Ansys

ADVANTAGE

EXCELLENCE IN ENGINEERING SIMULATION

ISSUE 3 / 2022

AMPLIFY THE POWER OF SIMULATION

Ansys

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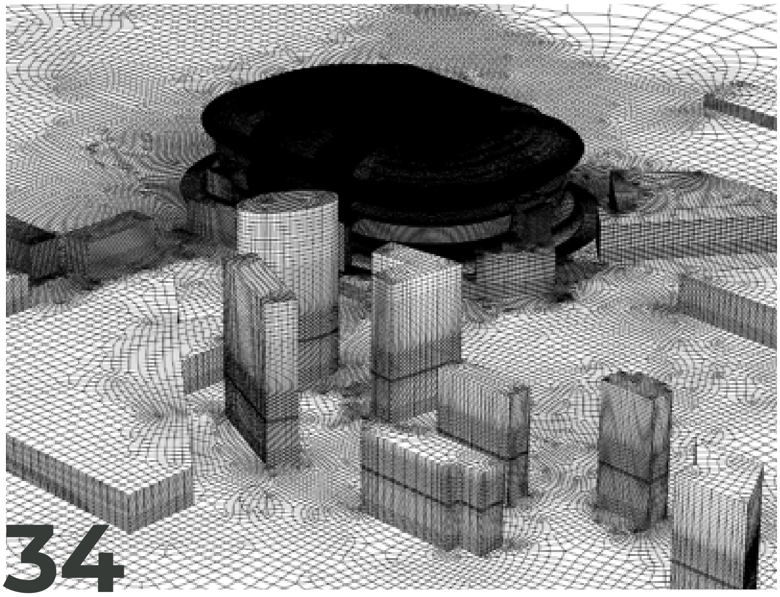

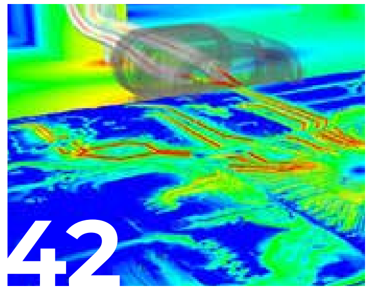

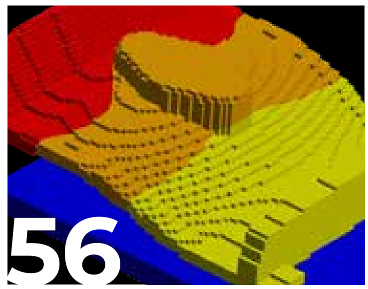

Focus on Transformation

ADVANTAGE

Welcome to *Ansys Advantage*! We hope you enjoy this issue containing articles by Ansys customers, staff and partners.

The Editorial Staff
ansys-advantage@ansys.com

Editorial Adviser
Mary Beth Clay

Executive Editor
Jamie J. Gooch

Managing Editor
Tim Palucka

Copy Editor
Abby Humphreys

Contributors
Laura Carter, Aliyah Mallak, Erik Ferguson, Jennifer Procario, Matt White

Editorial Contributor
Ansys Customer Excellence

Art Director
Ron Santillo

Designer
Dan Hart Design

ANSYS, Inc.,
Southpointe, 2600 Ansys Drive, Canonsburg, PA 15317

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Take a Leap of Certainty ... with Ansys

When visionary companies need to know how their world-changing ideas will perform, they close the gap between design and reality with Ansys simulation. For more than 50 years, Ansys software has enabled innovators across industries to push boundaries by using the predictive power of simulation. From sustainable transportation to advanced semiconductors, from satellite systems to life-saving medical devices, the next great leaps in human advancement will be powered by Ansys.

Ansys is the global leader in engineering simulation. We help the world's most innovative companies deliver radically better products to their customers. By offering the best and broadest portfolio of engineering simulation software, we help them solve the most complex design challenges and engineer products limited only by imagination.

Complete Simulation's New Mission

By **Jane Trenaman**, Senior Director, Product Management, Ansys

When Ansys began, more than 50 years ago, our goal was to help you use structural simulation to verify physical tests. Over the years, simulation came to be defined by the physics challenges being solved — structural, thermal, fluidic, optical, electromagnetic – and the Ansys product portfolio expanded, incorporating bestin-class physics simulation capabilities across a broad spectrum of engineering disciplines. Our goal was to help you answer the engineering challenges you faced.

Today, our goal is to help you design, develop, deliver, and operate the most innovative products and services imaginable using Ansys simulation. This requires more than just multiphysics. It requires many different people, processes, and systems that are often separated by geography, culture, expertise, and priorities. Consequently, our Ansys portfolio continues to expand. We now incorporate simulation technologies for collaboration and integration across the product life cycle— all the way from product requirements through early-phase ideation and conceptual design, to the detailed physical analysis, and the management of the product within its daily operating environment.

Simulation is a critical part of the solution to the biggest engineering challenges you face (including sustainability, autonomy, and electrification), as well as a fundamental element necessary for progress on your digital transformation journey. This issue of Advantage focuses on the integrated products, services, and partners that make it easier for you to make that journey.

LET'S START AT THE VERY BEGINNING

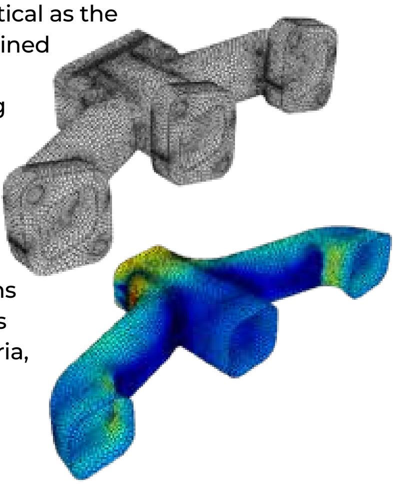
Where does a product design begin? For most products, it begins with a product requirement or specification. The management of these complex requirements has gradually been digitized, and in recent years, not just the requirement, but also the expected or desired behaviors of the product or sub-component. Simulation therefore now starts with the requirement and what is called model-based systems engineering (MBSE). MBSE replaces the stacks of paper that were once used with a digital model that becomes the single source of truth accessible to everyone working on a project, which models the behavior and interactions of the parts and components included within the product specification

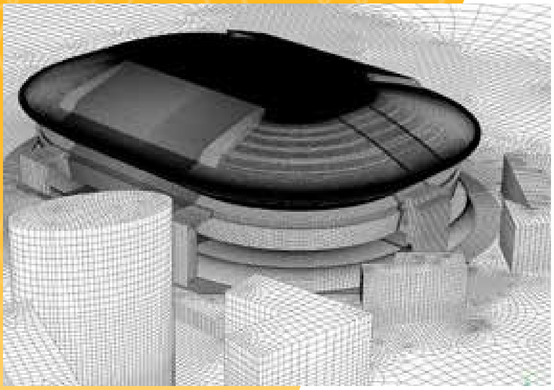
MBSE helps teams to capture and communicate new or changing requirements. It ensures that everyone has the same data to work with throughout the entire life cycle of the product. This requires an automated engineering workflow that provides a bi-directional connection between the systems model and the engineering analyses. Ansys ModelCenter is a vendor-neutral engineering workflow software solution that connects engineering analysis software to systems architecture, enabling the MBSE mission. This results in better decisions being enabled early in the product development life cycle and better target product designs.

THE RIGHT DESIGN

Even though innovative companies have shifted the use of simulation earlier in the product design process to reduce the number of physical prototypes needed and to identify the target product design early, simulation continues to be critical as the target design is refined and optimized.

Ansys optiSLang uses advanced automation and machine learning to explore and optimize one or more target designs to meet robustness and reliability criteria, among other parameters. It connects to both





Ansys and third-party tools, as well as your in-house solutions, to automate simulation workflows.

CAPTURE AND MANAGE THE DATA

More simulation means more data is generated. Our expanded definition of simulation includes tools to manage and connect that data. Ansys Minerva simulation process and data management software provides a web-based interface to ensure that data is accessible, reusable, traceable, and secure across your organization – by simulation experts and non-experts alike.

FLEXIBILITY OF USE AND ACCESS

Providing you with the flexibility to use our technologies to meet your needs is a key driver for our product and technology development. PyAnsys is a collection of open-source libraries that enable developers to access Ansys technologies using the Python development language. This project originated as a single package, PyMAPDL, and continues to expand to include core Ansys technologies like PyFluent, PyAEDT, and PyDPF. Having well documented, easy-to-access software libraries in Python allows our customers, partners, and external developers to use Ansys technology to build new applications, automate existing workflows, and extend the power of simulation to new, non-engineering professionals.

The increasing use of simulation also leads to ever increasing requirements for computation power and capacity. This can mean not just expensive hardware, but complexity of IT infrastructure and resource allocation and accessibility. Leveraging cloud-based technologies helps resolve these challenges. By distributing today's large, system-level, multiphysics problems over multiple remote processors, engineers can collaborate on high-fidelity solutions faster than ever.

Ansys offers multiple ways to run simulation on the cloud. Ansys Cloud (Direct) allows you to tap into the cloud compute strength of Microsoft Azure. Our new Ansys Gateway powered by AWS offering enables you to use your existing AWS cloud subscription to support your use of Ansys simulation. You can read how Ansys Cloud was used to simulate airflow in an entire stadium on page 34 and see how Emirates Team New Zealand is using Ansys simulation to help design its winning America's Cup yachts via Ansys Gateway powered by AWS on page 22.

YOUR MISSION IS OUR MISSION

The concept of digital mission engineering, in which digital modeling, simulation, and analysis incorporate the operational environment where designs will be used is a well understood concept within the aerospace & defense communities. By taking into account a product's effectiveness at every phase of the life cycle, we're expanding the definition of simulation out of the lab and into the field. Digital mission engineering means modeling systems, and systems-of-systems, in a realistic operational environment so you can evaluate how they will perform before you bend any metal on a prototype. In this way, critical engineering and planning decisions can be made early on, preventing errors from perpetuating, and avoiding resource waste. Learn more on page 14.

Similarly, digital twins take shape in an integrated, multidomain simulation that mirrors the life and real-world experience of a product, or an asset. Ansys Twin Builder is an open solution that enables engineers to create physics-based digital twins with hybrid analytics, offering more accurate and reliable data to support operational decision-making.

DELIVER DIGITAL TRANSFORMATION

Digital transformation involves more than just technological enhancements. Our global partner community includes more than 350 technology partners, channel partners in more than 40 countries, service partners, strategic partners, and academic partners. Technology partners collaborate with Ansys on developing new, world-changing solutions, while channel partners help you choose the right Ansys products for your needs and work with you to ensure you are using them in the most effective manner. Together, our partners reflect today's cross-silo workflows where an array of people, hardware, and software needs to work together to foster innovation.

I hope this issue shows you how the use of simulation can deliver unmatched insights and support your decision making across your entire engineering design life cycle. Simulation can help you transform the way you design, develop, deliver, and operate your products.

MODEL-BASED SYSTEMS ENGINEERING EXPLAINED

By **Tim Palucka**, Managing Editor, Ansys Advantage

Model-based systems engineering (MBSE) is a methodology that focuses on creating and exploiting digital system and engineering domain models as the primary means of exchange of information, feedback, and requirements, rather than relying on documents. It involves the entire process of capturing, communicating, and making sure all the digital models we use to represent a system are coordinated and maintained throughout the entire life cycle of the system.

“Automating and integrating the simulation into this system model allows the team to rapidly identify potential issues with changes to mission requirements ... The overall improvement versus the original process was about a 7X speedup in turnaround time.”

— **Phathom Atena Donald**, Systems Engineer, Lockheed Martin Space

Prior to about 2010, a system engineering design was likely to be a bunch of related papers and documents containing drawings, diagrams, mathematical formulas, requirements, and other specifications for how the system would work. But around that time, projects became too large to rely on disconnected documents. Problems included:

- **Upkeep of the design specification as the concept of the system evolved:** If an engineer changed a single dimension on one document, they had to go through the entire stack of documents and make sure the same change was made in all documents that contained that dimension. If other copies existed, they could not be sure that the change was recorded in all copies.
- **Human interpretation:** It is entirely possible that two engineers could read the same sentence in the specification and come away with different meanings, given the ambiguities of human writing systems and understanding.
- **Verifiability:** How could you be sure the system being designed satisfied all customer requirements?

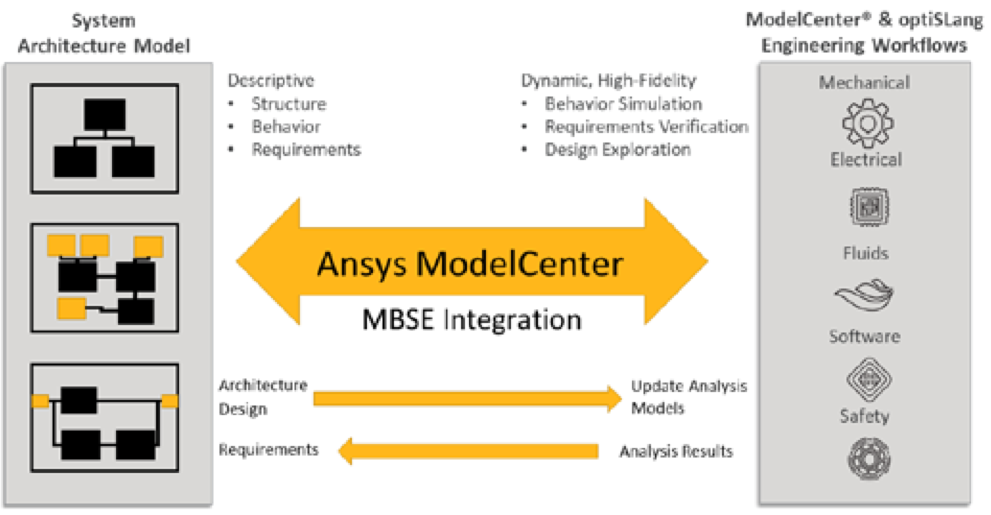
MBSE was developed to replace static documents with “intelligent” digital models that contain everything important about the system — the requirements, architecture, and interfaces between the pieces of the system. Instead of paper documents that were at best organized into folders, these digital models are connected by a “digital thread” that can be followed to understand the entire design.

The overarching systems architect model (SAM) serves as an “authoritative source of truth” for everyone working on the project. This digital model has a central location that can be accessed by all the engineers working on the project, but cannot be modified independently of others, preserving the single source of truth. Any changes made are automatically propagated throughout the model and checked for internal consistency and accuracy by the program.

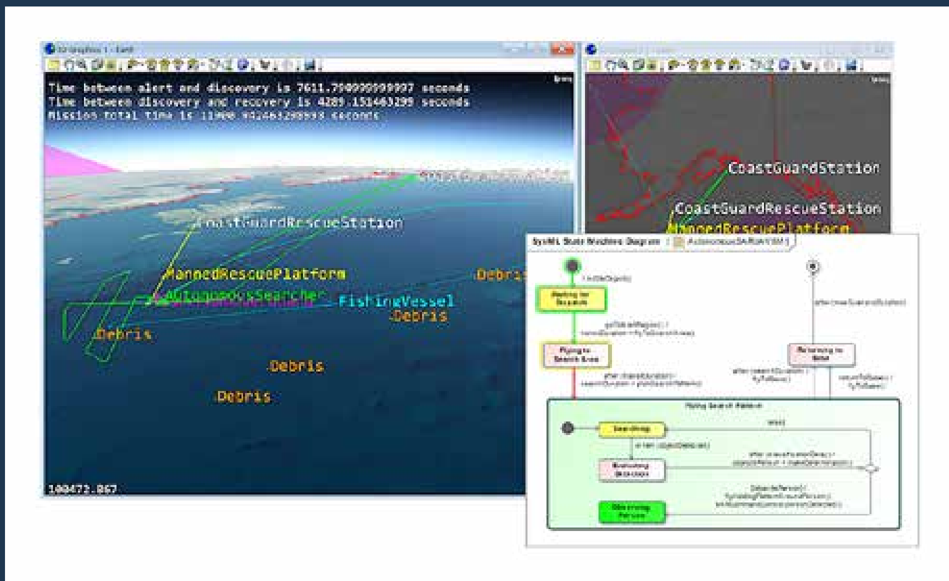
THE CORE COMPONENTS OF MBSE

MBSE relies on three major components:

1. **The SAM**, in which the system being designed is represented by a series of connected block diagrams to describe the system’s physical and functional architecture. It also contains a



Ansys ModelCenter connects the system architecture model with engineering simulation software.



Ansys ModelCenter's Behavior Execution Engine (BEE) integration ensures that system design meets behavioral requirements early in the development life cycle.

comprehensive list of qualities that the system is required to have or functions it is required to perform (i.e., the requirements). SAMs are created using specialized software programs and utilize purpose-built languages for describing system architectures.

2. **Engineering simulation software.** A SAM can be compared to a computer-aided design (CAD) drawing — it describes the system in detail, but there is no way to tell from the SAM alone if the system meets requirements. For this, the SAM must be coupled with engineering simulation. If the airplane you are designing is required to withstand 6 Gs, for example, engineers will need to run a simulation to tell them if the airplane they are designing is up for the task. Because a complex system might require engineers to execute many different types of simulation solvers — structural, fluids, electromagnetic, embedded software, safety, cybersecurity, etc. — it is important to be able to use many different types of simulation tools.
3. **A centralized computation center.** Whether located somewhere on the company's premises or in the cloud, this centralized computation center contains the SAM and the executable software. It performs all functions and stores all results of the MBSE process.

ACHIEVING AN MBSE ENVIRONMENT WITH ANSYS SOFTWARE

In MBSE, the combination of the SAM, CAD, and computer-aided engineering (CAE) simulation tools comprise key parts of the "digital thread" that links all the models and engineering data together. This occurs early in the design cycle and continues to function through the entire operational life cycle of the product until it is retired from use. When changes are made, the digital thread ensures that updates to one model are automatically transferred to all the models in the system.

Ansys software does not create the SAM, but instead provides the wide array of engineering simulations needed to verify the system design — and, most importantly, a way to connect them. Ansys ModelCenter, the software product obtained when Ansys acquired Phoenix Integration in 2021, provides that connection between the engineering simulation software and the SAM, enabling engineers to virtually verify their designs. So, if you are working on a project that has digital models containing structural, fluids, electromagnetic, safety, and embedded software simulations, ModelCenter will coordinate the operation and data collection from simulation tools such as Ansys Mechanical, Ansys Fluent, Ansys HFSS, Ansys medini analyze, Ansys SCADE, and others and connect these simulations to the SAM to enable MBSE. Consistent with Ansys' overall corporate strategy to provide an open ecosystem, ModelCenter is a vendor-neutral solution that can automate the execution of any simulation tool within a workflow, even those from other software vendors.

As the design cycle progresses and the product design is refined, engineers can use Ansys MBSE technology to assess whether the as-designed system meets the specified requirements, or whether changes have to be made. When changes are made to the requirements or the SAM, the entire procedure can repeat until results satisfy specifications, verifying that the design will work as intended throughout the product's lifetime. Only after these requirements have been satisfied will the team build a physical prototype of the design to perform physical tests on it.

The value of MBSE is that it enables better decisions to be made throughout the design life cycle, and as early in the design life cycle as possible. The earlier a problem can be identified, the easier and cheaper it is to correct.

MBSE provides value from requirements through to retirement by enabling a disciplined system engineering approach. The digital models can be inspected, verified, and validated against an authoritative source of truth, ensuring the internal consistency of the models. MBSE improves delivery, product yield, and both the top and bottom line.

MBSE IN ACTION

As an example, imagine that the Air Force has put out a bid to design a new plane that can fly 3,000 miles on a single load of fuel. You can design, build, and test the airplane by building multiple prototypes, or you can use a model-based approach.

If you decide to use an MBSE approach to design this complex new plane, you would first create a SAM that documents all the important requirements for the airplane (including the requirement that it needs to be capable of flying 3,000 miles on a single fueling). You would then use the SAM to describe the design you intend to build, including the system architecture, the desired behavior, interfaces between system components, etc. At this point, you would use simulation to verify that the design you described meets all the requirements (both physical and behavioral). Simulation would include fluids simulations to verify aerodynamics, structural simulations to verify mechanical strength, electromagnetic simulations for the functions of the communications devices, and others.

For more complex, mission-based applications, engineers can use digital mission engineering software to simulate the complex "system of systems" structure of modern aerospace and defense missions. (See page 14.)

In a real-world example, Lockheed Martin Space performed MBSE using Ansys ModelCenter to simulate the mission trajectory for the OSIRIS-REx spacecraft, whose mission was to grab a sample of an asteroid in a "touch-and-go" operation. In October 2020, OSIRIS-REx successfully conducted this maneuver to collect at least 60 grams of material, a far larger sample size than any other previous sample retrieval mission. It is due to return the sample to Earth in 2023.

"Automating and integrating the simulation into this system model allows the team to rapidly identify potential issues with changes to mission requirements, as well as perform continuous verification of requirements and mission design parameters throughout the life cycle of the spacecraft …" says Phathom Athena Donald, a Systems Engineer for Lockheed Martin Space. "The overall improvement versus the original process was about a 7X speedup in turnaround time."

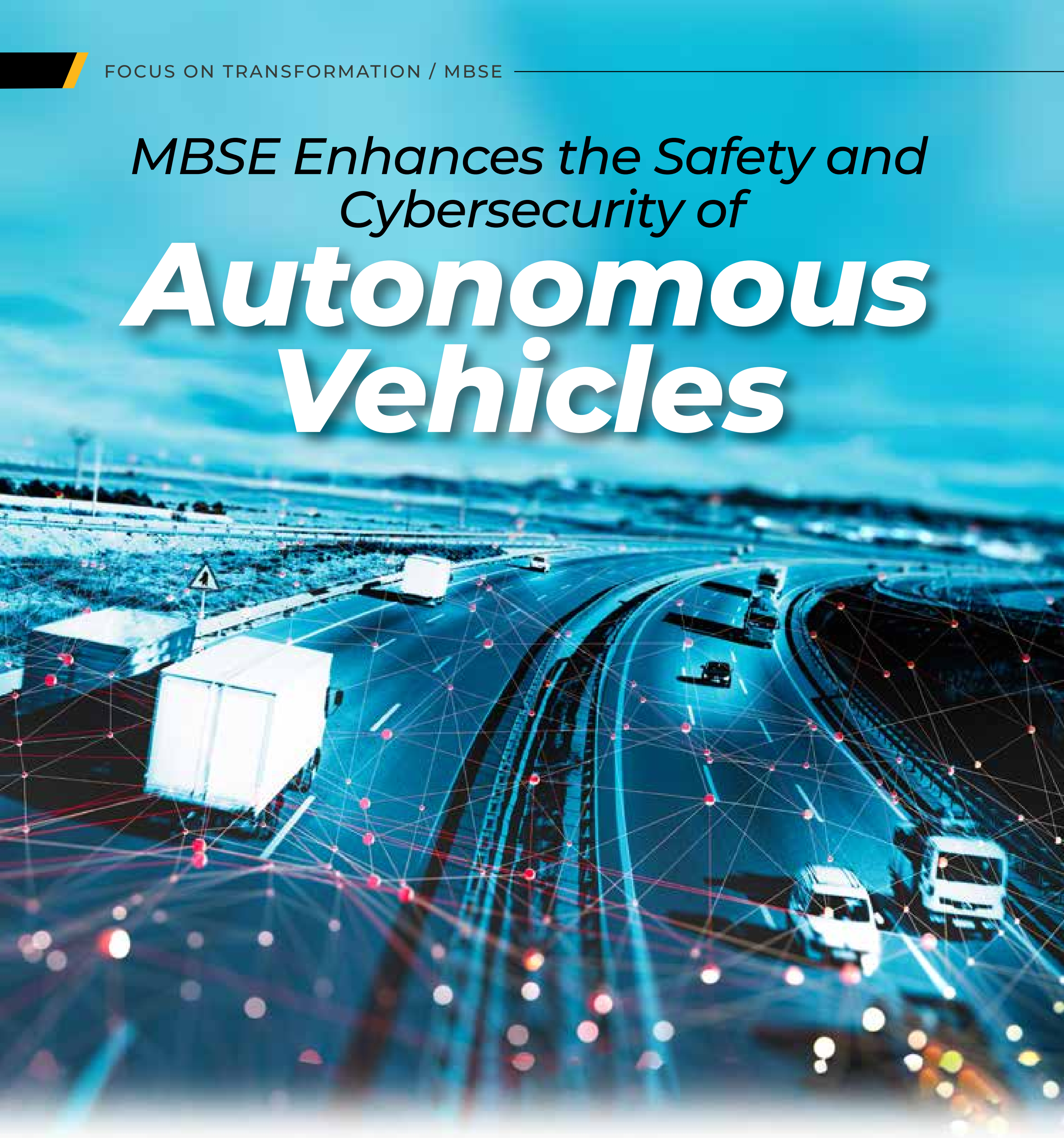
DEFENSE DRIVES MBSE ADOPTION

The biggest boost to MBSE came from the U.S. Department of Defense (DOD), which issued DODI 5000.02 on January 7, 2015, and reads: "The Program Manager will integrate modeling and simulation activities into program planning and engineering efforts." With this simple statement and the details that followed, the DOD essentially made MBSE a requirement for all proposals related to U.S. defense and weapon systems.

Based on this DOD requirement, Northrop Grumman delivered an MBSE-based proposal in 2020 that won them the prime contract for the U.S. Air Force's Ground Based Strategic Deterrent (GBSD) project. GBSD is designed to modernize the U.S. land-based nuclear infrastructure, replacing the aging LGM-30 Minuteman III intercontinental ballistic missile system (ICBM) with an integrated weapon system that will meet defense requirements through 2075.

While A&D is leading the charge, other sectors are quickly catching up. The automotive industry, in pursuit of solutions for complex autonomous driving challenges, is also rapidly adopting MBSE. As complexity increases in other sectors, such as semiconductors, medical devices, alternative energy, the smart grid, and 5G communications, MBSE adoption will likely accelerate there, too.

MBSE Enhances the Safety and Cybersecurity of Autonomous Vehicles



By **Tim Palucka**, Managing Editor, Ansys Advantage

The continuing enhancement of automobiles with advanced driver assist systems (ADAS) and the ongoing quest to produce fully autonomous vehicles (AVs) that communicate with each other on the road leads to larger, more complex systems. Simultaneously, it demands more safety and security in automobile systems design. But safety and security requirements can sometimes clash. To make a car safer requires additional components to monitor the operation of the vehicle, but these components may make the vehicle less cyber-secure by offering new entry points for hackers to access the control system and software.

To support development of such large, complex systems and provide a robust development framework for automotive system designs, Hitachi Industry & Control Solutions, Ltd. (Hitachi Industry & Control Solutions) of Japan established a specialized department called the MBSE Design Lab in 2019. It expanded to become the MBSE Design Center in October 2022. This model-based systems engineering (MBSE) Design Center features Ansys SCADE embedded software and Ansys medini analyze functional safety and cybersecurity simulation software as key elements of their approach to designing safe and secure automobiles.

Through the MBSE Design Center, Hitachi Industry & Control Solutions is practicing strategies to manage functional safety and cybersecurity when supporting automotive OEMs and tier-one suppliers in their design and development of automated driving, automotive infotainment, and automotive control systems. From the functional perspective, SCADE Architect is used to design architecture through step-by-step detailing. Ansys medini analyze makes it possible to run two types of analyses — safety and security — on one common model.

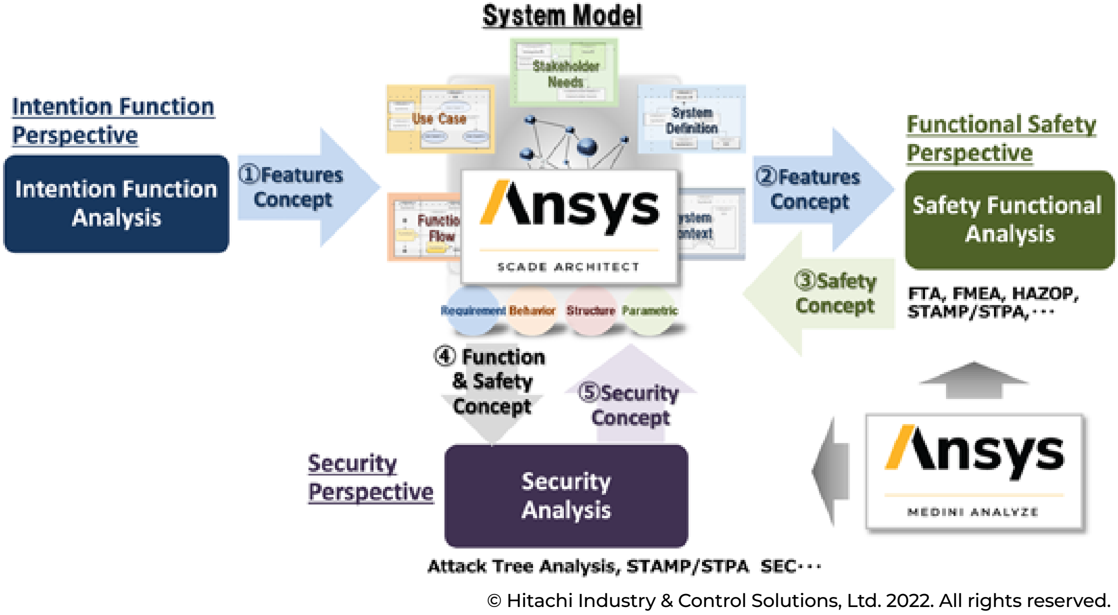
"We believe that the integration of Ansys simulation tools and MBSE gives us visibility into the entire design process, reducing development costs, improving engineering efficiency, driving innovation, and designing competitive products," says Takeo Hashimoto, General Manager of MBSE Design Center, Hitachi Industry & Control Solutions.

INVENTING AN MBSE SOLUTION

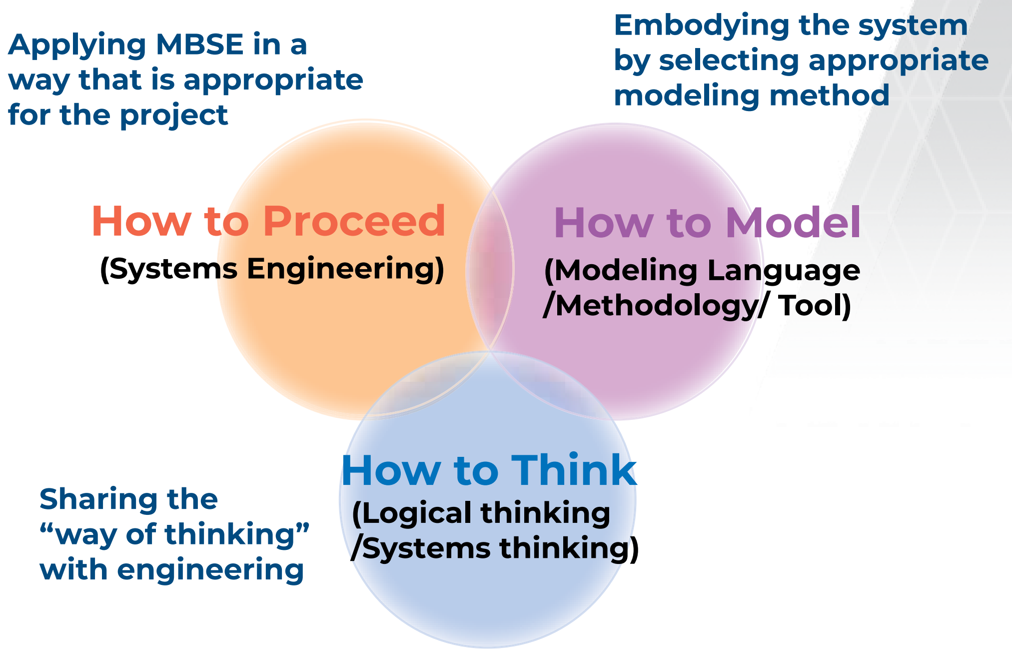
Hitachi Industry & Control Solutions has transformed their development style from traditional design to systems engineering to MBSE over the last 10 years. Before that time, developments in the automotive field started becoming increasingly large and complex, leading to problems at their customers' automobile development sites.

"The development sites were experiencing a lot of rework in the verification process, which could no longer be handled by conventional development methods," Hashimoto says. "We spent a lot of time studying how we should organize the requirements while effectively using existing assets to address the issue of insufficient documentation in the upstream process, which is the basis of the verification process."

This detailed study led them to the conclusion that systems engineering was the solution to their problems. As defined by INCOSE (International Council on Systems Engineering), systems engineering is "a transdisciplinary and integrative approach to enable the successful realization, use, and retirement of engineered systems, using systems principles and concepts, and scientific, technological, and management methods. In particular, it focuses on establishing, balancing and integrating stakeholders' goals, purpose, and success criteria, and defining actual or anticipated customer needs, operational concept, and required functionality, starting early in the development cycle."



Flowchart for managing functional safety and cybersecurity of automobiles using Ansys solutions at Hitachi Industry & Control Solutions



The three axes of MBSE at Hitachi Industry & Control Solutions

"But, at the time, there was very little literature on systems engineering in Japan," Hashimoto says. "We have been taught by pioneering universities in Japan and gradually developed it through repeated trial and error based on overseas literature and information from INCOSE. We were the pioneers of systems engineering practices in Japan."

Even with systems engineering in place, when it came time to proceed with the upstream process of requirements analysis and architecture design, the design information became too voluminous, and the traditional paper-based development style of systems engineering faced new challenges that made it difficult to develop and manage while maintaining overall consistency and integrity.

Soon, Hitachi Industry & Control Solutions was transforming to MBSE, which INCOSE defines as "the formalized application of modeling to support system requirements, design, analysis, verification, and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases."

In effect, by introducing MBSE — utilizing a system model that expresses the relationship between the multifaceted requirements and functions of the system — it has become possible to achieve a common understanding with stakeholders, including engineers, and to develop and manage large-scale and complex systems while maintaining overall consistency and integrity.

THE THREE AXES OF MBSE AT HITACHI INDUSTRY & CONTROL SOLUTIONS

Hitachi Industry & Control Solutions has developed a framework of MBSE through practice based on three axes.

The first axis, "**how to proceed**," involves applying MBSE in a way that is appropriate for the project while taking into account the essence of the system design process based on the systems engineering approach.

The second axis, "**how to model**," embodies the system by selecting appropriate modeling methods while organizing diverse perspectives into a coherent whole. Ansys SCADE Architect and Ansys medini analyze are deployed here not only for modeling but also for streamlining safety and reliability analysis and verification based on simulations.

The third axis, "**how to think**," combines systems thinking with logical thinking. It is the most important factor of their framework in the application of MBSE.

Hashimoto explains: "Systems thinking, which looks at the overall picture and clarifies the relationships among the components, and logical thinking, which maintains consistency among the elements while controlling the level of abstraction and logically capturing them, are necessary to promote essential discussions

> ***"We believe that the integration of Ansys simulation tools and MBSE gives us visibility into the entire design process, reducing development costs, improving engineering efficiency, driving innovation, and designing competitive products."***
>
> — **Takeo Hashimoto**, General Manager of the MBSE Design Center

among members and gradually organize ideas to build the whole. These two ways of thinking are the driving force behind MBSE for us, because they lead to team and corporate strength. Hitachi Industry & Control Solutions is promoting a curriculum to develop employees who can think in such a way."

INSERTING SIMULATION INTO THE MBSE PROCESS

MBSE makes it easy to analyze and simulate frequently in the early stages of the product development process to confirm requirements and begin reviewing design alternatives before spending money on prototypes that ultimately fail to meet requirements.

The engineering teams at Hitachi Industry & Control Solutions spent some time in determining how best to integrate Ansys simulation solutions into the product development process. Without this integration, requirements could not be validated and performance, cost, and risk tradeoffs could not be fully evaluated.

As mentioned earlier, in safety design it is standard practice to design external components to monitor for component failures. This is to ensure that anomalies caused by component failures are detected. However, in security design, this external component can also create a security risk that can be the starting point for an attack. Resolving these contradictory events is a key safety and security concern.

"Ansys simulation solutions are very helpful in visualizing the conflicting structure of safety and security requirements and ensuring traceability, as they allow for centralized management of requirements and design models from different perspectives, while providing an overview of the entire process," Hashimoto says.

Hitachi Industry & Control Solutions engineers use Ansys medini analyze to aggregate and analyze a single architecture, helping them to achieve an optimal design in terms of safety and security. They also use Ansys SCADE Architect in the item definition process, which allows for a step-by-step detailed design of the architecture that will be the scope of safety and security. The architecture can then be imported into medini analyze, which ultimately leads to the elimination of inconsistencies in the analysis target and in analysis granularity.

"We believe that this kind of collaboration between simulation software products is the greatest advantage of using Ansys tools," Hashimoto says.

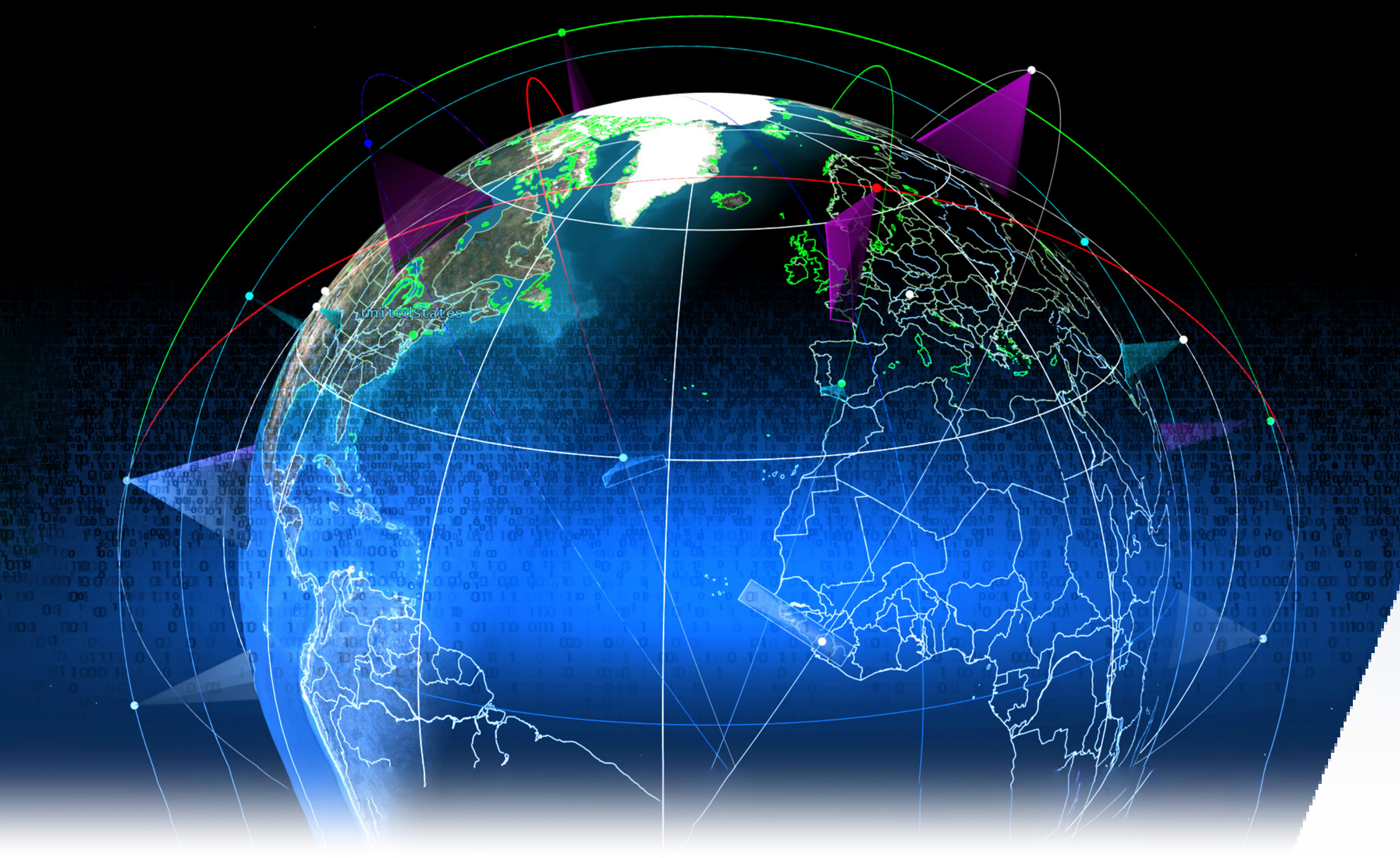
The MBSE approach using Ansys SCADE Architect models the entire system from various perspectives to provide a common understanding between experts in different domains of safety and security, contributing to the derivation of optimal architectural solutions.

"From an engineering firm's perspective, introducing the MBSE approach to a development site that is in turmoil due to the development of a large and complex system has the effect of promoting project efficiency," Hashimoto says, "because it enables the site to separate design and development work by organizing what needs to be done and for what purpose as part of system development. We believe this is the ROI for our engineering firm."

Using systems engineering and MBSE approaches, Hitachi Industry & Control Solutions has participated in 35 projects for 13 companies over the last 10 years. With the help of Ansys simulation solutions, they hope to increase this number significantly in the next 10 years.

"We will expand the value we provide to the entire workplace for the life cycle of their products," Hashimoto says. "With Ansys tools and Hitachi Industry & Control Solutions' MBSE-focused engineering, we will support autonomous development in the automotive field and help customers solve their manufacturing issues in a more connected society."

How to Engineer Mission Success

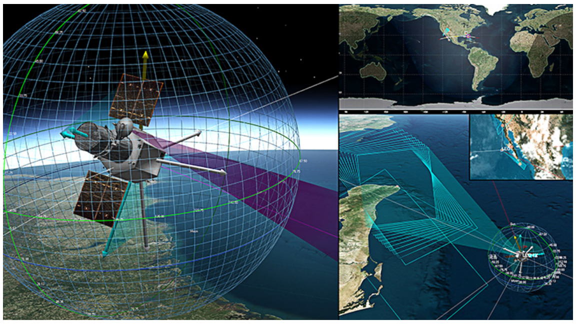


By Ansys Advantage Staff

The pressure was on, and the design engineers at an American aerospace giant needed a new approach to developing products. While the traditional approach — design, build, test, and repeat — had won them a long string of successes, times have changed. Indeed, their entire company was in the midst of an enterprise-wide digital transformation to respond to the new reality: products must get to market faster. Against this backdrop, the team of engineers decided to use simulation to achieve a much leaner approach: model, analyze, then build.

> ***"Digital mission engineering is the use of digital modeling, physics-based simulation, and analysis to incorporate the operational environment and evaluate mission outcomes and effectiveness at every phase of the life cycle."***

One essential element of this new approach was digital mission engineering — pioneered by AGI, now Ansys Government Initiatives. Digital mission engineering is the use of digital modeling, physics-based simulation, and analysis to incorporate the operational environment and evaluate mission outcomes and effectiveness at every phase of the life cycle. In other words, you simulate your product in a digital model of the conditions it must operate under and evaluate how well it will perform.



MISSION (DIGITALLY) ACCOMPLISHED

How did digital mission engineering assist with this team's project? The team needed to optimize an airborne communications gateway, to be used by a variety of warfighters. This gateway would comprise radios and antennas — some under wings, others on the fuselage — plus data links and voice systems.

The challenges were significant, starting with the millions of channel combinations to analyze and solve. Complicating this analysis were environmental factors such as co-site interference from the emitters and antennas sharing such a limited space. And, beyond the gateway's potential to hinder itself, the entire electromagnetic (EM) spectrum is an increasingly congested and contested domain.

Applying digital mission engineering, the team simulated the gateway by performing a variety of expected missions in a model of its operating environment. They analyzed the data from these simulations to understand interference on the gateway, effectively allocate the channels to be used, and determine antenna placement and pattern. Because these tests were simulated, the cycles of adjustment and reevaluation were only waiting on new data — not new prototypes.

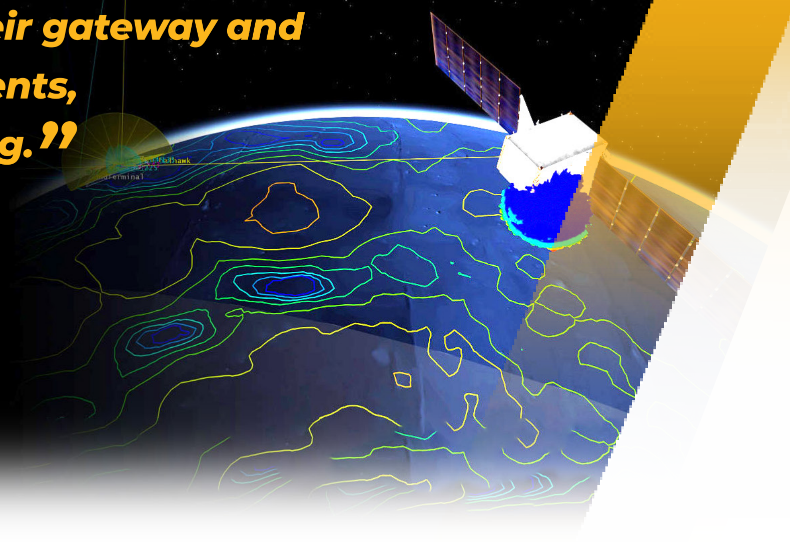
The result? The engineers achieved their goal in about half the time it usually took. Let's take a closer look at how they did it.

The process began with designing a mission model in Ansys Systems Tool Kit (STK) that represented the gateway's operational environment — what it needed to do, but also where and when. This enabled them to evaluate their designs to understand how real-world variables might affect them, and why, from the beginning.

The next step was to integrate Ansys HFSS (3D, high-frequency simulation) with STK to determine a link budget, which measures the total transmitted power in a radio system, including all gains and losses. Now the team could use its arsenal of simulation tools to optimize the gateway design, while gaining important insights about how each change would impact mission success with just a few clicks. Here are some of the ways that they applied simulation solutions and their mission model to the challenges they faced:

- Importing computer-aided design (CAD) geometry files of aircraft that would host the gateway into HFSS to create nominal antenna designs, understand the installed electrical response at various locations, and then pick the right spots and pattern for the antennas.

> ***"Through digital mission engineering, the engineering team could quickly understand the performance of their gateway and identify new requirements, without physical testing."***

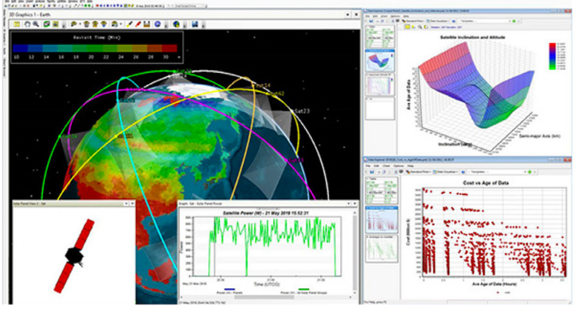


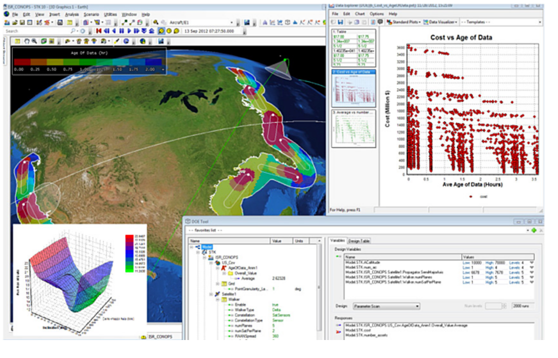
- Exporting the information from HFSS into Ansys Emit, which predicts interference in a complex system comprising multiple emitters that operate simultaneously. The results of this analysis indicated which channels or radios would have a destructive effect on avionics or other systems and services.
- Mitigating co-site interference by filtering and using frequency planning to reallocate the channels and antennas, then applying the changes to the analysis in HFSS.
- Importing the antenna response as installed, and the selection of clean channels, into STK. This enabled engineers to visualize the effects of all of the components on the whole gateway while they simulated various maneuvers and routes.

FASTER, SMARTER, BETTER

Through digital mission engineering, the engineering team could quickly understand the performance of their gateway and identify new requirements, without physical testing. The rapid iterations of modeling and analysis dramatically accelerated the project's timeline and enabled the team to deliver a first build that was closer to production-ready than legacy approaches could achieve. In a world where time to market is a crucial discriminator, digital mission engineering provides an unparalleled advantage.

Learn more about Ansys Digital Mission Engineering solutions
ansys.com/products/missions





As an example of digital mission engineering in aerospace, Ansys STK allows you to design the architecture, mission, and spacecraft, while defining requirements for payloads, communications, and ground infrastructure.

The Meaning of Mission

One of the trickier things to contend with is a simple question, one that you assume you know the answer to until you ask it: What do we mean when we say "the mission"? The reason it's not so simple is that people use the word mission in many ways. So, what do we mean when we talk about the mission in terms of digital mission engineering? Let's break it down.

A mission is:

- The things that a product, system, or platform is supposed to be able to do
- The environment it must do it in — including natural forces and competitive or adversarial activity

What are some examples of this kind of mission?

At the simplest, you might say that a spoon is supposed to enable you to eat soup, and a bowl of soup would then be its operational environment. Or consider a heat pump for your home, which must be able to heat and cool it. A heat pump's environment includes many factors, from weather outside the house to airflow inside it.

A mission can have conditions, too, like a car that must be able to safely transport four to six human passengers and some amount of cargo while averaging a certain fuel efficiency, and so on. If you've driven a car, then you're already very familiar with how dynamic that environment can be, and how those dynamic factors can affect the car's mission conditions in different ways.

Finally, consider a radar that detects aircraft, which someone else may not want it to do. There's a good chance that its environment includes competitive or adversarial activity — for example, an aircraft that's trying to jam it.

So, while the definition of mission can be distilled reasonably simply, the full expression of a particular mission can be multifaceted and intricate. And as you can imagine, the more complex the mission, the greater the advantage you gain from digital mission engineering.

DIVERSIFYING MISSIONS

Digital mission engineering was first implemented in the aerospace industry, and its use there continues to spread. At the same time, Ansys — and our customers — are proving that the same approach can be successfully applied to a diverse set of other systems, including automotive vehicles, maritime vessels, and smart cities.

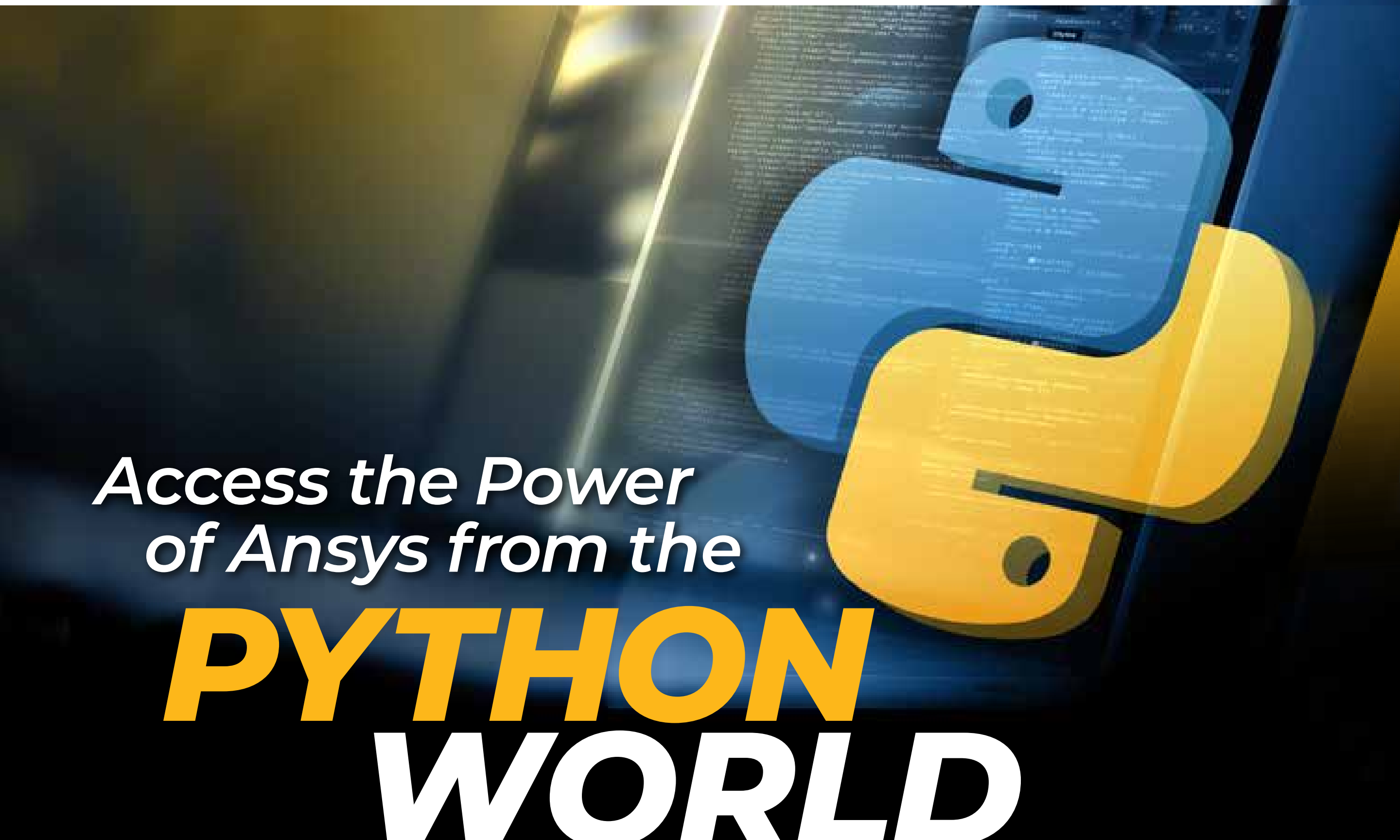
Let's look at an example of how digital mission engineering could apply to another industry: telecommunications. You might say that a cell phone's mission is to maintain data rates, links, and voice communication anywhere within a crowded urban environment. You have defined the things it must do and the environment it must do it in. In what ways could digital mission engineering provide insight about this phone's ability to perform its mission?

Here are few things you could analyze:

- Dynamic environmental factors, such as natural radio frequency (RF) interference on complex communications networks
- System-of-systems interactions, such as taking a picture while streaming a video conference call, while connected to a Bluetooth headset
- How motion affects performance. For example, a phone may rely on positioning information from GPS satellites, so it is important to consider how obstructions such as buildings vary as the device travels through a city.

Obviously, we're keeping things simple here. But once you understand the full meaning of mission in the context of digital mission engineering, you can begin to appreciate the multitude of applications waiting to be realized.

Properly applied, digital mission engineering increases efficiency and reduces costs, starting from the very beginning of product design and carrying all the way through to operations and maintenance. And by continuously validating real-world performance as you advance through the life cycle, you start each new phase with confidence that your design is ready for that next step. Moreover, once you see, firsthand, how efficient the approach makes your team, you can start to consider truly extraordinary leaps in innovation.



Access the Power of Ansys from the PYTHON WORLD

By Ansys Advantage Staff

Python is the world's most popular programming language, and the Python ecosystem contains an abundance of open source code libraries that developers can freely use to create new solutions. The PyAnsys code library breaks new ground by enabling developers to integrate Ansys-based simulation into their Python-based projects.

One way to look at simulation is this: Simulation delivers insights without the need to perform the real-world tasks that would otherwise deliver those same insights. Stresses can be tested without breaking — or even building — an expensive prototype. The characteristics of a new design — be they thermal, electrical, fluid, or whatever — can be explored without having to create the actual temperatures, pressures, currents, or flows. We can gain the insights that would otherwise have arisen from experience without actually having to create the experience — which is particularly valuable when gaining those insights might take 50 or 100 years or involve destroying multi-million-dollar prototypes.

The only real-world tasks that need to be performed in a world enabled by simulation are the manual tasks associated with configuring, running, and sharing the results of the simulations themselves.

But thanks to PyAnsys and other Ansys solutions that connect the digital thread, even that is changing.

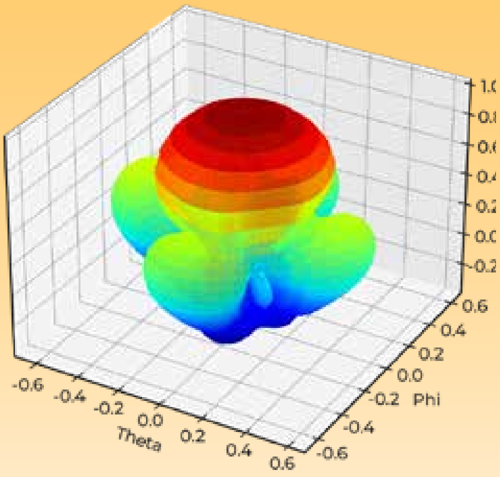
The GitHub community has been active in uploading PyAnsys-based projects for others to use, and Ansys has been reviewing the projects and working with developers to incorporate their ideas into new PyAnsys packages.

PyAnsys is a family of Python packages that enable users to interact with Ansys products, including MAPDL, AEDT, and others, in an unprecedented manner. The packages provide users with a modern programmable interface through which they can not only script the execution of a wide range of multiphysics simulations using the Ansys simulation stack, but they can also script workflows that incorporate simulation to other automated operations.

WHY PYTHON?

So why Python? The Ansys Parametric Design Language (APDL) has long provided extensive scripting and control capabilities for interacting with Ansys products. Individuals can write scripts in APDL (or Mechanical APDL [MAPDL], a finite element analysis program built on APDL), that facilitate setup, execution, and post-processing of simulations. The Ansys Customization Toolkit (ACT) also provides features for controlling and automating simulations in Ansys Mechanical. But that was just it: One could only use the scripting features of these tools from within the tools. There was no mechanism for interacting programmatically with any Ansys products from outside APDL, MAPDL, or ACT.

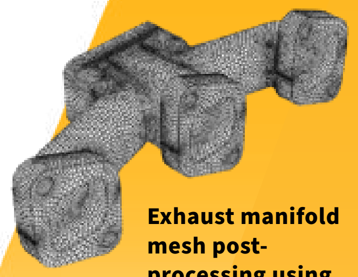
That changed in 2016 when a Python developer and Ansys MAPDL user named Alex Kaszynski created a code library that enabled him to interact with MAPDL using Python. The Python language is widely taught in schools and embraced enthusiastically by innumerable developers, and the Python ecosystem has an abundance of public and private code repositories that developers can draw from to create their own applications. Kaszynski posted his code library — called PyMAPDL — to GitHub, the open source online code repository, where interested users could download it and incorporate its functionality into their own projects that involved using MAPDL.



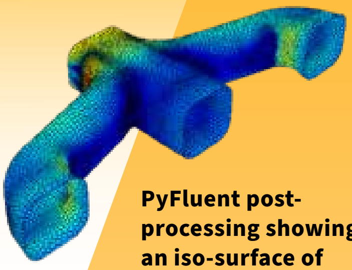
3D polar plot of antenna array output using PyAEDT

And download it they did. PyMAPDL was made available at no cost to users — though users intending to interact with Ansys MAPDL needed to license that application — and it soon became clear that Ansys users very much wanted the ability to interact more programmatically with the Ansys simulation stack.

This enthusiasm was clear to Ansys as well, which hired Kaszynski and encouraged him to continue the work he had begun.



Exhaust manifold mesh post-processing using PyFluent



PyFluent post-processing showing an iso-surface of the velocity of flow in an exhaust manifold

MOVING FORWARD PYTHONICALLY

That work today is ongoing. As of this writing, the PyAnsys page on GitHub offers a range of packages that can be used to interact "Pythonically" with Ansys products:

- Electronics simulation: PyAEDT
- Solid mechanics simulation: PyMAPDL
- Fluids simulation: PyFluent, PyFluent-Parametric, PyFluent-Visualization
- Post-processing: PyDPF-Core, PyDPF-Post
- Materials management: Granta MI BoM Analytics

Additionally, the PyAnsys page on GitHub offers access to a range of shared components that facilitate package interoperability and minimize maintenance.

Because the Python ecosystem provides code libraries with which users can create web applications with customized user interfaces (UIs), PyAnsys products can easily be called from those customized UIs. That ensures that PyAnsys-based projects are very easy to use because users need not be familiar with the UIs associated with each individual Ansys product. Even a Python script that accesses several different Ansys simulation tools can present users with a UI whose only options and input requirements are those that are relevant to the workflow being automated.

The GitHub community has been active in uploading PyAnsys-based projects for others to use, and Ansys has been reviewing the projects and working with developers to incorporate their ideas into new PyAnsys packages. The packages (along with full documentation and code examples) continue to be offered on GitHub as open source libraries under an MIT license. In addition, the Ansys Developer Experience has been introduced as a digital platform designed to encourage and enable the broader developer ecosystem to interact with Ansys.

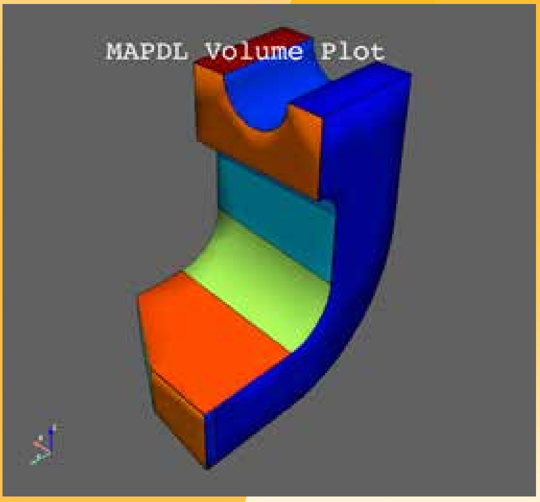
The Ansys Developer Experience aims to encourage the developer ecosystem to grow and mature, while improving the user experience by more easily accessing relevant resources and getting technical support.

The platform includes the developer portal, peer-to-peer discussion forums, and access to Ansys documentation and tools intended to enable developers to get up and running quickly. This is the first time that Ansys has dedicated platforms and resources to supporting developers using new and emerging Ansys technologies. The Developer Experience aims to encourage the developer ecosystem to grow and mature, while improving the user experience by more easily accessing relevant resources and getting technical support.

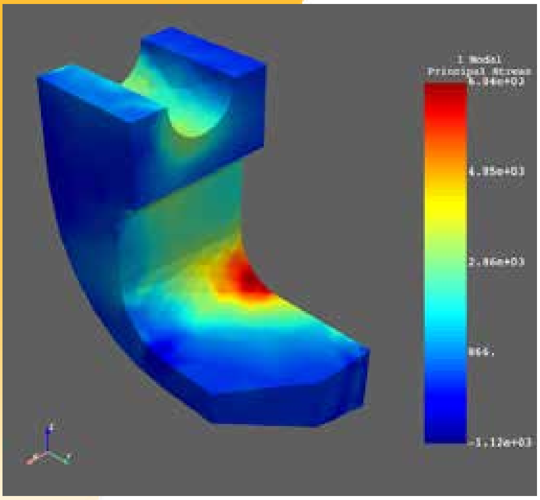
REAL-WORLD BENEFITS

For users around the world, PyAnsys presents tangible benefits. The engineering team at Bewind GmbH, a German systems design and engineering firm, for example, uses PyAnsys to create a customized, automated workflow to assess fatigue in its wind turbine blades more accurately and effectively. This approach saves significantly on time and costs by using the predictive accuracy of Ansys solvers to validate that the blades are both structurally sound and operationally efficient.

Other companies are already using PyAnsys to automate repetitive, complex simulations, such as those that might be used to train a machine learning (ML) or artificial intelligence



MAPDL volume plot of a lathe cutter



MAPDL modal principal stresses of lathe cutter

(AI) system. Training such systems may require thousands of simulations, and managing the execution and analysis of those simulations becomes significantly easier if execution can be managed programmatically through a Python script. Still other companies are adopting PyAnsys to help ensure that repeated simulations are conducted in exactly the same way so as to reduce the possibility of human error arising from the imperfect repetition of a complex task whose novelty has worn off.

The ability to orchestrate processes using Python also creates opportunities for engineers to rethink the manner in which activities are performed. By breaking a complex workflow into tasks that can be run in parallel using separate resources, for example, a Python script can dramatically reduce the amount of clock time required to complete the workflow. Activities that might previously have required ongoing coordination and hand-offs between a structures team, a fluids team, and a thermal team — each traditionally running simulations sequentially on different tools — can now be captured in a script that can be used in conjunction with other solutions in a connected digital thread to provide the information that all teams need.

For both end users and developers, the availability of PyAnsys packages and the ability to incorporate Ansys simulations into a broader ecosystem of activities opens new doors. Many organizations today are using PyAnsys to automate existing processes, which makes sense because they are the processes that are known and need to be performed in specific ways. But PyAnsys also creates opportunities to integrate the Ansys simulation stack into workflows that may never have been tried before. PyAnsys is yet another Ansys technology that enables interconnected innovation and, ultimately, digital transformation.

Visit the Ansys Developer Experience
developer.ansys.com

A New Cloud is on the Horizon:

INTRODUCING ANSYS GATEWAY POWERED BY AWS

By **Thomas Lejeune**,
Product Marketing
Manager,
Ansys

Cumulus. Stratus. Cirrus. All of us learned these cloud types at some point in science class — and experienced a sudden realization that not all cloud formations were the same. For at least a few weeks or months, it changed how we looked up at the sky, seeing distinctions and variations we'd missed before. It turned out that the concept of a "cloud" was a lot more complex than we'd originally thought.

Similarly, the concept of cloud computing has grown in nuance and complexity since the term was first used in 1993 to describe the use of a distributed computing platform. Today there is general agreement that there are three types of clouds: private, public, and hybrid. But within each of these three general classifications, there are seemingly endless cloud variations. Who owns the resources? How are they shared and accessed? How much control does the user have in specifying and controlling those resources?

> **“WE WERE SURPRISED BY HOW EASY AND SEAMLESS IT IS TO SWITCH FROM OUR INTERNAL CLUSTER TO THE CLOUD WITH ANSYS GATEWAY POWERED BY AWS. IT’S FAST AND INTUITIVE TO SWITCH BACK AND FORTH FROM CLUSTER TO CLOUD AS OUR NEEDS CHANGE.”**
>
> — Steve Collie, Aerodynamics Coordinator for Emirates Team New Zealand

Today, every organization seems to have a different answer. And, as companies become more digitally sophisticated, they’re demanding even more customized cloud approaches and configurations that meet their own unique computing needs — including the need for remote users to collaborate via cloud platforms.

Cloud providers are responding by delivering ever-increasing levels of flexibility, scalability, ease of use, and other service innovations — and with good reason: The global market for cloud computing is expected to grow from $405 billion in 2022 to nearly $1.5 trillion by 2028[1], reflecting an annual growth rate of 23.9%. Capturing a share of this market means understanding and meeting organizations’ changing requirements — and delivering more innovative, custom-tailored approaches to offering data storage, processing resources, and even shared virtual workspaces on demand.

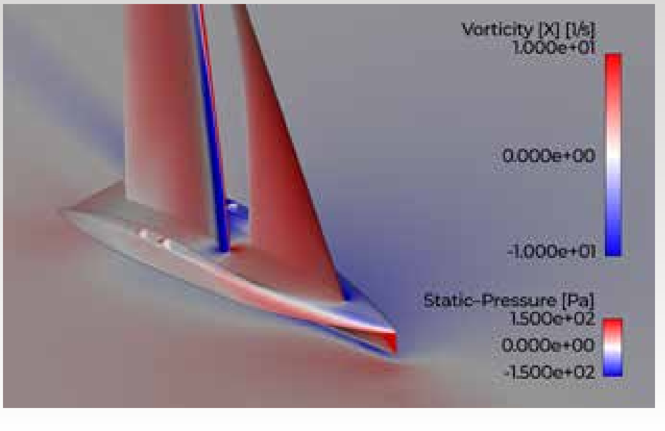
ENABLING INCREASED CONTROL AND CUSTOMIZATION FOR SIMULATION USERS

With its enormous data volumes and computational complexity, engineering simulation is ideally suited to a cloud computing environment. By distributing today’s large, system-level, multiphysics problems over multiple remote processors, engineers can arrive at high-fidelity solutions faster than ever. Cloud-computing approaches deliver these rapid solution times in a cost-effective manner by enabling product development teams to minimize technology ownership and maintenance demands while still accessing state-of-the-art hardware resources and the newest software functionality.

In addition to the existing managed-services solution that has already helped hundreds of Ansys customers, there is a new Ansys cloud solution on the horizon. In response to customers’ evolving needs for more customized cloud platforms, which provide individual users with more control over the specific cloud configuration and easier collaboration, Ansys recently announced the availability of Ansys Gateway powered by AWS.

Ansys Gateway powered by AWS is an intuitive, scalable, easy-to-use cloud solution available via AWS Marketplace. After customers subscribe and complete a series of onboarding steps, they can deploy and scale Ansys applications on a virtual desktop infrastructure (VDI) or high-performance computing (HPC) cluster via the Ansys Gateway web portal.

Instead of committing to a static, resources-constrained, on-premises HPC platform or



Emirates Team New Zealand simulations can exceed 50 million cells. Ansys Gateway powered by AWS lets them switch from their internal cluster to the cloud and back.

fixed software-as-a-service (SaaS) licensing agreement, customers can leverage their own AWS subscription and their own software licenses. By logging onto the Ansys Gateway powered by AWS web portal, they can easily initiate a simulation run of any size, from anywhere and at any time.

"We recognized that many organizations are already using AWS to manage their growing data volumes and processing needs," says Neehar Kulkarni, Product Manager for Ansys Cloud Solutions. "They may not want to add another cloud platform just for simulation. As its name suggests, Ansys Gateway powered by AWS is designed to be a user-friendly gateway, or portal, that enables our customers to easily leverage the enormous computing power of AWS for all their Ansys simulation needs."

Emirates Team New Zealand uses Ansys simulation software to optimize the designs of its winning America's Cup yachts via detailed simulations that are perfect candidates for Ansys Gateway powered by AWS.

The open architecture of Ansys Gateway powered by AWS enables Ansys software to run side-by-side with third-party computer-aided engineering and design solutions. Product development teams can boost their engineers' productivity by eliminating the need to switch back and forth between platforms as they complete analysis tasks and move on to the next step.

Ansys Gateway also improves engineering productivity, collaboration, and innovation by enabling each engineering team to create and manage its own virtual project space. Team members around the world can easily work together in this space by accessing the AWS resources closest to them. By acting as a platform for easy collaboration, the virtual project spaces delivered by Ansys Gateway powered by AWS reflect the way product development teams are working together today. AWS is a critical part of the equation because it streamlines the collaborative process and simplifies the complexity of bringing together geographically scattered team members.

"Helping customers get the most out of their Ansys simulation, we worked with Ansys on Ansys Gateway powered by AWS to boost innovation, accelerate time to market, and realize greater cost efficiencies. As a result of these efforts, customers now have a very secure, reliable, and accurate product that will push the boundaries of simulation," says Avi Kulkarni, Senior Partner Development Manager at AWS.

Ansys Gateway powered by AWS also addresses evolving Ansys customer needs by enabling complete customization of the remote simulation processing environment. "We've noticed that our customers are becoming more tech-savvy about HPC and cloud," says Krishna Samavedam, Senior Cloud Product Manager, Ansys. "With that knowledge comes a desire for greater control of the HPC resources.

"Ansys Gateway powered by AWS offers a nice balance between customization and ease of use. It's flexible enough for power users or cloud-savvy users — but simple enough for those users who just want to 'plug and play,'" adds Samavedam. "Even non-experts can quickly and easily configure, then iteratively reconfigure, an optimal VDI or HPC environment. They can see recommended virtual-machine configurations from Gateway and understand how these choices will impact their simulation run times upfront, before committing."

Jim Burnham, Strategic Partnerships Director for Ansys, emphasizes that, no matter which VDI or HPC resources users select, they always have access to the most recent software features and functionality from Ansys, as well as the most advanced hardware, delivered by AWS.

"The world's leading financial institutions, healthcare providers, and corporations are running on AWS today," Burnham notes. "So extreme power, speed, and security are a given. It's a partnership that makes sense for Ansys customers for many reasons."

TESTED, PROVEN PERFORMANCE FOR CRITICAL SIMULATIONS

While Ansys Gateway powered by AWS is a new offering, its fast and reliable performance has already been demonstrated by some of Ansys' most demanding customers. Emirates Team New Zealand, an Ansys power user, applies both Ansys Fluent and Ansys Mechanical to optimize the designs of its winning America's Cup yachts, both above and below the water.

The team's detailed simulations, which include dynamic changes in wind and weather conditions, as well as sail shapes, can exceed 50 million cells. Because the size was putting a strain on its internal computing cluster, Emirates Team New Zealand partnered with Ansys to test the ability of Ansys Gateway powered by AWS to supplement the team's on-premises HPC resources during peak usage periods.

"We were surprised by how easy and seamless it is to switch from our internal cluster to the cloud with Ansys Gateway powered by AWS," notes Steve Collie, Aerodynamics Coordinator for Emirates Team New Zealand. "We can quickly set up a customized workstation or cluster and select the best hardware. We can replace our hardware every day if we want, instead of replacing physical resources every four years. It's fast and intuitive to switch back and forth from cluster to cloud as our needs change."

While its internal HPC cluster provides Emirates Team New Zealand with a good baseline computing resource, Ansys Gateway powered by AWS provides instant and elastic additional capacity when Emirates Team New Zealand engineers are exploring computationally intense problems such as turbulence and cavitation, or running multiple simulations simultaneously.

According to Collie, Emirates Team New Zealand has realized important strategic benefits since switching to a hybrid computing approach.

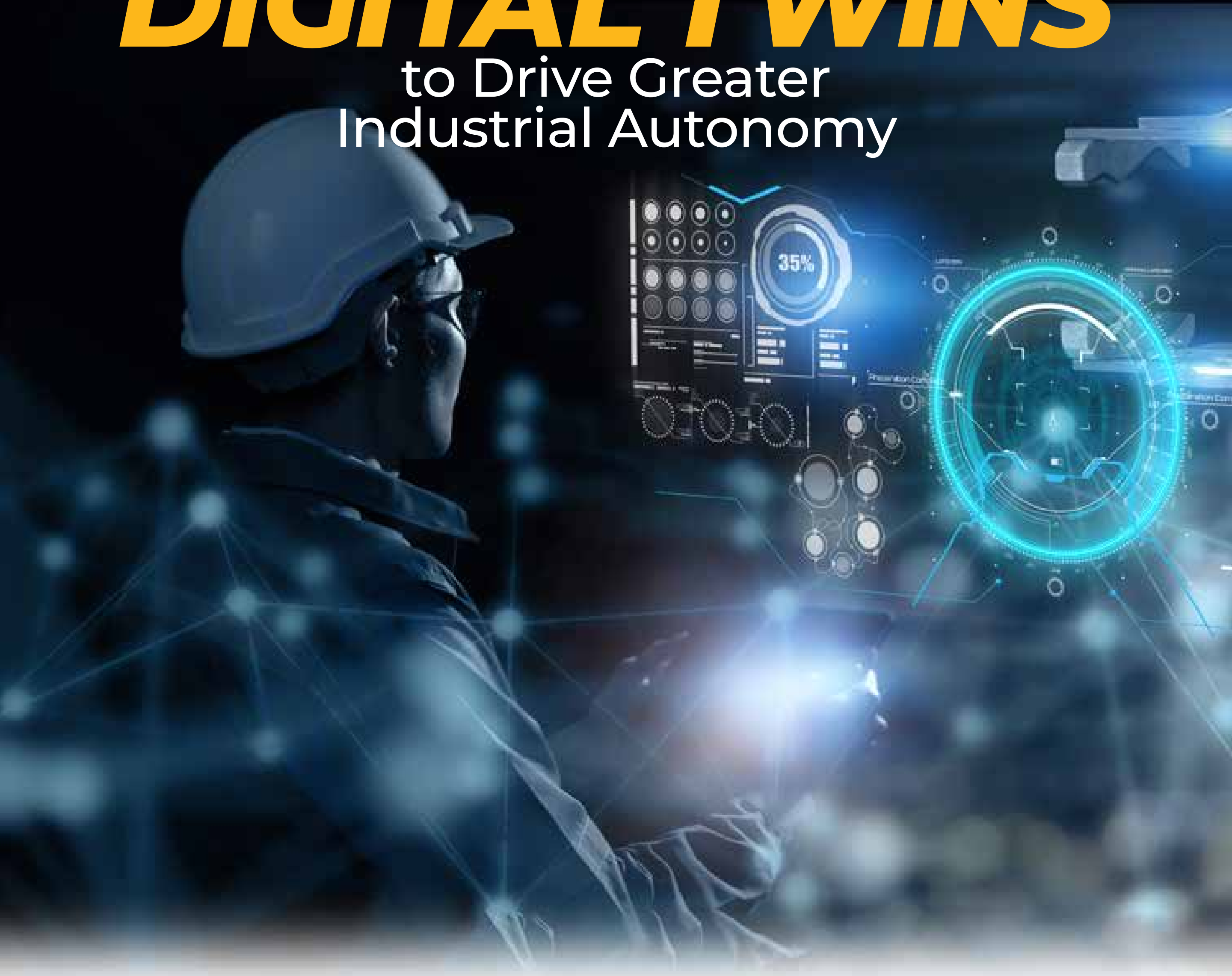
"Now Emirates Team New Zealand is able to scale up on demand to many times the simulation throughput of our internal cluster, simply by switching over to Ansys Gateway powered by AWS. As a result, we can significantly accelerate our design for the 2024 America's Cup."

Whether Ansys customers are relying on Ansys Gateway powered by AWS to manage all their simulation needs or taking a hybrid approach like Emirates Team New Zealand, they now have a robust new cloud services model, powered by AWS, to accelerate and streamline their most computationally intense product studies. By scaling up their computing capabilities via an easy-to-use cloud platform, every product development team can keep the wind in its sails, taking a decisive lead in the race to meaningful innovation and market leadership.

RESOURCES

1."Cloud Computing Market Forecast to 2028 - COVID-19 Impact and Global Analysis By Service Model, Deployment Model, Organization Size, and Verticals," The Insight Partners, June 2022, https://www.theinsightpartners.com/reports/cloud-computing-market

How Ansys and Amazon Web Services Use DIGITAL TWINS to Drive Greater Industrial Autonomy



By **Graziella Alves**,
Manager Product
Marketing,
Ansys

Digital twins can deliver a tremendous amount of value by improving engineering designs and delivering predictive modeling to support industrial operations. However, creating and deploying digital twins at scale requires coordination across several organizational silos and boundaries. For instance, much of the engineering know-how about assets is available within the product or engineering departments, typically codified in simulation models. By combining forces, Ansys and Amazon Web Services (AWS) are helping organizations bridge these silos to deliver scalable digital twin solutions.

"The world is moving more towards autonomous operations, and in particular for industrial autonomy use cases, we see digital twins as an enabling technology," says Adam Rasheed, Head of Autonomous Computing at Amazon Web Services (AWS). "You need to be able to understand how a system will behave under different scenarios to support autonomous decision making. Introducing a predictive modeling digital twin allows you to make predictions about the future under different potential scenarios."

Ansys and AWS are collaborating to help drive simulation-based digital twin solutions supporting industrial autonomy for our customers. The idea goes beyond pure 3D contextual visualization, which is a starting point that enables you to visualize all the data associated with your in-service physical assets in a particular environment. Within this context, we'll explain what a digital twin is, and how Ansys Twin Builder, AWS IoT TwinMaker, and advanced probabilistic methods can enable industrial autonomy for customers.

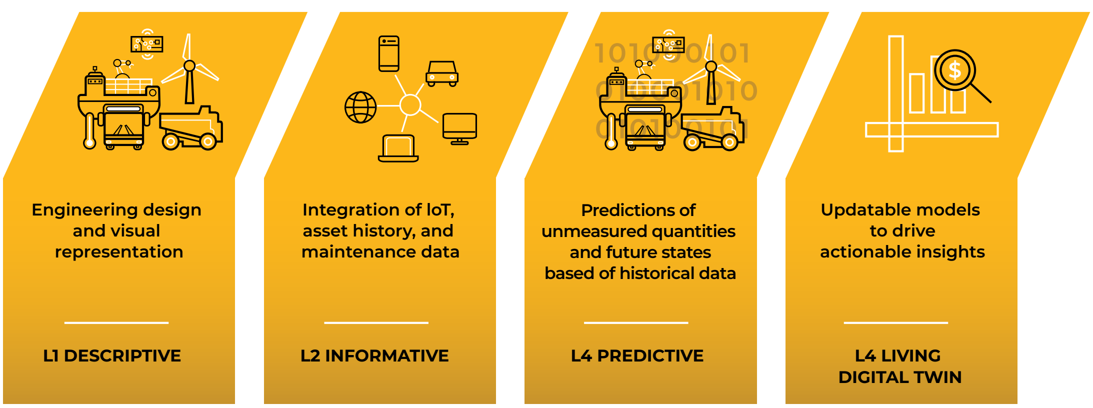
LEVELING UP TO DIGITAL TWINS

The generally understood definition of a digital twin is that it is a virtual representation of real-world entities and processes, synchronized at a specified frequency and fidelity. Often customers gravitate toward the idea of creating a digital twin for their unique use case prior to exploring the context of the challenge they are trying to solve. In a related blog[1], AWS proposed four distinct levels (L1-L4) of digital twins to consider. (See chart below.)

This is consistent with the customer journey that we have seen at Ansys — with levels 1 and 2 representing building blocks in terms of engineering modeling and data connectivity, and levels 3 and 4 representing more of the advanced predictive modeling analytics and insights that both Ansys and AWS can provide.

For the purpose of this article, we will be focusing on levels 3 and 4 as they are defined here:

- L3 focuses on modeling the behavior of the physical system, where the behavior is same as in the past (e.g., virtual sensors, anomaly detection or short-time horizons looking forward). The predictive models can be machine learning-based, first principles-based (e.g., physics simulations), or a hybrid. In this context, we're referring to physics and machine learning (ML) hybrid digital twins, such as those that can be generated by Ansys Twin Builder.



Digital twin levels framework adapted from: Verdantix, Five Digital Twin Strategies For Industrial Facilities, 2019.

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— **Adam Rasheed**, Head of Autonomous Computing at Amazon Web Services (AWS)

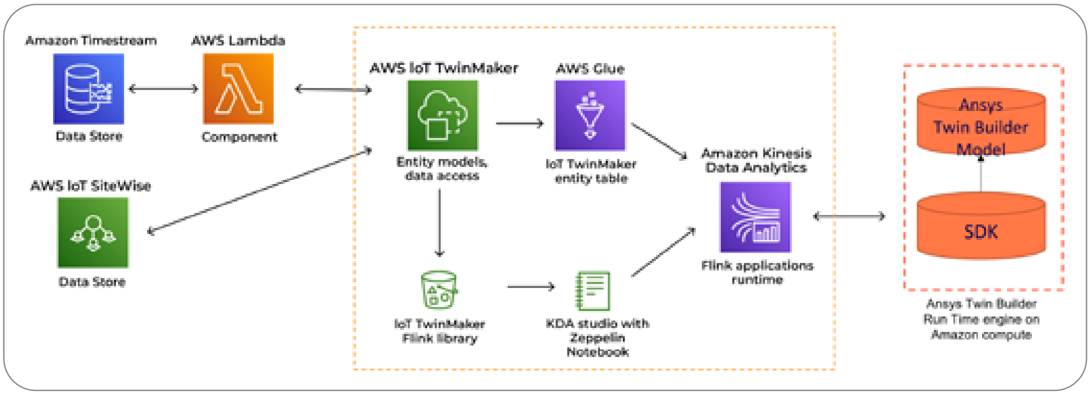
- L4 focuses on modeling behavior in which the physical system's inherent behavior changes over time. Changes in behavior can occur as physical systems degrade or receive maintenance and upgrades, and they are relevant when making accurate predictions over long timescales. This typically requires applying probabilistic update and uncertainty quantification methods on top of ML-based, first principles-based, or hybrid models.

For digital twins, the distinction between L3 and L4 is seen in how the operational data from the real-world system is used. For L3, the operational data is used as an input to a pre-trained L3 model that provides a response output. The implicit assumption is that the prediction is well represented by past behavior (e.g., historical data used to train the model). For L4, the operational data is used to update the model itself using probabilistic (Bayesian) calibration techniques. The updated model is then used to make the forward prediction. In this way, the L4 model is always learning and reflects the latest behavior of the physical system.

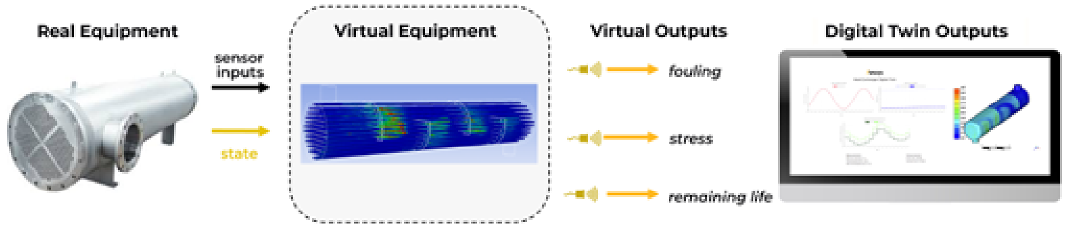
THE ANSYS TWIN BUILDER/AWS IOT TWINMAKER VALUE PROPOSITION

Ansys Twin Builder is an open solution that enables engineers to create physics-based digital twins with hybrid analytics. Each of these digital twins takes shape in an integrated, multidomain simulation that mirrors the life and real-world experience of that asset. Sensors mounted on an entity gather and relay data to a simulation model (the digital twin) to mirror the real-world experience of that product. Simulation-based digital twins enable tracking of the past behavior of an asset, provide deeper insights into the present, and can help predict future behavior of an asset — facilitating discovery that leads to system design optimization, predictive maintenance, and industrial asset management for customers. Ansys' simulation software — specifically, Twin Builder — provides the simulation technology needed to build predictive (L3) and living (L4) digital twins.

AWS IoT TwinMaker is an AWS service in the industrial internet of things (IoT) space that makes it faster and easier for developers



Export a Twin Builder twin model that easily plugs into AWS IoT TwinMaker.



Workflow of digital twin creation and deployment of heat exchanger equipment.

to create and use digital twins to optimize industrial operations, increase production output, and improve equipment performance. The service today focuses on 3D contextual visualization (L2) use cases, which involves ingesting IoT data from the physical system and overlaying that data on a 3D virtual representation of that system so that a user can have full contextual awareness of the state of physical system. The service also focuses on the three main customer pain points of ingesting and querying disparate data across silos, making it easy to maintain the asset data model over its lifetime and creating effective visualizations (which could be a 2D dashboard or 3D immersive experience). By connecting AWS IoT TwinMaker with the simulation digital twins from Ansys Twin Builder, customers are able to build and deploy holistic L3 and L4 digital twin solutions.

"AWS' focus on providing scalable services for digital twins via AWS IoT TwinMaker is great news for customers," says Sameer Kher, Senior Director of Digital Twins at Ansys. "As customers build up and scale out sophisticated digital twins, the ability to leverage Ansys' best-in-class simulation software via Ansys Twin Builder and deploy using the AWS IoT TwinMaker service is going to be extremely critical."

UNLOCKING SIMULATION INVESTMENTS TO ENHANCE OPERATIONS

AWS IoT TwinMaker provides the ability to connect to data from a variety of endpoints, including sensor data from both the physical asset and simulation models. This is where Ansys Twin Builder fits in. In many practical use cases, the physical asset might not have the right sensors, or sometimes it is even physically impossible to use a sensor.

For example, shell and tube heat exchangers (shown above) are typically used in oil refineries and in the chemical processing industry for heating and cooling applications. While quite robust, the primary failure modes tend to be caused by thermo-mechanical fatigue. While sensing temperature at every location on the heat exchanger could help identify hot spots and prevent failure, using physical sensors to do this is not feasible due to cost. An L3 digital twin of the heat exchanger, as demonstrated in this example, offers a solution. Using virtual sensors allows for a fine-grained representation of the temperature field. This representation can then be used to identify hot spots during operation. Suitable actions can then be taken to ensure that no failures occur.

As shown in the architecture diagram on the opposite page, adding Ansys Twin Builder into the mix also makes it easy to reuse existing simulation models created during the engineering design process and apply them within an operations context. The goal is to maximize the investment in simulations created during engineering design by making them available to operations. Using reduced-order models (ROMs) and system simulations, for example, engineers can build an accurate representation of a physical asset, then convert that into a runtime or software/instructions executed while a program is running for container-based deployment. The deployment easily fits into AWS IoT TwinMaker through APIs, which allows the customer to leverage simulations from their design engineering environment into the operations environment — including to a dashboard of the front end visible in AWS IoT TwinMaker, with Ansys simulation running as the predictive modeling engine behind the scenes.

RESOURCES

1. "Digital Twins on AWS: Unlocking business value and outcomes," Amazon Web Services blog, March 2022

TEACHING 'BRAINS' USING DIGITAL TWINS WITH MICROSOFT

By **Tim Palucka**, Managing Editor, Ansys Advantage

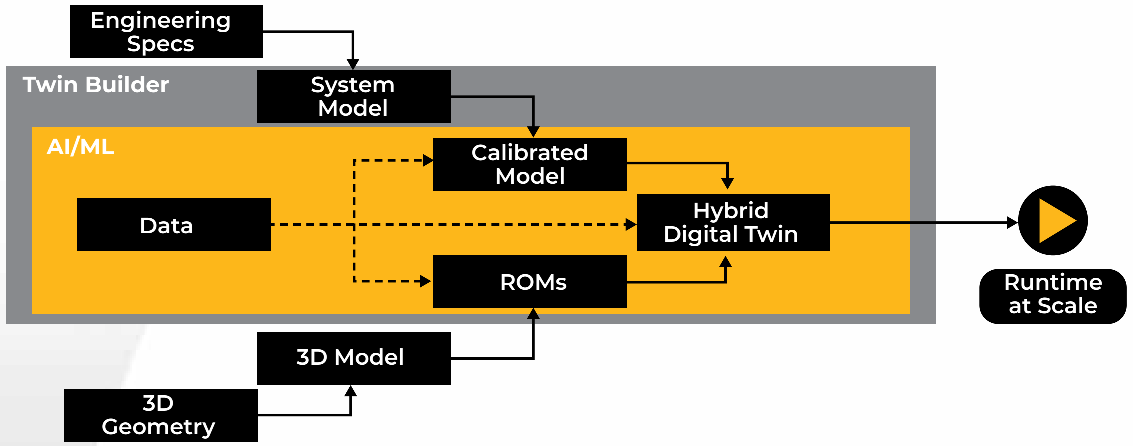
An engineer gathers operational data from a working industrial machine

Engineers are increasingly using artificial intelligence (AI) to automate processes and make decisions faster and more effectively than humans can. But, while engineers are experts in their area of specialization, most of them are not data scientists. Many don't have the time to learn data science and write the complex code that AI modules require.

Microsoft Project Bonsai helps engineers create AI-powered automation without using data science by graphically connecting software modules that have already been programmed to perform certain AI functions. A complete set of connected functions that can perform a task is called a "brain." A brain is a standalone, portable software module that can be used as part of an open loop to advise a human operator on the best decision to make. It can also replace the human entirely, making decisions and carrying them out by itself when configured in closed-loop mode.

Microsoft is working with Ansys Twin Builder software to create digital twins of equipment or processes to be automated using AI. Digital twins can generate the large amounts of data needed to train AI brains much more quickly and at lower cost than using physical machines for data generation.

> "THIS IS REALLY EXCITING FOR US BECAUSE WE CAN SIMULATE MANY DIGITAL TWINS SIMULTANEOUSLY, COLLECT THE DATA, SORT IT OUT ON OUR SIDE AND MAKE SURE THAT THE RIGHT DATA IS BEING GENERATED FOR OPTIMAL LEARNING."
>
> — Cyrill Glockner, Principal Program Manager, Microsoft



Flowchart showing how Ansys Twin Builder and Microsoft Bonsai AI-based machine teaching combine to produce a digital "brain"

MACHINE TEACHING VS. MACHINE LEARNING

As automated processes become more complex, the method of training an AI brain is changing, too. When the goal was simply image or text recognition, flooding the AI brain with tons of labeled data so it could pick out patterns worked well. This is the basis of machine learning (ML).

But when AI is being relied on to control a complex, multistep process on an industrial scale, ML is not as effective. The variety of inputs from numerous sensors of different types simply overwhelm the brain.

So, Microsoft engineers developed the concept of machine teaching (MT), which relies more on a human approach to learning. Just as a math teacher doesn't start trying to teach young students calculus before they have mastered the basic concepts of arithmetic, engineers can't expect an AI brain to understand how an electric turbine works before it learns about rotation.

"Imagine you're starting with the hardest problem where the chances of finding a solution are almost nil," says Cyrill Glockner, a Principal Program Manager at Microsoft. "The AI brain will never find a way to do that. But it can slowly work its way up to it by following a combination of exploitation and exploration, taking advantage of what it has already learned and looking across the data environment to ensure that it finds an optimal solution to the problem."

In practice, human experts first break the process down into smaller tasks. They then give the AI brain a few simple problems so it can begin learning how to use its algorithms to solve these easy challenges. Then they combine small tasks the brain has already seen into larger ones until it can automatically control large, complex systems.

"We basically reduce the mathematical

space that the AI brain has to look at by limiting it to certain parameters and ranges," Glockner says. "Then we increase the range over time. The brain only has to deal with the new delta, and it already has some methods that it found in the earlier, smaller range that can be applied to the larger ones as well."

THE ROLE OF DIGITAL TWINS

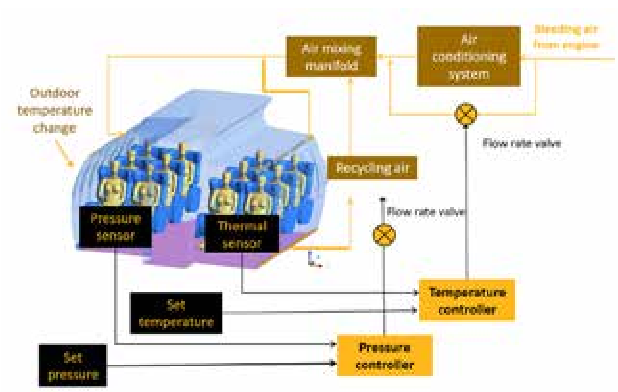
While it is important when initially training a brain using MT to start with small tasks and limited amounts of data, once the brain is well-trained, it requires large amounts of data to fully optimize its operations.

Typically, this involves generating huge amounts of data by running a physical process over and over. This data can then be fed into the brain to fine-tune its operation on the complete machine or process it was designed to automate. But generating so much data from physical processes is time-consuming and expensive. Also, if a condition occurs only once every trillion times — a "corner case" — and is not encountered during the training runs, the brain will not have seen it before and will not know how to react if the situation occurs later.

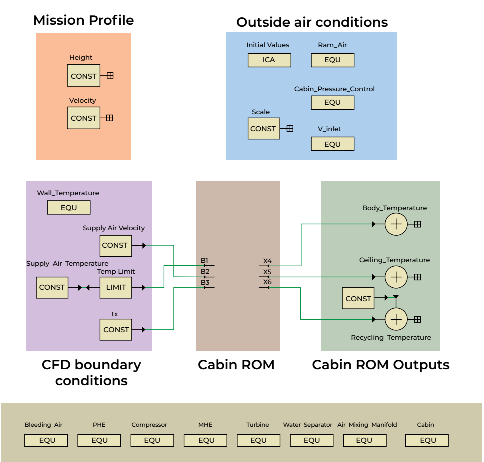
Working with Ansys Twin Builder, Microsoft Project Bonsai overcomes these limitations by running hundreds of virtual models of the machine or application simultaneously and feeding the data generated by these digital twins directly into the brain to optimize it. Using large numbers of virtual models instead of fewer physical ones reduces the time and cost of training a brain. It also enables engineers to introduce corner cases in the virtual environment — which might be potentially dangerous or damaging to a physical machine — so the brain has seen all possible scenarios before it is put into operation.

HOW IT WORKS

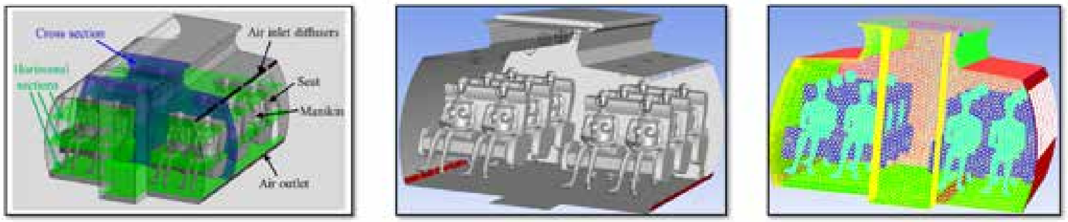
Engineers start by using Twin Builder to create a multiphysics system-level model by combining different modeling techniques such as 0D/1D modeling and reduced-order modeling (ROM) from higher-fidelity simulation results. These higher-fidelity models provide the greatest simulation accuracy, but take a long time and many computational resources to run. A ROM is a model that is smaller and less computationally intensive than the original, but it runs much faster while sacrificing very little in terms of the accuracy of the physics involved in the simulations. Twin Builder models the overall system using component libraries (e.g., pumps, valves, actuators, sensors, etc.) and ROMs for components requiring accurate predictions that typically cannot be achieved with 0D/1D modeling (for example, a complete field prediction of physical variables), which enables optimization and validation of component choices with the system response.



Variables, sensors, and actuators that comprise a cabin pressure control system



Schematic showing how cabin pressure and temperature requirements feed into the ROM to produce desired cabin conditions



A cabin pressure control system that combines a digital twin with a Microsoft Project Bonsai brain to control the temperature and pressure of an aircraft cabin

The physics-based digital twin model can be further improved by incorporating knowledge coming from asset data — for example, for model calibration or augmentation, which leads to a hybrid digital twin. The final models can be exported and deployed in the form of a Twin Runtime module.

"We can directly integrate Twin Runtimes into Microsoft Bonsai," says Christophe Petre, Manager, Product Specialist for digital twins at Ansys. "Twin Runtimes come with a very simple application programming interface (API), which can be used in different programming languages like a Python application, that tells the users how to manipulate the digital twins by transmitting inputs, simulating the models, and retrieving the outputs seamlessly."

Once the API is integrated with Bonsai, engineers can determine whether a virtual change to any operating condition improves the behavior of the equipment or process they want to control. They can also access new information, like virtual sensor data (something that you cannot measure physically but can be predicted with the model); explore "what-if" scenarios; or run simulations to see how the asset is aging to predict when maintenance will be required.

THE BRAIN AT WORK

A cabin pressure control system (CPCS) is one way to demonstrate digital twin technology and its integration with Bonsai. A CPCS is an avionics system designed to minimize the rate of change of cabin pressure. Its purpose is to ensure the safety of the airframe and passengers while maximizing comfort for aircrew and passengers during all phases of flight. It consumes part of the overall energy consumption of the aircraft and therefore requires complex controls.

In Bonsai, engineers can build the AI brain by graphically selecting and connecting functional blocks of control code that take cabin temperatures and pressures at various points in the cabin as inputs and issue active commands (e.g., "turn down air conditioning") as outputs.

In Twin Builder, the air conditioning subsystem can be modeled using 0D/1D components in Modelica, and a high-fidelity representation of the aircraft cabin can be modeled with a 3D computational fluid dynamics (CFD) model in Ansys Fluent. A ROM is created from this 3D model and connected to the system model in Twin Builder. This provides accurate virtual sensors distributed spatially in the cabin to monitor pressure and temperature.

Once the model is assembled and validated in Twin Builder, engineers can generate a portable, plug-and-play Twin Runtime application. Through the simple Python API, it can be ported to a digital twin workflow and used to train a Bonsai brain to create a controller. In this case, the digital twin will make predictions of the virtual sensors and, based on that, the AI controller will take actions on the air conditioning system to maintain the targeted pressure and temperature.

"Instead of using training datasets where you have either labeled or unlabeled data for supervised and unsupervised learning, we can use simulation at the digital twin as the data generator," says Glockner. "This is really exciting for us because we can simulate many digital twins simultaneously, collect the data, sort it out on our side and make sure that the right data is being generated for optimal learning."

Eager to see a live demo of Microsoft Bonsai and Ansys Digital Twin integration?

Visit us at the Microsoft booth (Hall 004, Stand E34) during Hannover Messe in April 2023

hannovermesse.de/en/

CFD SIMULATIONS PREDICT COVID-19 AEROSOL FLOW IN STADIUMS

***Thierry Marchal*,**
Industry Director for Healthcare Solutions, Ansys

The Johan Cruijff ArenA stadium in the Netherlands.
Copyright Johan Cruijff ArenA

February 19, 2020. Early in the pandemic, before lockdowns and suspension of sporting events. In Milan, Italy, 40,000 fans gathered to watch a Champions League Football (soccer) match between the Italian team Atalanta Bergamo and the Spanish team Valencia in San Siro stadium. Following the 4-1 win by Atalanta, local newspapers described it as a "magical" night for the fans in attendance. Two weeks later, when the halls of Bergamo hospitals were filled with people dying from COVID-19, one doctor had a different name for the sporting event: a "biological bomb." The game became widely known as "Game Zero," the place where potentially the pandemic really started in Italy.

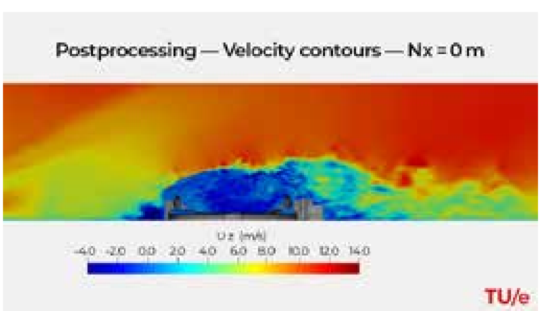
Professor Bert Blocken of the Eindhoven University of Technology in the Netherlands and KU Leuven in Belgium watched the thrilling game on television, then watched with sadness as the devastating results of such a large gathering of people emerged. Instead of doing nothing, he put his world-renowned knowledge and understanding of fluid flows and computational fluid dynamics (CFD) simulation software to work to understand how COVID-19 particles trapped in aerosols — suspensions of fine solid or liquid particles in gas, in this case air — expelled from the mouths of cheering fans traveled in the stadium and could potentially build up to concentrations high enough to cause so many infections.

"A football stadium is not an outdoor environment," Blocken says, especially these days when stadiums often have roofs with small openings and an enclosed circumference to protect fans from rain and wind. "That's a good design in terms of fan comfort, but in terms of stadium ventilation when a pathogen like COVID is in the air, it can be counterproductive."

So Blocken spent the next 18 months performing Ansys Fluent simulations of aerosol flows and build-up in stadiums, fitness centers, and classrooms. He validated his simulation results with extensive experiments involving artificial saliva in aerosol generators and sensors designed to emulate fans in stands when stadiums were closed to the public. And he explored how air cleaners could be used to make classrooms and fitness centers safer should COVID return in force.

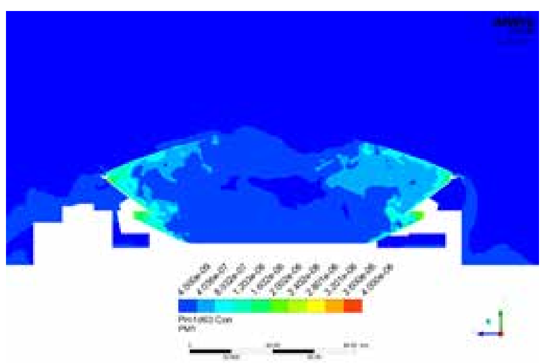
SIMULATING AND VALIDATING AEROSOL BEHAVIOR IN STADIUMS

If you've ever watched a professional football (soccer) game, you know that the fans begin cheering and singing before the game starts and continue long after it is over. With every chant, droplets in a wide range of diameters fly from the fans' mouths. Large droplets tend to travel only short distances before succumbing to the force of gravity, but the small aerosol particles can remain floating in the air for tens of minutes, even hours, and travel tens or hundreds of meters from the source. If you inhale one particle of the COVID virus, chances are you will not become infected, but frequent inhalation over a certain period of time could



Simulated wind velocity profile around Johan Cruijff ArenA

© Bert Blocken, TU Eindhoven & KU Leuven

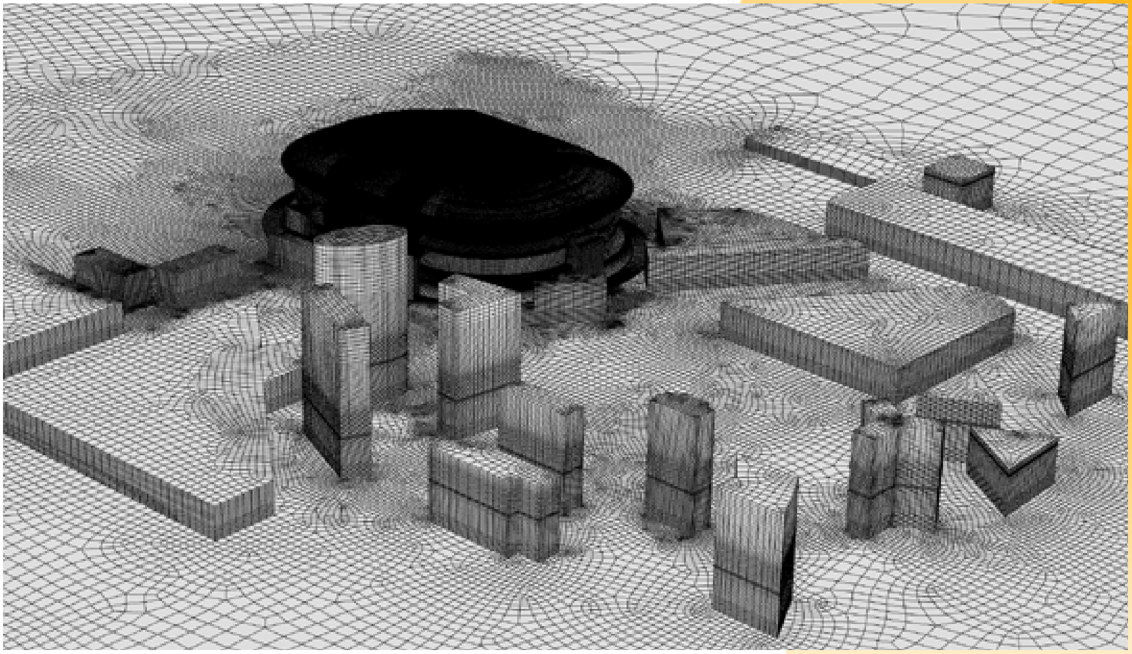


Relative aerosol particle concentration in size fraction PM1 in vertical cross-section through the stadium

© Bert Blocken, TU Eindhoven & KU Leuven)

"Using Fluent simulations, we filled the entire stadium with people. We had them all exhaling at different intensities, we had them cheering. We had them wearing masks to reduce particle concentrations. We had different temperature conditions, different wind speeds."

— **Professor Bert Blocken**, TU Eindhoven and KU Leuven



CFD meshing around and including Johan Cruijff ArenA

© Bert Blocken, TU Eindhoven & KU Leuven

give you a high enough viral load or dose to make you sick. The constant replenishment of aerosol particles from human mouths for two hours or more can be dangerous if those particles contain the COVID virus from infected people.

To better understand how aerosols travel, Blocken took on the challenge of performing post-match forensics to determine what might have happened at that Milan stadium in February 2020.

"It's very difficult to do this kind of 'crime scene' investigation afterwards and to see what really happened where and when," Blocken says. "Many people argued that some of these infections could have happened during transport to and from the stadium, and of course that's true. It has taken the world a long time to realize that aerosols are actually important here in this pandemic, and to realize that simulation could play a very important role in understanding how aerosols behave."

In December 2020, when people were barred from watching games in person, Blocken and his team of graduate students first performed physical experiments in the empty Johan Cruijff ArenA in Amsterdam. Using aerosol generators containing artificial saliva as substitutes for humans together with aerosol particle detectors in a small section of the stadium, they collected data on the size and concentration of aerosol particles as the weather conditions and the associated natural stadium ventilation changed from hour to hour and day to day.

A few months later, in March 2021, the COVID situation had improved enough that Blocken could validate the artificial aerosol study with 5,000 people in the stadium. The results verified that the December 2020 experiment had produced results that closely matched the aerosol distribution produced by people during a football match.

Still, these physical experiments fell far short of the complex reality of the scenario that Blocken wanted to study — a whole stadium full of people, at different elevations in the stadium, under varying wind speeds

Artificially generated aerosols were used to validate the computer models
© Bert Blocken, TU Eindhoven & KU Leuven

and directions, with a range of temperatures, with natural and mechanical ventilation. He estimates it would have taken more than a year to do all these physical experiments. Simulation made studying all these variations possible.

"Using Fluent simulations, we filled the entire stadium with people," Blocken says. "We had them all exhaling at different intensities, we had them cheering. We had them wearing masks to reduce particle concentrations. We had different temperature conditions, different wind speeds."

Funded by the Dutch government organization Health-Holland and The White House Consortium consisting of Ansys and Microsoft, Blocken and his team performed CFD simulations using the Johan Cruijff ArenA in Amsterdam as the model. The arena is surrounded by some high buildings, so they were also included in the 500 m by 500 m model because they would affect wind patterns inside the stadium. Using mesh sizes down to about 10 cm produced a large model containing approximately 30 million cells. The simulations also required using very small time steps for very long durations. The resulting 60,000 time steps made it necessary to run the Fluent simulations on powerful computers available from Microsoft Azure.

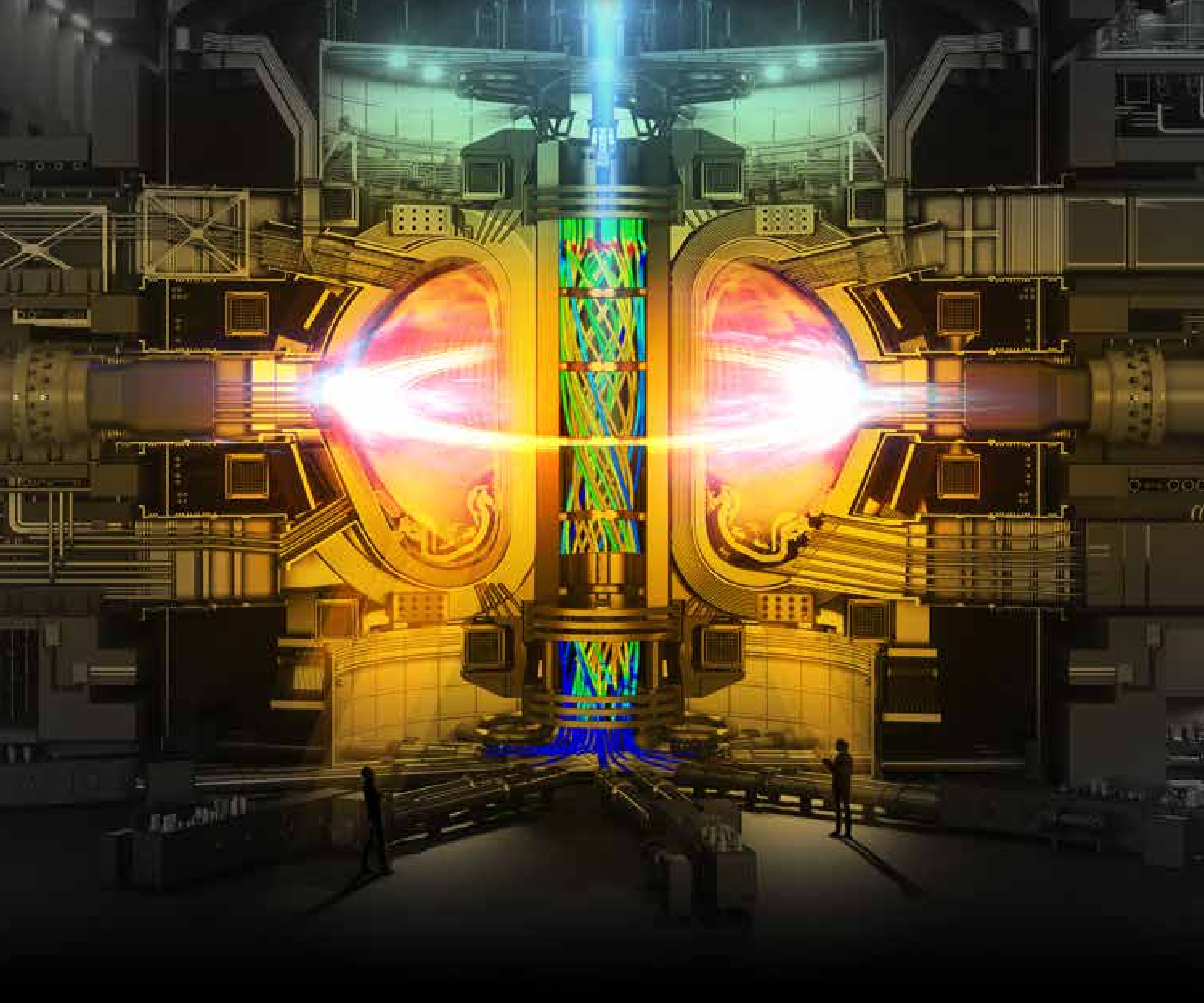
"This simulation setup gave us a very good view of what can happen in terms of actual aerosol concentrations and ventilation in the stadium,“ Blocken says, adding that wind speeds and direction and the ambient temperature proved to be important variables. "Maybe the most important thing with the simulation is that it allowed us to make an aerosol prediction protocol for the Johan Cruijff ArenA. Because of so many conditions that we simulated based on the local weather forecast, we can actually now predict what the aerosol concentration will be on that specific game day."

He hopes that should a new pandemic wave arise, stadium officials throughout the world will use his simulation protocol to make decisions about stadium closures on a case-by-case basis, rather than imposing months-long lockdowns that keep all fans at home. .

"This pandemic has taken us largely by surprise and we should never allow anything like it to happen again," Blocken concludes. "After this pandemic, let's not go back to business as usual. Engineering solutions like ventilation and air cleaning exist, and engineering methods, computer simulations, and measurement protocols also exist at a top-quality level, so let's all use them to fight aerosol-driven health issues (COVID, flu, pollen allergies, etc.)."

Optimizing Design Optimization Efforts

By Ansys Advantage Staff



In designing a new product or process, engineers must consider many variables to arrive at an optimal design. Depending on the product, these can include materials, mechanical strength, aerodynamics, thermal radiation, electromagnetic compliance and interference, optical properties, cybersecurity, and many other factors. A relatively simple product may only have to optimize one or two of these variables, but most new products are becoming increasingly complex, requiring the best balance of multiple properties to produce the optimal overall performance.

Simulation rarely occurs in isolation. An engineer may perform a stress simulation on the transmission mounts for a new car design, but that simulation likely takes place within a broader context; one that might also consider the stresses on the mounts of the engine, the rigidity of a car's frame, and so on. Not only are there many different components of that design that one might subject to different simulations, but each component comprises materials — and reflects design decisions — that could be modified if the outcomes of these stress simulations are outside of acceptable specifications.

So many simulations. So many variables. How does one efficiently arrive at an optimized overall design?

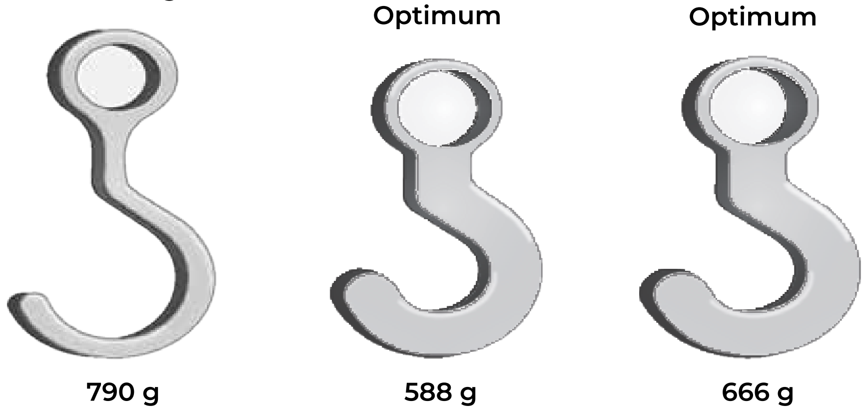
Ansys optiSLang can help answer that question.

THE KEY TO ROBUST DESIGN OPTIMIZATION

Ansys optiSLang is a process integration and design optimization (PIDO) solution that provides an organization with state-of-the-art robust design optimization (RDO) algorithms. It factors uncertainties and tolerance variations into account to automatically and efficiently identify the optimal configuration for a given design. Built into Ansys Workbench and Ansys Electronics Desktop (AEDT), optiSLang facilitates all aspects of RDO, including design exploration, optimization, robustness, and reliability analysis. It's not limited to specific Ansys simulation tools, either. Organizations use optiSLang in automated workflows that can incorporate simulations using virtually any Ansys or non-Ansys product. These workflows parse and pass data from one step to the next and can run until design goals are optimally realized.

Many organizations have already created workflows that perform these kinds of simulations, but in many instances they involve significant manual effort. Engineers with expertise in Ansys Mechanical, for example, will run their simulations and then manually pass the output of those simulations to another engineer who specializes in

Example Summary:



	Initial Design	Deterministic Optimum	Robust Optimum
Mass	790 g	588 g	666 g
Stress	439 MPa	200 MPa	176 MPa
Sigma Level	-	3.3	4.8
Failure Probability	>0.5	10^ -3	10^ -6

Ansys optiSLang has an easy-to-use user interface (UI) that simplifies the creation of workflows that automate multiphysics simulations, extractions, and transformations.

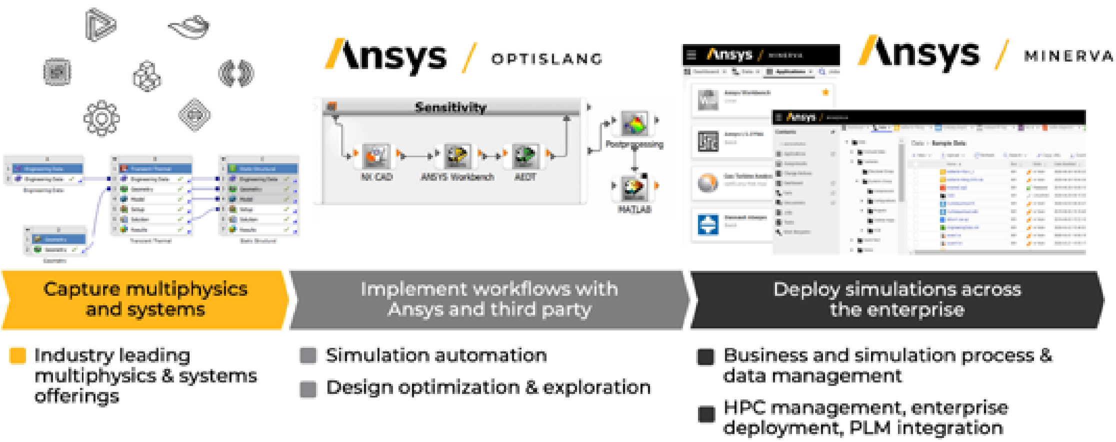
simulations using Ansys Fluent. If the next engineer in the workflow uses a custom-built or third-party simulation tool, the salient data from Fluent or Mechanical may need to be extracted or transformed before it can be used in the next application. Each of these manual steps takes time, and each creates an opportunity for errors to creep in. While an organization approaching RDO in this way can realize clear efficiencies through the use of simulation software at each step, the overall workflow can only be described as discontinuous and inefficient.

Ansys optiSLang changes that dynamic. Its easy-to-use user interface (UI) simplifies the creation of workflows that automate multiphysics simulations, extractions, and transformations. It facilitates the inclusion of custom code and third-party applications, pre- and post-processing tools, and sophisticated processing and analytic loops. It facilitates the management of processing tasks across a high-performance computing (HPC) environment. It also interacts with Ansys Minerva, a knowledge management application that secures critical simulation data and provides simulation process and decision support to simulation teams across geographies and functional silos. For workflows that might be used by different groups within an organization, Minerva also enables a team to build and publish optiSLang-based web apps that can easily be used by others within the organization.

WRANGLING THE VARIABLES

The ability to link a wide range of parametric simulation tools provides unprecedented insight into the variables that can inform a complex design. But that insight can also be a bit overwhelming. If everything from an individual component's material composition to its size, shape, and tensile strength can be manipulated, which are the most useful parameters to tune in pursuit of specified design goals?

Parameter identification is another area in which optiSLang shines. Ansys optiSLang relies on several design of experiments (DOE) algorithms, including the Meta-model of Optimal Prognosis (MOP) algorithm, that can analyze all these parameters and point an engineering team to the parameters that are most useful in a design refinement effort. With the insights provided by the DOE algorithms, an engineering team can quickly eliminate a wide range of simulations that it might have otherwise considered because those simulations would involve the manipulation of parameters that don't make much difference. Instead, the team can focus on simulations that involve a much smaller number of parameters, which can considerably expedite design refinements and reduce design costs.



Ansys optiSLang facilitates the creation of a wide range of complex workflows connecting Ansys and third-party solutions.

	Simulation Time (CPU time)	Engineering Time	Time Invested (overall)	Design Costs (total) $75/hour
Before (manual)	30 hours	25 hours	55 hours	$1,875
After (optiSLang)	20 hours	4 hours	24 hours	$300
Improvement	**-33%**	**-84%**	**-56%**	**-84%**

Using Ansys optiSlang to create a continuous workflow involving multiple simulation tools, one company reduced both total simulation time and total engineering time, resulting in a 56% reduction in stage completion time and an 84% reduction in costs. The 84% reduction in engineering time enabled the engineering department to accomplish far more over the course of a year.

	Simulation Time (CPU time)	Engineering Time	Time Invested (overall)
Before (manual)	10 hours	5 hours	15 hours
After (optiSLang)	5 hours	1 hours	6 hours
Improvement	**-50%**	**-80%**	**-60%**

Using optiSLang, a firm was able to reduce design iterations significantly by focusing in on those parameters that optiSLang identified as having the greatest impact on design goals. The optimized design led to increased margins and reduced manufacturing costs.

REFINING THE DESIGN FOR THE REAL WORLD

Just as optiSLang can help an engineering team determine which parameters can be optimally tuned to achieve the best design, it can also help determine whether the design itself is optimal in terms of desired robustness and reliability. It's one thing to optimize a design to meet a given set of specifications; whether those specifications themselves are or are not optimal is another question entirely. What if the specifications achieve a level of strength or quality that is greater than actually necessary?

In any given engineering scenario, there may be uncertainties in required tolerances, loads, materials, and more. There may be a great deal of variation when it comes to the conditions in which a given device may operate or in which a structure will exist. Ansys optiSLang includes a series of robustness and reliability analyzers that take all these variations into consideration to help a team determine optimal tolerances, loads, materials, and more. If the specified quality level can only be achieved through the use of a particularly expensive material, but a different, perhaps more appropriate level of quality could be achieved through the use of a lower-cost material, then the organization might be able to meet the critical robustness and reliability goals while saving money by using a lower-cost material. Conversely, if the analysis of the variations suggests that the original design specifications were insufficiently robust, optiSLang can help the team determine where to make refinements that will result in a design more likely to meet overarching performance and reliability goals.

Indeed, such design tweaks might involve any number of parameters — size, weight, materials, and more — with the result being that the organization creates a product that will meet customer, regulatory, or other requirements in the most efficient manner possible.

OPTIMIZE OPPORTUNISTICALLY

For teams using Workbench or AEDT, optiSLang is already embedded. Others can download a free trial version of optiSLang that can be used for 30 days (with full support from Ansys engineering). Visit ansys.com/products/connect/ansys-optislang and click Request a Trial.

Ansys optiSLang
ansys.com/products/connect/ansys-optislang

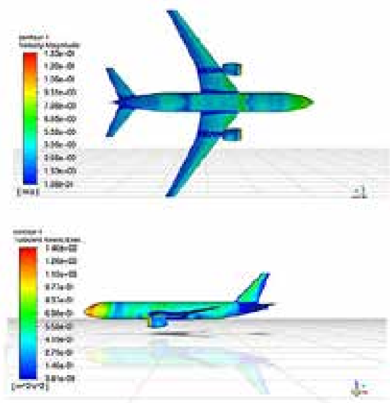
To Go Far, Go Together

By **Erik Ferguson**,
Sr. Project Manager,
Global Partnerships,
Ansys

The philosophy of an open ecosystem has driven the Global Partnerships team at Ansys for many years. Modern CAE tools and workflows are the result of strong collaborations between the companies that build the constituent parts. From long-standing titans in the software, hardware, and cloud computing industries to up-and-coming players developing breakthroughs in machine learning, healthcare, and sustainability, Ansys is securing and growing partnerships to give potential customers the confidence to take a “leap of certainty” and include simulations in the way they create products in the digital age.

There is a saying, commonly attributed as an African proverb, that concisely illustrates a universal truth: "If you want to go fast, go alone; if you want to go far, go together." Building on that foundation, partners play a critical role in helping Ansys deliver best-in-class simulation workflows. In addition to the tremendous success and growth of the Academic and Startup ecosystems, the near doubling of the Technology Partner ecosystem membership since 2017 reflects the value that partners are recognizing and reinforces Ansys' core mission of empowering customers to design and deliver transformational products.

The open ecosystem undergirds the Partner team's focus of driving customer value and scale. For Ansys, a partnership may exist for many reasons, but chief among these are providing more value to our customers by extending the overall Ansys CAE ecosystem. By making tools available on-demand via major cloud platforms and improving simulation workflows through more seamless integrations, partners are essential to enabling Ansys to deliver true business value to our mutual customers.

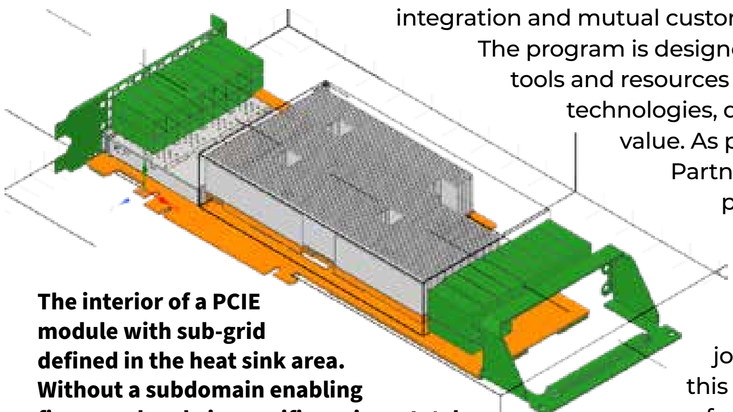


External aerodynamic benchmark results on a multi-GPU solver

ANSYS TECHNOLOGY PARTNER PROGRAM

Our global partner community includes more than 350 Technology Partners, providers of highly specialized software products, high-performance computing, and cloud hosting services that complement Ansys solutions with leading products and services in a variety of industries. The new Technology Partner Program offers four tiers of membership for the community. Each tier has its own set of benefits and requirements, and partners can rise from one tier to the next by meeting certain thresholds of product integration and mutual customer success.

The program is designed to provide partners with the tools and resources needed to connect our respective technologies, drive growth, and deliver customer value. As program members, Technology Partners gain market visibility via promotion of their solutions to Ansys customers and are eligible for marketing and sales collaboration based on their program tier and joint strategy with Ansys. It is this collaboration that paves the way for the design workflows that are catalyzing the next generation of technological breakthroughs.



The interior of a PCIE module with sub-grid defined in the heat sink area. Without a subdomain enabling finer mesh only in specific regions, Intel engineers would spend far more compute time to simulate an entire server.

ANSYS AND EMA: TACKLING SERVER EMI

In the electronics industry, electromagnetic interference (EMI) is a growing issue with the increasing speed and density of components in modern devices. At Intel, engineers were looking to predict the interference produced across an entire server. This required the power of Ansys electromagnetics workhorses Ansys HFSS and Ansys SIwave combined with the functionality of EMA3D Cable software from our partner Electro Magnetic Applications (EMA).

Over a two-year period, Ansys and EMA worked closely with Intel to modify EMA3D Cable

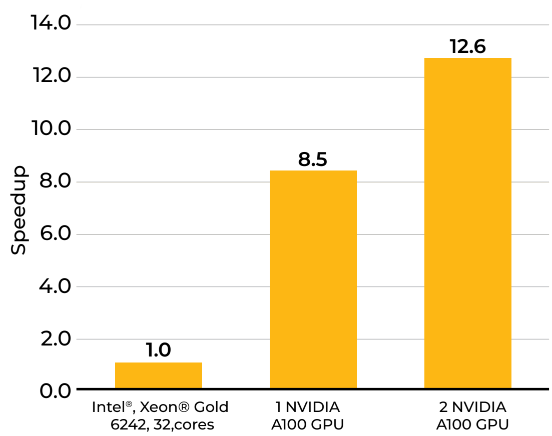
to improve meshing speed and add a subgrid capability to increase resolution for specific device subcomponents. Once the fields were imported from HFSS and SIwave, these enhancements to EMA3D Cable enabled Intel to simulate the cabling and thin wiring within the enclosure. This joint effort now allows Intel's signal integrity engineers to simulate all six cards in a server at once, as compared to previous efforts that required simulation of a single card six different times. With this new workflow, the Intel team can understand and solve EMI issues at the design stage before observing them in the lab, further demonstrating the value of tool integration to solve complex problems.

ANSYS AND NVIDIA: FASTER SIMULATION, LOWER HARDWARE COST

On the hardware side, Ansys and NVIDIA have collaborated for many years to ensure that customers have the most efficient performance for running large simulations by parallelizing the computations. Indeed, customers can benefit from the power of NVIDIA's graphics processing units (GPUs) to accelerate simulation across the board in structural, fluid, and electromagnetics analyses. For fluids simulation in particular, GPU acceleration was first made available in Ansys Fluent in 2014 with the introduction of NVIDIA's AmgX solver, which enabled speedups for certain classes of problems. However, before this year, the entire Fluent code was not optimized to run fully on GPUs.

With NVIDIA's recent advances in their GPU hardware and toolkits, their creation of dedicated program languages has given developers the tools to better architect fluids solver modules for GPUs.

The desire to unleash the full power of GPU acceleration helped push Ansys to release a new multi-GPU solver in Fluent in 2022. Using the new solver, exponential speedups can be achieved running even a single NVIDIA A100 Tensor Core GPU as compared to multicore CPU clusters. Such performance gains are just one benefit, as our studies have shown that engineers who run their fluids simulations on GPUs can reduce hardware costs by up to 7x and power consumption by up to 4x. These cost savings can help customers meet their long-term sustainability goals.



Speedup for different configurations of CPU and NVIDIA A100 GPUs

ANSYS AND MICROSOFT: BOOSTING CHIP DEVELOPMENT

To meet the continuous demand from consumers for high-performance electronics, the devices themselves continue to become physically smaller or pack more features into the same footprint. Radio frequency integrated circuits (RFICs) have become key enablers of these technologies by making it possible to integrate most of the necessary electronic components into a single chip. High-fidelity simulations for the electrical properties of full RFIC designs, however, have been a struggle for chip manufacturers due to computational complexity and meshing limitations.

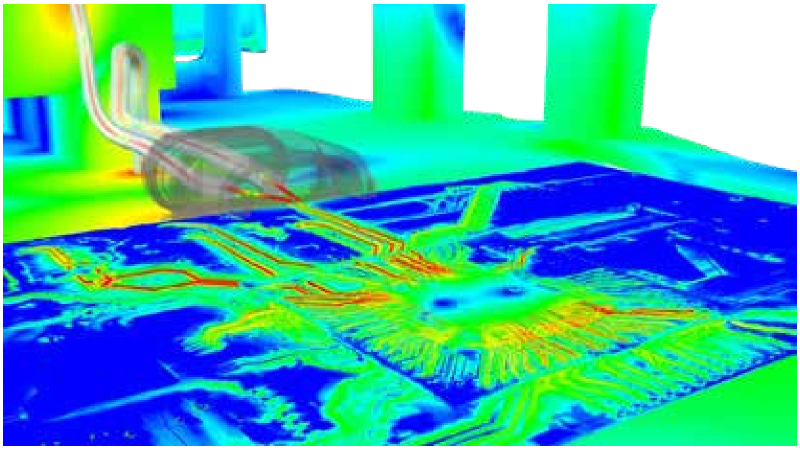
In partnership with Microsoft, Ansys Cloud Direct is enabling IC designers to solve an adaptively converged mesh in Ansys HFSS for an entire RFIC by using hundreds of

compute cores on Microsoft Azure. By offering designers access to what is effectively an "on-demand supercomputer" through a simple GUI, cloud computing on Azure makes it possible for engineers to get the highest level of accuracy possible faster than ever before. For manufacturers, this could mean avoiding the kinds of mistakes or product delays that could cost them millions of dollars in additional R&D time and future revenue.

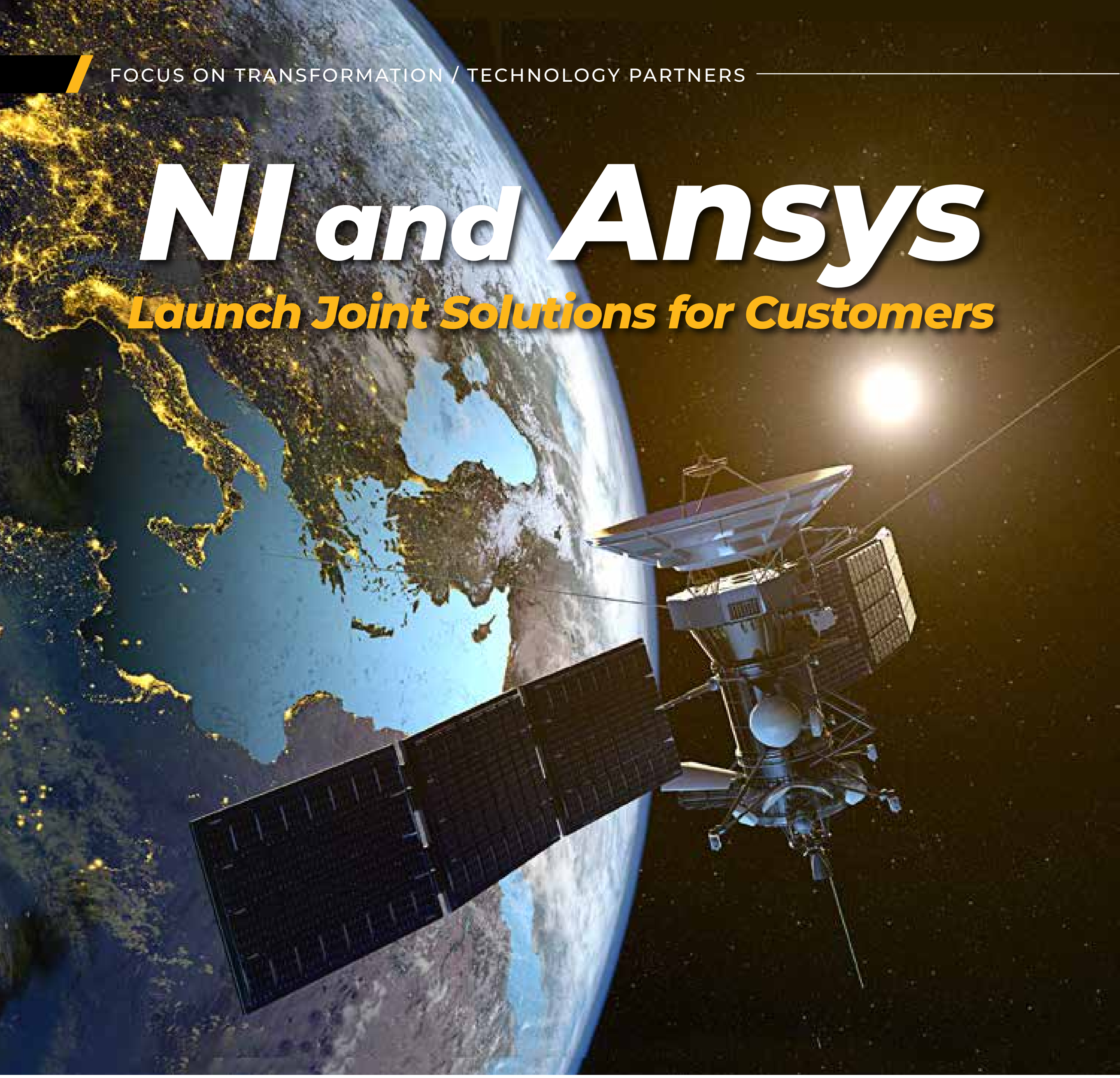
LOOKING AHEAD

Ansys has achieved some notable successes this year by working closely with partners across the ecosystem of software, hardware, and cloud providers. In addition to the stories highlighted here, we also recognized several other partners with awards for their outstanding contributions at our second annual Technology Partner Day in conjunction with Ansys Simulation World in May.

As we look for the next "big bet" integrations, we will continue to evolve our partner community to drive further adoption of CAE simulation. This includes the PyAnsys project to catalyze a Python developer ecosystem that will extend Ansys solutions, and to ensure that all Ansys tools are accessible on the cloud platforms that are important to our customers. Together with our partners, these steps will be made with confidence.



An Ansys HFSS simulation of a radio frequency integrated circuit employing Mesh Fusion at the chip, package, and PCB levels using Ansys Cloud Direct on Microsoft Azure.



NI and Ansys

Launch Joint Solutions for Customers

By **Jennifer Procario**,
Staff Writer,
Ansys Advantage

One thing Ansys and NI customers have in common is a shared desire for accuracy. Whether a group of designers creates models using a tool from Ansys' vast simulation portfolio, or a group of engineers authenticate those models using NI's validation software and hardware, accuracy in design is a common objective.

While these groups can work independently and still achieve results, how much more successful would design and development be if they connected their approaches using joint solutions?

This potential has been the driving force behind the NI and Ansys partnership. The success of this technology pairing has already been seen in the automotive space with hardware-in-the-loop (HIL) solutions for cameras in advanced driver assistance systems (ADAS) and autonomous vehicles (AVs). But most recently, the companies are off-roading onto new terrain by integrating NI tools with Ansys Systems Tool Kit (STK) digital mission engineering software to deliver solutions for the aerospace industry and beyond, with customer needs at the heart of the collaboration.

BETTER RESULTS AND VALIDATION

In its more-than-40-year history, NI continues to produce modular hardware, software, services, and systems that set the standard for validation through automated test equipment and automated measurement systems. This year, NI demonstrated a satellite link emulator (SLE) at the Farnborough International Air Show. The SLE connects with STK, which provides physics-based modeling for analyzing platforms and payloads in a realistic mission context.

To develop the SLE, which has the potential to validate next-generation satellite communication links, NI uses a HIL approach by connecting NI's PXI hardware and LabVIEW field-programmable gate array (FPGA) technology into the STK platform. This combination enables communication links between satellite and ground stations to be validated against realistic channel parameters in real time by simulating within a digital mission engineering environment.

"Our tools — NI and Ansys — can work individually just fine, but the pace at which our customers are being asked to innovate and the complexity of the systems they're trying to develop is prompting us to ask, 'What are the connections that we could make between our tools that would make that workflow more seamless, more real-time, or more iterative?'" says Luke Schreier, Senior Vice President and General Manager of Aerospace, Defense, and Government Business at NI. "How can we reduce the 'throwing it over the wall' effect and failure to 'close the loop' with real data from real-world experiments that feed back into the simulation?"

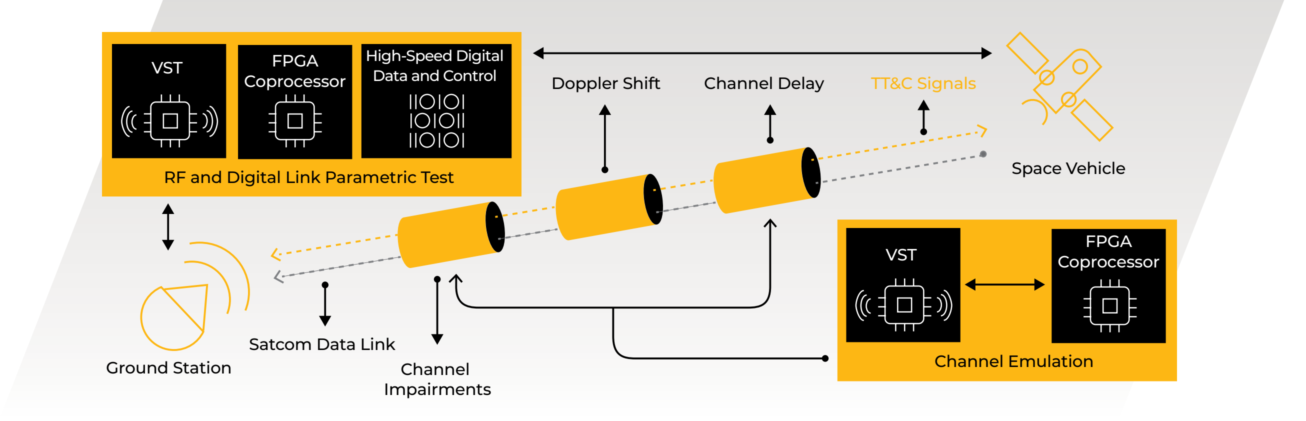
The SLE is just one instantiation of this HIL concept to "close the loop" with real data, demonstrated within an electromagnetic (EM) environment with the connection between a satellite and ground station. However, HIL concepts can be expanded to other communication links such as 5G, other terrestrial networks, or even other systems that interact using EM energy.

"What we've done as a partnership most recently is focus on mission-critical applications around communications and satellites," says Chris Behnke, Chief Offering Manager of Radar, Electronic Warfare, and Communications at NI. "We've interfaced the STK software, which provides the accurate simulation to our real-time hardware platform, and that allows us to validate the hardware under the same conditions that the simulation was run. Subsequently, it allows us to update that simulation with real measured data. It's a synergistic cycle where we can inform the system-under-test with the simulation, and then further inform the simulation based on the results of the testing itself."

This collaborative approach provides customers with more insight to better inform their designs and missions in real time, which reduces error, time needed for development, material and operational costs for the project, and, most importantly, risk. Consequently, the value of the partnership for both Ansys and NI customers exceeds monetary value and results in richer, higher-fidelity simulations that ensure the safety and success of products and missions.

DIGITAL MISSION ENGINEERING IN MOTION

STK expands upon standard simulation tools by applying simulation in a mission-planning setting. Though other simulation tools can achieve results, such static, one-off models often lead to disconnected solutions that need to be pieced together or compared later. Alternatively,



In the connection between Ansys STK and NI solutions, STK provides the platform motions, kinematics, payload models, and other environmental impacts that contribute to forming a realistic simulated radio frequency (RF) link. This provides an executable simulation loop where engineers can design and test their RF systems through both software-in-the-loop (SIL) and hardware-in-the-loop (HIL) strategies.

"As the simulation is running, you can look at your simulation results and your real-time hardware results in unison and in sync to see both sides of the coin."

— **Chris Behnke**, Chief Offering Manager of Radar, Electronic Warfare, and Communications at NI

STK provides a 3D, multidomain platform that is equipped for larger system-level projects and supports various engineering disciplines within one application. This enables customers to see how critical engineering dynamics affect each other in a real-time environment. This insight can inform designs — and the validation of those designs — more comprehensively, speedily, and accurately both in unison and in motion.

"A satellite, for example, can travel 17,000 miles per hour in space. The ability to model the motion of the platform, the kinematic effects, and the radio frequency environment effects all have an impact on the mission," says Shashank Narayan, Senior Director of Research and Development in Digital Mission Engineering at Ansys. "As platforms move, relationships with other platforms change, and the ability for a satellite to surveil a certain area depends on where it is in orbit. With the help of design reference missions (DRMs) using STK, you can model these scenarios and then test against the DRM using NI tools."

Essentially, a DRM enables systems thinking, automation, and fact-based decision-making across a product's life cycle to ensure the safety and success of a mission. In simplest terms, it helps design or prepare a "reference," or plan.

Key features of STK that equip it for such mission planning include communications, radar, and electro-optical and infrared (EOIR) modeling. With the communications capability, you can model all the physical components of a system, including the RF environment. Similarly, the radar capability enables you to model system performance in synthetic aperture radar (SAR) or search and track modes. This means you can model monostatic, bistatic, and multifunction radars in the context of your mission to account for the participation of every asset. The EOIR capabilities expand upon this by enabling teams to model EOIR detection, tracking, and imaging performance, which support the product throughout its life cycle.

LabVIEW is a graphical programming environment developed by NI, which engineers use to develop automated research, validation, and production test systems.

"The simulation is only as good as the data you put into the model — so from our perspective, the STK software provides an accurate first simulation, and then our platform gives the ability to measure the physical input and output points or the physical hardware as it actually operates, which gives you a next level of detail that you can then circle back to your design," says Behnke. "The real-time nature really comes into play when the hardware and software solutions can run in parallel. As the simulation is running, you can look at your simulation results and your real-time hardware results in unison and in sync to see both sides of the coin."

UPCOMING MISSIONS MADE POSSIBLE

Many of NI's validation solutions are based on the premise of merging test instrumentation with digital signal processing (DSP), which allows customers to emulate parts of the system that may not be designed yet, or perhaps the ecosystem for which the asset is being designed. By implementing validation into a mission-planning platform, not only is predictive foresight strengthened surrounding these known variables, but the potential to visualize unprecedented scenarios that have unknown variables can also be realized.

"Simulation environments like STK almost inherently propose different combinations of I/O that a normal validation process might not explore, and that's where the merger of the two tools and approaches is really beneficial for the customer," says Schreier. "But making these connections is more than just the sum or connection of two different tools. It is potentially unlocking innovation or accuracy that wasn't even possible before."

Ansys Channel Partners:

A Link Around the World

By Ansys Advantage Staff

In today's interconnected world, working in isolation isn't a sustainable business model. The path to goal completion is dotted with dependencies. No project, no team, no company is an island, and Ansys is no exception.

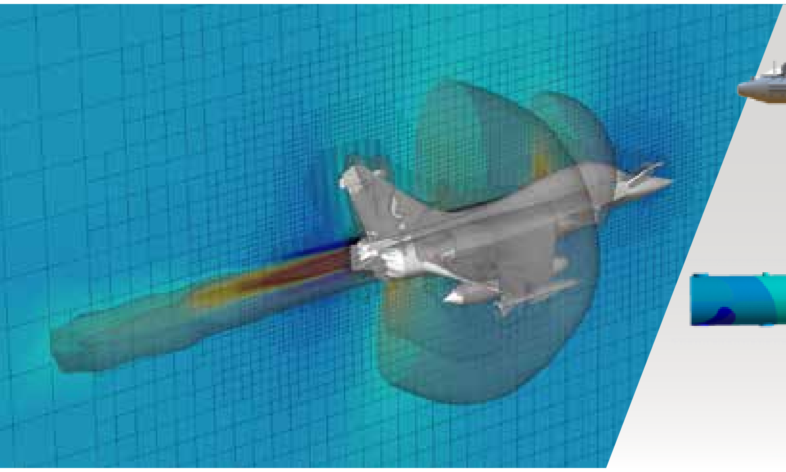
To deliver its software worldwide, provide the outstanding service customers expect, and help enable transformative innovation, Ansys extends its sales, support and training efforts through a network of nearly 160 channel partners. These independent companies represent Ansys across the globe.

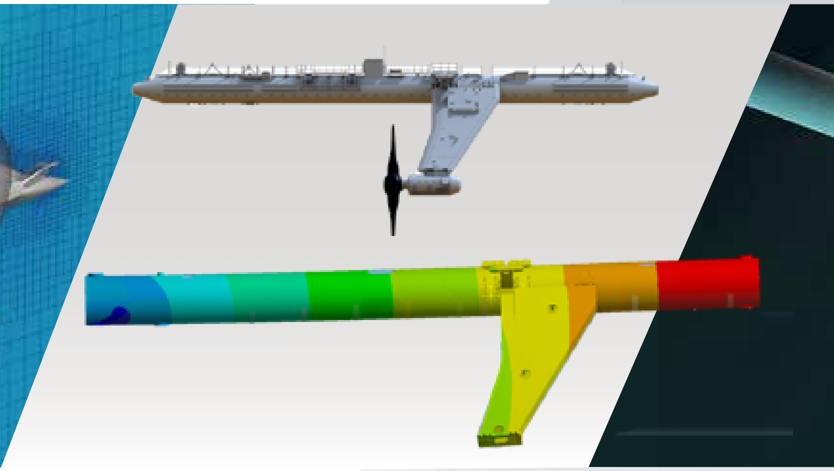
VALUE BEYOND THE SALE

For Erke Wang, Managing Director of Ansys Elite channel partner CADFEM GmbH, the function of the channel partner is easy to describe: helping to ensure both customer success and sustainable growth for Ansys through long-term relationships and local market knowledge.

The reality of how that gets accomplished isn't simple and there are no shortcuts. Channel partners are not transactional vendor-types who walk away after the deal is done.

Instead, like Ansys itself, they do everything they can to optimize the value their customers receive from Ansys products. That means helping with implementation, adoption, customization and workflow integration, as well as providing both startup training and long-term learning.





Iso-surface of the Mach number of a jet, simulated by Ansys Elite Channel Partner Rand Simulation

Tidal energy turbine developed by Orbital Marine, supported by Ansys Elite Channel Partner EDRMedeso

For example, Rand Simulation, a division of Rand Worldwide and an Ansys Elite channel partner, designed the Ansys Development & Ongoing Proficiency Training (ADOPT) program. Jason Pfeiffer, Vice President, Rand Simulation, said the program provides continuing education on an annual basis to "strengthen user proficiency and overall Ansys ROI through direct collaboration and mentorship from our team of fluids, structures, and electronics experts."

Channel partners sometimes go even further, becoming a hands-on, in-house simulation surrogate for small- and medium-sized customers who don't have simulation specialists on staff.

STRENGTH IN NUMBERS

Besides selling software and creating (and maintaining) happy customers, channel partners provide boots on the ground to help Ansys grow. Because channel partners are well-known organizations with long histories and strong reputations, they can trade on established customer relationships and market credibility to give Ansys a foothold in areas where it would be time-consuming and costly to start from scratch — or where it wouldn't make strategic sense.

"It's very hard to have Ansys people everywhere," says Chokri Guetari, Ansys technical support manager. "In fact, in some markets, the channel partner presence is far stronger than our direct presence."

Channel partners also provide strength in numbers, nearly doubling the Ansys force, according to Guetari. He's not talking just about the sales team, by the way, but also about "engineers, people with advanced degrees, including Ph.Ds., who understand local requirements and know the pains and pressures their clients face."

Helping customers overcome today's challenges is just part of the channel partner workload. They're also focused on what the future may hold. For CADFEM's Wang, that means providing Ansys with insight into new technology trends and giving the company a headstart into the features engineers will need in the years to come. It also means developing the next generation of simulation engineers, something CADFEM does through its long-term collaborations with local universities and research institutes.

"We're helping educate and prepare future simulation engineers to make them available for industry," Wang says.

According to Guetari, the training Ansys provides for its channel partners is just as forward-looking. It prepares channel partners to sell and support Ansys products effectively across the entire product range.

"We have an ongoing mentoring and development program to help channel partners gain experience with all the products we offer that is very similar in content and quality to what our direct organization goes through," Guetari explained.

To be sure that the development activities meet all the expected benchmarks, channel partners participate in a certification program that measures performance and provides additional training.

MAKING THE GRADE

Most channel partners represent all Ansys products. There are some exceptions, however.

As Ansys has expanded through

> ***"We have an ongoing mentoring and development program to help channel partners gain experience with all the products we offer that is very similar in content and quality to what our direct organization goes through."***
>
> — **Chokri Guetari**, Ansys Technical Support Manager

KOLLIDE NFL helmet, simulated with support from Ansys Elite Channel Partner the SimuTech Group

acquisition and its product portfolio has grown more complicated, some smaller channel partners have found it challenging to cover everything and have become more specialized instead, focusing on their market's higher-demand products. Among larger channel partners, specialization is common. They typically have staff experts in widely used products such as Ansys Fluent or Ansys Mechanical on board.

Guetari sees specialization as a possible precursor to increased vertical integration.

Ansys is already adding more vertical channel partners who focus on specific technology, he says. Some have been swept in with an acquisition; as Guetari explained, when Ansys purchases a company or software product, there are often channel partners who "come along" with it. No one wants to overlook the level of expertise those channel partners offer. There's no guarantee from the start, however, that they will become affiliated with Ansys.

"During a transition period after the acquisition, we'll figure out if the channel partner is a good match, if there's an alignment," Guetari says. "If there is, then they become an Ansys partner."

If that new partner has what Guetari called "the will, intent, and capability" to expand, it's generally strategic for them to expand to other products as well. But that's not always the case. Sometimes, the channel partner who excels at one thing continues to do so, with Ansys leveraging their expertise by having them support other partners and the direct team.

As an example, when Ansys acquired structural analysis software LS-DYNA, it also brought in the acknowledged LS-DYNA expert, DYNAmore.

HERE FOR THE LONG TERM

Given all of the advantages channel partners offer to Ansys and its customers, it's no surprise the ecosystem continues to grow.

What's probably more of a revelation, though, is how long some of Ansys' channel partner relationships have been going on.

The fact is, Ansys started selling through channel partners from day one. Companies like CADFEM, PADT, and SimuTech have been with Ansys for at least 30 years. Other channel partners, including Ozen Engineering, Tae Sung S&E, Pera Global, Cybernet Systems, Taiwan Auto-Design Company, and LEAP Australia, have a decade or two under their belts.

What's behind the longevity? What makes being an Ansys channel partner a winning proposition?

Wang says it comes down to a few things: working with the best simulation company, getting guidance to succeed, and shared values.

"We value the opportunity to represent the highly respected Ansys brand, which provides world-class simulation products developed for the global market and executed in the local market by us," Wang says. "Ansys provides support for us to succeed. Our long-term relationship, built on mutual trust, integrity, and common values, is the foundation for developing and growing our Ansys business."

In the end, Ansys and their channel partners are all about breaking down silos and building up customer performance. Together, we bring engineers the software they need to connect to other software, interrelate with other teams and, ultimately, intersect with product success.

State-of-the art digital cockpit domain controller containing one system on a chip (SoC) driving five displays

Automobile Digital Cockpit Enhances Infotainment and Safety

By **Laura Carter**, Staff Writer, Ansys Advantage

The proliferation of portable digital technologies has quickly transformed our lives. If you want to check your email, know how many steps you've walked, or identify the closest Starbucks, you can use your laptop, watch, tablet, or smartphone to find out. At the same time, the advent of 5G and autonomous driving is accelerating expectations for ultra-high speed, low-latency performance, and multiple connections wherever we are — including in our vehicles.

"Ansys tools like Ansys HFSS enable us to consistently stretch our performance goals through the optimization of our designs and help eliminate time-consuming design re-spins in the process."

— **Frank Gitzinger**, Director of Product Development, Digital Cockpit, HARMAN

Drivers, plus everyone they choose to bring along for the ride, are looking for a seamless transition from home to their vehicles and destinations without compromising their digital lifestyles. With help from Ansys, HARMAN, a global leader and innovator in connected car technology, is delivering the hardware and software services needed to enable this experience.

"Fun in the car has moved from the actual driving experience behind the wheel to continuing your lifestyle experience with all the preferences you have in your car," says Frank Gitzinger, Director of Product Development, Digital Cockpit, at HARMAN. "Ideally, streaming your favorite songs at home, then jumping into the car — your playlist seamlessly continues through your USB, Apple CarPlay, or a similar connected app. And when you arrive at your destination, you should be able to continue listening on your phone. This experience will be as convenient as possible, enabled by our 5G technologies to ensure you're always connected to the internet and the cloud."

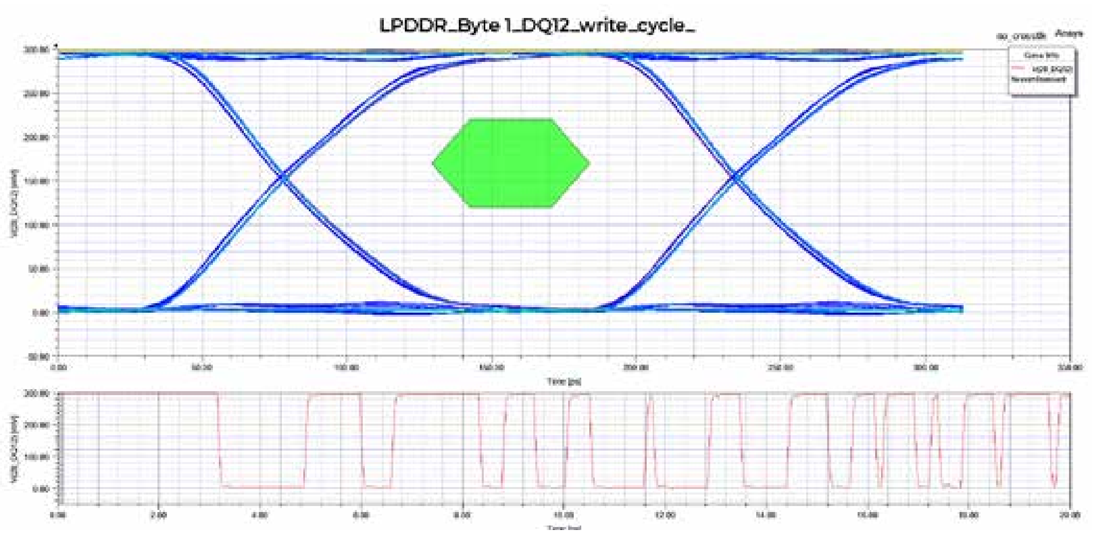
BALANCING PERFORMANCE AND POWER CONSUMPTION

As fast as our digital environment has been changing, achieving this level of performance sounds simple enough. But most in-vehicle infotainment systems still have limited functionality due to infrequent hardware updates and computing capabilities, as well as a lack of apps and services to support them. The shift to electrification and autonomous driver assistance puts added demands on original equipment manufacturers (OEMs) to balance power consumption with vehicle performance, requiring faster rates of data transfer, high-speed digital interfaces, and next-gen memory. This is where DDR5, a synchronous, dynamic random-access memory that uses less power and allows higher data rates, comes into play. DDR5 elevates the performance and efficiency of next-gen mobile and other automotive apps to dramatically improve 5G, artificial intelligence (AI), and camera and display technology.

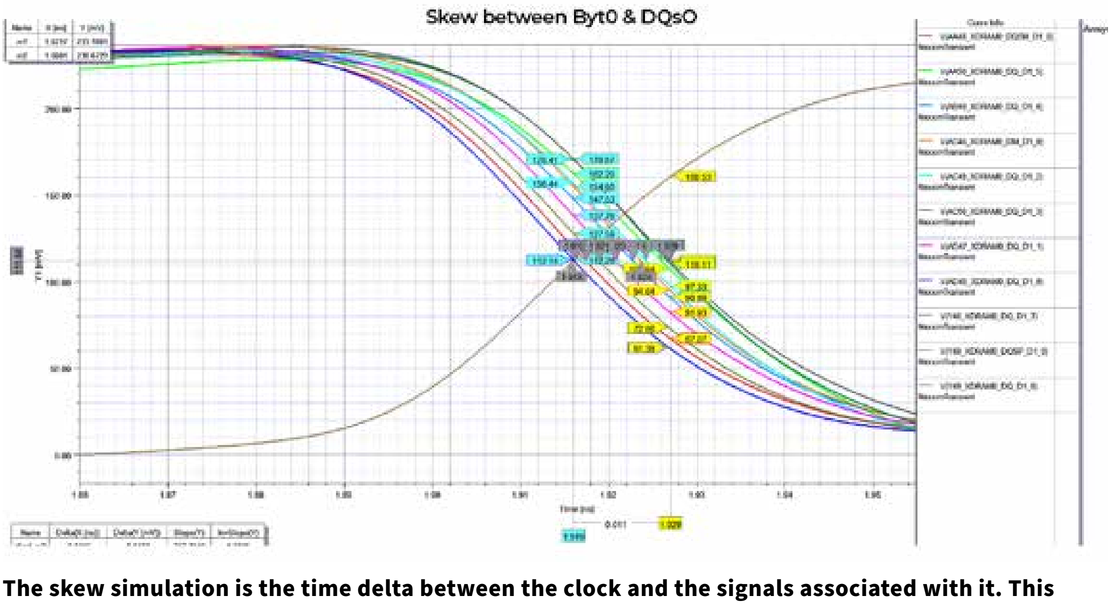
Implementing DDR5 into HARMAN's cockpit environment is a complex task, so it's difficult to have confidence in the layout without signal integrity (SI) simulations, largely due to the high-speed transfer rate and the complexity of the SI constraints involved. Extremely high data rates coupled with a poorly designed circuit board result in undesired interference, which can lead to a complete interruption in data transfer and, ultimately, to failure. To avoid this scenario, Gitzinger and team used Ansys HFSS simulation software to simulate every aspect of their controller design, from the main processor, also known as system on a chip (SoC), to memory. Drawing on performance data, they could validate designs with simulation and fulfill the requirements of the JEDEC, a global standards body for electronics, and other regulatory bodies simultaneously.

"Every generation of SoC we integrate in our products offers higher performance at about the same level of power consumption of the cockpit controller," says Gitzinger. "We're getting more speed and more data without compromising vehicle range. Ansys tools like Ansys HFSS enable us to consistently stretch our performance goals through the optimization of our designs and help eliminate time-consuming design re-spins in the process."

The goal of many OEMs in the automotive space is to transform the instrument panel into a display offering critical safety and infotainment information. HARMAN is using an electronic control unit (ECU), also known as the cockpit controller, to do this. Gitzinger's team recently used Ansys simulation to enable this technology in high-end infotainment systems offered by renowned German, North American, and Chinese carmakers. The digital design incorporates a very powerful cockpit domain controller driving all displays, which are seamlessly integrated into the dashboard, and also enables projection of smartphone applications.



The eye diagram is an indicator of signal quality, simulating the signal integrity (SI). It helps to predict performance and identify possible sources of problems like crosstalk, jitter, and impedance matching.



The skew simulation is the time delta between the clock and the signals associated with it. This simulation ensures that the signals in the same group will transfer the data at the same time.

SOLVING HIGH-SPEED SIGNAL MEASUREMENT CHALLENGES WITH ANSYS HFSS

High-speed signals are not easily measured with conventional measuring activities. Using HFSS, engineers can analyze signal quality and timing relationships across the various nets that compose the memory interface of their infotainment system quickly, with extreme accuracy. Additionally, results can be generated at any point between the transmitter and the receiver.

In the case of a complex circuit board, for example, HARMAN has several transitions from one layer to another, then onto another integrated circuit (IC), then to a connector. The piece of copper between one IC and another is called the net. Signal probing of the net, which is required to test SI, is not always possible in a real physical application. If you have a multilayered printed circuit board with four to eight layers, you can't always reach the inner layers to test the signal properly with a traditional measurement device. Using HFSS, HARMAN can do a digital probing of the signal at each of those nets to quickly and accurately verify that signal timing and behavior is tuned for optimal performance.

For Gitzinger, the benefits of using Ansys simulation software are easy to grasp. For his team, testing accuracy in a simulation environment enabled by real physics is the key to accelerating development while reducing costs.

"No one in the industry can afford to run unnecessary loops in hardware design because it takes months," says Gitzinger. "Each time involves fixing the schematics, redoing the design, and then building new prototypes, which is a pretty expensive endeavor. So, we use Ansys HFSS tools to shorten the development lead time and keep costs at a reasonable level to be able to provide the best electrical performance we can."

Steering wheel incorporated into the HARMAN digital cockpit

TURNING UP THE VOLUME ON INFOTAINMENT

Frank Gitzinger, Director of Product Development, Digital Cockpit, at HARMAN, puts his electrical engineering background — including time spent at Visteon and Bosch — to good use leading a team of functional experts and project leads within HARMAN's Digital Cockpit business unit. Looking to the future, Gitzinger believes the integration of in-vehicle functionality will be even higher, involving deeper digital integration of additional features like HVAC controls, passenger entertainment and rear seat entertainment options, and even advanced driver assistance systems (ADAS)-related in-cabin features like driver monitoring or cabin monitoring. Signal integrity (SI) analyzed within the constraints of power integrity in an automotive cockpit environment is integral to these advancements, but relatively new in the field of simulation.

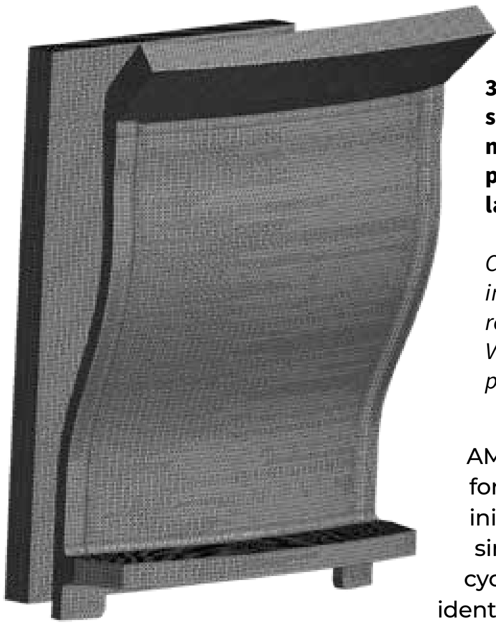
"When you have a processor that drives five displays and output music to an amplifier that's fully loaded, the increased current draw affects the whole system's behavior," says Gitzinger. "It's a scenario that influences data line quality, and a new field that needs to be elaborated in much more detail in the future to predict the performance of these high-performance systems more accurately. The accuracy of Ansys HFSS tools to analyze signal integrity will continue to play an integral role in shaping automotive cockpits of the future."

Scrapping Errors, Not Materials, with Simulation

By **Laura Carter**,
Staff Writer,
Ansys Advantage

Additive manufacturing (AM) is promising to be one of the biggest trends in sustainable manufacturing. New design practices such as topology optimization result in much lighter optimized parts, which translates, for example, into lighter vehicles and greater fuel efficiency. During the 3D-printing process, a part is created through the melting, binding, or fusing of a prescribed amount of material to support a reduced-waste environment. That's not to say that 3D printing isn't somewhat wasteful — printing shapes often requires supports or structures that prevent deformation of a part during the printing process, resulting in a nominal amount of discarded material. But what happens in the case of failed prints?

> ***"Ansys' tools, including Additive Suite, have dramatically improved overall part quality while speeding up the development process for Combitech customers."***
>
> — **Tomas Sjödin**, Head of Computer-aided Engineering (CAE) and Analysis, Combitech



3D-printed demonstrator showing a tetrahedral mesh used for simulation of printing with the selective laser melting (SLM) method.

Credit: All simulation images in this article originated from a research project sponsored by Vinnova's strategic innovation program (SIP), Production2030.

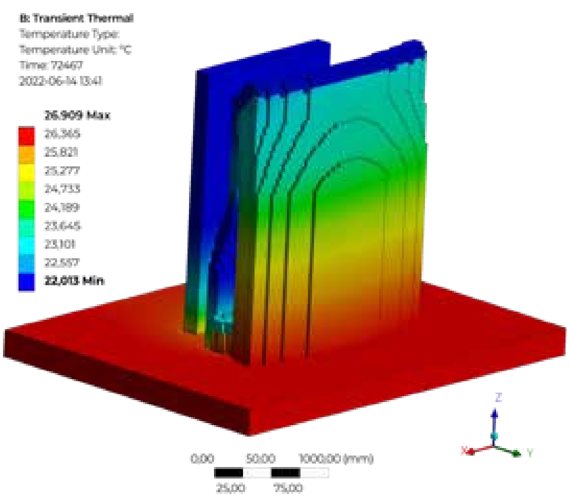
Engineers can potentially scrap a significant number of parts and materials to realize success during the design phase. Addressing errors often comes only after a failed part is identified late in the manufacturing process, along with the realization that continuing to print it is not an option. Additive manufacturing design methodologies may still be unfamiliar to most manufacturers, and relying on a trial-and-error approach to printing is impractical. Using Ansys software enables Combitech, an independent consulting company primarily in the Nordic region, to help their customers identify printing process issues that lead to failed prints of parts through simulation.

"We do the design work and simulate the production process at the part level," says Tomas Sjödin, Head of Computer-aided Engineering (CAE) and Analysis at Combitech. "For some customers, we only do the design work, and for other customers, we only do the simulation work of the production process. In other products we simulate the performance of the actual part itself, considering variables such as stiffness, fatigue, or strength."

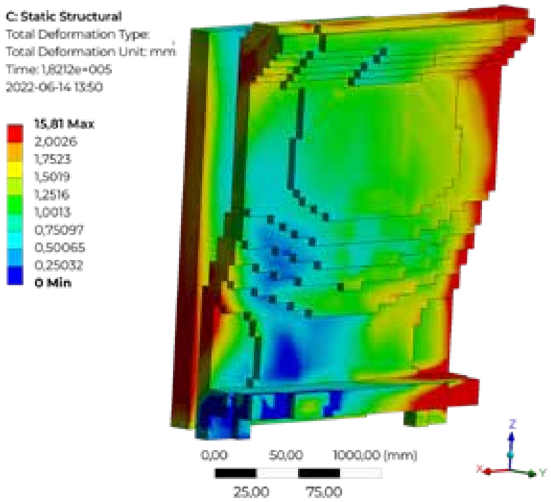
DRAWING THE LINE BETWEEN SUCCESS AND FAILURE

The idea to simulate production emerged from Combitech's well-established working methods for sheet metal design verification, which involves sheet metal forming simulations. In addition to achieving a final product design, the methodology ensures that a product meets, and can be successfully manufactured in consideration of, customer requirements. Similarly, Combitech increased their activity within AM to streamline production for their customers. They initially wanted to be able to simulate an actual production cycle in the 3D printer to identify any issues during the printing process that led to failure. Together with Ansys, Combitech has carried out a number of projects to strengthen their competence in this area.

"Among our customers we see an increased use of 3D printing, both to save time and increase performance," says Sjödin. "I come



Transient thermal distribution of build part with the support structure and base plate for printing with the SLM method



Simulation of static structural deformation after printing (i.e., after the removal of base plate and support structure)

from the automotive industry and have been working a lot with body-in-white and sheet metal parts. For every single stamped automotive part manufactured, there's a sheet metal stamping simulation of it before it's produced, with no exceptions. This is to find and solve every issue before tools are ordered. We're using the same strategy for 3D printing — before every part is sent to the printer, the process should be simulated to avoid print failure before production begins."

WHEN ACCURACY COMES DOWN TO A FRACTION OF A MILLIMETER

Using Ansys simulation solutions, Combitech has carried out a research project and two industrial projects in the defense industry. One of these projects required the use of selective laser melting (SLM), an aspect of AM that requires a high-power-density laser to melt and blend metallic powders together. This method was used on a part that included cooling channels to maintain specific mechanical properties and cool down electronics. Each cooling channel was measured down to 1 millimeter in diameter. Another requirement was that the surface should be flat down to 0.1 millimeters, ruling out milling as an option after printing.

The big challenge was achieving a detailed geometry that required a very fine mesh with long simulation times. In this scenario, Sjödin's team wanted to see if Ansys Additive Suite could handle these high demands for accuracy. The overall goal was to implement changes to the geometry to achieve less distortion and meet the demand for the final geometry in a part with a very flat surface. Initially, this was a challenge for the customer — the first part they printed had a 1-millimeter surface deviation.

Using several tools in Additive Suite, the geometry was imported as STEP files and machine data was collected from the printer operator. Afterward, the team compared the

Ansys Simulation Software: A Catalyst for Environmental Change

Recognizing additive manufacturing as a potential catalyst for environmental change, Vinnova's strategic innovation program (SIP) Production2030, an initiative that funds advanced research projects that create sustainable competitiveness for Swedish manufacturing, sponsored the work of Combitech's Tomas Sjödin together with more than 20 other industry partners. Ansys simulation software was used to study efficiencies along the entire digital production chain, from ID to printed part. This involved a large flow of information necessitating a lot of documentation, from requirements down to the traceability of the powder and more. Accurately studying the digital information flow during the 3D printing process involved test cases using Ansys Additive Suite, with the intention of mimicking the workflow of a real project involving the manufacture of several parts. The ultimate aim of the project was to gauge efficiency and traceability along the digital production chain.

"Normally when you manufacture with traditional tools, you can always go back to the tools you have to reproduce and see what you can control, or what you can get from production," says Sjödin. "But when it comes to 3D printing, you can send your 3D-printing data to a printer in Sweden, the U.S., or wherever, which means you lose control of your data and the quality of the product. You can also lose your data. You want to make sure you have the appropriate cybersecurity in place so that no one can steal your data and use it in other factories. Ansys simulation solutions were instrumental in helping us track the flow of production and our data."

simulation results with scanned data. Additive Suite's integration capabilities were critical to Combitech's overall success, enabling them to seamlessly import part geometry from STEP files for analysis. They also used their own scripts to compare scanned data from real parts with the simulations' results, which helped them identify the causes of printing failures and arrive at a different solution for their customers.

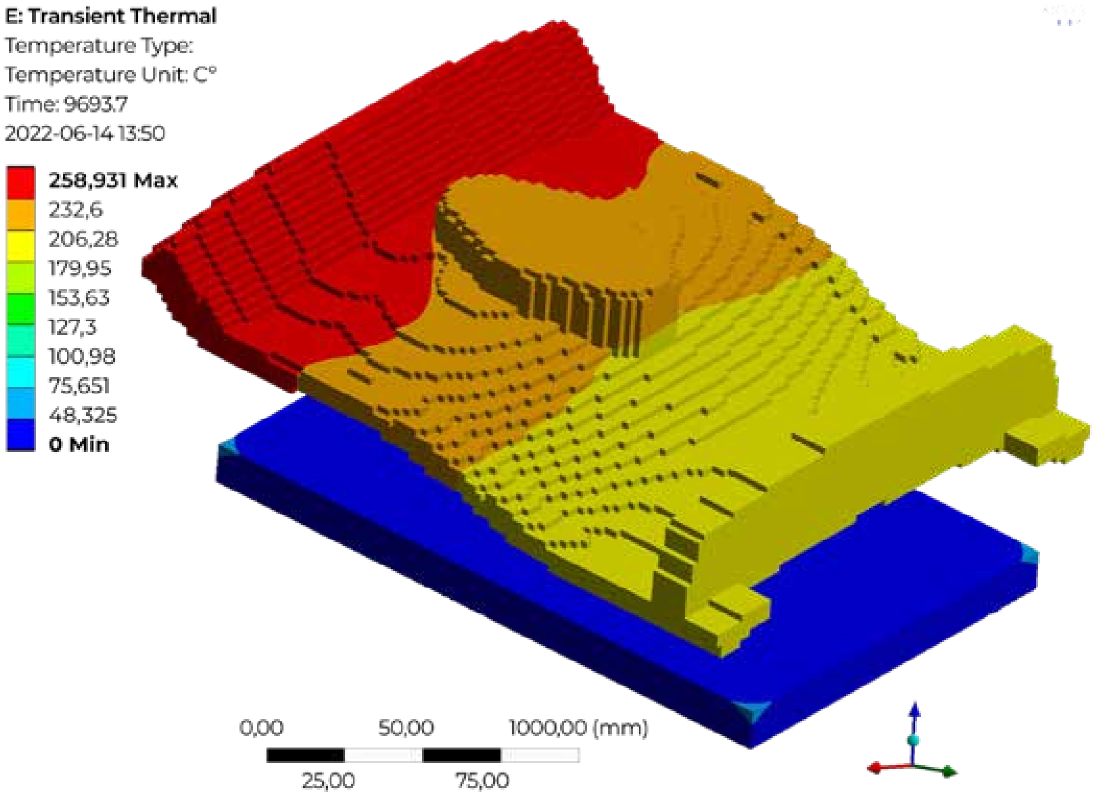
Pre- and post-processing were done on engineering laptops in Windows; however, all design analyses were done on the Linux cluster with the appropriate number of CPUs. Due to the detailed geometry, engineers had to use a very fine mesh requiring long simulation times to achieve less distortion and meet customer requirements for the final geometry.

ADDITIVE SUITE REDUCES CUSTOMER COSTS

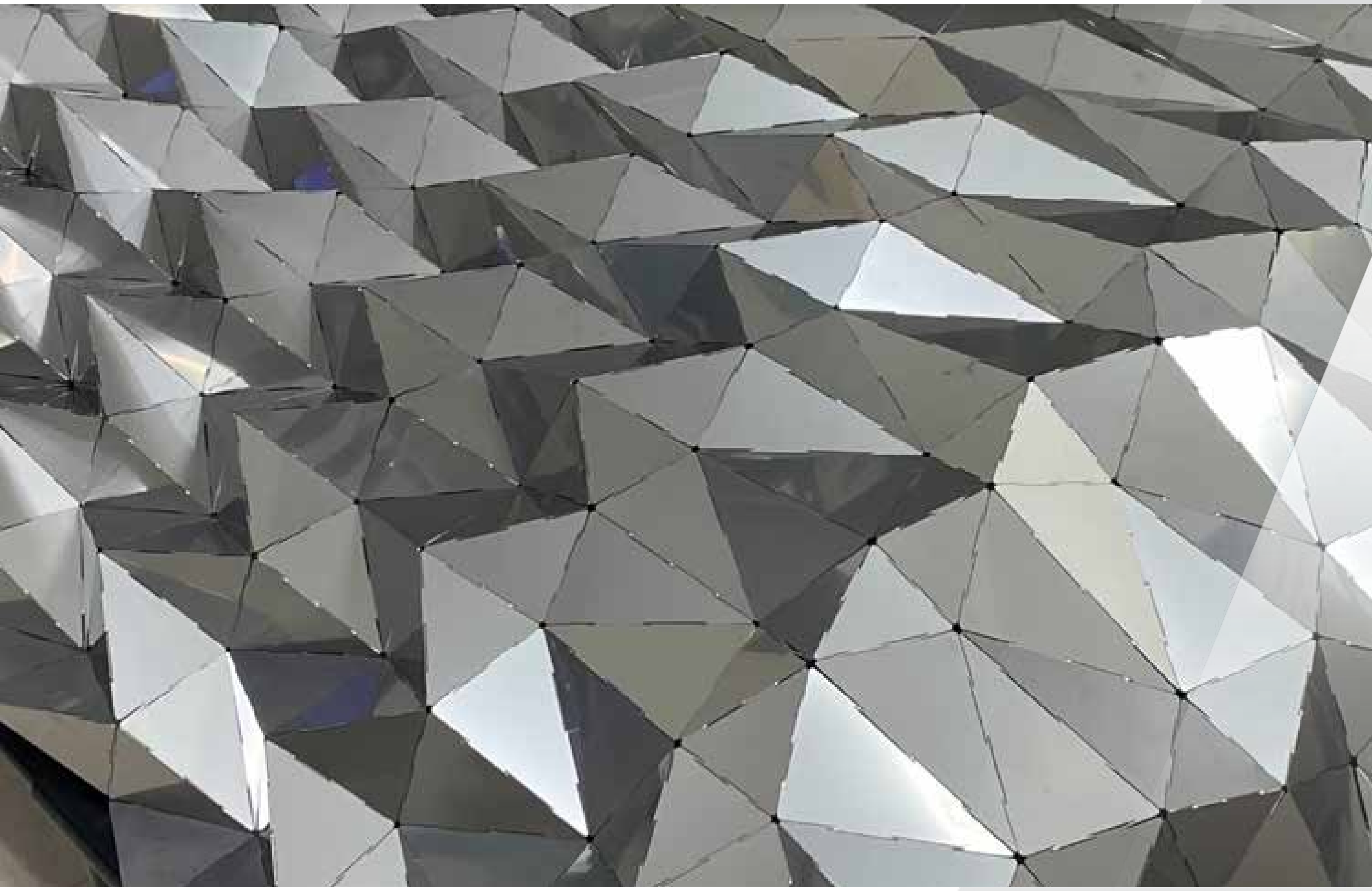
Sjödin's team also achieved success using Additive Suite for a smaller wire arc additive manufacturing (WAAM) project that also involved laser metal deposition (LMD) — a direct energy deposition technique that is often used to 3D-print metallic parts or add features to an existing metallic structure. During this process, a high-power laser is used to melt a metal surface while simultaneously depositing a metal powder or wire. Together with the customer, the team wanted to investigate the possibility of simulating the WAAM process involving a smaller product and a different printing method than what was previously used. With help from Additive Suite, the team managed to capture the overall phenomena and gain confidence in the method, results, tools, and timing required for the manufacture of a slightly different application.

"The results are very promising for Ansys Additive Suite in capturing physical phenomena that occur in reality," says Sjödin. "I am convinced that simulations of the manufacturing process for AM will become standard work in the future, in the same way that simulation of sheet metal forming is today. By using Ansys simulations, we can reduce the number of failed parts and can correct a design before it costs our customers more time and money in 3D printing."

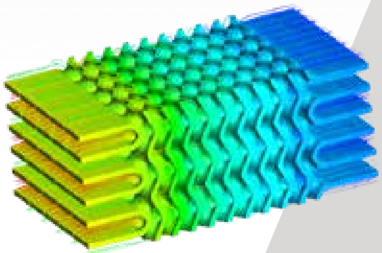
Ansys' tools, including Additive Suite, have dramatically improved overall part quality while speeding up the development process for Combitech customers. Using these tools, Combitech will continue to set new quality standards for production with simulation that make for lighter, low-waste solutions for aerospace, medical, transportation, energy, consumer products, and more.



3D-printed demonstrator using the powder-based laser metal deposition (LMD-P) method, showing transient thermal distribution after printing

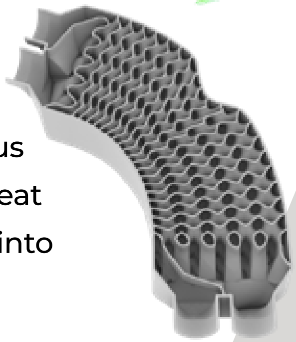


Nature Architects Reshapes a Cleaner Future with Metamaterials



By **Jennifer Procario**, Staff Writer, Ansys Advantage

Nature Architects provides shape design solutions for manufacturers to incorporate various physical functions such as vibration, acoustics, heat conduction, deformation, and weight reduction into their products by using metamaterials.



Nature Architects uses Ansys Fluent to analyze two-fluid heat exchange performance in lattice structures.

> ***"By innovating designs based on the use of conventional manufacturing methods, we can improve the efficiency of product design and add value to products. Ansys simulation is beneficial for the automation and advancement of analysis in our proprietary design system."***
>
> — **Taisuke Ohshima**, CEO, Nature Architects

Metamaterials are structures that realize functions beyond the physical functions of materials, such as resins and metals, through artificially designed geometric structures. Appropriate use of metamaterials will make it possible to achieve advanced physics properties that were previously thought impossible to achieve using conventional materials and components.

Metamaterials include structures that generate mechanical movement through elastic deformation such as moving parts that are referred to as compliant mechanisms. In addition, metamaterials can be used to create advanced physics properties in a single structure without assembly. Such structures have conventionally been achieved by assembling mechanical parts or combining different materials. Typically, these are made by additive manufacturing, but in some cases, conventional manufacturing methods such as injection molding, press molding, and machining can be used.

In this way, metamaterials can be used to incorporate new physics properties into products without increasing the number of assembled parts. In addition, metamaterials enable designers and engineers to go beyond conventional methods by balancing multiple trade-offs in design requirements, such as light weight and high stiffness.

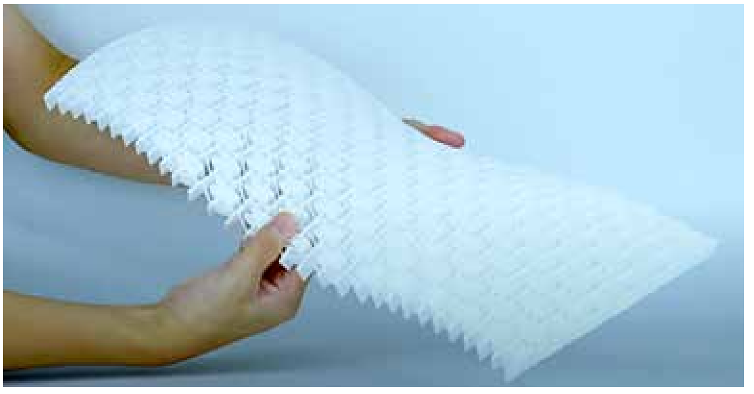
With support from the Ansys Startup Program, which encourages early-stage startups by offering affordable access to Ansys' simulation solutions, Nature Architects is using simulation to advance this emerging technology and build more metamaterials and structural solutions that will reshape the future.

SIMULATING NEW GEOMETRIC DIMENSIONS

Founded in 2017, Nature Architects set out to empower designers and engineers to create products capable of functions that defy the bounds of conventional materials and components. Metamaterials allow developers to control diverse functions through shape and at times achieve capabilities that were previously impossible.

To appreciate the unique capabilities of metamaterials, you must first recognize the constraints of nature and physics. A basic example of this can be demonstrated with any stretchy material such as rubber or spandex.

The movement of a robot hand, which typically requires at least 30 parts, including hinges and other rigid mechanisms, can be reproduced using Direct Functional Modeling and a single compliant mechanism that requires no assembly.



The perforated structure of the engineering plastic plate follows the human body and deforms in such a way as to disperse pressure efficiently. It is made up of diagonal beams that include a re-entrant honeycomb structure and boxes that are properly aligned to achieve a double-curved surface.

When you pull on both ends of a rubber band, it becomes narrower and longer. In mechanical engineering, this concept is the basis of the Poisson effect — the deformation of a material perpendicular to the point of force or direction of loading — or, in this example, the direction that the hand pulls the rubber band. For the rubber band, Poisson's ratio is the relationship of the width as the band narrows and contracts to its extended length in the pulling direction. By knowing Poisson's ratio for a material, you can predict its reaction to stresses in a repeatable manner.

However, by creating metamaterials with a negative Poisson's ratio, it is possible to generate new properties that enable the material to react differently than expected, or what is even considered possible. For a rubber band, this could result in widening of the band upon pulling its ends, instead of narrowing. Materials constructed with a negative Poisson's ratio are also known as auxetic materials.

The simple geometry of elastomers with holes realizes controlled buckling deformation and efficient conformity to the human body.

Integrating this concept to construct mechanical metamaterials, Nature Architects developed their signature Direct Functional Modeling (DFM) technology to create structures that go beyond what regular materials can achieve.

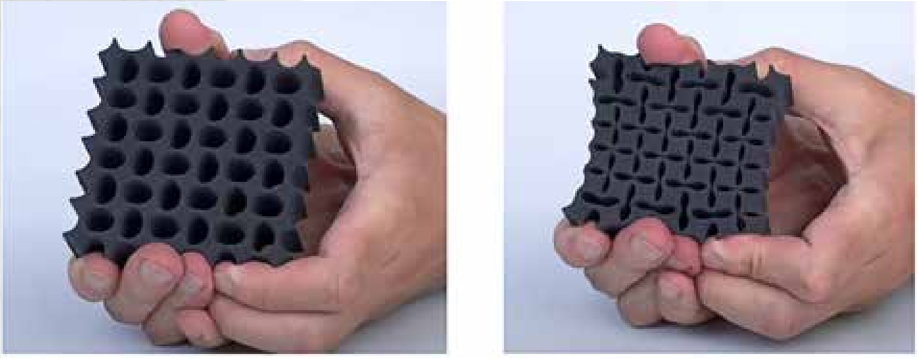
The company can design a material that substitutes plastic for rubber by utilizing metamaterials. For example, the cushioning portion of an office chair is made of an integrated plastic honeycomb structure to achieve flexibility that disperses body pressure efficiently. Appropriate substitution of materials can create added value, such as lower cost, improved design through better moldability, improved recyclability, and lighter weight.

In addition to enhancing creative possibilities, metamaterials have the potential to contribute to sustainability because they can add functionality without increasing material usage.

"By combining structures that express innovative functions, such as metamaterials, with inverse calculation techniques, we are able to achieve a high level of function-to-shape," says Taisuke Ohshima, CEO at Nature Architects, describing the company's DFM technology. "The Ansys Startup Program has allowed us to use advanced simulations that would have been cost-prohibitive to implement at the startup stage of the company and has helped us automate and advance our analysis and design systems, expanding the range of industries and problems we can handle as a company."

Ohshima and fellow engineers have integrated simulation to conquer what they say is a top challenge in geometric design: the automation of new structure discovery. Using Ansys Mechanical for structural analyses and fluid-structure interaction, the team implements Ansys Mechanical Parametric Design Language (MAPDL), a scripting language that automates simulation tasks and streamlines workflows. This automation allows the team to visualize and explore countless new structures. Engineers can also use MAPDL to build models with new variables and parameters through features including design optimization and adaptive meshing.

"Automation of simulations and advancement in dealing with nonlinear problems are helping us to develop systems to overcome this challenge," says Ohshima. "We have a customized and automated system for DFM using Ansys Mechanical APDL, from geometry definition to analysis and post-processing, benefiting from a wide variety of constraints and elements."



The simple geometry of elastomers with holes realizes controlled buckling deformation and efficient conformity.

Additionally, the group uses Ansys Fluent to analyze two-fluid heat exchange performance in lattice structures, which enables them to design heat exchangers.

SOLUTIONS IN ACTION

DFM technology boosts the capabilities of traditional functional modeling by generating the appropriate metamaterial structure instantly based on its desired physical function. With DFM, Nature Architects can add various physical functions into products that were unattainable before, including flexibility, deformation, thermal conductivity, and vibration absorption. DFM technology is used most effectively for products that deal with motion, such as automotive, aerospace, and robotics, as well as components such as fans, springs, switches, and levers. By reimagining these compliant mechanisms, Nature Architect engineers produce the desired movement through integrated structures, reducing the need for external operating parts and components, including hinges, screws, and bolts.

If the movable parts can be made as a single piece using a compliant mechanism, it is possible to eliminate the need for multiple parts, and therefore, assembly. In addition, if a compliant mechanism is properly designed with DFM, it is possible to integrate those functions into the piece, creating the same functionality in a single unit.

With a team of 15, Nature Architects does not directly produce end products, but supplies metamaterials and DFM solutions to manufacturers, often collaborating in development and supporting product design. Essentially, Nature Architects builds and operates software modules equipped with DFM technology to automate the design process for each customer and project.

Currently, Nature Architects provides three solutions using DFM technology, including DFM PULSE, DFM TOUCH, and DFM UNWELD, which enhance capabilities in vibration, haptics, and sheet metal processing, respectively. Applications range from automobiles to music equipment.

An automotive component company currently uses DFM PULSE to isolate vibration in components around sensors and is working with a leading air conditioning (AC) manufacturer to develop vibration isolation components for AC systems. A construction company integrates DFM UNWELD technology to manufacture building components, and DFM TOUCH is being used to develop equipment for the entertainment industry.

Metamaterials are key building blocks to DFM solutions and offer a range of properties depending on the needs of the company or application. For example, the triangular prism-based auxetic lattice structures used for the cushion padding mentioned above possess unprecedented rigidity control that provides stress relief for automotive sensor peripheral components and can also be implemented to reduce vibration. Traditionally, vibration isolation techniques require elasticity from external components such as rubber or springs, but DFM technology recreates these compliant mechanisms in other materials. For instance, DFM PULSE can be used to fabricate elastic properties with metamaterials to alter any composite or material, including glass, plastic, wood, or metal.

"By innovating designs based on the use of conventional manufacturing methods, we can improve the efficiency of product design and add value to products," says Ohshima. "Ansys simulation is beneficial for the automation and advancement of analysis in our proprietary design system."