WHITE PAPER

ANSYS® HFSS™ and SGI® UV™ 2000 Takes Electromagnetic Simulation to New Heights

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1.0 Introduction

ANSYS and SGI have worked together for over 15 years to bring Virtual Product Development (VPD) solutions to our joint customers worldwide. As a leading HPC solution provider, SGI optimizes its hardware and data management offerings for the various CAE domains in which ANSYS customers operate – like finite element analysis, computational fluid dynamics, electronics and electromagnetics, and design optimization.

ANSYS brings clarity and insight to its customers' most complex design challenges through fast, accurate and reliable simulations. ANSYS software technology enables organizations to predict with confidence that their products will thrive in the real world.

Most recently, SGI teamed with ANSYS to enable ANSYS HFSS to perform larger, more-complex electromagnetic (EM) simulations — simulations that in the past have been impossible to perform — eliminating the risk of simulation failure and lost time due to insufficient computing memory, and enabling users to perform more simulations in less time.

This paper discusses how the latest version of ANSYS HFSS (Release 16) takes full advantage of the SGI UV 2000 advanced symmetric multiprocessing (SMP) system to achieve these objectives. Utilizing SGI's sixth generation technology, engineers and scientists can leverage hundreds of processing cores and terabytes of coherent shared memory to solve very large EM field simulations, as well as perform more simulations in less time and with greater efficiency versus using traditional HPC clusters.

> "In my 15 years as an ANSYS HFSS applications specialist, I never imagined that we could realize 3-D full-wave electromagnetic-field simulations of the magnitude we are seeing today using the SGI UV 2000 system. It is a true testament to the combined power of the ANSYS HFSS solvers for high-performance computing and the large shared memory and CPU scaling delivered by the SGI UV computing architecture.
>
> As a consumer of computer resources for full-wave computational electromagnetics, the scaling of simulations to multi-terabyte's of RAM on the SGI UV 2000 system just works."

Steve Rousselle,
ANSYS Technical Director

1.1 ANSYS HFSS and High Performance Computing

HFSS with High Performance Computing (HPC) can be applied to several classes of problems using embarrassingly parallel and large-scale parallel solutions.

Embarrassingly parallel workloads typically are used to solve numerous variations, for example multiple frequency points or parametric geometry. Scaling is essentially linear and can be handled either by the SGI UV system or a standard cluster.

Large-scale parallel workloads are another matter. Because they involve large scale parallel solutions and very large memory footprints, techniques to significantly increase simulation capacity are required. Simulating antenna integration into a vehicle – whether it's an advanced jet aircraft or a sleek new automobile design – is a prime example of large complex simulations using HFSS. Automotive manufacturers also use HFSS to run large EM simulations of full platforms, not just components. Commercial and military satellite manufactures make up another robust body of users.

To solve these complex workloads, HFSS with HPC uses mesh- or matrix-based techniques that are effectively handled by shared memory systems.

Domain decomposition is one of the most effective approaches to run large-scale jobs. For example, an aircraft model can be automatically subdivided into multiple domains, which are then solved independently on separate nodes or CPUs. Once the individual meshes are solved, they are reassembled into the full, high-fidelity solution.

By splitting the problem up into smaller domains, the size of the memory footprint for each individual domain is significantly reduced and processing time is much faster. Another major benefit of this approach is that multi-threading limitations on a single domain are bypassed and excellent scaling is possible using multiple smaller domains. This is another instance where HFSS with HPC allows engineers and researchers to solve larger problems more quickly and tackle projects that were previously considered impossible to compute.

2.0 Solving the Big Ones – Cosite and Radar Cross Section Analysis

In the aerospace and defense market there are two types of large-scale EM problems that crop up repeatedly – cosite analysis and radar cross section (RCS) analysis.

2.1 Cosite Analysis

Cosite analysis examines the coupling of antenna to antenna. Because of the electrical size of typical cosite analysis, the power of in-memory computing is required to calculate a coupling matrix that indicates how much energy is moving from one antenna to another. UV 2000 delivers this at massive scale.

Figure 1 shows the electromagnetic hot spots around the antennas which allow engineers to determine the communication between the sites and where the antenna performance degrades.

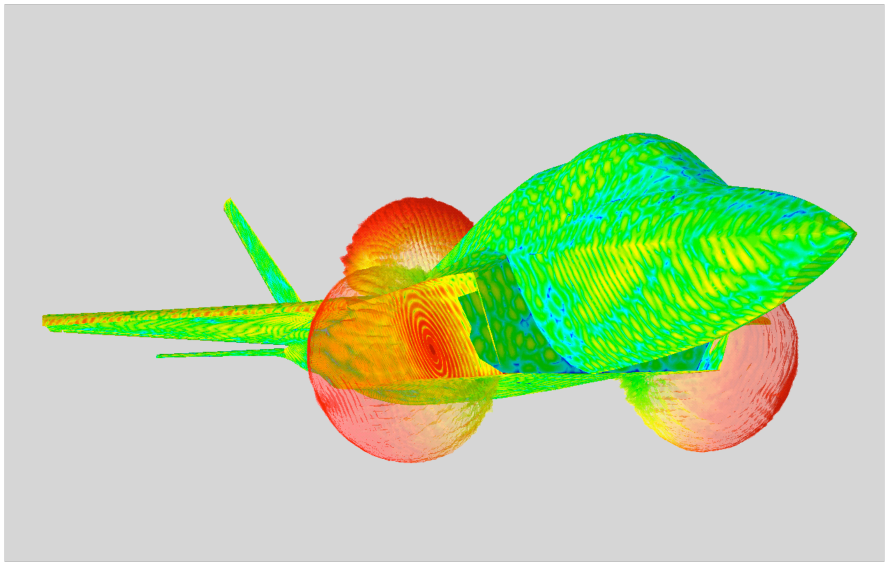


Figure 1: HFSS cosite analysis

Three antennas are used in this example presenting a complex set of conditions with regard to how electrical fields interact with the fuselage and the antenna's ability to radiate and receive signals. In some instances however, designers develop aircraft or other vehicles with 30 or more antenna. HFSS with SGI UV 2000 enables designers to simulate antenna placement and determine optimal placement performance before time-consuming and expensive physical testing.

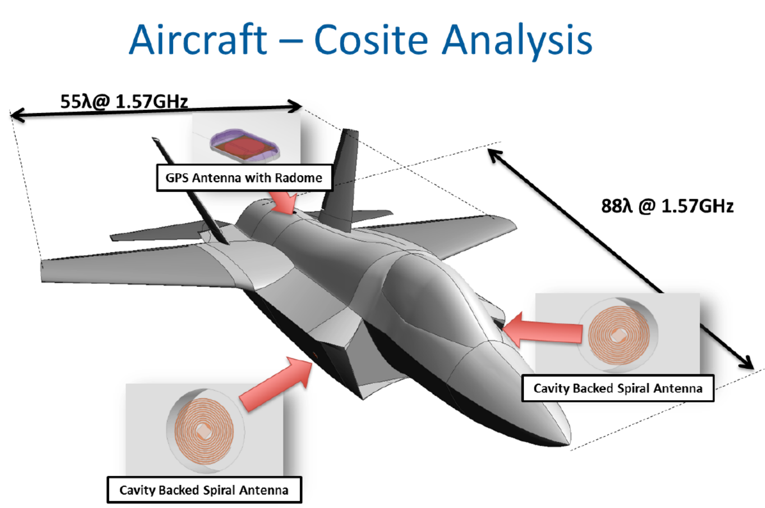


Figure 2: Antenna configuration for cosite analysis

In the example in Figure 2, the antenna isolation needs to be predicted. With over 100 million degrees of freedom, a clustered system adds additional complexity to the analysis. Running ANSYS HFSS using an SGI UV 2000 with 1.3 terabytes of cache-coherent shared memory in a single system, solved the problem. The solution time took 12 hours and included domain decomposition as well as the full simulation.

2.2 Radar Cross Section Analysis

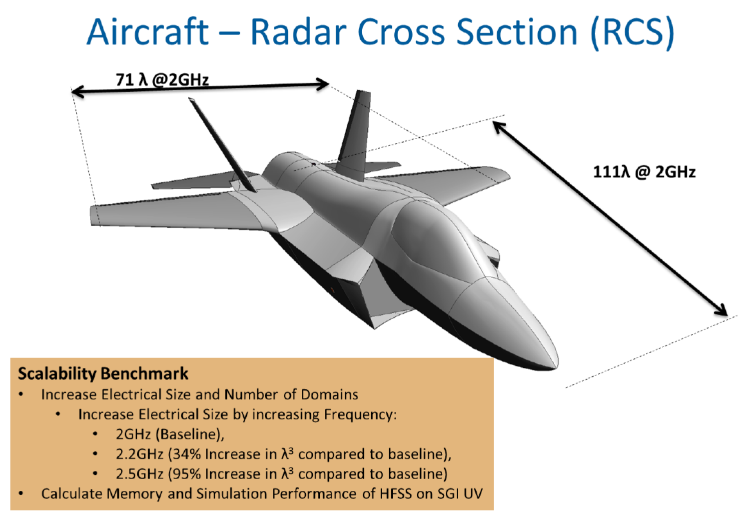
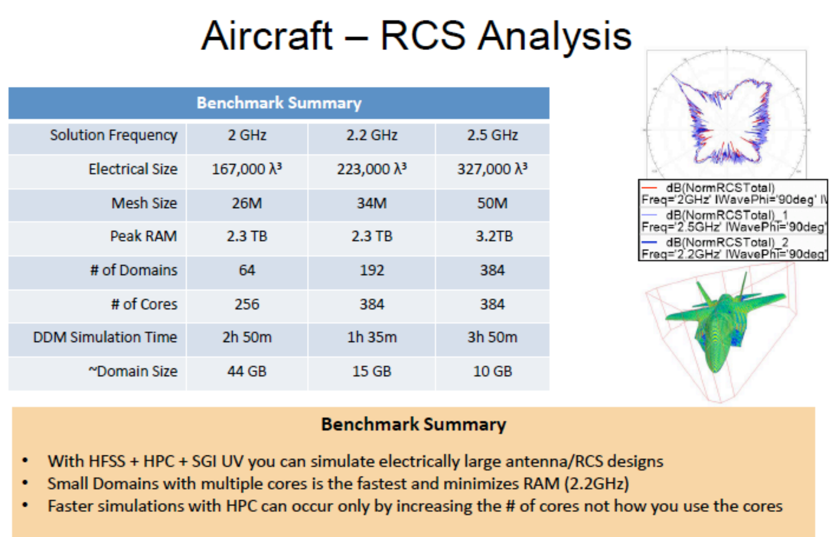


Figure 3: Radar cross section analysis

Like cosite analysis, RCS problems include very large, complex geometries. In the example shown in Figure 3, the cross section is 71 by 111 wavelengths (λ) at 2 GHz. HFSS with HPC was used to determine how well this problem scaled as the radar signature of the aircraft increased in frequency from 2.0 GHz to 2.2 GHz and then 2.5 GHz. Although the frequency was amplified by only a small amount, the number of wavelengths was dramatically increased by almost 100 percent.



Benchmark Summary			
Solution Frequency	2 GHz	2.2 GHz	2.5 GHz
Electrical Size	167,000 λ³	223,000 λ³	327,000 λ³
Mesh Size	26M	34M	50M
Peak RAM	2.3 TB	2.3 TB	3.2TB
# of Domains	64	192	384
# of Cores	256	384	384
DDM Simulation Time	2h 50m	1h 35m	3h 50m
~Domain Size	44 GB	15 GB	10 GB

Figure 4: RCS analysis benchmark summary

At 2 GHz, 256 cores were required to solve a design with 167,000 cubic wavelengths and 170 million unknowns. At 2.5 GHz, researchers essentially doubled the size of the problem, moving up to 327,000 cubic wavelengths with only a modest increase in memory footprint – 3.2TB compared to 2.3TB at 2 GHz.

The analysis at 2.5 GHz included over 300 million unknowns and a mesh size of 50 million that was decomposed into 384 domains. By splitting the problem into multiple small domains, the domain partitioning time was increased but the overall time to solve the problem did not significantly rise.

Breaking the Boundaries

For large electromagnetic simulations like those described above, typical production environments composed of standard grid clusters have proven to be inadequate – often the job exceeds the cluster's memory and computational resources. Upon reaching this memory impasse, engineers will often fall back on approximation methods. This allows them to move ahead, but only by sacrificing accuracy. And, for many, especially those in the aerospace and defense industries, accuracy is paramount. By using ANSYS HFSS with the SGI UV 2000, design and test engineers can run full-wave simulations with the high level of accuracy required by these demanding customers.

In fact, running HFSS on the SGI UV 2000 has allowed engineers to solve complex electromagnetic simulations that they could not even consider before. In current trials, such as cosite analysis and radar cross section analysis, ANSYS and SGI engineers were able to run jobs that were three times larger than customers had been able to solve in the past by using the SGI UV 2000 platform. This to opens up a whole host of new possibilities.

3.0 Solving the Small Ones - A Case Study

Designers in the consumer electronics and semiconductor manufacturing sectors work with problem sizes that are typically smaller. These can include design optimization, large frequency sweeps with multiple data points, or statistical analysis to meet Six Sigma requirements. By running multiple variations of product simulations in parallel, the SGI UV 2000 helps reduce failure rates and bring products to market more quickly.

Qorvo and the Silver Bullet

An example of tackling small problems more efficiently and effectively with HFSS running on the SGI UV 2000 is Qorvo. Created in January 2015 by a merger of TriQuint and RFMD, Qorvo is a global leader in scalable and dynamic radio frequency (RF) solutions for mobile, infrastructure and defense applications.

The new company was working with increasingly complex simulations that pushed the limits of its ANSYS software running on IBM® Platform™ LSF® grid servers. Qorvo needed a simple solution that could meet the needs of a wide range of users – from novice to advanced – while markedly reducing simulation run times.

The answer was the use of ANSYS HFSS running on the SGI UV 2000 high-performance, shared-memory system. The results have been outstanding.

The combination of HFSS and the SGI platform with its 2TB of RAM and 128 cores has become Qorvo's "silver bullet resource," delivering fast results when the capabilities of company's standard production LSF grid servers are exceeded.

A typical recent job that took nearly 16 hours of processing in the LSF environment was completed in a little over eight hours running on HFSS powered by the SGI UV 2000. Corner layouts that required sequential simulations that took more than 20 hours to run on the LSF cluster, were generated in four hours. Also, by using the SGI UV 2000, there were no simulation failures due to insufficient memory.

Overall, HFSS with HPC has enabled a tremendous reduction in assessment time, allowing Qorvo's engineers to run a greater number of analyses in a shorter time, resulting in better products and satisfied customers.

4.0 For More Information

For more information on SGI UV 2000
http://www.sgi.com/UV

For more information on ANSYS HFSS
http://www.ansys.com/Products/Simulation+Technology/Electronics/Signal+Integrity/ANSYS+HFSS

For more information on a customer use case
http://www.sgi.com/pdfs/4545.pdf

To listen to the recorded webinar "Qorvo: Leader in RF Solutions Gives HPC Insight To Meet Computational Needs"
http://www.ansys.com/Resource+Library/Webinars/Qorvo:+Leader+in+RF+Solutions+Gives+HPC+Insight+To+Meet+Computational+Needs+-+Webinar

For more information on the ANSYS and SGI partnership
http://www.ansys.com/About+ANSYS/Partner+Programs/HPC+Partners/SGI

5.0 About SGI

SGI is a global leader in high performance solutions for compute, data analytics and data management that enable customers to accelerate time to discovery, innovation, and profitability. Visit sgi.com for more information.

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