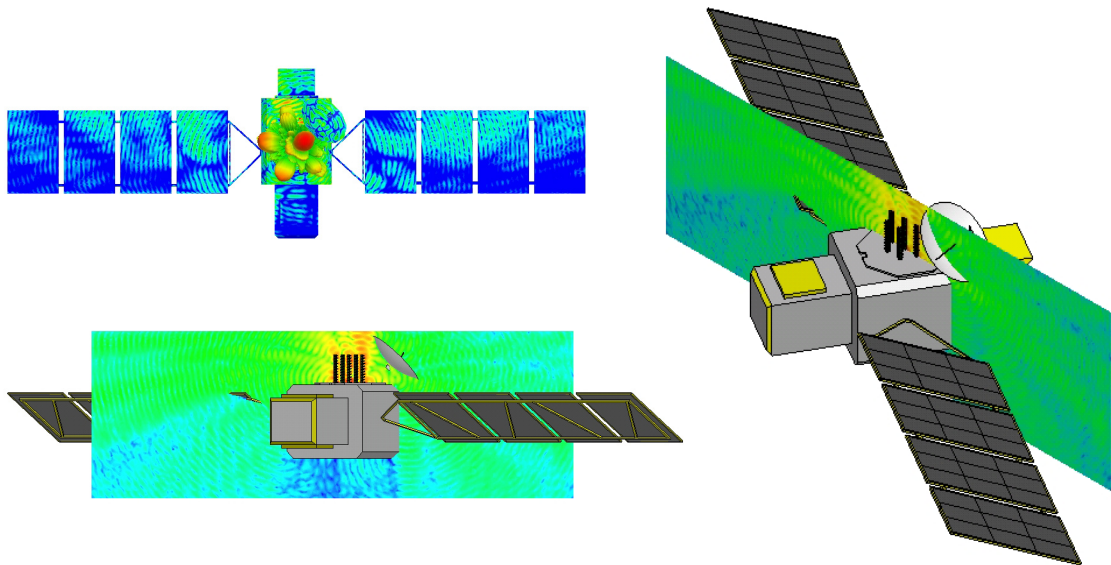
memory of a network of machines. DDM splits the finite element mesh of the geometry automatically into a number of smaller mesh sub-domains. HFSS determines the optimum number of domains, depending on mesh size and the number of computers and processors available. The domains are analyzed separately on a single machine or on a network of machines, after which an iterative procedure on domain interfaces reconstructs the full solution. This network memory access allows the simulation of very large models for which one machine might not have enough memory. It also reduces simulation time and overall memory load, offering, in some cases, better-than-linear speedup with each additional processor.

A seven-element phased array of helix elements can be simulated in HFSS 12.0 across the 3 GHz to 4 GHz S-band. The array is excited uniformly to provide broadside radiation. Mutual coupling among the elements and edge effects of the finite-sized groundplane are included because the array is simulated with all elements and the ground plane present. Such a model is useful for understanding these effects and for preliminary design. In the real world, an antenna is ultimately installed on some larger system, so

the helix array can be simulated as placed on a satellite spacecraft. For example, since real estate is precious on a satellite platform and other services must share the spacecraft's environment, a second high-gain antenna is mounted on the spacecraft. This placement has the potential of disrupting radiation from the helix array. HFSS 12.0 with domain decomposition was used to simulate both antennas and the spacecraft in a single simulation.



Uniform excitation of a seven-element helix array at S-band with mutual coupling and ground plane edge effects



HPC with domain decomposition solved the helix array on a spacecraft with other antennas nearby. This large problem solved with HFSS software used 1.3M tetrahedra, 25M unknowns and 35 computer cores.

Field interaction is significant when the array beam is steered 10 degrees off boresight. The radiation of the array interacts with the back side of the high-gain reflector antenna. The size and scope of this simulation is unprecedented in full-wave simulators.

#### Multiprocessing and Distributed Solve Options

The multiprocessing option is used for solving models on a single machine with multiple processors or multiple cores that share RAM. Operations during the solution process are parallelized across the available cores on that machine, thus significantly reducing the simulation time.

The DSO option allows users to distribute parametric sweeps to explore variations in geometry, materials, boundaries and excitations. Additionally, users can distribute frequency sweeps to generate responses over a broad frequency band of interest. This time-saving capability splits multiple predefined parametric design variations and/or frequency points, solves each simulation instance on a separate machine, and then reassembles the data. Thus, DSO

dramatically accelerates parametric studies and design optimization.

#### Volumetric Meshing

A new highly robust volumetric meshing technique results in even more efficient and higher-quality meshes, which reduces memory and simulation time. The new technique meshes the 3-D volume with uniformly distributed tetrahedra, followed by boundary refinement and surface meshing. By following this procedure, HFSS software can reliably mesh geometries imported from other CAD tools while creating an even higher-quality mesh for finite element simulation.

#### New Element Technologies

Curvilinear elements and mixed element orders allow for higher accuracy and more efficient distribution of computational resources. Curvilinear elements model the fields exactly on curved surfaces and, in these cases, provide higher accuracy even with a coarser mesh discretization. Mixed element orders allow for an automated and judicious localized application of element order based on geometry and electromagnetic requirements. Smaller features are solved more efficiently by lower-order elements, while large

homogenous regions benefit from higher-order elements, all element orders being automatically and appropriately “mixed” in one mesh. Mesh refinement is now performed on both the size and order of the elements.

#### Adjoint Derivatives

Adjoint derivative computation provides a highly efficient and accurate procedure to evaluate the derivatives of S-parameters with respect to geometric and material model parameters. This technique provides sensitivity information for use in device tuning, tolerance evaluation and optimization. These derivatives are employed to speed up the sequential nonlinear programming (SNLP) optimizer included with the Optimetrics add-on program.

HFSS software has been used around the world to design some of the most remarkable electronic and microwave products. For designing smart phones to high-speed computer backplanes to high-performance antenna systems, HFSS is the tool of choice by engineers who know that reliable electromagnetic simulation is imperative to successful high-performance design. ■