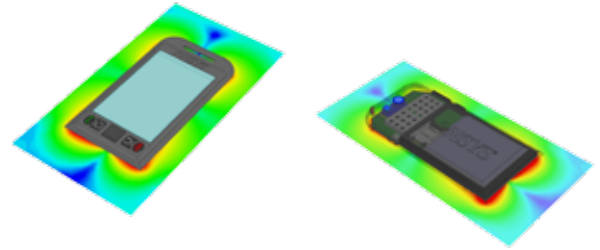


Realize Your Product Promise™

The ANSYS logo is displayed in white text on a black rectangular background. The word "ANSYS" is in a bold, sans-serif font. The background of the slide features a green and white abstract pattern of concentric circles and radiating lines, resembling a lens flare or a signal, which is partially obscured by the ANSYS logo box.

**ANSYS**

**HFSS**



Smart phone front view with electronic field displayed (left); back view with housing cut away to show internal geometry with electric field (right)

## Achieve high-frequency, high-speed component design with state-of-the-art tools from ANSYS.

ANSYS HFSS delivers the most accurate EM simulation results, every time.



Engineers rely on the accuracy, capacity and performance of ANSYS HFSS to design components such as on-chip embedded passives, IC packages, PCB interconnects, antennas, RF/microwave components and biomedical devices.

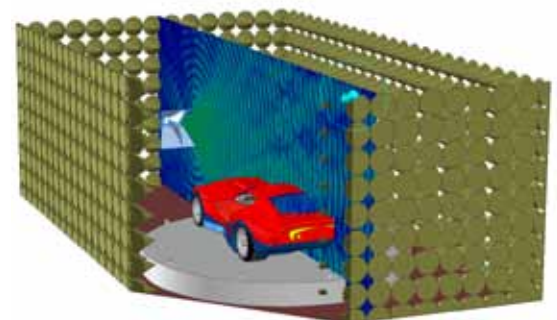
Since performance of electronic devices depends on electromagnetic (EM) behavior, you need a fast, accurate account of how your design will behave in real-world implementations — long before any prototype is built. ANSYS HFSS™ simulation results give you the confidence you need: The technology delivers the most accurate answer possible with the least amount of user involvement. As the reference-standard simulation tool for 3-D full-wave electromagnetic-field simulation, HFSS is essential for designing high-frequency and/or high-speed components used in modern electronics devices.

Understanding the EM environment is critical to accurately predicting how a component — or subsystem, system or end product — performs in the field, or how it influences performance of other nearby components. HFSS addresses the entire range of EM problems, including losses due to reflection, attenuation, radiation and coupling.

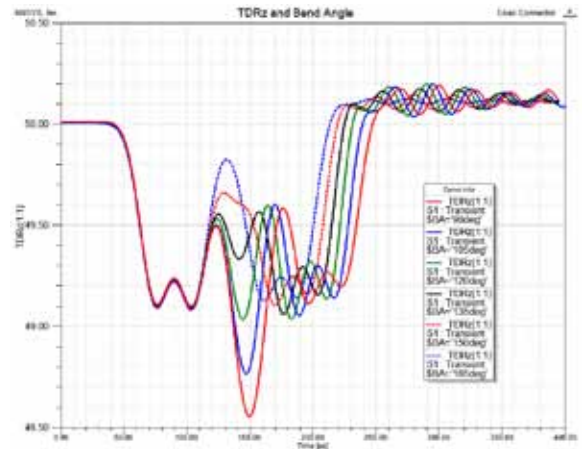
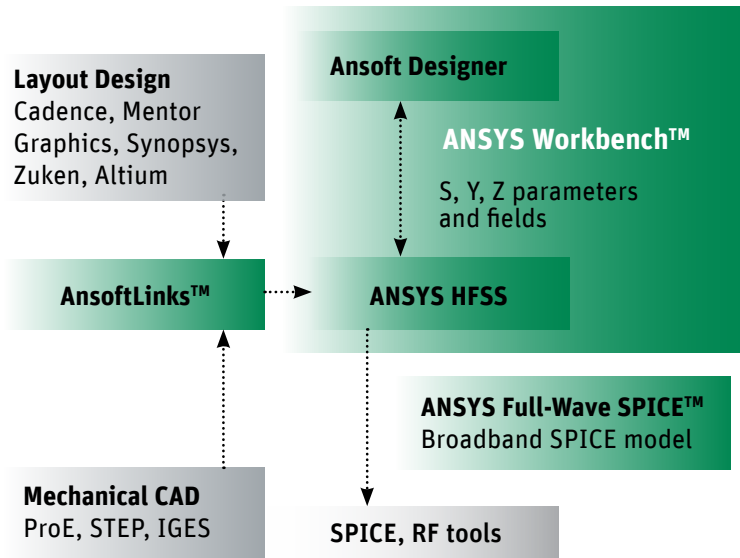
The power behind HFSS lies in the mathematics of the finite element method (FEM) and the integral, proven automatic adaptive meshing technique. This provides a mesh that is conformal to the 3-D structure and appropriate for the electromagnetic problem you are solving. With HFSS, the physics defines the mesh; the mesh does not define the physics. As a result, you can focus on design issues rather than spend significant time determining and creating the best mesh.

HFSS benefits from multiple state-of-the-art solver technologies, allowing users to match the appropriate solver to any simulation need. Each solver is a powerful, automated solution process in which the user specifies geometry, material properties and the desired range of solution frequencies. Based on this input, HFSS automatically generates the most appropriate, efficient and accurate mesh for the simulation, thereby leading to the highest-fidelity solution possible.

HFSS results yield information critical to your engineering designs. Typical results include scattering parameters (S, Y, Z), visualization of 3-D electromagnetic fields (transient or steady-state), transmission-path losses, reflection losses due to impedance mismatches, parasitic coupling, and near- and far-field antenna patterns.



Car in anechoic chamber with test antenna and antenna fields

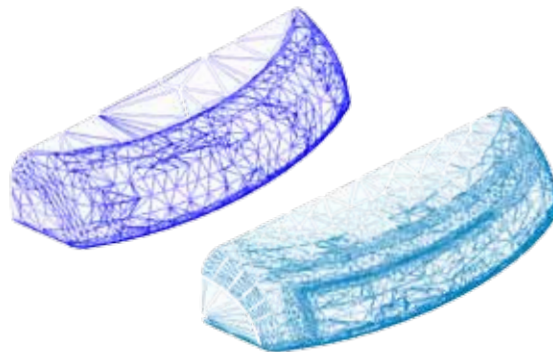


HFSS, part of the ANSYS high-frequency electromagnetic design portfolio, is integrated with ANSYS Workbench for coupling EM effects into multiphysics analyses, such as temperature and deformation.

TDR time domain response plot of connector vs. various angles

Engineers can use HFSS with confidence, knowing that they have achieved an accurate solution set regardless of the type of EM simulation performed.

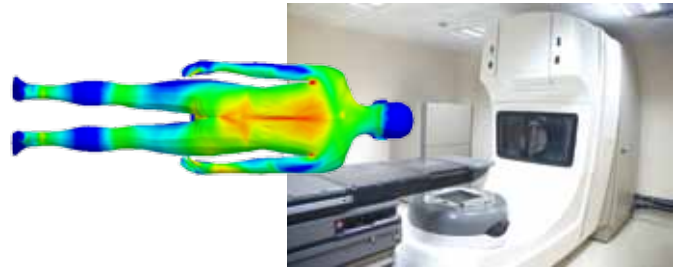
To solve the most demanding high-frequency simulations, all HFSS solvers are equipped with high-performance computing (HPC) options including domain decomposition and distributed processing. HPC decreases computation time and leverages existing computer resources to more rapidly solve very large simulations.



Initial (top) and final (bottom) conformal antenna mesh for a smartphone show substantial mesh refinement using the HFSS fully automated adaptive meshing technique.

### Integration into ANSYS Workbench

The power and accuracy of HFSS is accessible through the ANSYS Workbench™ platform. This tool enables multiphysics simulations in a central user interface that links directly with enterprise mechanical CAD tools. With this capability, you can simulate thermal- and fluid-based problems that require input from HFSS. In addition, you can share fully created HFSS models across the enterprise. Mechanical, thermal and fluid engineers can leverage HFSS results to complement their individual simulation's needs.

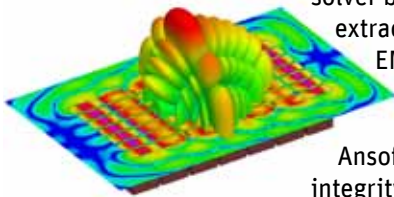


Advanced medical applications make use of electromagnetic fields, including magnetic resonance imaging (MRI), implants and hyperthermia treatment. In this MRI application, HFSS simulated the specific absorption rate that results on the body.

## The complete high-frequency solver toolbox enables simulation across multiple applications.

ANSYS HFSS is the industry-standard EM simulation package for RF and microwave as well as signal integrity design. It is ideal for analyzing any physical structure that relies on electromagnetic fields, currents or voltages for operation.

Using a 3-D full-wave frequency domain EM-field solver based on the finite element method, HFSS extracts scattering parameters, visualizes 3-D EM fields, generates far-field radiation plots and provides ANSYS Full-Wave SPICE™ models. You can use these models in Ansoft Designer and other tools for signal integrity investigations.



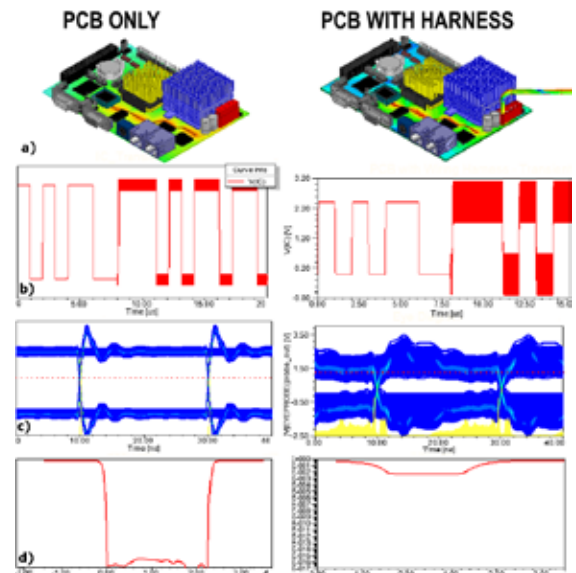
HFSS for RF and microwave applications: 7x7 WR90 waveguide array, scanning with regard to -45 to +45 degrees theta

### RF and Microwave

HFSS has long been used by RF and microwave engineers to design high-frequency components found in communication systems, radar systems, satellites, smart phones and tablet devices. The technology addresses a wide range of RF and microwave engineering challenges, and these applications benefit greatly from the automated meshing feature and resulting high solution accuracy. The end result is the highest-fidelity solution with the best-in-class solution time.

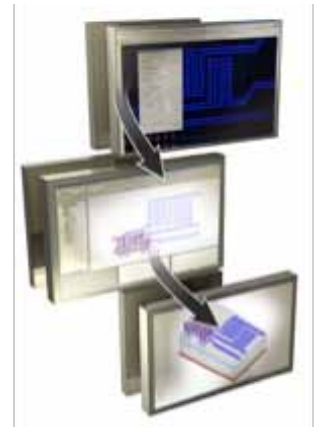
### Signal Integrity

With HFSS, engineers can easily design and evaluate signal integrity and EM interference in connectors, transmission lines and vias on printed circuit boards (PCBs), high-speed components used in computer servers and storage devices, multimedia PCs, entertainment systems, and telecom systems. Engineering teams around the world regularly leverage our tools to bring a competitive edge to their designs.



Signal integrity simulation results due to induced EMI on high-speed serial cable attached to PCB

## Leverage the accuracy of HFSS from your ECAD interface with Solver on Demand.



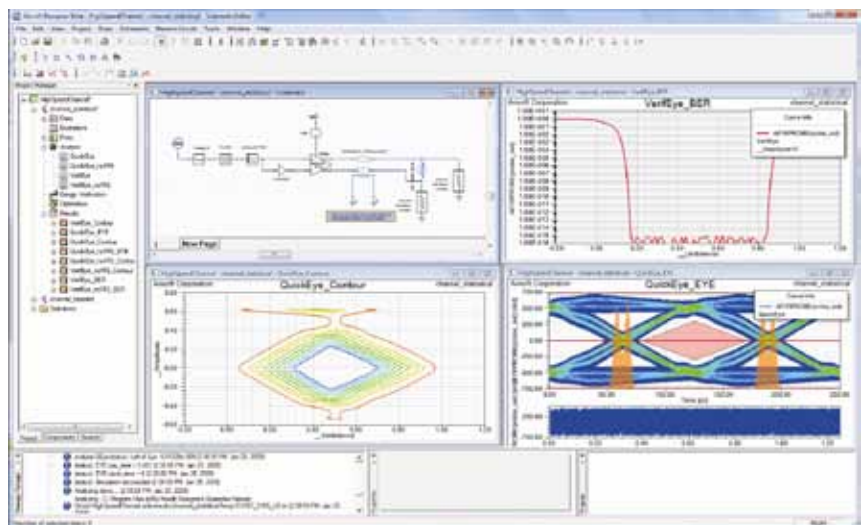
Solver on Demand provides access to the power of the HFSS 3-D finite element solver while making model creation extremely simple and fast.

### Solver on Demand

If you're not familiar with 3-D modeling, creating fully solvable 3-D models in HFSS can be a complicated, time-demanding process: assigning source locations or excitations, determining solution space boundary definitions solution frequency sweep range, among others.

Solver on Demand® technology enables you to access the HFSS solver directly from the intuitive, stackup-based, layout interface of Ansoft Designer. This interface is for engineers who need the 3-D simulation accuracy and reliability of HFSS but prefer to work in a 2-D layout-based modeling environment — so engineers of all experience levels can capitalize on the accuracy of HFSS without having to leave a familiar ECAD environment. You can also access Solver on Demand from your preferred Cadence® ECAD tool.

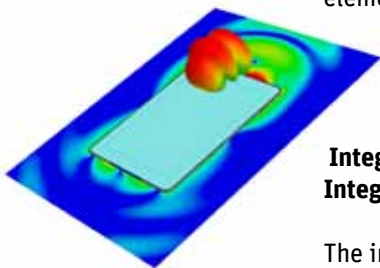
HFSS Solver on Demand is optimized for ECAD import, drawing and parameterization of EM designs. It supports traditional ECAD primitives such as padstacks, traces, wirebonds and solderballs. Because models are modifiable, Solver on Demand provides a great advantage if you are optimizing a particular section, transition, interconnect or passive component on silicon for a PCB, package or chip.



Ansoft Designer is the foundation for a highly accurate design flow that allows you to precisely model and simulate complex designs.



## With our advanced solver options, you can take on the largest and most complex design problems.



Electric field and far-field antenna pattern produced by tablet device antenna

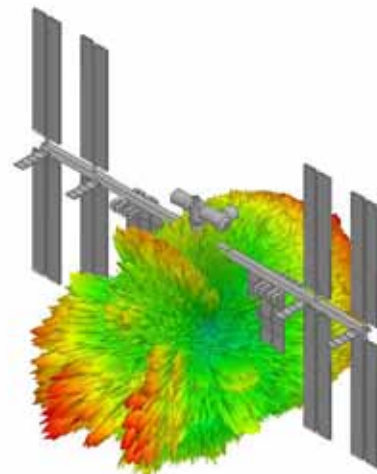
HFSS offers multiple state-of-the-art solver technologies, all based on the proven finite element method. You can select the best solver for a given situation and, in many cases, reap advantages from combining solvers in a linked project.

### Integral Equation and Hybrid Finite Element–Integral Equation

The integral equation (IE) solver is an effective add-on tool for radiation and scattering studies of large, mostly conducting structures. It employs the method of moments (MoM) technique to solve for current distribution on surfaces of conducting and dielectric objects. Using the HFSS interface, IE shares geometry, material and certain critical solver technology with HFSS, including the adaptive refinement feature that automatically generates an optimal mesh. The IE solver uses the adaptive cross approximation (ACA) method in conjunction with an iterative matrix solver to reduce memory requirements, enabling you to apply it to very large problems.

The IE solver add-on also allows you to create HFSS models that use a hybrid FEM–IE methodology to solve large EM problems. The hybrid finite element–integral equation solver provides an ideal open truncation for the HFSS FE solution through a direct integral-equation–based calculation of an open-boundary condition.

Using the IE add-on to HFSS, you get the best of two powerful techniques: the finite element method’s ability to handle complex geometries plus MoM’s direct calculation of the free-space Green’s function, which leads to accurate radiating and scattering solutions. Antenna designers can realize increased accuracy for radiated far-field solutions, leading to more confidence in their EM solutions. HFSS–IE essentially shrinks simulations involving antenna platform integration by allowing a conformal radiation boundary, including concave geometries, which reduces the overall volume of the FE domain.

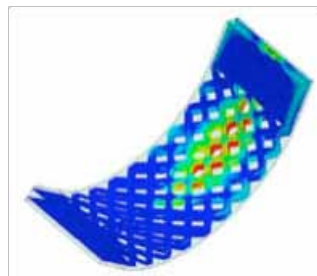
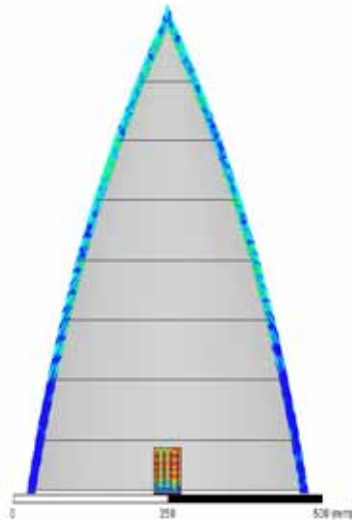


Far-field antenna pattern of International Space Station antenna using HFSS physical optics solver



*“We can import CAD models directly into the ANSYS EM simulation package. The coupled thermal–electromagnetic tools provide us with insight into interactions between pacemakers and MRI scanners, which is a very complex problem. Using simulation allows us to really understand the problem so that we can mitigate hazards.”*

**Mariya Lazebnik**  
Senior Scientist  
Medtronic



Antenna with radome solved using HFSS hybrid finite element–boundary integral solver

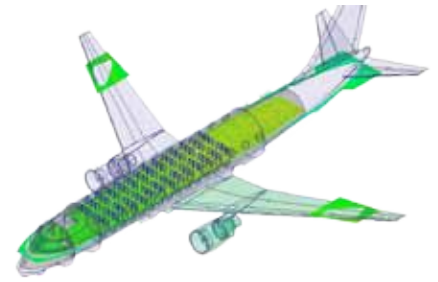
Differential signal propagating in time through a flexed cable, solved with HFSS transient using conformal finite elements

## Transient

HFSS transient is a 3-D full-wave transient, or time domain, EM field solver based on the discontinuous Galerkin time domain (DGTD) method. You can easily perform time-based simulations, such as time-domain reflectometry (TDR), using any general time-based or predefined input pulse. In addition, you can solve applications with short-duration pulsed excitations — such as ground-penetrating radar, electrostatic discharge, EM interference and lightning. This tetrahedral finite element technique relies on the same automated meshing technology used by HFSS, making our transient tool an ideal complement to a traditional frequency-domain HFSS solution.

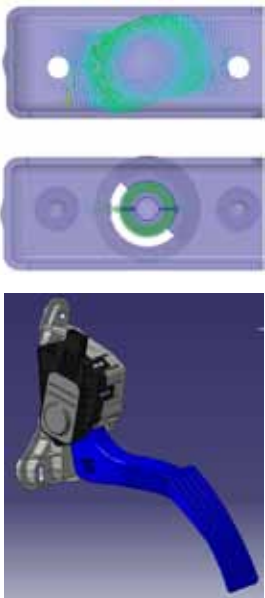
## Physical Optics

The physical optics (PO) solver is ideally suited to investigate extremely large EM structures. You can use PO in designing large reflector antennas, satellites or antenna platforms, such as commercial and military aircraft. This solver is extremely fast and uses a minimum of computing resources, allowing rapid insight into major design considerations associated with large EM structures.



Electric field at WiFi frequency calculated inside modern jetliner

## HPC options leverage compute power to rapidly solve large-scale EM field simulations with rigor and accuracy.



### Domain Decomposition

The domain decomposition method (DDM) accesses the memory of a network of machines to simulate very large models. HFSS determines the optimal number of subdomains based on mesh size along with the number of processors/machines available; DDM automatically splits the finite element mesh into a number of subdomains. Each subdomain is analyzed separately, then an iterative procedure on the subdomain interfaces reconstructs the full solution. This network memory access procedure allows you to simulate very large models that would exceed the computing resources of a single machine. Additionally, DDM reduces simulation time and overall memory load, offering better-than-linear speedup with additional processors in some cases.

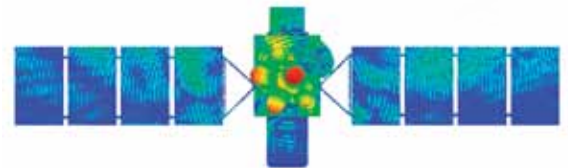
KSR International used HFSS to evaluate inductance sensors for electronic throttle controls, reducing the need for physical prototypes and shortening design time from three months to two weeks.

### Spectral Decomposition

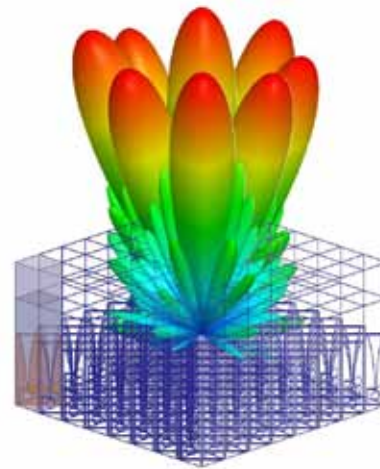
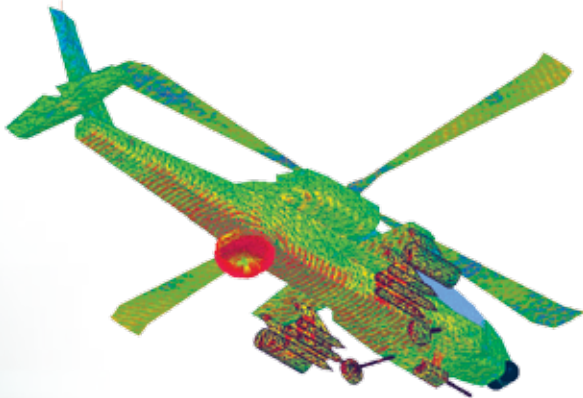
With the spectral decomposition method (SDM), you can distribute broadband frequency sweep points across a number of processors or machines. This time-saving capability automatically distributes the frequency points, solves each frequency point on a separate machine and then reassembles the overall frequency domain data. The unique process dramatically decreases the overall simulation time required to obtain highly accurate broadband scattering parameters.

### Distributed Solve

The distributed solve option (DSO) allocates parametric sweeps to explore variations in geometry, materials, boundaries and excitations. The time-saving capability splits multiple predefined parametric design variations, solving each simulation instance on a separate machine. Dramatically accelerating parametric studies and design optimization for a given design task, DSO provides the highest level of parallelization and compute performance for a distributed simulation effort.



Domain decomposition fosters innovation, enabling you to solve problems that were previously thought of as unsolvable.



The ANSYS distributed solve capability allows a single user to distribute parametric studies or frequency sweeps across a number of computers, expediting total simulation time. Engineers can explore variations in geometry, materials, boundaries and excitations as well as distribute frequency sweeps. This allows your team to easily optimize designs and perform statistical and sensitivity analyses.

256-element dual-polarized Vivaldi antenna array simulated with finite array domain decomposition algorithm; far-field patterns for a variety of scan angles overlaid atop geometry

### Multiprocessing

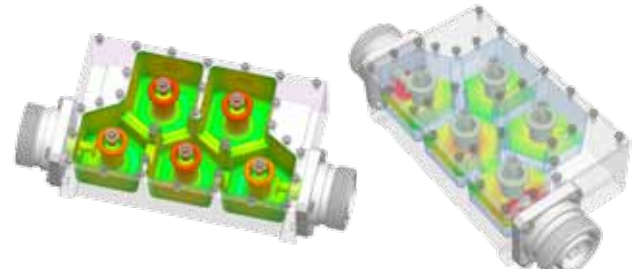
Multiprocessing (MP) applies multiple cores on a single, shared memory machine for solving an HFSS FEM or integral equation solution. MP accelerates various aspects of the solution process — such as matrix factorization, meshing and field recovery — leading to faster overall solution times.

### Finite Array Simulation

The finite array simulation capability uses domain decomposition and the repetitive nature of arrays to quickly, efficiently and fully characterize a finite antenna array. Using this capability, you can determine all mutual couplings between array elements as well as fully capture the array edge effects. Finite array simulation uses minimal computing resources, so it can simulate a finite array in a short time.

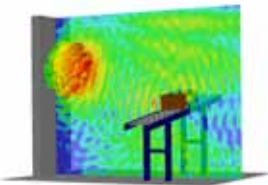
	Multiprocessing	Licenses Distributed Solve	HPC
<b>Capability</b>			
Distributed Solve Engines			X
Multiple Cores	X		X
Distributed Frequency Sweeps		X	X
Distributed Design Variations		X	

HFSS takes advantage of the power of modern computer hardware with multiprocessing, distributed computing and HPC options.



Geometry (left) and electric field (right) inside microwave cavity filter

## HFSS is an integral part of the ANSYS suite, which solves multiphysics problems with ease.



RFID system simulation showing transponder antenna pattern and electric field of full-sized system in realistic environment

ANSYS HFSS and related electromagnetics tools are but one part of our suite that delivers cutting-edge functionality — depth, breadth, a plethora of advanced capabilities and integrated multiphysics — providing confidence that your simulation results reflect real-world outcomes. The comprehensive range of solutions provides access to virtually any field of engineering simulation that a design process requires. Organizations around the world trust ANSYS to help them realize their product promises.

### Design Analysis and Optimization

To understand a design’s performance, you must identify the effect of all design parameters — which can easily lead you to all changes required to meet product requirements. HFSS links to ANSYS DesignXplorer™ to provide in-depth product understanding, illustrating the relationship between design variables and product performance. The coupling helps you perform statistical yield analysis and design of experiment studies for six sigma analysis.

### Preparing Layout and Geometry

With the addition of AnsoftLinks for ECAD, HFSS integrates tightly with layout design tools from Cadence, Mentor Graphics®, Synopsys®, Altium and Zuken™. Using AnsoftLinks for MCAD, users can directly import ProENGINEER®, STEP, CATIA® and IGES file formats. In addition, ANSYS DesignModeler™ aids in creating geometry; ANSYS SpaceClaim Direct Modeler exports models directly into HFSS.

### Multiphysics and Systems Integration

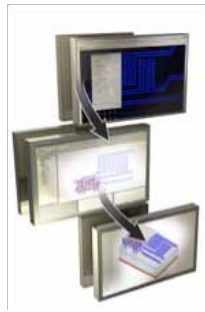
Integration with the ANSYS Workbench platform enables you to simulate thermal- and fluid-based problems that require input from HFSS. Furthermore, HFSS forms an integral part of a system solution that involves circuit and components. You can analyze components with HFSS and then merge them into a circuit. The process leads to a unique system simulation, in which system performance relies on physics-based models.

**Modeling**



Comformal multi-band antenna model for smartphone

**Solver on Demand**



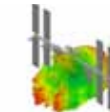
**Solvers**



Integral equation



Hybrid

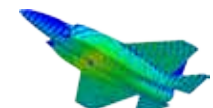


Physical optics



Transient

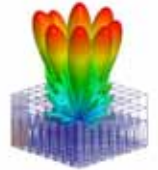
**Integral HPC Options**



Domain decomposition



Distributed solve



Finite array

**Pre-Processing**

**Simulation**

**Post-Processing**

**Archive**

**Other ANSYS Engineering Simulation Capabilities**

**ECAD, MCAD**



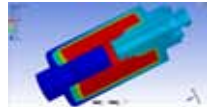
The ANSYS suite provides modeling and geometry creation functions as well as tools for importing CAD data from various sources. In addition, we collaborate with leading CAD developers to ensure an efficient workflow.

**Integration**



ANSYS Workbench is the framework for the industry's broadest and deepest suite of advanced engineering simulation technology. It delivers unprecedented productivity, enabling Simulation-Driven Product Development™.

**Multiphysics**



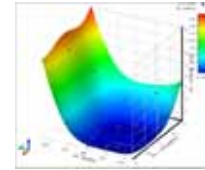
To help ensure a successful product, R&D teams must accurately predict how complex products will behave in a real-world environment. The ANSYS suite captures the interaction of multiple physics: structural, fluid dynamics, electro-mechanics, and systems interactions. A single, unified platform harnesses the core physics and enables their interoperability.

**HPC**



High-performance computing enables creation of large, high-fidelity models that yield accurate and detailed insight. ANSYS offers scalable solutions and partners with hardware vendors to ensure that you get the power and speed you need.

**Design Optimization**



Good design starts with identifying the relationship between performance and design variables. ANSYS DesignXplorer enables engineers to perform design of experiments (DOE) analyses, investigate response surfaces and analyze input constraints in pursuit of optimal design candidates.

**Data Management**



ANSYS EKM™ addresses critical issues associated with simulation data, including backup and archival, traceability and audit trail, process automation, collaboration and capture of engineering expertise, and IP protection.

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ANSYS is dedicated exclusively to developing engineering simulation software that fosters rapid and innovative product design. Our technology enables you to predict with confidence that your product will thrive in the real world. For over 40 years, customers in the most demanding markets have trusted our solutions to help ensure the integrity of their products and drive business success through innovation.

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