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ADVANTAGE

EMPOWER INNOVATORS TO DRIVE HUMAN ADVANCEMENT

ISSUE 1 | 2026

Focus on Industry Transformation

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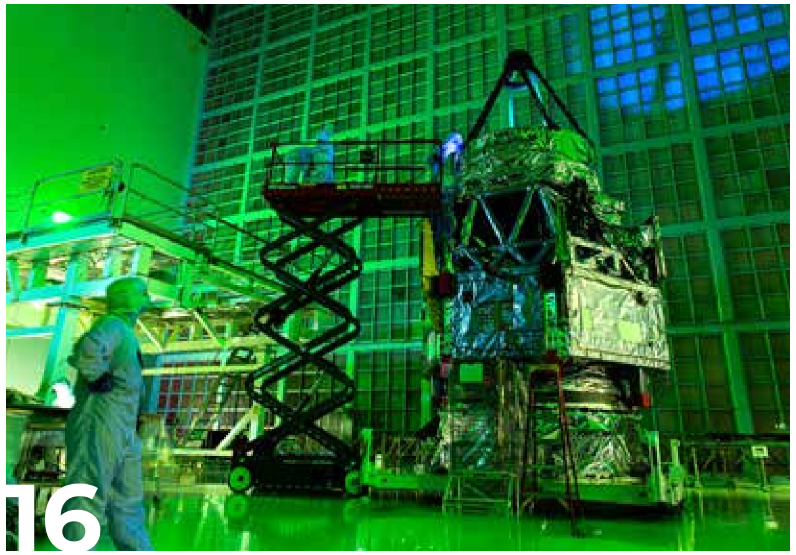

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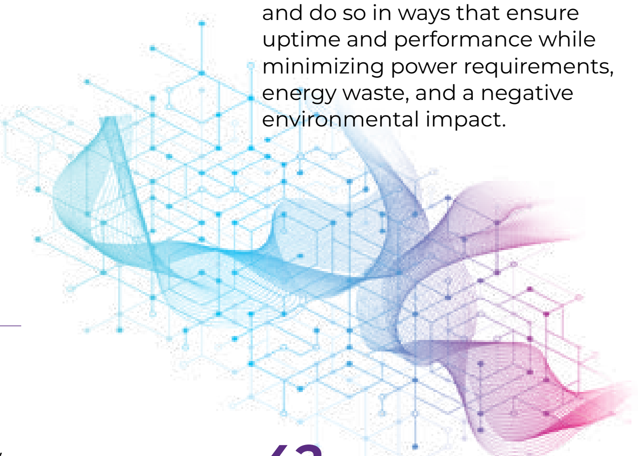

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ADVANTAGE

Welcome to Ansys Advantage! We hope you enjoy this issue featuring articles focused on how intelligent systems are transforming industries.

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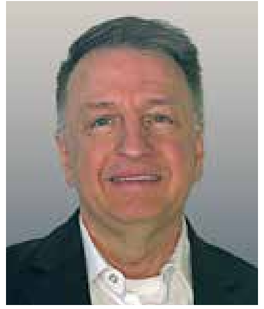
Synopsys, Inc. (Nasdaq: SNPS) is the leader in engineering solutions from silicon to systems, enabling customers to rapidly innovate AI-powered products. We deliver industry-leading silicon design, IP, simulation and analysis solutions, and design services. We partner closely with our customers across a wide range of industries to maximize their R&D capability and productivity, powering innovation today that ignites the ingenuity of tomorrow. Learn more at www.synopsys.com.

Issue 1 / 2026

Engineering an AI Stack To Improve Human Lives

By **JAMIE J. GOOCH**, Executive Editor, Ansys, part of Synopsys



You've probably heard the proverb that necessity is the mother of invention, but the world is in need of a great many things. Who decides what inventions are necessary for society as a whole? We could pour our time and energy into artificial intelligence (AI) to produce funnier videos to share on social media, fill out our expense reports, clean our homes, or cure cancer, among other possibilities. But in 10 years, how will we describe the results of the inventions we created?

"The pervasive use of physical intelligence that will dramatically change and improve human lives," predicted Synopsys President and CEO Sassine Ghazi when asked that question while participating in a 2026 World Economic Forum panel in Davos, Switzerland.

Ghazi joined Abdullah AlSwaha, minister of communications and information technology for Saudi Arabia; Laura D'Andrea Tyson, distinguished professor at the graduate school Haas School of Business, University of California, Berkeley; and Vimal Kapur, chairman and CEO, Honeywell, in the panel discussion: "How Can We Unlock New Sources of Growth? Converging Technologies To Win."

"I think perhaps the dominant conversation this year at Davos has been exactly the subject of our panel today, which is converging with technology to win," said panel moderator Andrew McAfee as he introduced the panel. McAfee is a scientist at Massachusetts Institute of Technology (MIT) who co-founded the MIT Initiative on the Digital Economy and Workhelix. "This is the topic at Davos 2026."

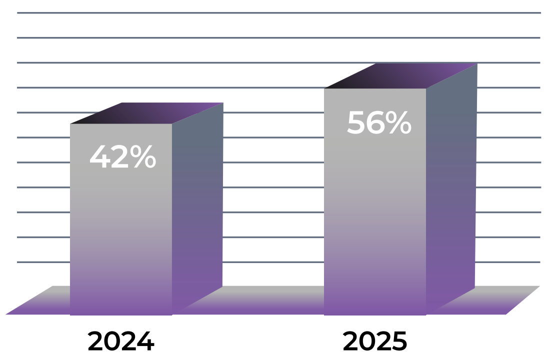
WHAT IS A WINNING TECHNOLOGY?

The direction of our collective technological ambition is not a question that can be answered by economic supply and demand alone. Breakthroughs require risk-takers. Some innovations have immediate market value; others require long-term investment, regulatory approval, and societal changes to come to fruition.

To change the world with the next big thing requires the convergence of innovators in business, government, academia, and civil society to share their time and talents with one another. Much like systems engineering, this ecosystem provides insights into how innovations are interrelated — just on a much larger scale. For example, if the energy sector invests in AI to help conserve commercial power or produce it more efficiently, that might yield an energy surplus that can then be applied to government-funded academic research into healthcare. Understanding those priorities and trade-offs can help both businesses and society thrive.

Engineers know a thing or two about trade-offs. Despite the seemingly limitless possibilities for applying AI to society's challenges, there are constraints. AI requires purpose-built semiconductors and energy to turn those inventive AI models into useful products and services that customers are willing to buy.

Shipping Intelligent Products



Globally, over half of engineers (56%) said they have incorporated AI into designed products and solutions they are shipping to customers, a significant increase from the previous year.

Source: "The Reality of Artificial Intelligence: Engineers get behind AI, despite its challenges," Avnet Insights Survey of 1,200 engineers, January 2026.

"That's the beauty of constraining the problem," said Ghazi during the panel discussion. "Engineering comes to life when you constrain the problem."

ACCELERATE YOUR AMBITIONS WITH CONFIDENCE

Two of those age-old constraints — complexity versus speed — aren't going anywhere in the age of AI. AI and the accelerated computing technologies it relies on are obviously a driver of efficiency. AI is also a source of complexity. It's a paradox that engineers increasingly encounter as they integrate AI efficiencies into their workflows while creating AI-enabled products. Those intelligent products add complexity to engineering, which then demands even greater AI efficiencies.

Just as different aspects of society cannot meet the challenges and promises of AI alone, multiple technology providers are needed to fully capitalize on future possibilities. That's why an open ecosystem is key.

Just as different aspects of society cannot meet the challenges and promises of AI alone, multiple technology providers are needed to fully capitalize on future possibilities. That's why an open ecosystem is key. Individual tool efficiencies will get you only so far without integrations to connect them up and down the tech stack.

With the integration of Ansys, Synopsys is equipping you with unparalleled solutions to revolutionize how you design and build products — from silicon to systems. With Ansys and Synopsys as one company, you will gain access to both an expanded partner ecosystem and solutions to help you optimize even the most complex workflows, eliminate inefficiencies, and provide you with a cohesive means to innovate at an accelerated pace that meets tomorrow's needs without sacrificing quality.

Moreover, the integration of simulation-powered digital engineering into your workflow fosters better collaboration across engineering teams. With insights shared in real time, stakeholders can align on design objectives, helping you deliver innovative products faster. You're empowered to tackle challenges with clarity and confidence, knowing that you have access to a forward-thinking partner that helps you meet the demands of today's competitive landscape.

WE'RE JUST GETTING STARTED

The articles in this issue illustrate how industries are already being transformed by technological convergence — from software-defined vehicles and data centers to robotics and more. These intelligent systems are silicon-powered, software-defined, and AI-infused. Our customers continue to amaze us with how they use our solutions to push the limits of what is possible.

But this is just the beginning of what a silicon-to-systems ecosystem will provide. The future of innovation is defined by your ability to create intelligent products and systems that learn, adapt, and enhance human experiences in ways that we once thought were unattainable. If you're engineering for the pervasive use of physical AI that will dramatically change and improve human lives, you need the tools to transform groundbreaking ideas into solutions that improve society, streamline industries, and push technology forward.

The Ansys 2026 release one (R1) delivers a major step forward in system-to-silicon engineering design by unifying physics accuracy, enabling intelligent acceleration, and delivering real-world performance insight. As products become more software-defined, densely integrated, and multidisciplinary, engineers need visibility across mechanical, electrical, thermal, and fluid domains.

The latest release strengthens system-aware multiphysics simulation to enable faster design cycles and reduced program risk. AI, graphics processing units (GPUs), high-performance computing (HPC), and cloud technologies accelerate innovation — turning complexity into speed, scalability, and real-time design exploration. Finally, new capabilities in multiphysics digital twins provide a deeper understanding of how products behave in the field, enabling teams to optimize performance, reliability, and efficiency long before hardware exists. Together, these advancements help organizations move confidently forward with greater agility and engineering insight.

We hope you enjoy the issue.

Despite algorithmic wizardry and unprecedented scale, the engineering behind AI has been relatively straightforward. More data. More processing. More I/O.

But that's changing.

Engineering Physical AI

By **THOMAS ANDERSEN**, Vice President, AI and Machine Learning, Synopsys

With an explosion of investment and innovation in robots, drones, and autonomous vehicles, "physical AI" is making the leap from science fiction to everyday reality. And the engineering behind this leap is anything but straightforward.

No longer confined within the orderly, climate-controlled walls of data centers, physical AI must be engineered — from silicon to software to system — to navigate countless new variables.

Sudden weather shifts. A cacophony of signals and noise. And the ever-changing patterns of human behavior.

Bringing physical AI into these dynamic settings demands far more than sophisticated algorithms. It requires the intricate fusion of advanced electronics, sensors, and the principles of multiphysics — all working together to help intelligent machines perceive, interpret, and respond to the complexities of the physical world.

THE NEXT FRONTIER FOR AI: PHYSICS

We have taught AI our languages and imparted it with our collective knowledge. We've trained it to understand our desires and respond to our requests.

But the physical world presents a host of new challenges. If you ask AI about potholes, it will tell you how they're formed and how to repair them. But what happens when AI encounters a large pothole in foggy, low-light conditions during the middle of rush hour?

Our environment is highly dynamic. But the one, unbending constant? Physics. And that's why physics-based simulation is foundational to the development of physical AI.

For AI to function effectively in the real world, it needs finely tuned sensors — such as cameras, radar, and lidar — that deliver correlated environmental data, allowing physical AI systems to accurately perceive and interpret their surroundings.

Physics-based simulation allows engineers to design, test, and optimize these sensors — and the systems they support — digitally, which is significantly less expensive than physical prototypes. Answers to critical "what-if" questions can be attained, such as how varying weather conditions or material reflectivity impact performance. Through simulation, engineers can gather comprehensive and predictive insights on how their systems will respond to countless operating scenarios.

Equally important to being able to "see" our world is how well physical AI is trained to "think." In many cases, we lack the vast, diverse datasets required to properly train nascent physical AI systems on the variables they will encounter. The rapid emergence of synthetic data increasingly helps innovators bridge the gap, but accuracy has been a concern.

Ansys Perceive EM radio frequency channel and radar signature simulation software in NVIDIA Omniverse models 5G/6G antenna signals of moving vehicles in Denver.

Exciting progress has been made on this front. Powerful development platforms — such as NVIDIA's Omniverse — can be used to create robust virtual worlds. When integrated with precise simulation tools, these platforms enable developers to import high-fidelity physics into their scenario to generate reliable synthetic data.

multidomain systems. Electrical engineers, mechanical engineers, software developers, and others must work in lockstep from concept to final product. And their work must accelerate to meet shrinking development cycles.

The complexity of today's intelligent systems demands solutions with a deeper integration of electronics and physics. Engineering solution providers are moving fast to meet this need. The Synopsys acquisition of Ansys, for example, combines the leaders in silicon design, IP, and simulation and analysis. Together, we can deliver holistic system design solutions for customers to rapidly innovate AI-powered products.

Ansys electromagnetic simulation software within a rendering of downtown San Jose, California, in NVIDIA Omniverse with 5 cm resolution

REENGINEERING ENGINEERING FROM SILICON TO SYSTEMS

Design and engineering methodologies have traditionally been siloed and linear, with a set of hardware and software components being developed or purchased separately prior to assembly, test, and production.

These methodologies are no longer viable — for physical AI or other silicon-powered, software-defined products.

Consider a drone. To fly autonomously, avoid other objects, and respond to operator inputs, many components must work in concert. Advanced software, mechanical parts, sensors, custom silicon, and much more.

Achieving this level of precision — within imprecise environments — can't be achieved with traditional methodologies. Nor can it be delivered within the timelines the market now demands.

Digitally enhanced products must be designed and developed as highly complex,

Our ways to innovate must be as multi-dimensional and dynamic as the world we live in, and with this, traditional engineering processes must be reengineered. It will be our key to unleashing physical AI and enabling technologists to achieve their next breakthrough.

LEARN MORE

Discover the latest product releases from Ansys, part of Synopsys.

ansys.com/products/release-highlights

This article originally appeared in Electronics Weekly.

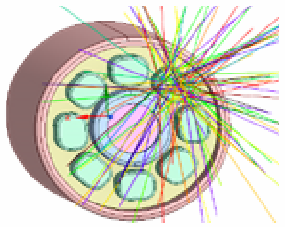
Envision More Innovative Medical Devices With Ansys Optics

By **KERRY HERBERT**, Senior Product Marketing Manager, Ansys, part of Synopsys

From the application of artificial intelligence (AI) to wearables and personalized, patient-specific designs, medical device innovation has reached an inflection point. In 2025, the market for smart medical devices was $90.54 billion, and it's expected to reach $185.5 billion by 2030, more than doubling in five years.

Optics plays a leading role — both in increasing device innovation and fueling overall market growth. From simple lenses to complex laser-based systems, the use of light and optics underlies a range of modern medical imaging devices, treatment techniques, and diagnostic tools. Consider these examples of optics at work in healthcare:

- **Imaging systems.** Devices like endoscopes rely on optical components to capture high-quality images of internal organs, tissues, and cells for diagnostic purposes.
- **Laser treatments.** Many modern medical therapies and beauty applications, such as laser eye surgery and laser hair removal, use optics to deliver precise laser beams to targeted areas.
- **Surgical assistance.** Advanced surgical systems incorporate optical-based navigation to provide surgeons with real-time visual information, enhancing their accuracy.
- **Patient monitoring.** Optical sensors are widely used in non-invasive monitoring devices like pulse oximeters and glucose measurement devices. While optics has become increasingly critical in modern healthcare, the design of these systems comes with an array of engineering challenges. Medical devices must be compact and lightweight, which means that optical systems must be miniaturized without sacrificing performance. Optical components must also be incredibly precise in their design. Even the slightest misalignment or distortion in optical components can compromise the effectiveness of a device, leading to inaccurate results or even harmful outcomes.



Optical ray-tracing is used to analyze the image quality of an endoscope camera system under different lighting conditions.

How can medical device development teams balance all these competing product demands while still working quickly to capture the innovation opportunity? The answer is engineering simulation.

Optical systems must also perform reliably in the face of temperature fluctuations and mechanical stresses. For example, lasers used in medical therapies generate heat, and optical components must withstand thermal effects without performance degradation. These high-performance demands are accompanied by strict regulatory requirements. Optics-based medical devices must undergo rigorous validation and testing before they can be used on human patients. This, along with sustainability mandates, is placing new pressure on device manufacturers for energy efficiency, as well as high performance.

Finally, in today's highly competitive healthcare markets, devices must be optimized for cost-effective production at speed and scale. Balancing performance with manufacturing cost constraints is essential to bring medical devices to market at competitive prices.

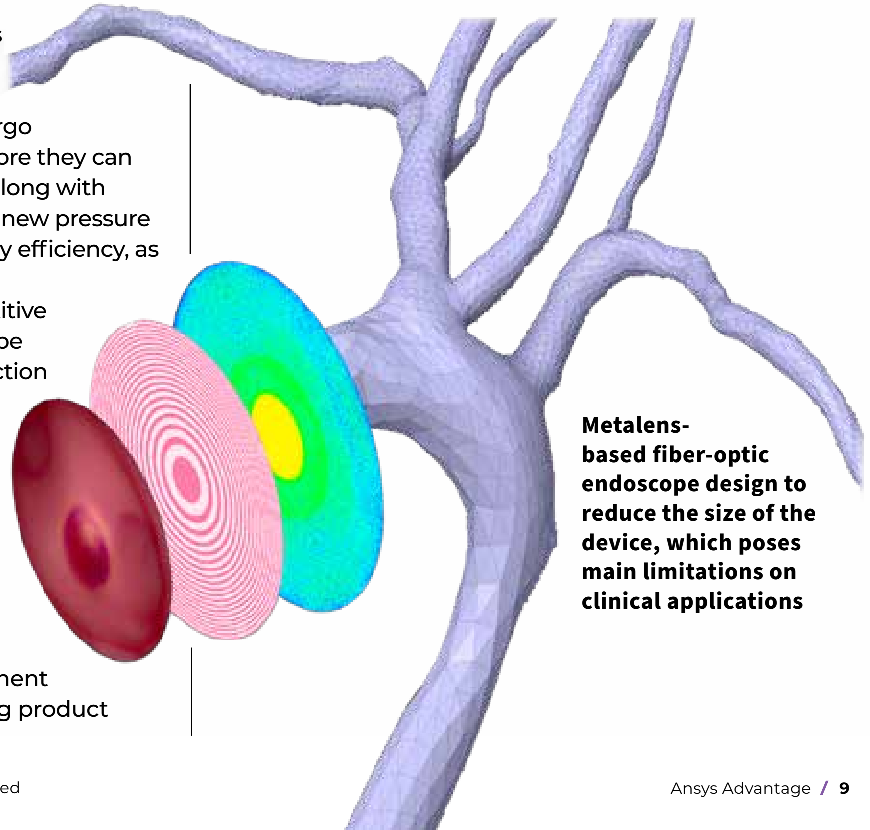
SIMULATION: AN EARLY, ACCURATE LOOK AT DEVICE PERFORMANCE

How can medical device development teams balance all these competing product demands while still working quickly to capture the innovation opportunity?

The answer is engineering simulation. By designing, testing, perfecting, and validating advanced optical designs in a risk-free virtual space, engineering teams can confidently produce leading-edge devices that simultaneously meet the tight constraints of size, weight, precision, durability, power usage, regulatory compliance, and manufacturing cost. They can drive significant time from the development cycle to speed innovative new designs to market — supporting both revenue growth and improved patient outcomes.

Ansys Optics is a comprehensive simulation suite widely adopted by leading medical device manufacturers to accelerate the development of advanced optical architectures while meeting stringent requirements for performance, reliability, manufacturability, regulatory compliance, and sustainability.

Ansys Optics enables multiscale simulations ranging from full-wave electromagnetic models on the nanoscale to ray-tracing



Metalens-based fiber-optic endoscope design to reduce the size of the device, which poses main limitations on clinical applications

on the component and system level for complex optical assembly design in a virtual environment, enabling engineers to optimize key performance metrics across multiple domains simultaneously.

For healthcare applications, this can mean minimizing chromatic and monochromatic aberrations in imaging systems, maximizing optical throughput and signal-to-noise ratios, or achieving precise focal plane and depth-of-field requirements. By performing these analyses upfront, engineers reduce reliance on costly physical prototyping cycles and accelerate convergence to manufacturable designs.

CASE STUDIES: A GLIMPSE OF ANSYS OPTICS IN ACTION

Hundreds of customers, including healthcare leaders, have leveraged the power of Ansys Optics to optimize their optical systems and improve the performance of their products. Let's look at three examples in the healthcare industry.

CORNELL UNIVERSITY

A visionary team of researchers at Cornell University used Ansys Optics to develop a new instrument for multiphoton microscopy (MPM) at the micron scale. While existing commercial spectrophotometers only accommodated deep imaging within highly scattered living tissue at the centimeter scale, Chris Xu and Aaron Mok wanted to measure optical transmission in much smaller specimens, including mouse skulls, mosquito and fruit fly cuticles, and the skin of Danionella, one of the world's smallest fish. They used Ansys Zemax OpticStudio optical system design and analysis software to test and verify their new instrument, proving the effectiveness of using single-mode optical fibers to isolate ballistic photons in the tissue spectrometer, generate spatially resolved transmission maps for five types of micron-scale tissue samples, and provide a measurement system for tissue analysis at a very small scale.

INAOE

During the pandemic, Jorge de Jesus Alvarado-Martinez and his team at the Instituto Nacional de Astrofísica, Óptica, y Electrónica (INAOE) developed an optical system to improve thermal imaging technology for syndromic surveillance. The system identifies people with elevated temperatures, a key indicator of serious infections, and differentiates crowd members based on bioclinical signals like cough and temperature. Off-axis mirrors were chosen for this solution, as they eliminate obscuration and provide a wide field of view (FOV). The team used the Footprint Diagram tool in OpticStudio software to observe parameter values based on aperture size and FOV dependency. The system achieved cost savings, faster development, and easier materials selection. This innovative approach aims to improve public health by detecting, monitoring, and understanding health events, enabling timely response and intervention to protect populations from exposure.

IMPERIAL COLLEGE LONDON

Researchers at Imperial College London used optical design software from Ansys to pioneer a new method of lens selection for fluorescent microscopes that must be refocused remotely. While 3D imaging in optical systems often involves scanning the sample or moving the objective back and forth with respect to the sample, these methods often fall short — because movement produces vibrations. Christopher Dunsby and Wenzhi Hong used OpticStudio software — which includes a dynamic catalog of stock manufactured lenses — to define a standardized, reliable practice for lens selection. Their formula states that the overall magnification must equal the ratio of the sample medium's refractive index to the refractive index in which the image is formed. By automating this process, Dunsby and Hong are eliminating guesswork and accelerating microscopy design for optics teams worldwide.

Medical optics must function as part of multiphysics systems, where optical behavior is strongly coupled to mechanical, electrical, and thermal effects. Ansys Optics enables engineers to evaluate device performance under real-world operating conditions. For example, in the development of a laser-based therapeutic platform, engineers can simultaneously model Gaussian beam propagation, scattering in biological tissue, and thermo-mechanical deformation of optical components. These coupled simulations ensure that lenses, mirrors, and fibers remain within tolerance, minimizing beam steering errors and preserving energy delivery precision.

In addition, optics solutions from Ansys, part of Synopsys, support thermal-optical and stress-optical modeling, enabling engineers to predict refractive index changes, birefringence, and lens warping due to temperature gradients. With these insights, teams can implement thermal mitigation strategies, such as optimized heat sinking, athermal lens designs, or active cooling solutions, to ensure consistent device performance under elevated operating loads.

By combining rigorous electromagnetic solvers with system-level multiphysics analysis, Ansys Optics provides optical and photonics engineers with a robust framework for designing next-generation medical devices that meet optical performance targets and stringent regulatory and reliability standards.

FASTER, MORE COST-EFFECTIVE, MORE COMPLIANT DESIGNS

By enabling rapid, high-fidelity design iterations, Ansys Optics significantly accelerates the optical product development cycle and facilitates innovation in medical optics and photonics.

Engineers can leverage a combination of ray-tracing, wave-optics, and structural and thermal solvers for multiphysics simulations to virtually explore a broad design space, evaluating multiple optical architectures, coatings, source models, and material selections without fabricating hardware. This virtual prototyping approach reduces reliance on costly iterations, enables earlier identification of aberrations, stray light, or thermal-induced misalignments, and ultimately shortens time to market while improving manufacturability.

Ansys simulation also streamlines the path to regulatory compliance, a critical requirement in the medical device sector, where optical safety and performance standards are tightly enforced. Using optics solutions from Ansys, engineers can simulate and validate device behavior. By generating simulation-based evidence, Ansys Optics not only supports design verification and validation but provides the documentation required for regulatory submissions, reducing delays associated with physical test-only strategies.

Furthermore, engineers can conduct advanced risk and failure mode analyses, such as modeling thermal runaway in high-power laser diodes or simulating worst-case stray-light conditions in diagnostic imaging systems, ensuring that safety margins are satisfied prior to prototyping and clinical testing.

Through its ability to couple optical, thermal, structural, and electromagnetic analyses within a single platform, Ansys Optics empowers photonics engineers to design devices that achieve both technical excellence and regulatory compliance efficiently and with high confidence.

INCREASE YOUR FOCUS ON INNOVATION WITH ANSYS

The integration of simulation into the design process is no longer a luxury but a necessity for staying competitive and fueling innovation in the fast-paced healthcare market. By leveraging the power of Ansys Optics, product development teams can create optics-based medical devices that push the boundaries of what's possible, ultimately improving patient outcomes and advancing healthcare technologies.

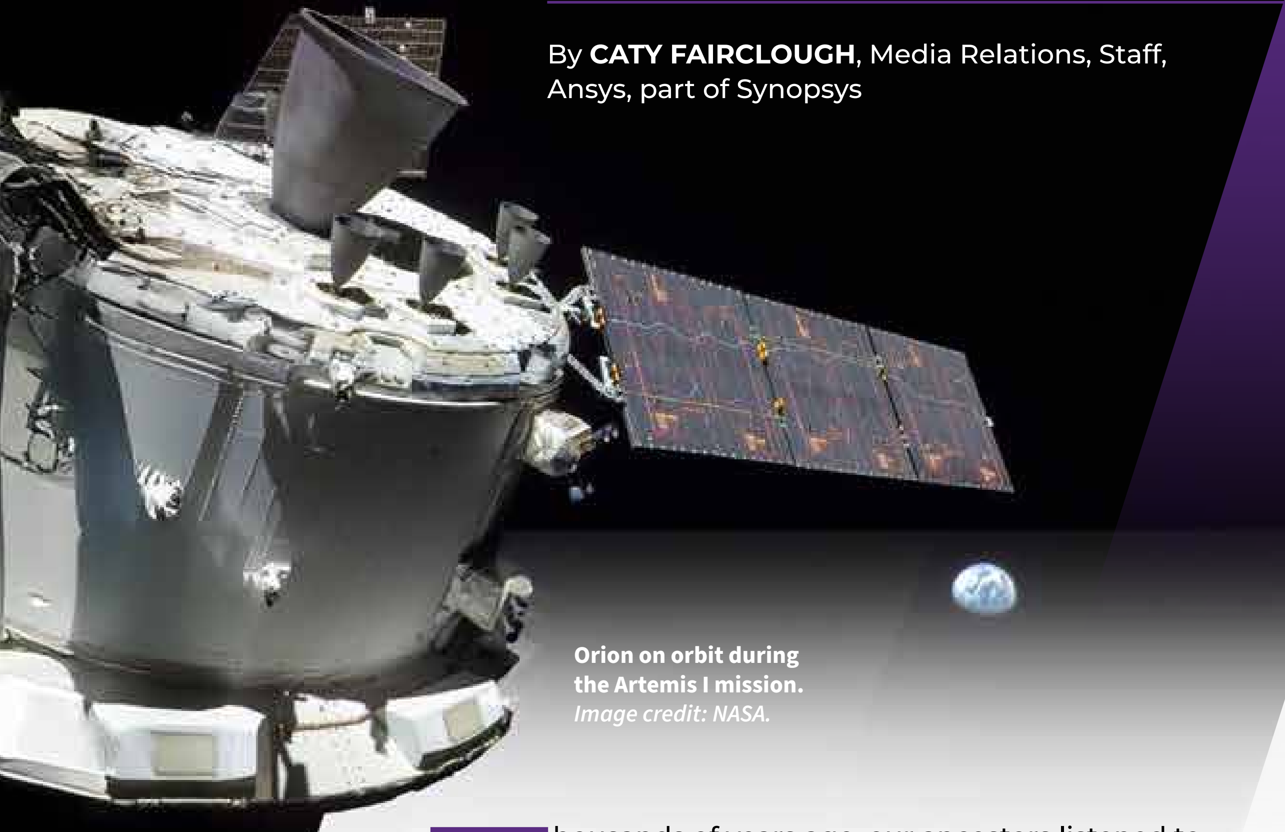
LEARN MORE

Download the "Ansys Optics Miniaturization Solutions" e-book.

ansys.com/resource-center/brochure/ansys-optics-miniaturization-solutions

Modern 'Gods': Apollo, Artemis, and the New Lunar Economy

By **CATY FAIRCLOUGH**, Media Relations, Staff, Ansys, part of Synopsys



Orion on orbit during the Artemis I mission. *Image credit: NASA.*

Thousands of years ago, our ancestors listened to storytellers share tales of the Greek pantheon, the gods said to have authority over everything from the sky and thunder to love and beauty. These gods shaped the way people understood the world around them. And today, spacecraft carrying the names of these same gods are carving their way through the darkness surrounding Earth to change not only the way we view our world but our universe.

The first of these missions were part of the Apollo program, which ran from the 1960s through the 1970s and was named after Apollo, the Greek god of the Sun, music, dance, poetry, prophecy, and more. Perhaps Apollo alone could have foretold the great tragedies and accomplishments of the Apollo program, such as when Neil Armstrong and Edwin "Buzz" Aldrin became the first humans to walk across the face of the Moon on July 20, 1969, during the Apollo 11 mission.

The Artemis missions, which began in 2022, are named after Apollo's twin sister, Artemis. Like her brother, Artemis is a multifaceted deity, the goddess of wild animals, the Moon, and the hunt, among other things. The Artemis program is similarly complex, with goals ranging from growing the lunar economy to advancing the scientific pursuits started with Apollo and inspiring the next generation.

While their namesakes are ancient, the Apollo and Artemis programs are anything but. These missions are not only expanding our knowledge of the universe — they've relied on and developed innovative technologies to launch us into a new era of lunar exploration.

OUR FIRST STEPS TOWARD A NEW ERA: THE APOLLO MISSIONS

The six lunar landing missions and 11 crewed missions of the Apollo program yielded numerous historic and scientific triumphs.

Scientific achievements range from the crew of the Apollo 15 mission proving Galileo's theory that objects in a vacuum fall at the same rate regardless of mass to the final Apollo mission, 17, culminating in not only the most extensive lunar exploration of the program but the collection of 243 pounds of lunar materials. Through the research conducted by these missions, we've made exciting discoveries, including that the Moon is an evolved rocky body, not a primordial object, and that there is abundant hydrogen from the Sun contained in lunar regolith (the Moon's soil).

Apollo didn't just let us learn more about the Moon either — we also gained critical insight about Earth itself. Pictures of Earth taken from the Apollo 7 and 8 missions, for instance, helped inspire a worldwide change in our relationship with the environment and highlighted issues, such as diseased crops, from a new perspective. This knowledge led to NASA's Landsat program, which observes Earth's resources from space.

Another key triumph of Apollo was helping pave the way for the Artemis program.

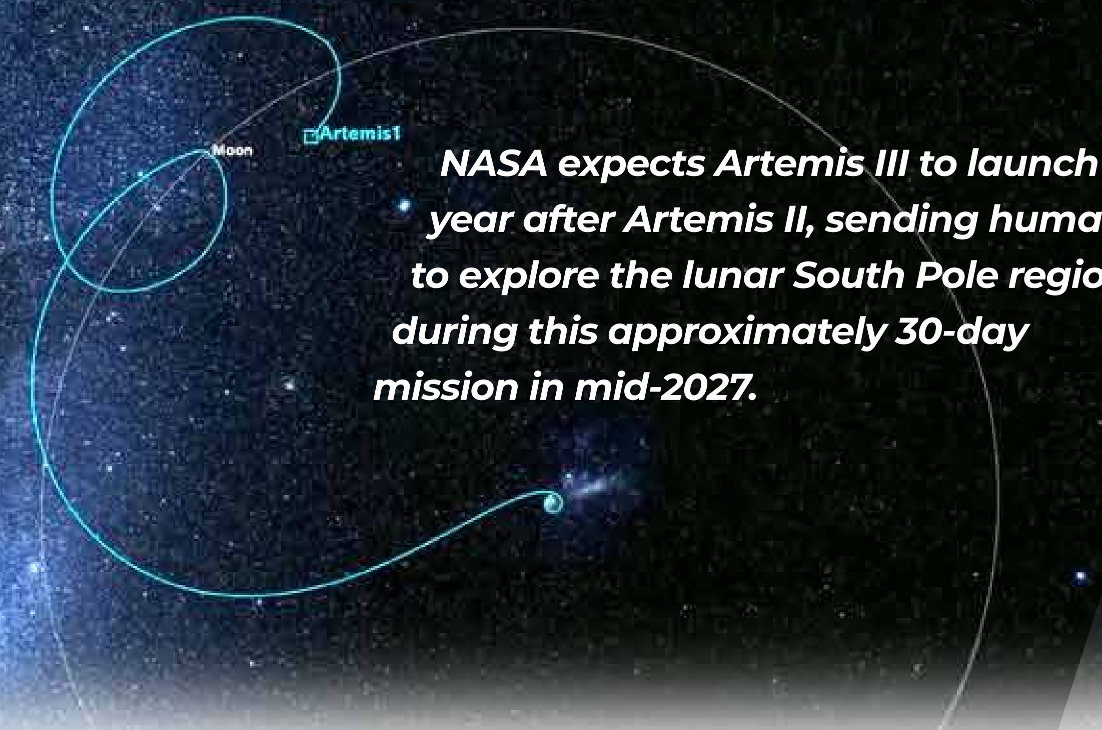
SETTING THE CELESTIAL STAGE FOR THE NEW SPACE ECONOMY WITH ARTEMIS

It wasn't until the following century that Apollo's twin, the Artemis program, left our planet. The Artemis program is more than a continuation of the Apollo program; it's an evolution with broad long-term goals, including building sustained infrastructure on the Moon (such as a lunar base), advancing scientific discovery, using previously unexplored orbital options, and working toward sending astronauts to Mars.

The Artemis program will make history in other ways too. It will see the first woman and person of color set foot on the Moon and relies on worldwide commercial and governmental cooperation, such as via the Artemis Accords.

The flight map for the Artemis II mission. Image credit: NASA, public domain, via Wikimedia Commons.

NASA expects Artemis III to launch the year after Artemis II, sending humans to explore the lunar South Pole region during this approximately 30-day mission in mid-2027.



Simulating the Artemis mission trajectory

Through the Artemis program, NASA also hopes to aid the growing lunar economy. As Kathryn Flood, senior manager of application engineering at Ansys, part of Synopsys, puts it, the Artemis program is functioning as a truly "multinational experience," involving contributions from organizations around the world. These collaborations show that we will take the next steps toward a lunar economy together as a global community.

Achieving these goals is a work in progress, which began when the Artemis I mission launched Nov. 16, 2022. This uncrewed mission enabled NASA to test its deep space exploration systems, including the Orion spacecraft — which will be used to carry astronauts in future missions — and the Space Launch System (SLS) rocket with NASA's current ground systems.

The next mission, Artemis II, is coming up soon. Scheduled for early 2026, Artemis II will be a 10-day crewed mission around the Moon. This will be the next step toward enabling a long-term lunar presence and, eventually, Mars missions.

NASA expects Artemis III to launch the year after Artemis II, sending humans to explore the lunar South Pole region during this approximately 30-day mission in mid-2027. This mission will involve collecting samples, deploying experiments, and using a few new key technologies, including a human landing system (which transports astronauts to the lunar surface from lunar orbit and back) and advanced spacesuits.

Artemis IV will build upon previous missions and involve constructing the first lunar space station and other foundational systems that we'll need for long-term lunar exploration throughout the entire Artemis campaign. This mission will require the use of additional technologies and structures, including a Lunar Gateway (a small space station that will be assembled and operated in lunar orbit and serve as a waystation for astronauts traveling to the Moon and beyond, as well as for research and communications), and advanced versions of previously used technologies.

EXPLORING TECHNOLOGICAL INNOVATIONS POWERING SPACE EXPLORATION

Before missions like Apollo and Artemis can change our understanding of the universe and make their mark on history, they must first be designed, developed, and deployed with the highest possible level of care.

To achieve this, innovators can turn to the solutions that Synopsys has to offer, which can aid all aspects of these missions, from development to launch and beyond. "One of the most exciting parts about working here is that because we have such a broad and deep portfolio of tools, we can work with you at every step for every piece of the mission," says Flood.

As an example, let's take a closer look at mission planning and operations. Here, engineers can use Ansys software, such as Ansys Systems Tool Kit (STK) digital mission engineering software and Ansys Orbit Determination Tool Kit (ODTK) orbit measurement processing software, for everything from initial mission planning, orbit determination, SLS communication link analysis, flight trajectory visualizations, and antenna radiation pattern analysis to real-time operations and launch clearance. Engineers can also better ensure safety and success with hardware in the loop (HiL) simulations and advanced design reference missions (DRMs), which have been relied on since the early Apollo missions.

Artemis I launching. *Image credit: NASA/Joel Kowsky.*

In regard to the Artemis program, Synopsys solutions can aid engineers is by helping them design and develop the SLS and Orion by using:

- Ansys Thermal Desktop thermal-centric modeling software to ensure that the correct temperature range is maintained
- Ansys Fluent fluid simulation software to model aspects, such as engine fuel, or perform reentry fluid analyses for the Orion crew
- Ansys Mechanical structural finite element analysis software to study vibrations
- Synopsys services, including Synopsys Technology Computer-Aided Design (TCAD), to create rad-tolerant, safe, and secure designs for the harsh space environment, such as for on-board electronics and communications
- Communications and dependable electronic sensors — all of which involve chips — which are imperative to the success of these missions
- Ansys EMC Plus electromagnetic interface and compatibility simulation software, the Ansys STK Shield Plus capability, and Ansys Sherlock electronics reliability prediction software to perform electromagnetic (EM) assessments, mitigate EM risks, design electronic hardware, and more
- The Ansys SCADE embedded software product collection to ensure the safety and reliability of embedded software

As for the human element, the spacesuits used by the crew can also be developed and optimized with Synopsys products. In addition to Thermal Desktop and Fluent software, as well as products for the embedded chips and electronics, the Ansys Hans Human Body Model could be used to further develop and optimize these suits.

Then, after the mission is over, Synopsys solutions can still provide insights and help. Take physical and digital twins, for example. Using a physical twin model, NASA was able to simulate and evaluate the oxygen tank explosion on Apollo 13. Today, Synopsys offers technologies that aid in the creation and use of digital twin tools and analyses, such as the Ansys Twin Builder simulation-based digital twin platform and Ansys TwinAI AI-powered digital twin software.

Throughout unbelievably complex programs like Apollo and Artemis, there seems to be no limit to the applications of Synopsys solutions.

"The thing about our technology is that we know that you get one shot at this, and if something goes wrong, there are lives on the line," says Flood. "Our software has to be right, and we know the importance of making sure that every single aspect of our software is going to be technically accurate because it is critically important to the people using our software and designing these systems that they get it right. … We're there with you every day to make sure that things do go well every time."

FACING THE DARK DEPTHS OF SPACE AND FINDING HOPE

From making history and changing how we view the universe to turning science fiction into reality and inspiring generations, the Apollo and Artemis programs have had — and will continue to have — a profoundly positive impact on all of humanity.

By enabling us to return to the Moon — and beyond — the Artemis program is helping us "get back to being a world of explorers who are exploring not only our world but the cosmos," says Flood. "We're a people of exploration. That's what we do as humans. … It's about getting back to exploring and getting to understand our universe and our place in it with senses that robots can't provide."

These missions can be aided by dynamic solutions from Synopsys, which enable space innovators to overcome challenges and achieve their star-studded goals.

LEARN MORE

See how simulation is reshaping the future of innovation in the space industry.

space.ansys.com

Disclaimer: NASA was not involved in the creation of this article and did not endorse the use of images in this article.

Peering Into the Past and Redefining the Future With Space Telescopes

By **CATY FAIRCLOUGH**, Media Relations, Staff, Ansys, part of Synopsys

Humanity has always looked to the stars. You could say that stargazing is a connecting thread throughout our collective history. From Earth's oldest cave paintings to Galileo's discoveries in the 1600s and beyond, the stars have long inspired and aided human society.

Now, centuries later, our capacity to learn about the stars and the universe around us has seen a meteoric rise. Advances in optical engineering and the deployment of ground- and space-based telescopes will help us see farther than ever before.

Let's explore two advanced space telescopes that enable global scientists to expand our understanding of the universe: the James Webb Space Telescope and the Nancy Grace Roman Space Telescope.

SPACE SUPERSTARS: THE JAMES WEBB AND NANCY GRACE ROMAN SPACE TELESCOPES

Before the Hubble Space Telescope launched in 1990, scientists were already wondering what would be next. According to NASA, conversations about what would become the James Webb Space Telescope (also known as Webb or JWST) began in 1989.

While Webb follows in Hubble's footsteps and complements its work, it is unique in a few key ways. For instance, Webb:

- Orbits the Sun instead of Earth
- Is optimized for infrared wavelengths, which results in longer wavelength coverage that enables it to see colder, older things in the universe and points of interest that can't be observed with ground-based telescopes
- Uses a folded primary mirror that fit in the rocket and is composed of 18 hexagonal segments that, when precisely tuned to act as a single surface, are capable of collecting six times more light than Hubble

Rocket launching with Webb onboard. *Credit: NASA/Bill Ingalls.*

> ***"Webb is giving us clearer views of things that we've already understood, but because it's looking at the infrared part of the spectrum, we're seeing things that we could never see before. It's completely transformed the developmental models of the universe … and is giving us a window into other worlds and into the creation of the universe that we're all a part of."***
>
> **— ADAM GORSKI,** Director of National Security Solutions, AGI

- Relies on an unfolding extra-efficient sunshield and passive cooling to avoid having a lack of coolant end its mission
- Was the largest (at the time) foldable, self-assembling telescope launched into space

Webb launched Dec. 25, 2021, with high hopes of expanding our knowledge of the universe and serving as the premier observatory of the next decade. Through Webb, astronomers around the world can study our universe's history. This includes exploring everything from the big bang and the life cycles of stars to the formation of solar systems that can support life.

While Webb is still actively changing how we view our world, in the great tradition of space telescopes, the next big thing is already on the way. Named after NASA's first chief astronomer, the Nancy Grace Roman Space Telescope (also known as Roman) was adopted by NASA in 2010 and is currently expected to launch no later than May 2027.

From the outset, Roman differs from Webb in a few ways. For instance, it had an interesting start when the National Reconnaissance Office (NRO) offered a spy satellite for repurposing in cosmological research. As for its core science, the Roman telescope sees in the visible and near-infrared, similar to Hubble. However, Roman's field of view will be around 100 times larger than Webb's, which will help complement Webb's existing capabilities to see deeper into space. This means that Roman's findings can select areas for Webb to investigate more closely.

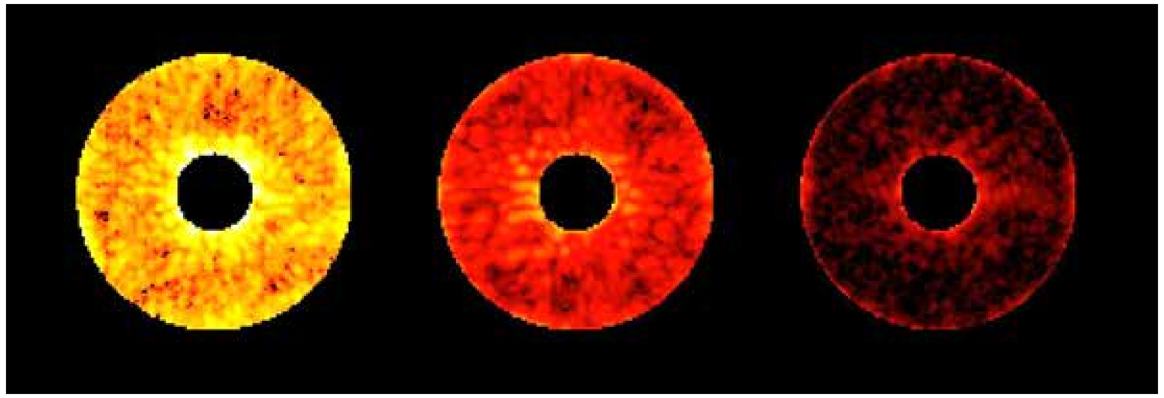
As for what is catching Roman's "eye," the goals of this telescope include observing the universe to learn more about dark matter, dark energy, cosmic expansion over time, exoplanets, and completing the Galactic Plane Survey, which will map around 20 billion stars and aid in creating the most advanced picture of the Milky Way's structure to date.

To achieve these goals, Roman, like its predecessors, will also rely on advanced technologies, such as its 300-megapixel infrared camera wide-field instrument and a high-performance coronagraph. Crucial technological innovations for Roman include extreme lightweighting of the primary mirror and an advanced array of detectors to cover the large field of view.

HOW SILICON, SIMULATION, AND SYSTEMS HELP SPACE TELESCOPES EXCEL

Before Webb and Roman can pull off these amazing feats, engineers must first create optimized designs that can thrive in space. Designs must be rad-tolerant, safe, secure, and capable of deploying the latest innovative technology while also reducing weight, minimizing costs, and ensuring that timelines are met.

Adding to this complexity is the fact that



Three computer readouts from the Roman coronagraph instrument, which show a test of "digging the dark hole." *Credit: NASA/JPL-Caltech.*

Engineer observing Webb's primary mirror segments. *Credit: NASA/MSFC/David Higginbotham.*

Inspecting Roman's primary mirror. *Credit: NASA/Mike Guinto.*

Roman and Webb are designed to be deployed around a million miles from Earth. Webb orbits Sun-Earth Lagrange point 2 (L2) and Roman will also observe from L2. While this location provides a few key benefits, including enabling the telescopes to stay in line with Earth as it moves around the Sun and blocking out most of the light and heat coming from the Sun and Earth, it also means they cannot be repaired by an astronaut if something goes wrong. Instead, their designs must be flawless by the time they reach the launchpad.

The complex designs of these space telescopes make this an incredible challenge. For example, the entire optomechanical assembly must be folded for launch and then deployed in space. Ensuring that this can happen successfully involves considering the vacuum of space, radiation, thermal changes, vibrations, and more — all from Earth.

This is where companies like Synopsys come in. Synopsys has a long history of working as a contractor for government partners, and Ansys, part of Synopsys, has also been a key solution provider for space telescopes like Webb and Roman. As Jeff Baxter, director of application engineering at Ansys Government Initiatives (AGI), says, "Simulation is critical to getting things 'first time right,' especially in space because you only have one chance."

One way that Ansys simulation solutions can make the most of this one chance is during the testing and development phases. For instance, Webb could not be fully tested in the zero gravity and extremely cold temperatures of space. So how could engineers be sure it would survive an L2 orbit using Earth-based testing?

"Simulations had to bridge the gap," says Erin Elliott, principal R&D engineer at Ansys. Those working on space telescopes can use simulation solutions to accurately design and verify system performance. Elliott knows this firsthand since she was part of the team that developed the software and hardware for Webb's primary mirror alignment.

Here, Elliott heavily relied on Ansys Zemax OpticStudio optical system design and analysis software. Elliott shared in an interview with Engineering.com that she used Zemax software for tasks such as testing best- and worst-case scenarios to align Webb's 18 segments perfectly so they could function like a single mirror. Elliott and her team used Zemax software to simulate the complex optics of Webb in the absence of a full-scale model, enabling efficient and accurate testing in a virtual space environment.

This was of the highest importance since Webb's mirrors needed to be developed with extreme precision, including making changes as small as the width of a virus to optimize the design, says Adam Gorski, director of national security solutions at AGI.

In the years since Webb's development, Zemax software has been updated to include an application programming interface (API) that "makes it easy to embed it in your simulations ... so you can run one big simulation," says Elliott. Other helpful updates include the introduction of the structural, thermal, analysis, and results (STAR) tool, which enables thermal and structural deformation data to be directly added to optical models, as well as improved analysis and handling for off-axis mirrors and manufacturability considerations. These updates will make creating the next great space telescopes even easier.

Zemax software has also been used to simulate a spot diagram as part of the characterization of Roman's slitless spectrometer for a study on Roman's wide-field instrument's compact prism assembly for slitless spectroscopy — and more.

This is just the start of how Synopsys can help space telescopes achieve their missions. As Elliott says, "All space telescopes have some things in common" and could benefit from using:

- Ansys Systems Tool Kit (STK) digital mission engineering software and Ansys Orbit Determination Tool Kit (ODTK) orbital measurement processing software as critical parts of a flight dynamics system to build complex design reference missions (DRMs), to design trajectories, to perform operational orbit determinations, and more
- Ansys Thermal Desktop thermal-centric modeling software to simulate and verify thermal predictions on the delicate heat-sensitive instruments on space telescopes
- Ansys Mechanical structural finite element analysis software to find solutions to the precise mirror pointing and analyze the critical support structure

Additional solutions that can assist the innovators designing and developing space telescopes include Ansys HFSS high-frequency electromagnetic simulation software, Ansys ModelCenter model-based systems engineering software, and the Ansys System Architecture Modeler (SAM) capability.

From systems to silicon, every piece of a space telescope must be confidently designed to exist in the harsh space environment. Synopsys solutions have enabled and will continue to enable researchers to strike this balance. For instance, the combination of simulation and chips design solutions will enable engineers to efficiently design and optimize for the space environment by using trusted products that can be found in one place.

These solutions are more than just helpful; they are imperative to succeeding in space. As Gorski puts it, Webb "was one of the hardest endeavors in all of human history, and it really wouldn't have been possible without Ansys software."

FROM PEERING INTO OUR MYSTERIOUS PAST TO MAKING DISCOVERIES THAT CAN CHANGE OUR FUTURE

The impact of space telescopes extends from solving some of the universe's earliest mysteries to inspiring the next generation of scientists.

"Webb is giving us clearer views of things that we've already understood, but because it's looking at the infrared part of the spectrum, we're seeing things that we could never see before," says Gorski. "It's completely transformed the developmental models of the universe ... and is giving us a window into other worlds and into the creation of the universe that we're all a part of."

This insight has led to many critical discoveries in the four years since Webb launched. These include:

- Discovering that a nearby exoplanet has life-supporting molecules
- Spotting a new moon orbiting Uranus
- Studying a potential moon-forming disk that is located around an exoplanet
- Spotting massive galaxies in an infant universe, as well as complex organic molecules in a primordial galaxy
- Investigating the largest star-forming region in our galaxy
- Finding clues to the universe's expansion rate and supermassive black holes
- Detecting three spots that could potentially be "dark stars"
- Learning more about star-forming regions inside a nebula
- Capturing a detailed view of a doomed star before it exploded, which may provide key information on red supergiant stars

In the search for knowledge on doomed stars, Roman will soon be able to assist Webb. Using its wider field of view, Roman will be able to help look for evidence of these stars when they are being consumed by black holes.

Webb and Roman aren't the only space telescopes making a big impact, either. The upcoming Habitable Worlds Observatory (HWO) will search for signs of life on planets orbiting different stars while also facilitating astrophysics research.

While the achievements and findings gained from space telescopes may seem removed from our day-to-day existence — they are literally happening millions of miles away — they have a tangible impact on our lives and in advancing key technologies. The technologies developed to ensure that these telescopes succeed in their missions can also help advance satellites and will result in advancements in a wide range of Earth-based industries, including the automotive, medical, and robotics fields. In this way, these same space technologies are powerful enough to support many aspects of modern life, from GPS to weather prediction, not just the study of the stars.

And this is only the start. As humanity has always looked to the stars, we will continue to do so — we've only explored a tiny part of our universe after all. Space telescopes and solutions from Synopsys enable mission success that will help us make new discoveries across time.

Simulation, analysis, and chip design solutions, in the space industry and beyond, can help innovators make these discoveries, enabling us to better understand not only our past, present, and future but our place in the universe too.

LEARN MORE

Watch the Space Mission Analysis and Design Webinar Series.

ansys.com/webinars/space-mission-analysis-design-series

Disclaimer: NASA was not involved in the creation of this article and did not endorse the use of images in this article.

Driving Smart Manufacturing From Chip to System

Explore how simulation and semiconductors advance manufacturing from behind the scenes to the factory floor, transforming industries with intelligent workflows, equipment, and products.

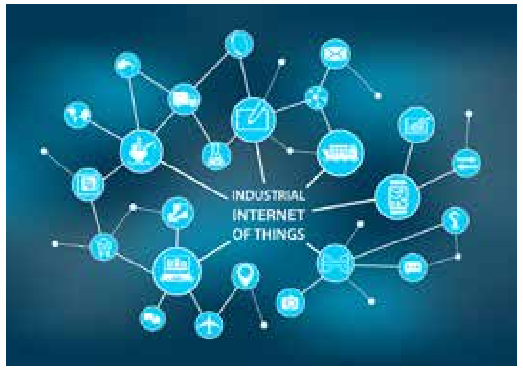
By **JENNIFER PROCARIO**, Media Relations, Staff, Ansys, part of Synopsys

What if manufacturing could operate faster, smarter, and with fewer disruptions? Imagine a world where factories adapt instantly to new demands, humans and robots collaborate effortlessly, and processes improve in real time.

This vision comes to life with semiconductors driving innovation through artificial intelligence (AI)-powered solutions; Industrial Internet of Things (IIoT) devices, such as sensors; and 5G connectivity.

Semiconductors transform how industries operate, serving as the invisible force behind automation, data-driven decisions, and real-time monitoring, all while supporting the human-centricity that defines Industry 5.0.

Combined with multiphysics simulation, these technologies enable more than smart manufacturing — they redefine what's possible and pave new paths for innovation. Multiphysics simulation provides a virtual environment for testing and optimizing industrial processes, delivering critical insights, analytical models, and predictive accuracy that support IIoT devices and related data. It integrates AI and machine learning (ML) algorithms to optimize this insight and support advanced technologies, including digital twins, additive manufacturing, and automation.



Let's explore how digital engineering solutions optimize smart manufacturing from chip- to system-level, unlocking new possibilities for products and workflows.

Traditional factories face challenges, including inaccuracies, delays, and unpredictable equipment problems. Smart manufacturing helps overcome these challenges by providing efficiency, speed, and foresight.

UNDERSTAND WHAT MAKES SMART MANUFACTURING SMART

Traditional factories face challenges, including inaccuracies, delays, and unpredictable equipment problems. Smart manufacturing helps overcome these challenges by providing efficiency, speed, and foresight. What is smart manufacturing? CESMII, The Smart Manufacturing Institute, describes it as a streamlined, collaborative approach to coordinating business, digital, and physical systems at factories, at plants, and across the value chain.

With advanced sensors and data-driven processes, factories and plants are no longer reactive — they are informed, connected, and proactive with the ability to continuously improve. Automation manages everyday tasks while decision-making models address unique problems quickly. By adopting smart manufacturing, traditional factories evolve into smart factories, equipped to meet today's evolving market demands.

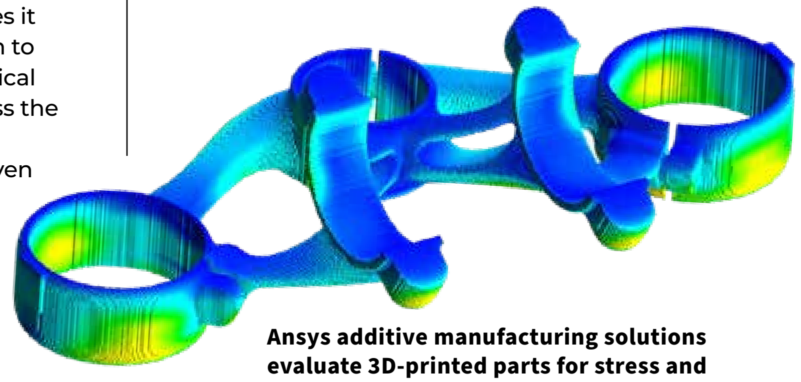
Smart factories rely on interconnected machines, networks, and modern technologies. Examples include AI/ML, IIoT sensors, and cloud computing. These tools gather information, transfer data quickly, and improve workflows, often in tandem with automation or robotics.

Although additive manufacturing is not typically categorized as an automation technology, 3D printing plays a key role in many smart manufacturing settings. It streamlines design and fabrication, reducing production time and enabling rapid prototyping. It also helps create complex parts while lowering costs.

According to Deloitte's 2025 Smart Manufacturing and Operations Survey, which included 600 respondents from large manufacturing companies, manufacturers are investing in technologies like sensors, automation, and AI to implement smart manufacturing processes. When asked about their top one or two goals for the next two years, 41% said they're planning to invest in factory automation hardware, 34% in active sensors, and 28% in vision systems.

DISCOVER THE FOUNDATION OF SMART MANUFACTURING

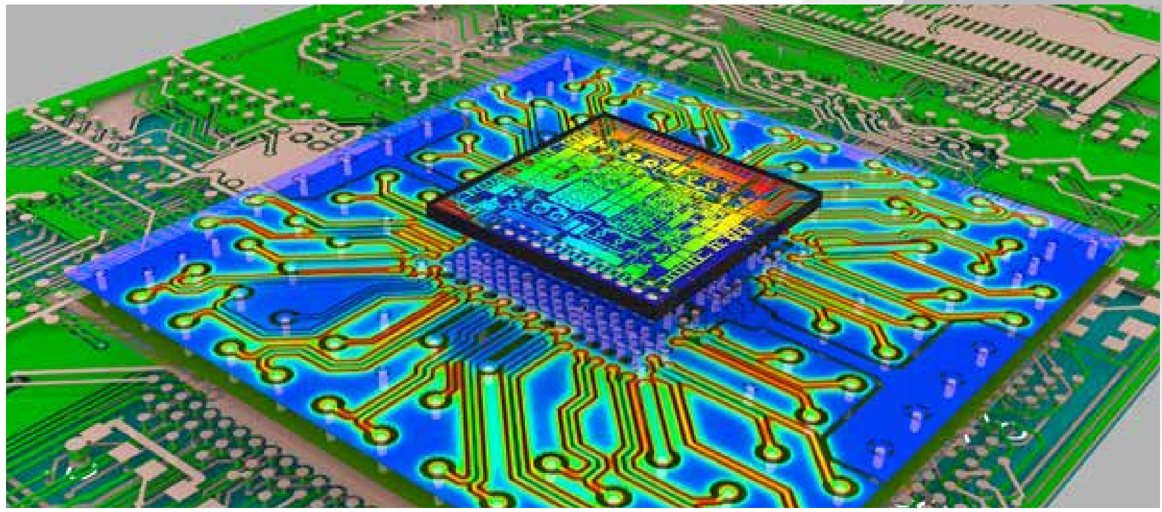
What drives the success of smart manufacturing? The proper foundation: smart infrastructure. Smart manufacturing uses hardware and software to maintain production lines with minimal interruption, reducing the likelihood of issues. For



Ansys additive manufacturing solutions evaluate 3D-printed parts for stress and flaws.

DID YOU KNOW?

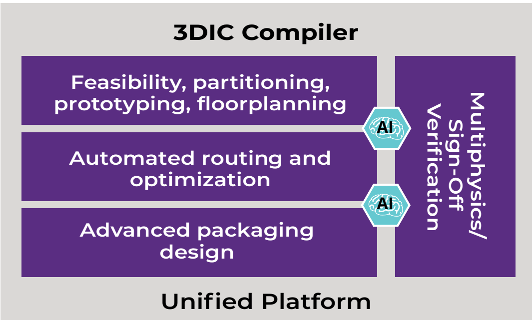
- Conductors allow electricity to flow while insulators resist it, but semiconductor materials can do both.
- Logic chips, such as central processing units (CPUs), are the "brains" of electronic devices. They use logical operations, such as "and," "or," and "not" to perform computations and control functions.
- An application-specific integrated circuit (ASIC) is customized for a specific use, while a field programmable gate array (FPGA) can be modified for different applications.
- A system on chip (SOC) combines components such as a CPU, memory, input/output, and more onto a chip.
- A 3D integrated circuit (3DIC) is manufactured by stacking and connecting multiple integrated circuits vertically.



Multiphysics simulation and electronic design automation (EDA) solutions support semiconductor design and manufacturing processes.

example, many smart manufacturing devices connect to an Internet of Things (IoT) network, with IIoT linking industrial physical assets to digital systems for data-driven decisions. By collecting data from embedded sensors in its infrastructure, the system optimizes to achieve desired results and uses predictive analytics to detect potential issues.

Simulation and digital twins support IoT sensors by providing a virtual environment for monitoring, analyzing, and testing physical assets and processes. However, IoT sensors



The Synopsys 3DIC Compiler platform supports co-design and optimization for 2.5D and 3D multi-die designs.

rely on semiconductors for data detection, processing, and sharing. Microcontrollers, a type of system-on-a-chip (SoC), and microprocessors, such as central processing units (CPUs) and graphics processing units (GPUs), use semiconductors to interpret sensor signals.

IoT sensors provide real-time data, which can be fed into a digital twin, an integrated virtual representation of a physical asset. This enables real-time monitoring, predictive maintenance, scenario testing through "what-if" analyses, and performance optimization, all without impacting the physical system.

AI/ML algorithms play an important role in smart manufacturing and infrastructure by identifying data patterns, optimizing processes, preventing defects, and predicting maintenance needs. They also help store and process IoT sensor data on cloud-based servers. Cloud systems support automation, analytics, and advanced communication technologies, such as 5G, which lower latency and increase bandwidth.

As reported by Deloitte, 57% of manufacturers at the facility or network level are using cloud computing, the same percentage are implementing data analytics, 46% are integrating IIoT solutions, and 42% are employing 5G connectivity.

FIND YOUR SOLUTION

Synopsys engineering solutions consider individual components and whole systems, from initial chip design to the factory floor. But before semiconductors can power smart manufacturing processes, they must be well designed and manufactured.

Electronic design automation (EDA) tools play a critical role in chip design, verification, and silicon life cycle management (SLM). For example, the Synopsys 3DIC Compiler platform supports 2.5D and 3D multi-die designs. Advanced chip design supports complex data processing, high-speed communication, and automation. This drives real-time analysis and customization, a fundamental aspect of Industry 5.0.

While Industry 4.0 focused on technology and automation, Industry 5.0 focuses on the human relationship with those technologies. The European Commission describes Industry 5.0 as more comprehensive than Industry 4.0, emphasizing pillars for sustainability, human-centricity, and resilience.

Semiconductors support each pillar, particularly human-centricity, by processing high volumes of sensor data that inform customized industrial equipment and processes. This includes smart control systems that adapt to specific needs and hardware for unique applications.

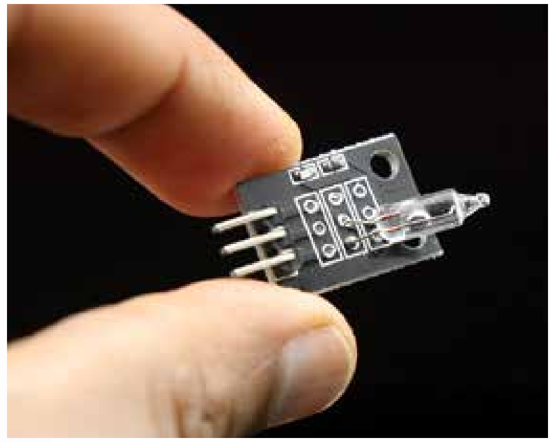
Multiphysics simulation supports design and manufacturing across industries, including the semiconductor industry. For example, the Ansys HFSS-IC chip-to-system electromagnetic simulation platform provides signal and power integrity analysis for heterogeneous integrated circuit (IC)-to-system designs, enabling early design insights and increasing accuracy for sign-off. This expedites the time to market for foundry-certified designs.

Similarly, engineers integrate simulation techniques, such as model-based systems engineering (MBSE) and model-based process engineering (MBPE), to enhance manufacturing processes, from stamping, casting, and forming to mixing, bottle filling, and packaging.

Krones AG, a leading manufacturer of packaging and bottling line systems, recently applied Synopsys solutions, including GPU-native Ansys Fluent fluid simulation software, to create a virtual assembly line, which reduces waste and cuts simulation cycles from three to four hours to less than five minutes. The application was supported by Synopsys, industry leaders, and strategic partners, including Ansys Apex Channel Partner CADFEM Germany GmbH.

Multiphysics simulation encompasses all areas of physics from mechanics and fluids to electromagnetics and materials science, refining manufacturing processes and decreasing dependence on physical prototypes. Outside of multiphysics, Ansys digital twin solutions integrate AI/ML to test manufacturing processes further while Ansys additive manufacturing solutions assess 3D-printed parts for stress and flaws.

Danfoss Drives, a subsidiary of energy-efficiency powerhouse Danfoss, integrates simulation solutions from Ansys, part of Synopsys, and Industry 5.0 technologies to optimize production of its signature alternating current (AC) drives. By using simulation solutions, including AI/ML, digital twins, and Python-based tools, the company democratizes simulation, reduces physical prototypes, cuts costs, and saves time while supporting sustainability.



Tilt switch sensor modules are commonly used in lifting, mining, and construction equipment to detect potential instability, tipping, or rollover and alert machine operators.

"Normally, we had four prototypes: a really early one, one that our engineers work on, one for production and preproduction, and then the final one," says Michael Laursen, head of virtual design, test, and optimization at Danfoss Drives. "With Ansys simulation and digital twin models, we have been able to take one of those physical prototypes out of the loop, and that saves us six to nine months in development time and a lot of money. Time is super important, but the cost of early prototypes is also significant."

From silicon to systems, Synopsys engineering solutions equip smart factories with advanced digital tools that enhance innovation, operations, and performance.

LEARN MORE

Download the e-book "Optimize Industrial Processes and Manufacturing With Digital Engineering."

ansys.com/resource-center/white-paper/digital-engineering-for-industrial

Navigate the Top Automotive Industry Challenges With SIMULATION

By LAURA CARTER, Media Relations, Senior Staff, Ansys, part of Synopsys

You can't get from point A to point B if you don't know where you're headed. In the automotive industry, that means navigating a development road map shaped by rapid advancements in electrification, autonomy, and connectivity, among others.

Given the current trends, what does success look like in this highly competitive environment?

For Chinese carmakers, it's a matter of timing. They're developing electric vehicles (EVs) in roughly 24 months from concept to launch. That's twice the speed of legacy automakers, where lead times reach upward of 40 to 50 months.

Meanwhile, global production continues to hover at some 93 million units. This is a saturation point for a market closely tied to profit per vehicle. There's little room for new players. To remain viable, everyone else must maintain, if not grow, their positions amid a continuously shifting market dynamic.

Of course, a geopolitical climate framed by tariffs and trade barriers; delayed technology rollouts, including the slow transition to EVs; and slower-than-planned transitions to software-defined vehicle (SDV) and autonomous driving (AD) technologies aren't helping.

In response to these pressures, automakers are forced to quickly pivot. They're scaling back EV production in favor of hybrids or reallocating production facilities to optimize costs. Such shifts, however, are neither simple nor inexpensive. In the end, they require extensive retooling and planning, making them both complicated and costly to execute.

BREAK THINGS DIGITALLY TO SCALE SOFTWARE DEVELOPMENT

SDV vehicle architecture substitutes the simplicity of a zonal architecture defined by the individual electronic control units (ECUs) of vehicle platforms past for one reliant on tightly integrated software stacks running across dozens of interconnected ECUs.

Software validation at this level of complexity typically depends on physical prototypes, such as bench setups and hardware-in-the-loop (HIL) rigs. The work is cumbersome. It's slow-going. And it's costly.

When you can break things in a digital environment, everything changes.

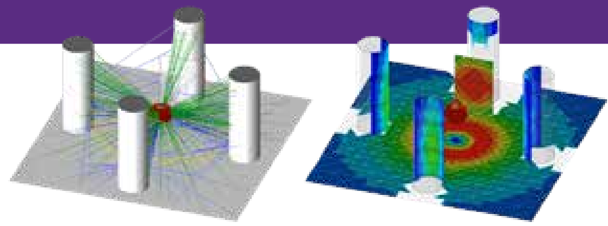
The use of virtual ECUs (vECUs) enables rapid, iterative software stack development and testing before hardware exists. A vECU can emulate the behavior of all ECU components, giving engineers the freedom and flexibility to execute the same code intended for the real ECU; debug high-level and low-level functions; validate integration earlier; and run massive test campaigns in parallel.

> ***"By employing simulation, it's possible to develop chips that specifically go into a vehicle and have some sort of AI aspect in terms of their utilization."***
>
> — **WADE SMITH**, Director of Application Engineering, Ansys, part of Synopsys

Of course, ECU virtualization alone isn't enough. To validate real-world behavior, virtual ECUs must be connected to accurate system, plant, sensor, and environment simulations.

"Simulation and vECUs together create a continuous, hardware-independent development loop, which is exactly what is needed to master the complexity of SDVs, zonal architectures, and autonomous driving software," says Pierre Vincent, director of application engineering at Ansys.

By coupling high-fidelity simulation platforms with virtual ECUs, engineering teams can recreate the complete operational context across a range of functions. These include dynamics, sensors, actuators, traffic, weather, and specific edge cases that are either dangerous or impossible to test in real life.

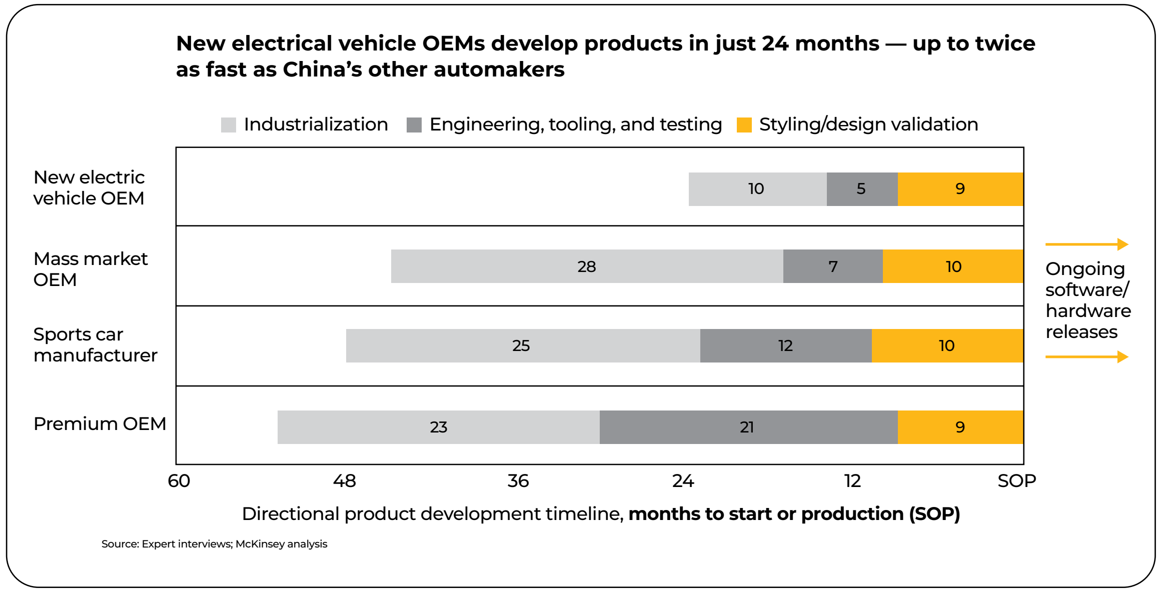


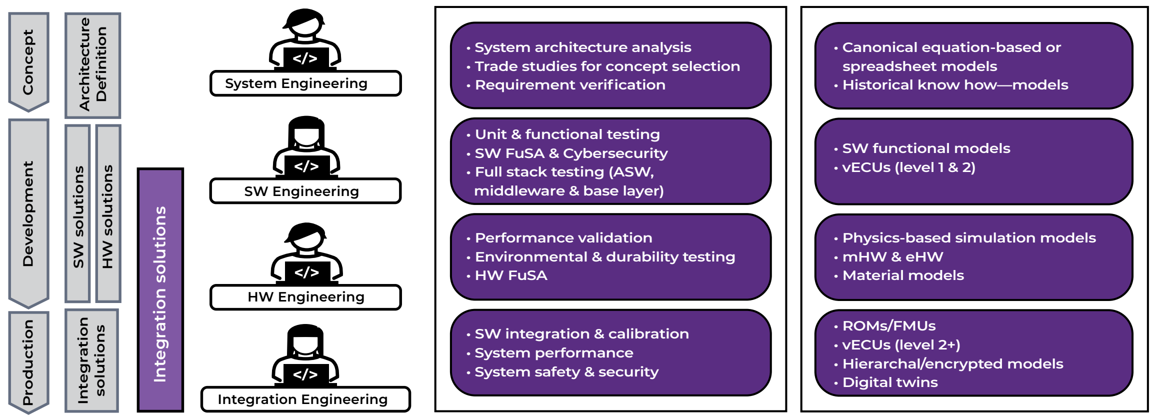
Ansys HFSS 2025 R2 can plot current density on the ray footprint when using SBR+ (shooting and bouncing rays with advanced diffraction).

"Physics-based simulation of hardware like actuators and sensors, in combination with AI, can take hardware virtualization to a whole new level," says Gopinath Penamalli, automotive technical account manager at Ansys. "Integrating them with vECU at multiple levels to virtualize the full system (both hardware and software) will lead to continuous validation through virtualization, a 'shift-left' strategy that is key to realizing SDV."

CONNECTING INCREASINGLY COMPLEX VEHICLES

A collection of intricate systems of interdependent electronics and software is becoming foundational to the vehicles we drive, managing everything from engine efficiency to driver assistance to infotainment





Modern vehicles require collaboration among many engineering disciplines.

and more. Their complex electronics are increasingly integrated with a growing number of radio frequency (RF) applications involving a wider band of radio signals, which presents significant engineering challenges.

All these systems must play well together in highly reliable environments.

"These digital features involve more processing, requiring the introduction of more complex digital elements," says Wade Smith, director of application engineering at Ansys, part of Synopsys. "They are always noisy, and engineers are integrating them with radio frequency elements like antennas, filters, and amplifiers that thrive in a quiet environment. So essentially, what you're doing is putting the toddler in a library."

If all this sounds complicated, well, it really is. Due to continued reductions in product turnaround times, engineers don't have the time to physically build, test, and repeatedly validate systems. The only way to get to the same level of confidence that these systems are going to work is to simulate them as much as possible, from many different angles.

For example:

- Simulation of physical systems can help determine the operation of chips placed and interconnected on printed circuit boards (PCBs) in hostile environments.
- Automotive OEMs can obtain 3D models of components from their vendors and add them into their large systems to compare and contrast how they operate.
- Antennas can be placed around a vehicle and tested virtually to quantify potential interference and shielding effectiveness.
- Multiphysics simulations can be used to test the reliability of components and systems operating in different thermal and mechanically stressed environments.
- A virtual model of a vehicle can be deployed into a virtual environment, using NVIDIA Omniverse libraries, for example, to test operation in real-world scenarios.

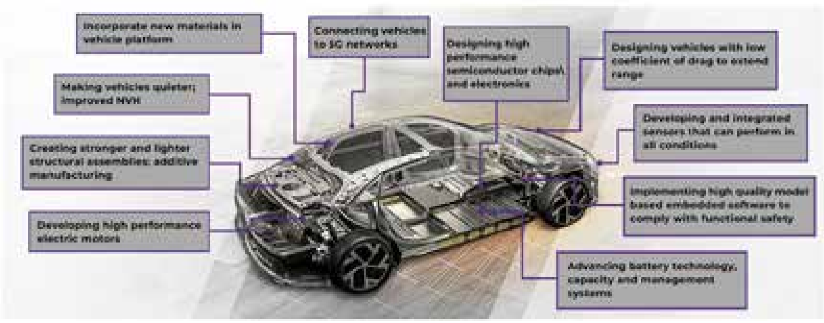
"By employing simulation, it's possible to develop chips that specifically go into a vehicle and have some sort of AI aspect in terms of their utilization," says Smith. "Analysis can begin at the chip level and can continue on to a virtual deployment of a car driving around a city being tracked by a 5G tower spraying automotive radar to detect people, vehicles, street signs — really anything else in the environment."

Of course, this work is particularly valuable in the leveling up of autonomous systems.

REPRIORITIZING AUTONOMY INVESTMENTS

Full autonomy remains a long-term goal for mass market passenger car manufacturers.

In the near term, automakers are focused on developing advanced driver-assistance system (ADAS) features that cater to consumer expectations for safety and convenience. These offer a practical bridge to achieving full autonomy, without the prohibitive costs and complexities inherent in the development of fully self-driving systems.



Automotive engineers face challenges to meet consumer demands.

As ADAS continues to evolve, automakers are investing in perception and localization technologies to enhance vehicle safety and automation.

Localization, or the process of pinpointing a vehicle's position relative to its surroundings, depends, in part, on sensor technologies crucial to collecting data related to the movement and orientation of a vehicle in its environment. Anything that interferes with these activities on the road can lead to failure.

Among the regulations responsible for automotive safety, one of the more complex is FM VSS 127, which tends to put significant constraints on carmakers. They must pivot to a multimodality strategy to satisfy regulatory requirements. Ultimately, it all comes down to robustness and safety.

"Engineers are selecting the sensor suite necessary to ensure they detect, for example, an animal during nighttime conditions crossing the road," says Emmanuel Follin, senior manager product management at Ansys, part of Synopsys. "And this level of detection is too complex to be done without accurate cameras plus lidar or thermal cameras. It's really all of those regulations that are pushing innovators in the direction of multimodality instead of only selecting one sensor to do everything."

ACCELERATING AUTONOMOUS DEVELOPMENT

It's practically impossible to physically drive and record all the data needed to validate autonomous functions because it involves literally thousands of use cases. Instead, OEMs can turn to synthetic data generation.

By integrating Omniverse libraries with Ansys AVxcelerate Sensors autonomous vehicle sensor simulation software applications, engineers can build immersive, physically accurate models in the Ansys software interface, supporting real-time collaboration and improving communication of results. Moreover, PyAnsys, a family of Python packages that enable users to interact with Ansys products, automatically formats simulation data so simulation practitioners and developers can easily customize and automate simulations inside applications built with Omniverse libraries and OpenUSD.

NVIDIA Cosmos, a platform of world foundation models purpose-built for physical AI, is a key enabler for scaling synthetic data generation. The combination of these models and frameworks with Omniverse libraries helps developers to scale data generation, bring more diversity to their datasets, and accelerate the training of the AI-based algorithms that power self-driving vehicles.

"What is meant by data augmentation in this instance?" says Follin. "Let's say you go on an AI program and ask it to take an image and make yourself beautiful or to make the Sun shine on you. In a sense, you are doing the same thing with multiphysics simulation and an enriched dataset of images — video scenarios you can use to more accurately validate sensor perception and ADAS function. It's essentially another level of simulations that add more variety and more diversity during training."

SIMULATION EMPOWERS CARMAKERS TO OVERCOME INDUSTRY CHALLENGES

Growing vehicle complexity, fueled by advanced technologies, regulations, and competition, continues to exert downward pressure on engineering executives. Success in this market means that automakers must identify solutions that lead to faster decision-making and innovation through enhanced collaboration. Yet the integration and flow of decisions across teams remain a challenge, exposing significant operational risks.

For decades, simulation has been used to virtually test components and systems, reducing the need for costly physical prototypes. It's a reliable way to validate software and hardware interactions early in the development process, reducing the risk of issues during production that can lead to launch delays. Simulation also enables automakers to streamline workflows and optimize designs efficiently and precisely to maximize profitability.

Now, many automotive regulatory bodies are permitting more virtual testing as a means of substantiation. Of course, virtual testing won't completely replace time behind the wheel. However, simulation can reduce the need for extensive physical testing, reduce time to market, and reduce the cost of discovering issues during physical testing.

"Historically, virtual testing of autonomous functionality was limited to OEM internal processes to reduce development costs," says Follin. "Now, even regulatory bodies are encouraging it because the size of the regulation is so much larger. This is good news, given the current economic constraints of the automotive market, as some simulation engineering teams are tasked with reducing the cost of validation by a factor of three, without compromising on safety."

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Explore automotive simulation solutions.

ansys.com/industries/transportation-and-mobility

What's NExT?

A New Generation of Modular Public Transport

By **LAURA CARTER**, Media Relations, Senior Staff, Ansys, part of Synopsys; and
SUSAN COLEMAN, Project/Program Management, Executive Director, Ansys, part of Synopsys

NExT is poised to change the future of public transportation with its innovative modular electric vehicle designs, with help from the Ansys Startup Program.

> ***"Being able to simulate stress and deformation of components before manufacturing them saves a significant amount of time compared with verifying it in the real world with physical testing."***
> — **EDOARDO FANTIN**, Chief Engineer, NExT

While media attention, environmental mandates, and government policy debates focus largely on privately owned cars and trucks, public transportation holds even bigger promise to drive increased sustainability. Around the world, 3.78 billion people rely on public transport every day, supporting a growing industry with annual revenues of $233 billion, according to Fortune Business Insights.

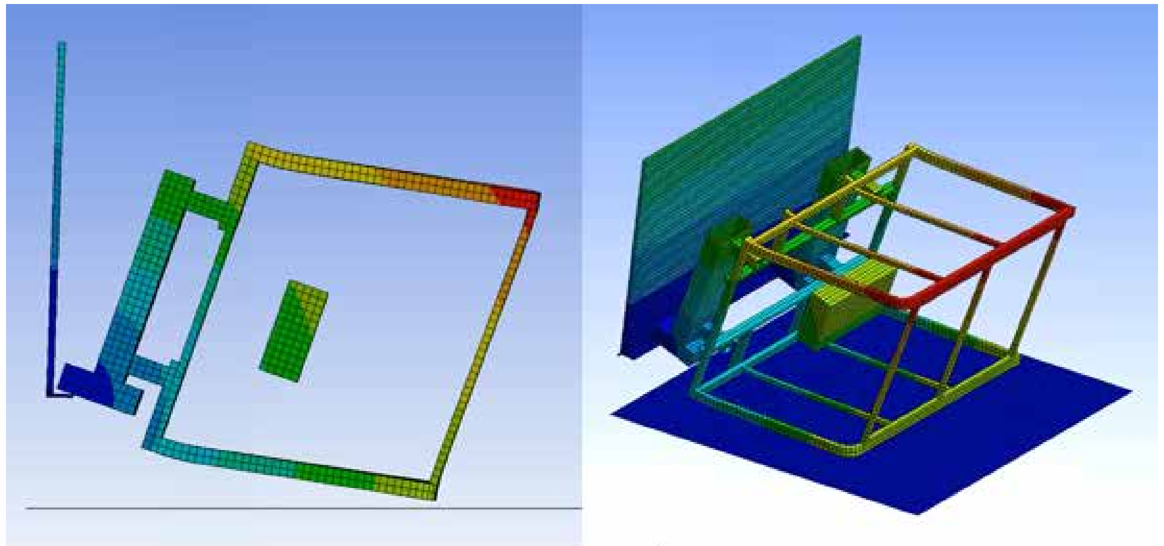
Electric buses are the fastest-growing transportation category, projected to grow from 279,236 vehicles in 2024 to over 1 million units by 2032. It's no surprise, really, as the benefits of bus electrification are undeniable. In China alone, it's been estimated that electric buses eliminate 440,000 tons of CO_2 annually.

But Tommaso Gecchelin — founder and chief technology officer at NExT, an Italian startup company — believes that the global transportation industry can do even better.

"We often see buses running totally empty," says Gecchelin. "It's a normal scenario in every big city because public transportation vehicles are sized based on the maximum capacity. They're unable to adapt to varying demand throughout the day."

Gecchelin founded NExT in 2017 to address this problem. The company's fleet of modular electric vehicles, or pods, are built to dynamically adapt transportation capacity based on demand. During peak commuting periods, up to five pods can be joined together using a robotic system. The result? A single, structurally sound vehicle with no articulation (up to 3 pods), which matches the capacity of a large urban bus. During less busy periods, transit authorities can convert them to smaller, lower-capacity configurations of one or two pods.

Because NExT's zero-emission vehicles



Vehicle rollover crash test simulation conducted according to the ECE-R66 standard

Modular vehicles from NExT can reach speeds of 60 miles per hour and have a charging range of 200 miles or more. NExT estimates that the vehicles reduce energy consumption by 50%-60% compared with traditional electric buses.

Nine prototype vehicles have been successfully road-tested in Padua and Dubai. NExT began mass production last year, supported by simulations that optimized manufacturability.

NExT's modular vehicles can be flexibly configured to meet changing transportation demand. Transit authorities can employ a single pod during low-demand periods or join up to five pods to match the capacity of a traditional 18m bus.

can adapt flexibly to demand, the company estimates that they have the potential to reduce electricity consumption by 50%-60% in public transit applications. This is due to lower propulsion needs and reduced heating and cooling requirements in their interior spaces during off-peak hours. And, because public transit operators can charge unused pods on a scheduled basis, cities can strategically distribute energy usage and reduce the strain on electricity grids.

With 50% less wear-and-tear than rigid capacity buses, NExT's modular pods could potentially reduce maintenance needs and extend product life for lower long-term waste. Their smaller profile bus could also reduce traffic congestion by up to 80%.

NExT's modular vehicles can be flexibly configured to meet changing transportation demand. Transit authorities can employ a single pod during low-demand periods or join up to five pods to match the capacity of a traditional 18m bus.

CHARGING UP INNOVATION WITH THE ANSYS STARTUP PROGRAM

It all adds up to a winning proposition — but also significant engineering challenges. Optimizing vehicle performance is the job of an eight-person development team at NExT that includes Edoardo Fantin, chief engineer of NExT. Through the Ansys Startup Program, and with support from Braitec Srl, Fantin uses advanced simulation solutions to optimize NExT product solutions for safety, aerodynamics, stress, and other key performance characteristics.

Created to fuel innovation in small companies with limited funding, the Ansys Startup Program has provided more than 2,700 startups with advanced Ansys software, high-performance computing (HPC) resources, technical support, and access to learning resources.

According to Fantin, the ability to leverage the power of simulation has been critical in advancing the design of NExT's modular vehicle concept. "The engineering challenge is significant, as our vehicles are an absolute novelty in terms of form, motion docking capabilities, vehicle dynamics, and fleet management systems," says Fantin. "We basically started from the ground up to answer the question, 'How can we take electric public transport to a new level of efficiency?'"

In refining and improving the design concept, Fantin has studied a wide range of performance dimensions using Ansys software. "I often use Ansys Mechanical structural finite element analysis software to perform FEM analyses on critical vehicle components such as the cabin structure, the vehicle frame, and the coupling system," he notes. "The latter, in particular, is a highly stressed component due to the masses of the vehicles involved, and we need to verify how those stresses are transmitted to the vehicle frames.

"Being able to simulate stress and deformation of components before manufacturing them saves a significant amount of time compared with verifying it in the real world with physical testing," Fantin adds. "We've been able to improve vehicle performance while also eliminating weight and driving substantial production cost savings. That's extremely important for a startup."

Fantin has also performed dynamic simulations, such as cabin rollover, with Ansys LS-DYNA nonlinear dynamics structural simulation software. Additionally, he's applied Ansys Fluent fluid simulation software to optimize the vehicle's aerodynamic drag coefficient, a key factor in estimating and reducing energy consumption.

"I first used Ansys software during my engineering studies at the University of Padua," says Fantin. "The software is considered the industry standard, and the simulations accurately represent real-world behavior. I feel fortunate to be able to access Ansys solutions and other resources through the Ansys Startup Program."

THE FUTURE OF TRANSPORT: COMING TO A CITY NEAR YOU

Last year, NExT began mass production of its modular pods. It intended to roll out 30 vehicles in 2025, followed by another 100 in 2026. The company is undertaking a multistage development and testing plan with Dubai's Road and Transport Authority to support Dubai's ambitious goal of becoming the most sustainable city on the planet by 2050. Nine prototype vehicles have already been tested in Dubai and Padua, where the company headquarters is.

"The steps we're taking right now are among the most important in the company's history," says Fantin. "We're beginning mass production of the NExT vehicle, thanks in large part to strategic partners like Ansys who believed in our vision and supported us. They're an important driver of our success."

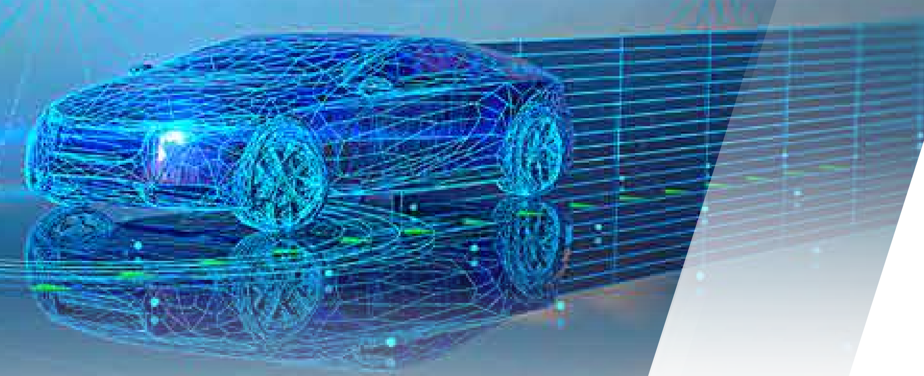
LEARN MORE

Explore the benefits of the Ansys Startup Program.

ansys.com/startup-program

Issue 1 / 2026

Synopsys Prediction: New Cars Will Contain 600 Million Lines of Code by 2027



By **TOM DE SCHUTTER**, Senior Vice President, Product Management, Synopsys; and **MARC SERUGHETTI**, Vice President of Product Line Management, Synopsys

The 1977 Oldsmobile Toronado was ahead of its time.

Featuring an electronic spark timing system that improved fuel economy, it was the first vehicle equipped with a microprocessor and embedded software. But it certainly wasn't the last.

While the Toronado had a single electronic control unit (ECU) and thousands of lines of code (LOC), modern vehicles have many ECUs and 300 million LOC. What's more, the pace and scale of innovation continue to accelerate at an exponential, almost unfathomable rate.

It took half a century for cars to reach 300 million LOC.

We predict that the amount of software in vehicles will double in the next 12 months alone, reaching 600 million LOC or more by 2027.

THE FUSION OF AUTOMOTIVE HARDWARE AND SOFTWARE

Automotive design has historically been focused on structural and mechanical platforms — the chassis and engine. Discrete electronic and software components were introduced over time, first to replace existing functions (like manual window cranks) and later to add new features (like GPS navigation).

For decades, these electronics and the software that define them were designed and developed separately from the core vehicle architecture — stand-alone components added in the latter stages of manufacturing and assembly.

This approach is no longer viable.

Not with the increasing complexity and interdependence of automotive electronics. Not with the criticality of those electronics for vehicle operation, as well as driver and passenger safety. And not with a growing set of software-defined platforms — from advanced driver assistance (ADAS) and surround-view camera systems to self-driving capabilities and even onboard agentic AI — poised to double the amount of LOC in vehicles over the next year.

From the chassis down to the code, tomorrow's vehicles must be designed, developed, and tested as a single, tightly integrated, highly sophisticated system.

SHIFTING AUTOMOTIVE BUSINESS MODELS

The rapid expansion of vehicular software isn't just a technology trend — it's rewriting the economics of the automotive industry. For more than a century, automakers competed on horsepower, handling, and mechanical innovation. Now, the battleground is shifting to software features, connectivity, and continuous improvement.

Instead of selling a static product, OEMs are adopting new, more dynamic business models where vehicles evolve long after they leave the showroom. Over-the-air updates can deliver new capabilities, performance enhancements, and safety improvements without a single trip to the dealer. And features that used to be locked behind trim levels can be offered as on-demand upgrades or subscription services.

This transition is already underway.

Some automakers are experimenting with monthly fees for heated seats or performance boosts. Others are building proprietary operating systems to replace third-party platforms, giving them control over the user experience — as well as the revenue stream. By the end of the decade, software subscriptions will become as common as extended warranties, generating billions in recurring revenue and fundamentally changing how consumers think about car ownership.

THE ENGINEERING CHALLENGE BEHIND OEM TRANSFORMATION

Delivering on the promise of software-defined vehicles (SDVs) that continuously evolve isn't as simple as adding more code. It requires a fundamental rethinking of how cars are designed, engineered, and validated.

The 1977 Oldsmobile Toronado was the first car with a microprocessor. *(Source: GM Heritage Archive.)*

Hundreds of millions of LOC must push data seamlessly across a variety of electronic components and systems. And those systems — responsible for sensing, safety, communication, and other functions — must work in concert with millisecond precision.

For years, vehicle architectures relied on dozens of discrete ECUs, each dedicated to a specific function. But as software complexity grows, automakers are shifting toward fewer, more powerful centralized compute platforms that can handle much larger workloads. This means that more code is running on less hardware, with more functionality consolidated onto a handful of high-performance processors. As a result, the development challenge is shifting from traditional ECU integration — where each supplier delivered a boxed solution — to true software integration across a unified compute platform.

As such, hardware and software development practices can no longer be separate tracks that converge late in the process. They must be designed together and tailored for one another — well before any physical platform exists.

This is where electronics digital twins (eDTs) are becoming indispensable. By creating functionally accurate virtual models of vehicle electronics and systems, design teams can shift from late-stage integration to a model where software and hardware are co-developed from day one.

eDTs and virtual prototypes do more than enable earlier software development at the component level — they allow engineers to simulate, validate, and optimize the entire vehicle electronics. This means that teams can see how data flows across subsystems, how critical components interact under real-world scenarios, and how emerging features might impact overall safety and performance. With eDTs, automakers can test billions — even trillions — of operating conditions and edge cases, many of which would be too costly, too time-consuming, or otherwise infeasible with physical prototypes.

By embracing eDTs, the industry is not just keeping pace with escalating complexity — it is reengineering long-standing engineering processes, accelerating innovation, and improving the quality and safety of tomorrow's vehicles.

THE ROAD AHEAD

Our prediction of cars containing 600 million LOC by 2027 isn't just a number. It signals a turning point for an industry that has operated in largely the same manner for more than a century.

Many automakers are reimagining their identity. No longer just manufacturers, they're becoming technology companies with business models that resemble those of cloud providers and app developers. They're adopting agile, iterative practices, where updates roll out continuously rather than in multiyear product refreshes. And they're learning how to design, develop, test, and evolve their products as a unified system — from chassis and engine to silicon and software — rather than a collection of pieces that are assembled on a production line.

Unlike the 1977 Oldsmobile Toronado, the car you buy in 2027 won't be the same car you drive in 2030 — and that's by design.

LEARN MORE

Download "Navigating Software-Defined Vehicle Development," a Synopsys e-book.

synopsys.com/resources/navigating-software-defined-vehicle-development.html

Automotive Model-Based Systems Engineering as a Single Source of Truth in Automotive Development

By **LAURA CARTER**, Media Relations, Senior Staff, Ansys, part of Synopsys

As we move through 2026, the dynamics affecting the state of the automotive industry are not only continuing but accelerating. Automakers are leaning on hybridization as a bridge to sustainable mobility while electric vehicle (EV) growth stabilizes amid persistent infrastructure and affordability challenges. At the same time, increased demands for software-defined vehicles (SDVs) and advanced driver-assistance systems (ADAS) are colliding with the rapid rise of artificial intelligence (AI), further reshaping how vehicles are designed, developed, and experienced.

Remaining competitive in 2026 and beyond will depend on how effectively manufacturers and suppliers embrace AI and digital engineering to manage growing complexity and tightened development cycles to deliver vehicles that are smarter, safer, and more efficient.

So, how will they contextualize this success? The answer lies in identifying solutions that lead to faster decision-making and innovation through enhanced collaboration. Yet for many original equipment manufacturers (OEMs) and suppliers, the integration and flow of decisions across teams remains a challenge, exposing significant operational risks.

In this environment, model-based systems engineering (MBSE) emerges as a critical methodology in managing high levels of automotive complexity. It enables engineers to work collaboratively to navigate requirements and confidently validate next-generation vehicle designs early, with greater efficiency.

"If you have good automotive system engineers, in the past they would sit around a table. Maybe it's a virtual table," says Scott Ragon, principal product manager at Ansys, part of Synopsys. "They could exchange documents and do a good job of design. But as the complexity level of vehicle design goes up and as the number of people involved in the process increases, that strategy doesn't work anymore. The traditional way of doing systems engineering breaks down. MBSE is a more structured, organized alternative to doing systems engineering that delivers exponentially better results."

> ***"MBSE is a more structured, organized alternative to doing systems engineering that delivers exponentially better results."***
>
> — **SCOTT RAGON**,
> Principal Product Manager, Ansys, part of Synopsys

Despite the potential benefits of MBSE, however, adoption across much of the automotive industry requires a significant cultural shift. A model-driven approach must be embraced, and traditional workflows need to conform to current challenges. MBSE often calls for integration across supply chains using proprietary tools and methods, which can create a seemingly formidable transition for many. But it doesn't have to be that way.

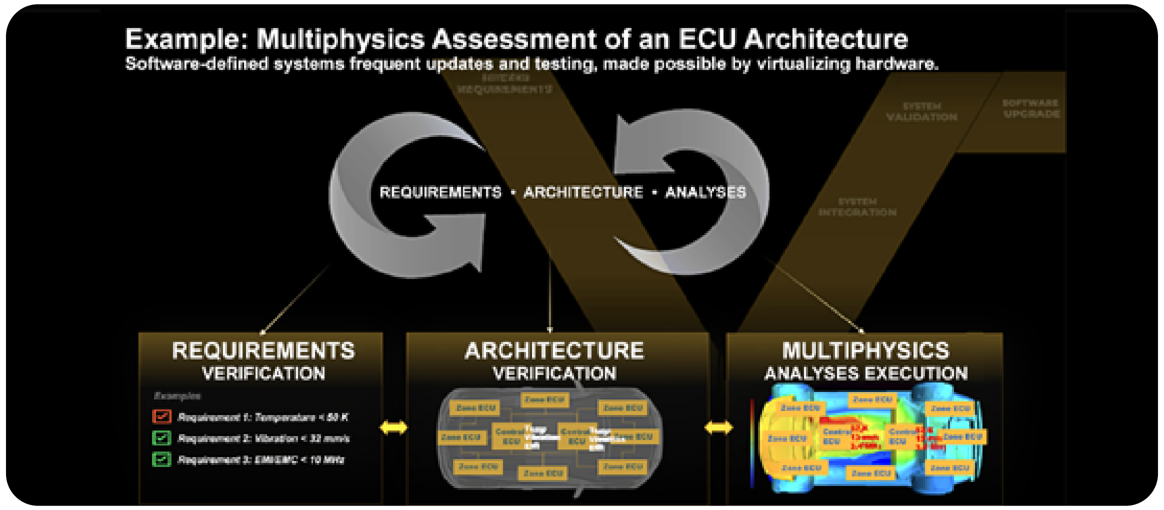
THE ROLE OF MBSE IN AUTOMOTIVE

MBSE is a methodology that focuses on using digital systems and engineering domain models as the primary means of exchanging information, feedback, and requirements, as opposed to document-centric systems engineering. It involves capturing, communicating, coordinating, and maintaining digital models of a given system throughout its life cycle.

MBSE can play a pivotal role in automotive innovation. It offers a structured, model-driven approach that can successfully manage the complexity of the interconnected systems and advanced software defining today's vehicle systems. MBSE also addresses the gaps often associated with traditional automotive engineering by centralizing the system design process to ensure traceability from requirements to implementation.

If MBSE were a superpower, it would give automotive engineers the ability to create a source of truth embodied in one shared system architecture model. Universal access to a single-source model ensures that every stakeholder has access to consistent, updated, accurate information regardless of the vehicle component, subsystem, or systems being worked on. It also reduces the risk of inconsistencies and redundancies across teams that result from a more siloed engineering approach.

Simulation plays a pivotal role in automotive MBSE as it helps engineers ensure that they are meeting key requirements, facilitates understanding among all stakeholders regarding product behavior, and helps them address complex problems. In the context of EVs and SDVs, MBSE connects design requirements to the appropriate simulation workflows to speed up verification and validation.

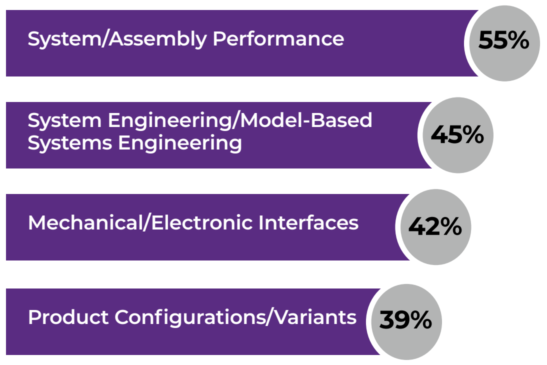


For instance, during EV powertrain development, MBSE helps engineers analyze trade-offs among battery size, motor specifications, and component weight to optimize for range, cost, and performance while satisfying all requirements.

"All design decisions in electric powertrain come down to performance relative to cost," says Tushar Sambharam, senior principal application engineer at Ansys. "When you're facing design decisions in EV development, you're making a choice, and that choice always has implications. What cell electrochemistry, battery cooling system, or motor specifications should I choose? And how will these choices impact other choices and my objectives for performance — like vehicle range — and cost? These types of understandings can easily be developed through an MBSE workflow."

Simulation Is at the Center of Digital Engineering

Over the next 12-24 months, how will product development leverage computer-aided engineering/simulation technologies?



SOURCE: IDC InfoBrief, sponsored by Ansys, part of Synopsys, Transform Product Innovation with Multiphysics Simulation for Digital Engineering, #US53846425, October 2025

MBSE AND THE FUTURE OF SDVS

During SDV development, MBSE facilitates the defining and refining of electrical and electronic (E/E) architectures in consideration of dynamic software updates and advanced vehicle functionalities. Front-loading much of an SDV's functionality onto a software-driven framework poses its own set of challenges during development. It's a task compounded by dynamic updates that will be pushed out to many different systems over the life of the vehicle.

MBSE provides a foundational framework necessary to design, validate, and maintain the complex E/E architectures supporting SDVs. Its value is in sorting through platforms encompassing numerous components, including electronic control units, sensors, actuators, and wiring supporting ADAS, infotainment, autonomous, and electrified systems.

Leveraging MBSE to define zonal E/E architectures, for instance, helps streamline electronic control unit (ECU) placement by grouping functions within specific zones of the vehicle and connecting them to a central high-performance computer (HPC). It enables engineers to map these zones, define the flow of data, and validate vehicle architecture against automotive manufacturing requirements for safety, cost, and performance.

MBSE offers an iterative approach to continuous integration/continuous deployment (CI/CD) workflows and practices, automating and enhancing the software development life cycle with a focus on system quality and reliability. Taking this approach can positively impact any number of things, from integrating code changes to releasing software.

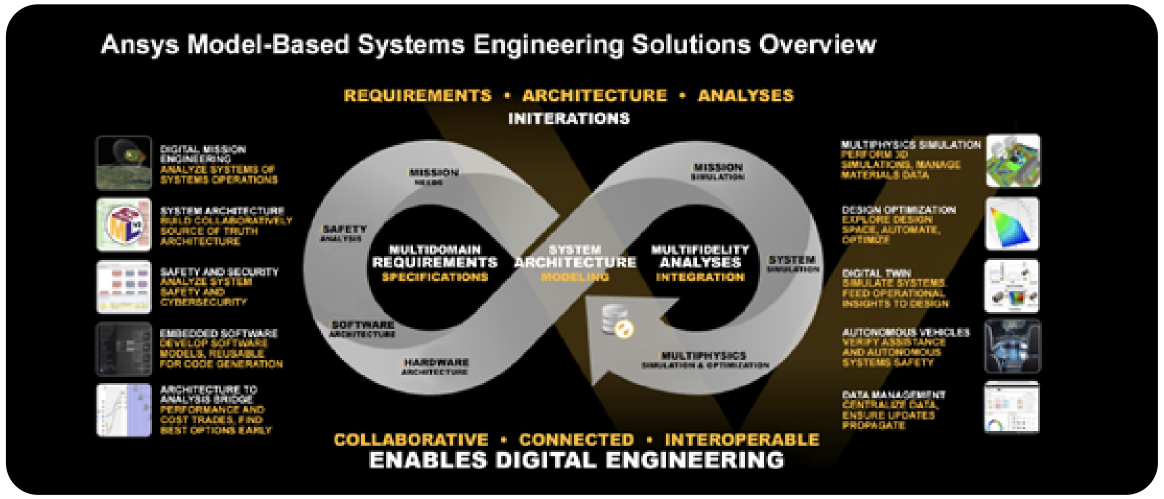
"When engineers are changing software dynamically, further verification and validation follow," says Sambharam. "Directly or not, you still cannot breach the thresholds of the constraints around the workings of a vehicle. For example, let's say I updated the software and my battery is overheating. That's not the kind of issue you can expect in a vehicle — that's a safety-critical issue. What CI/CD says is, every time you develop something, you validate it through an MBSE approach to make sure it's working fine before moving into deployment."

Specifically, the continuous integration of software updates into an MBSE framework enables engineers to validate changes against system requirements while ensuring compatibility with existing vehicle hardware — without compromising safety or performance. This includes the continuous deployment of changes automatically to production after successful testing.

DELIVERING ESSENTIAL MBSE TECHNOLOGY STACKS

What makes MBSE so valuable for OEMs and tier suppliers is its usefulness in delivering on historically crucial priorities related to cost, time to market, and late-stage defects. MBSE provides a structured approach to testing and requirement verification that empowers engineers to identify and resolve design issues early in the development cycle, preventing costly rework and recalls later in production.

To this end, many tools support primary MBSE objectives in automotive engineering during vehicle development:



- A cloud-native SysML v2 platform, the Ansys System Architecture Modeler (SAM) capability provides a foundation for building and managing complex system architectures in a virtual environment. Acting as a central collaborative repository for system design, it ensures traceability and helps teams to define relationships among components.
- Ansys ModelCenter MBSE software connects system architecture models to simulation environments, enabling model-based requirement verification. It empowers engineers to create and automate multitool workflows and optimize product designs.
- Ansys medini analyze system-oriented safety analysis software supports functional safety analysis and compliance with safety standards like ISO 26262, ensuring that safety-critical requirements are identified and verified early in the design process.
- The Ansys Scade One model-based embedded software development solution facilitates the development of embedded software via certified code generation that seamlessly integrates with the overall system architecture. This tool plays a critical role in creating control software for EVs and SDVs.
- The Synopsys TPT test tool for embedded software and systems is focused on automotive platforms. It turns complexity into clarity with powerful API automation, full coverage for virtual ECUs, and intelligent status tracking.

Our open ecosystem bridges the gaps between the tools used to design these systems. It provides a structured, efficient, and integrated way of partnering with teams, suppliers, and customers to deliver differentiated vehicle technology.

Specifically, the SAM capability can be leveraged to catch design flaws early in a design cycle. The tool's real-time collaboration features promote interaction among all engineers involved in the design process, enabling OEMs and suppliers to seamlessly share models and collaborate simultaneously on system designs. This is an important advantage, as a single vehicle incorporates components from multiple suppliers.

"With the advent of SysML V2, it will be possible for our customers to share models between different vendors' tools," says Ragon. "So, you will be able to create a model in the Ansys tool, and if you know someone down the supply chain is using a competitive tool, you can give them your model and they can import it into their tool. SysML v2 therefore promises to fundamentally alter the proprietary and vendor-locked nature of SysML v1."

FUTURE ASPIRATIONS FOR MBSE IN THE AUTOMOTIVE INDUSTRY

MBSE is poised to transform how vehicles are designed, developed, and maintained. It can help engineers manage complexity and achieve early validation through innovative workflows to better address EV and SDV development challenges. Ansys offers aspirational software frameworks in a collection of tools and solvers that can facilitate MBSE across the automotive industry.

LEARN MORE

Download the "Navigating Vehicle Engineering in a Software-Defined World" e-book.

ansys.com/resource-center/white-paper/vehicle-engineering-in-software-defined-world

Meeting the Energy Demands of AI Data Centers

By **ALIYAH KONARKOWSKI,** Media Relations, Staff, Ansys, part of Synopsys

The drive to construct data centers capable of meeting the needs of a world eager to build on the possibilities enabled by artificial intelligence (AI) has created a power demand that is unprecedented. In 2018, United States data centers consumed 76 TWh of power — 1.9% of total U.S. energy consumption. Yet by 2028, U.S. data centers are projected to need between 325 and 580 TWh of power — accounting for some 12% of total U.S. energy consumption.

Those numbers represent huge challenges for every aspect of an AI data center, from the chips and printed circuit boards (PCBs) to the cooling systems in the facility. In short, the question of how to meet the energy demands of an AI data center is not limited to the server farm itself. It is a challenge that touches every system in the center. Thus, meeting that challenge effectively requires a holistic approach, one that looks at all aspects of the data center, not just the glamorous elements in the server room where the AI appears to reside. Ansys, part of Synopsys, provides the tools needed to address the energy demands of data centers from the chip to the facility level.

SIMULATING SERVER ROOMS

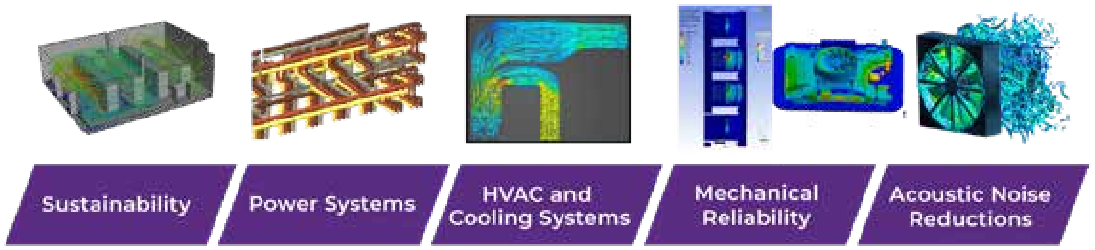
Data centers, regardless of their purpose, are large facilities comprising multiple server rooms filled with racks that hold individual servers. For the most part, they all look the same regardless of who built them. However, before the first rack is installed, engineers must consider several key aspects to ensure the server room operates as efficiently as possible, starting with power.

Data centers must obtain their power from somewhere, and with water usage, grid limitations, and thermal dissipation already being areas of concern for the public, many companies are considering sustainable energy alternatives, such as wind, solar, and nuclear. Engineers can use simulation solutions such as Ansys Fluent fluid simulation software, Ansys Granta MI materials data management software, and Ansys Discovery 3D simulation software to assess the environmental footprint of their chosen power source early in the design phase. Such an assessment enables engineers to understand which areas, components,

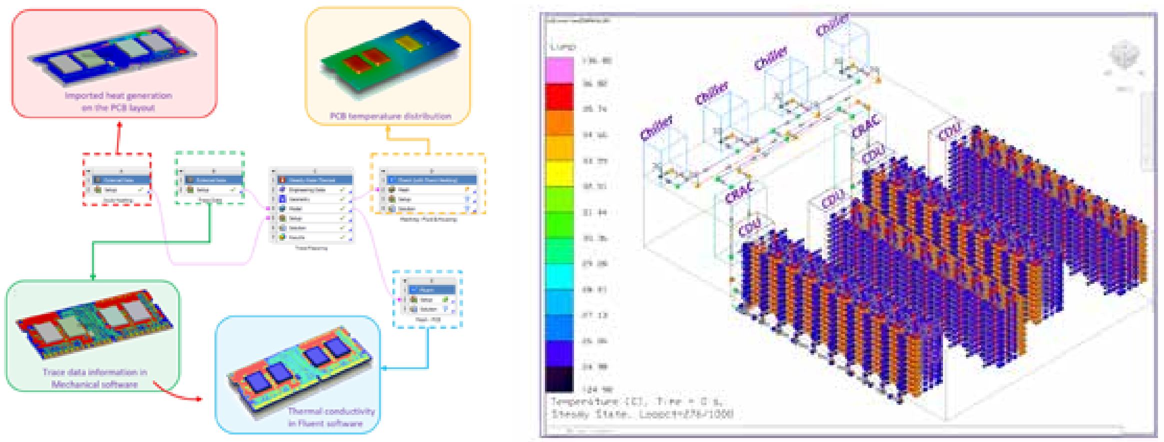
ABI Research estimates that there were 6,111 public data centers worldwide in 2025 and predicts there will be 8,378 data centers in operation by 2030.

materials, processes, and other factors have the largest impact on the data center's environmental footprint.

Engineering teams must then ensure there is sufficient, clean, and reliable power for the facility to operate efficiently. Determining the power demands of a data center isn't straightforward because server power requirements fluctuate with workload and server configurations.



Engineering considerations for a server room



Left: different thermal management simulations at the chip level. Right: a thermal management simulation of a liquid- and air-cooled server room.

Simulation solutions such as the Ansys Maxwell advanced electromagnetic field solver and Ansys Q3D Extractor parasitic extraction electromagnetic simulation software can help evaluate the power demands and optimize for load balance and power quality.

However, one of the greatest areas of concern for server rooms is the cooling system. If you've ever sat next to a computer, you know how hot they can get. Now multiply that by tenfold. Maintaining the optimal server room temperature and humidity range is crucial for ensuring performance and hardware longevity. Overheating can lead to downtime, while unstable humidity levels can cause corrosion or static discharge. Engineers can use simulation solutions, such as Fluent software, Ansys Icepak electronics cooling simulation software, and Ansys Thermal Desktop thermal-centric modeling software, to modify layout and equipment specifications for optimal thermal management, avoiding costly trial-and-error procedures and unnecessary investments in additional cooling. Simulation solutions can also address acoustic and noise outputs created by data centers so they create little disturbance to the communities they reside in.

UNLIMITED COSMIC POWER, ITTY BITTY LIVING SPACE

If the server rack is the bones of a data center, then the chip is the brain. Today's chips increasingly integrate specialized processing elements and memory in sophisticated multi-die packages. Designing these systems requires understanding complex interactions across electrical, thermal, and mechanical domains that can only be predicted through comprehensive multiphysics simulation. Power delivery networks and thermal management systems must be analyzed holistically, as electrical performance affects thermal profiles while heat dissipation impacts electrical performance in a continuous feedback loop. This interdependency is particularly critical for the neural processing units (NPUs) used in AI workloads, which can experience dramatic power fluctuations during different computational phases.

Similarly, high-bandwidth, low-power interfaces between dies demand detailed electromagnetic analyses to ensure signal integrity while operating within increasingly tight power constraints — a challenge that grows more complex as die-to-die communication speeds increase. The complexity extends to power integrity across multiple domains, as NPUs and other specialized processors typically operate at different voltage levels and varying power requirements.

Mechanical stress in chips presents another challenge, as the complex structures experience thermal expansion and contraction during assembly and operation that can affect both reliability and electrical performance through stress-induced parameter shifts.

Multiscale physics challenges have also become increasingly important as system designs span from nanometer-scale transistors to centimeter-scale packages and beyond. This wide range of physical dimensions requires simulation tools, such as Synopsys RedHawk-SC power integrity simulation software, Synopsys Exalto silicon-optimized electromagnetic modeling software for signoff, Synopsys Pathfinder-SC electrostatic discharge reliability signoff for large IP and 3D integrated circuits (3D-IC), and other Synopsys high-performance computing (HPC) and data center solutions, capable of seamlessly transitioning between different scales while maintaining accuracy and computational efficiency.

KEEPING IT COOL WITH THERMAL MANAGEMENT

While a server room filled with high-performance chips attracts much of the attention associated with an AI data center, as much as 60% of the power used in an AI data center is consumed by the systems built to keep those chips cool. If an engineer can reduce the amount of heat generated in the server rooms, less work is required to keep those rooms cooled to a suitable temperature.

If an engineer can reduce the amount of heat generated in the server rooms, less work is required to keep those rooms cooled to a suitable temperature.

How racks are configured and how air or water flows through the racks and rooms can have a significant impact on energy requirements. Simulation software can model a wide range of rack and server configurations that enable engineers to find optimal combinations of compute performance, thermal performance, and more. In addition to these options, engineers can incorporate simulations of cooling solutions such as two-phase cooling and immersion cooling — individually or in combination — to determine the optimal configuration of the data center's core, thereby optimizing compute performance, energy consumption, heat output, cooling system efficiency, and cost.

However, even if every element in the data center has been designed and built to minimize power consumption and heat dissipation, heat will still be generated by the activities within the data center. Cooling systems will draw that away from the server room, and in a well-designed data center, that heat can be turned back into power through heat exchange and waste heat recovery systems — and that power can then be reused within the data center in place of power that would otherwise need to be drawn from the generation systems. Simulation solutions, such as Ansys Mechanical structural simulation software, Fluent software, and Thermal Desktop software, enable engineers to identify opportunities to optimize power consumption throughout an AI data center.

THE FUTURE OF DATA CENTERS WITH DIGITAL TWINS

No single manufacturer or designer will create every component required in an optimized AI data center. Chip companies build chips, server and network vendors build systems that use those GPUs, and other vendors build heating, ventilation, and air conditioning (HVAC) systems; power conditioning and transformation systems; security systems; and more.

A designer architecting an AI data center can use the Ansys TwinBuilder simulation-based digital twin platform to create a digital twin of the data center using simulations of components and facilities built by other manufacturers and vendors. The manufacturers and vendors can save their own models in a reduced-order model (ROM) format that enables the AI data center designer to work with simulations of their data center components. Building a digital twin of an AI data center enables a designer to fully model and tune every aspect of the data center's performance — from compute performance to energy consumption. The designer can manipulate aspects of the design to simulate changes — thereby exploring the effect on emissions or power consumption, for example, if an element in the cooling infrastructure is altered — all before breaking ground on the data center itself.

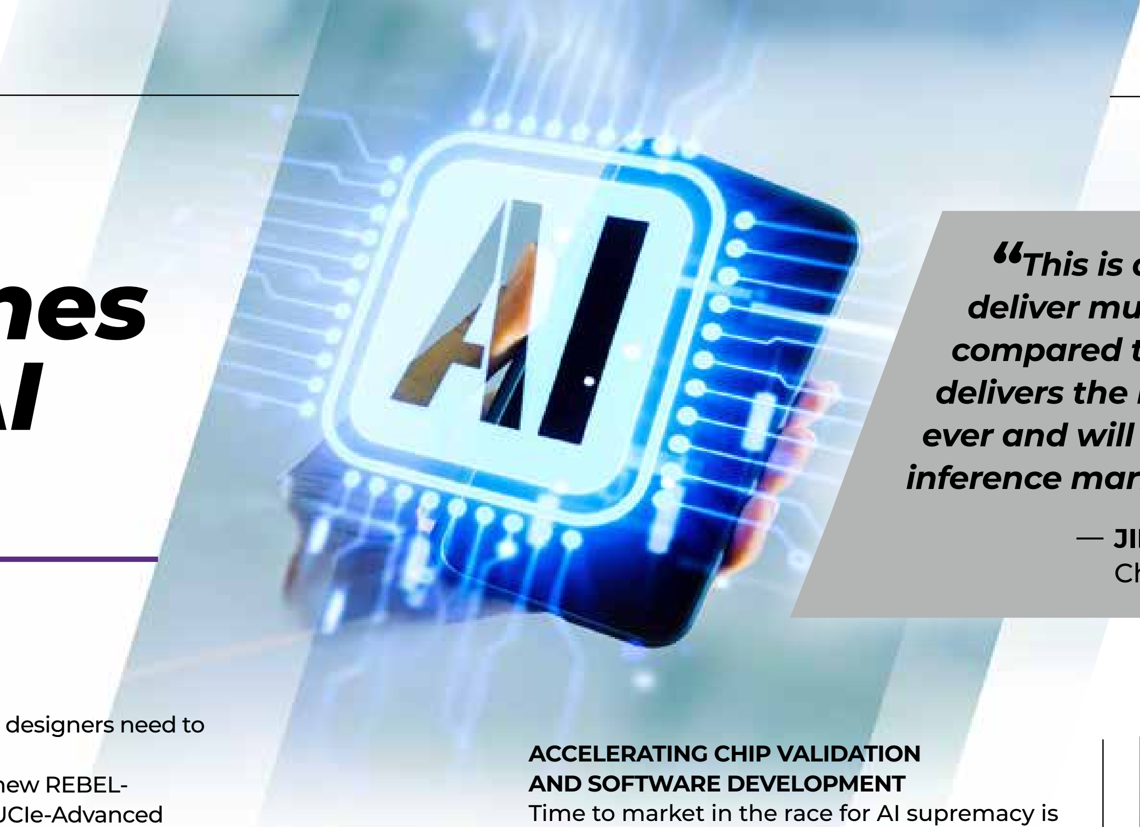
Then, once the optimal design has been modeled in the digital twin, the digital twin becomes the guide for deployment and scaling out of the data center itself. Once the data center is built, the digital twin can be connected logically to the data center, enabling it to be used to monitor and manage performance aspects.

The energy demands of an AI-enabled future are eye-popping. Yet so too is the potential for transformation enabled by AI. With the right tools, designers can build data centers that can enable a future powered by AI, and do so in ways that ensure uptime and performance while minimizing power requirements, energy waste, and a negative environmental impact.

LEARN MORE

Design reliable data centers with simulation solutions.

ansys.com/applications/data-centers



Rebels With a Quad: Rebellions Redefines Energy-Efficient AI for Data Centers

By **FRANK SCHIRRMEISTER**,
Executive Director, Strategic Programs, System Solutions, Synopsys

"This is a powerful solution, and we can deliver much higher energy efficiency compared to GPUs. We believe REBEL-Quad delivers the highest performance per TCO ever and will make a huge impact in the AI inference market."

— **JINWOOK OH**, Rebellions Co-Founder and Chief Technology Officer

To go up against the biggest players in the AI hardware industry, startup chip designers need to take a radically different approach — and innovate rapidly.

That's exactly what AI chip unicorn Rebellions has accomplished with its new REBEL-Quad semiconductor. Unveiled at Hot Chips 2025, REBEL-Quad is the world's first UCIe-Advanced AI accelerator, purpose-built for frontier large language models (LLMs) with hundreds of billions of parameters. The 4-homogeneous-chiplet system-on-chip (SoC) design delivers up to 2,048 teraflops in 8-bit Floating Point (FP8), putting it in the same performance class as leading GPUs.

The key difference: superior energy efficiency.

REBEL-Quad delivers 1.6X higher throughput and 50% lower power consumption, resulting in 3.2X more transactions per second per watt (TPS/W) than top-tier GPUs (tested on Llama 3.3 70B in FP8).

For data centers grappling with skyrocketing energy usage due to AI workloads, Rebellions is betting that REBEL-Quad offers significantly better total cost of ownership (TCO) with similarly high performance.

"This is a powerful solution, and we can deliver much higher energy efficiency compared to GPUs," says Jinwook Oh, Rebellions co-founder and chief technology officer. "We believe REBEL-Quad delivers the highest performance per TCO ever and will make a huge impact in the AI inference market."

TARGETING NEW MARKETS

REBEL-Quad marks Rebellions' first big swing in the U.S. and Europe. Founded in just 2020, the chip startup is backed by Arm, as well as South Korean leaders SK Hynix, SK Telecom, Korea Telecom, and Samsung Ventures & Securities. Its previous ATOM-Max semiconductor, now in mass production, primarily targets Asian markets.

But with REBEL-Quad, Rebellions is eyeing bigger opportunities.

"U.S. customers are very sensitive to TCO," says Oh. "Even though it's a pretty crowded market, if we can provide a strong TCO benefit, I think there will be strong demand."

Outside the U.S., Oh expects REBEL-Quad to provide an alternative for many countries that want to host their own AI data centers but struggle to source GPUs.

"They are craving GPUs," he says. "Our solution will be a good substitute. I believe this solution will replace many GPU markets."

COLLABORATING TO COMPETE

A key part of Rebellions' go-to-market strategy is positioning itself as a systems company, collaborating with the likes of Marvell Technology and Credo Technology for SoC design and chiplet components, as well as AI server rack and infrastructure partners like Pegatron and Penguin Solutions. The company's goal is to design and manufacture proprietary accelerator boards and full server rack systems specifically tailored to REBEL-Quad.

"We want to provide a performant and energy-efficient solution in a rack scale," says Oh. "By understanding the requirements and limitations of AI-dedicated data centers, we can provide the best, optimized solution for those environments."

Expanding its circle of collaborators, Rebellions recently joined the Arm Total Design ecosystem, a group of industry leaders developing custom systems based on Arm Neoverse Compute Subsystems (CSS).

"Arm is becoming a keystone of this ecosystem," says Oh. "Choosing the right partners and building the right solution on top of an ecosystem are the most important factors for increasing our performance so that we can compete against the big companies."

ACCELERATING CHIP VALIDATION AND SOFTWARE DEVELOPMENT

Time to market in the race for AI supremacy is critical, and Rebellions partnered with Synopsys to accelerate the validation of its breakthrough semiconductor using Synopsys ZeBu and Virtualizer tools.

At the core of REBEL-Quad is a modular SoC with four identical compute chiplets integrated using high-bandwidth UCIe-Advanced links. Alongside the chiplets on an I-Cube S package, four HBM3E memory stacks provide 144GB total capacity and about 4.8TB/s aggregate bandwidth.

"Validation is challenging, but ZeBu is a perfect platform for that," says Oh. "Its speed, capacity, and support from the Synopsys team made the emulation of this project successful."

Working closely with Synopsys, Rebellions implemented REBEL-Quad using a hybrid combination of ZeBu and Virtualizer, leveraging the latter for virtual prototyping and accelerated software development.

"Our software programmers picked a design based on their needs," says Oh. "If they needed to validate all the functionality thoroughly, they went with the whole mapped solution. But if they wanted to develop their software stack quickly, they would use Virtualizer."

Rebellions designers were able to run an LLM, enter prompts on a host, and observe token acceleration in the full system context. Integrating the user's end application into the design process allowed developers to "shift left" TPS/W testing to earlier stages of development. While end users of AI accelerators focus on maximizing tokens processed per second, fast validation using platforms like ZeBu is essential during development to minimize the time required to execute each token. With emulation, this execution can be reduced to just minutes, depending on the complexity of the setup.

Rebellions REBEL-Quad AI Accelerator

"We prepared most of the software stack during the presilicon phase, which helped us go from first silicon to live demo in just five weeks. That's a major achievement," says Oh. "Even more impressive was how closely ZeBu's performance predictions matched the actual silicon: 98% accuracy."

THE RACE IS ON

In the race to deliver powerful, energy-efficient AI semiconductors to the world, startups need to innovate faster than ever. With the development of REBEL-Quad, Rebellions has engineered an AI accelerator card for efficient, scalable inference — and demonstrated that it's one to watch in a highly competitive market.

LEARN MORE

Download "Mastering AI Chip Complexity: Your Guide to First-Pass Silicon Success," a Synopsys e-book.

synopsys.com/ai/ai-chip-development/mastering-ai-chip-complexity-ebook

New Fujitsu Chip To Power Greener, Smarter Data Centers

By **GREG SORBER**, Communications, Principal, Synopsys

***THE PROJECT'S GOAL:** 40% energy savings compared with current data centers while maintaining the large capacity and compactness required to handle explosive increases in data volume.*

Around the globe, businesses and governments are seeking ways to mitigate the rapidly increasing energy consumption of data centers.

Nowhere is the issue more urgent than Japan, which aims to achieve carbon neutrality by 2050. The ambitious national commitment is driving innovation across industries, including the development of next-generation "green" data centers — facilities that combine high performance with high energy efficiency.

Fujitsu is playing a vital role in these transformative efforts. The global technology giant has been at the forefront of advanced processor development for 60 years, and in response to its home country's 2050 carbon-neutral goal, Fujitsu is participating in a national project to develop new, more sustainable data centers. The project's goal: 40% energy savings compared with current data centers while maintaining the large capacity and compactness required to handle explosive increases in data volume.

To succeed, Fujitsu knew that incremental improvements wouldn't be enough. Maximizing energy efficiency without sacrificing performance demanded a bold leap forward with a new processor architecture designed from the ground up.

OPTIMIZED BALANCE

Fujitsu's answer is its FUJITSU-MONAKA processor. This highly power-efficient chip (named for a Japanese sweet made of azuki bean paste and crisp mochi wafers) marks a significant step toward greener data centers and achieving the national project's goal of 40% energy savings.

FUJITSU-MONAKA's innovative design carefully optimizes how its components deliver speed and reliability while keeping energy use in check. It features a 3D many-core architecture, integrating three distinct units: a core die with Arm cores, an SRAM die for last-level cache, and an I/O die supporting DDR, PCI Express Gen6, and more. The core die leverages a 2 nm process to deliver exceptional performance and low power consumption while the SRAM and I/O dies use a 5 nm process to optimize cost and efficiency.

"By selecting the optimal process for each die, we achieve both low cost and high performance with low power consumption," says Nobuyuki Matsui, processor development manager at Fujitsu.

FUJITSU-MONAKA is based on the Armv9 architecture and features Fujitsu's own custom microarchitecture, both of which are optimized for state-of-the-art Arm server systems.

READY FOR ARM

A non-negotiable factor of developing FUJITSU-MONAKA was compliance with Arm SystemReady. This rigorous testing program guarantees compatibility and reliability across the Arm ecosystem that powers many devices worldwide, ensuring that customers don't encounter unexpected hardware or software issues.

But compliance with SystemReady is no simple box-checking exercise. In recent years, several Arm server designs have encountered SystemReady violations only after silicon is already manufactured. Fujitsu needed to avoid this nightmare scenario.

"In SoC (system-on-chip) development using cutting-edge processes, the cost and impact of a respin are significant," says Matsui. "It is increasingly important to catch issues in the presilicon phase."

Fujitsu Processor Development Manager Nobuyuki Matsui at Synopsys User Group (SNUG) Japan 2025

To address these risks early, Fujitsu needed to run exhaustive tests using Arm's Architecture Compliance Suite (ACS) packages. These tests require extremely long RTL simulations with tens of billions of cycles, as well as a dedicated software environment for simulating PCI Express devices and increasing test coverage.

PRESILICON EMULATION WITH ZEBU

Fujitsu turned to Synopsys ZeBu Server 5, a high-speed hardware emulator, to engineer a sophisticated emulation environment.

"For efficient verification, the stability of the test environment is crucial," says Matsui. "We created a ZeBu Server 5 emulation model connecting the exerciser as a virtual device, prepared firmware with the exerciser driver, and built the ACS execution software environment."

- A virtual system adapter (VSA) was used to flexibly switch virtual devices at runtime, enabling comprehensive ACS execution and OS boot testing without recompilation.
- Multiple PCI Express exercisers were connected to maximize test coverage.
- Custom firmware environments supported both bare-metal and UEFI testing.
- A proprietary system-level architecture simulator also contributed to "shift-left" verification.

"By checking with the architecture simulator before hardware emulation, we could detect issues earlier," says Matsui.

His team also equipped simulation models with advanced debugging tools, including instruction execution traces, long-term software analysis, and PCI Express transaction monitoring. ZeBu Server 5's high-speed waveform acquisition features further enabled rapid debugging.

Testing FUJITSU-MONAKA required long ACS runs — more than 130 billion cycles in all and nearly 60 hours of simulation — and ZeBu Server 5 save/restore functions enabled Matsui's team to pause, resume, and troubleshoot tests as needed without losing progress.

"With ZeBu Server 5, we could save not only the emulator state but also the state of virtual devices running on the emulation host," says Matsui. "Using save/restore functions, we improved debugging efficiency."

CHARTING THE FUTURE OF SUSTAINABLE DATA CENTERS

In the end, the FUJITSU-MONAKA processor passed the Arm SystemReady presilicon tests, ensuring compatibility with the global Arm ecosystem. It was a key moment in the processor's development, and Matsui credits Fujitsu's collaboration with Synopsys and use of ZeBu Server 5 for making it possible.

"By conducting ACS presilicon tests, we achieved improved verification coverage," he says. "We performed long simulations and debugging, detected and investigated system specification and hardware logic issues, and confirmed SystemReady compliance in the presilicon phase, completing tape-out."

The early detection saved valuable time and resources — but just as importantly, it provided confidence that FUJITSU-MONAKA will ultimately deliver on its promise of energy efficiency and reliability.

Set for release in 2027, FUJITSU-MONAKA marks a milestone in Japan's journey toward carbon-neutrality. By leveraging advanced architecture, rigorous presilicon verification, and strategic partnerships with technology leaders like Synopsys, Fujitsu is redefining what's possible for green data centers.

PROJECT SUMMARY

BUDGET

Up to **190.12** billion yen

CO2 REDUCTION EFFECT (WORLD)

In 2030: **1,275.6** million tons/year

In 2050: **8,919** million tons/year

ECONOMIC EFFECT (WORLD)

In 2030: Approximately **89** trillion yen

In 2050: Approximately **358** trillion yen

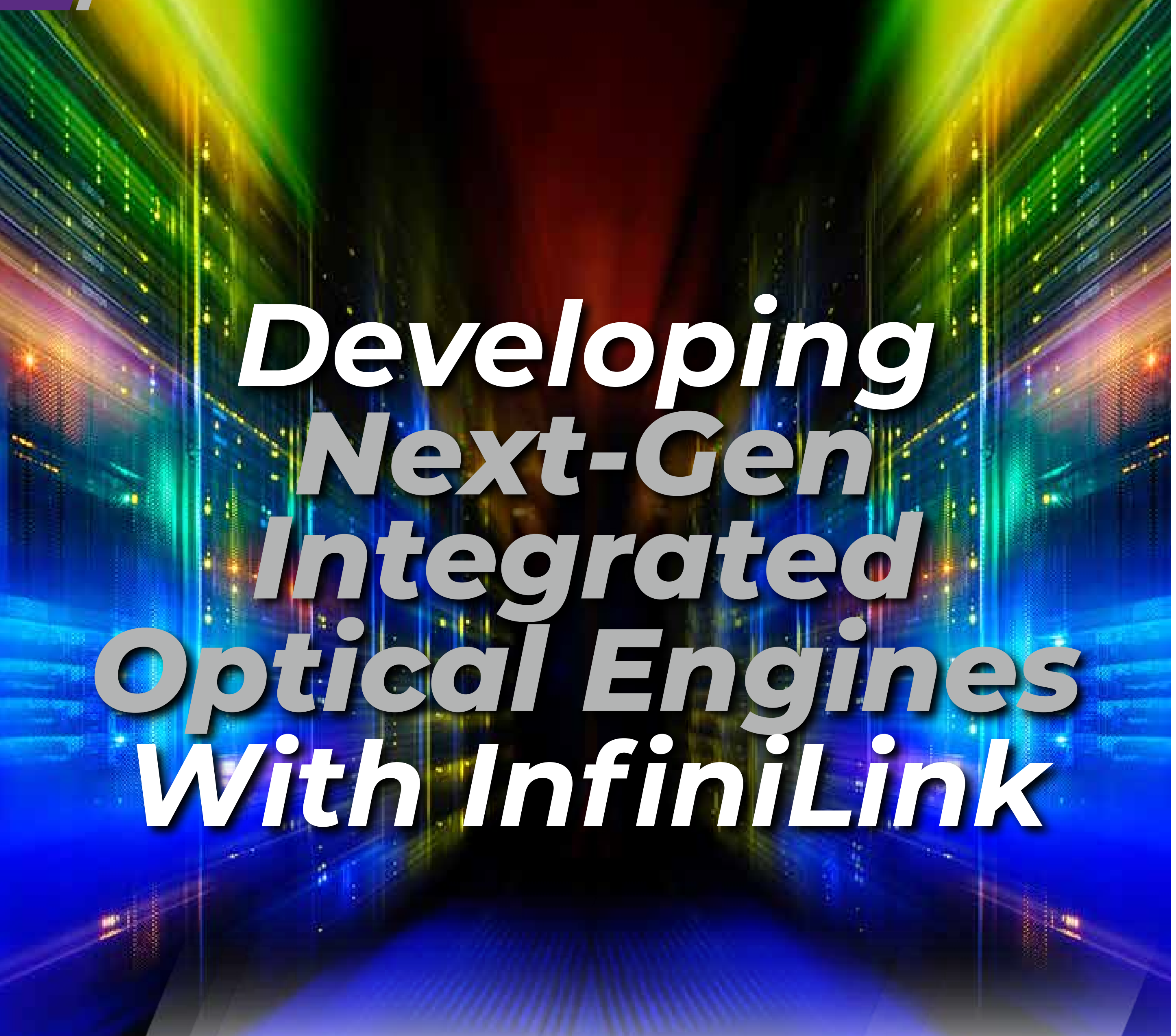
CREDIT: *New Energy and Industrial Technology Development Organization/Green Innovation Fund Projects*

Japan aims to reduce the power loss of next-generation power semiconductors by more than 50%, improve data center efficiency by over 40%, and develop edge computing technologies to achieve a 40% reduction in power consumption of the entire system by 2030.

LEARN MORE

Download "Innovate Faster with Synopsys Multi-Die Solution," a Synopsys e-book.

synopsys.com/multi-die-system/innovate-faster.html



Developing Next-Gen Integrated Optical Engines With InfiniLink

By **SUSAN COLEMAN**,
Senior Director Academic and Startup Programs, Ansys, part of Synopsys; and
EMILY GERKEN,
Corporate Communications Specialist, Ansys, part of Synopsys

Data demand is soaring worldwide as high-resolution video streaming, virtual reality, the Internet of Things (IoT), high-performance computing (HPC), and artificial intelligence and machine learning (AI/ML) drive an insatiable appetite for data. As a result, networks and data centers face increasing pressure to expand bandwidth, reduce latency, and lower power consumption globally.

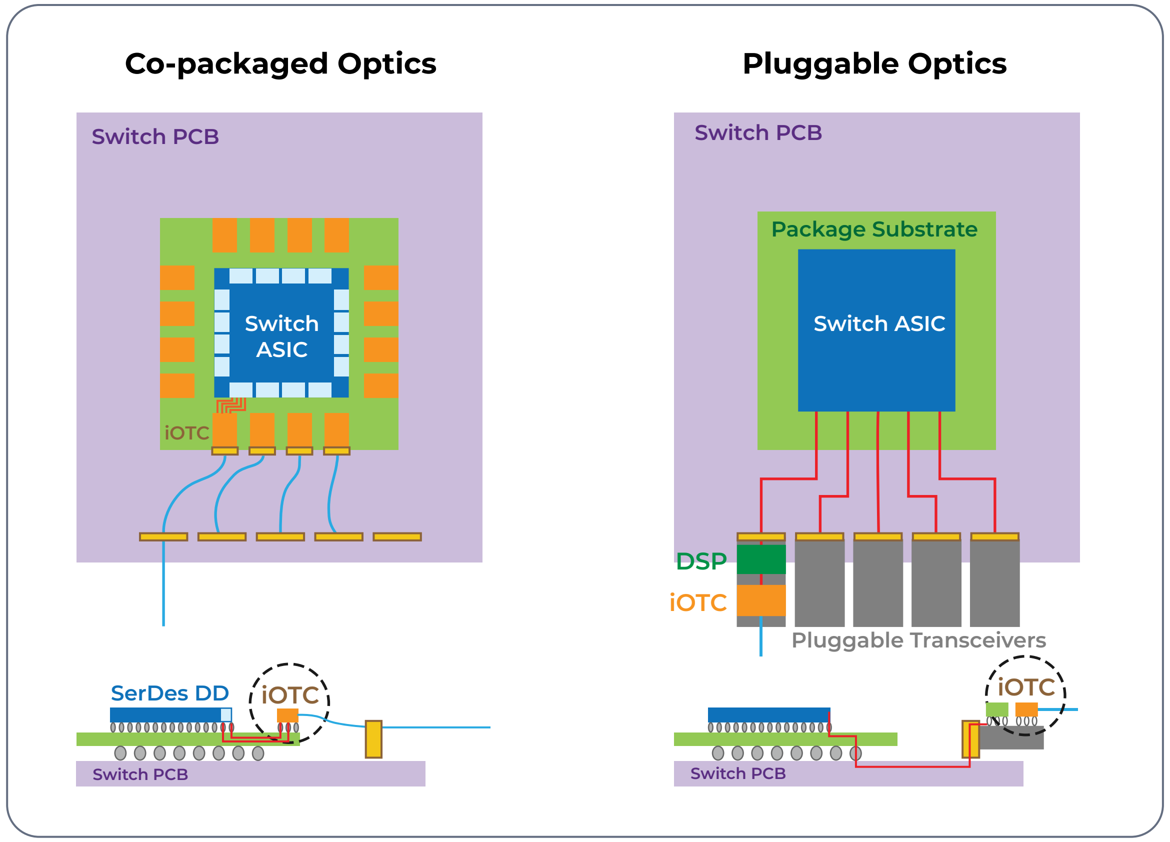
InfiniLink, an innovative semiconductor startup based in Cairo, is addressing these challenges by developing advanced optical data connectivity chips for AI-driven data centers. InfiniLink designs integrated optical transceiver chiplets (iOTCs), leveraging deep expertise in analog mixed-signal design and silicon photonics. As AI workloads and data-intensive applications escalate, traditional electrical and optical interconnects are hitting their limits in power efficiency and scalability. InfiniLink's iOTC technology offers a breakthrough — enabling both low-power pluggable transceiver modules and high-bandwidth-density co-packaged optical (CPO) engines.

In optical interconnects for data centers, a serializer/deserializer (SerDes) is a high-speed electrical interface that converts parallel data into serial signals and vice versa. It operates at the host side, enabling high data rates over a small number of electrical lanes. The SerDes interfaces with optical engines, which perform the actual electrical-to-optical (E/O) and optical-to-electrical (O/E) conversion for transmission over fiber.

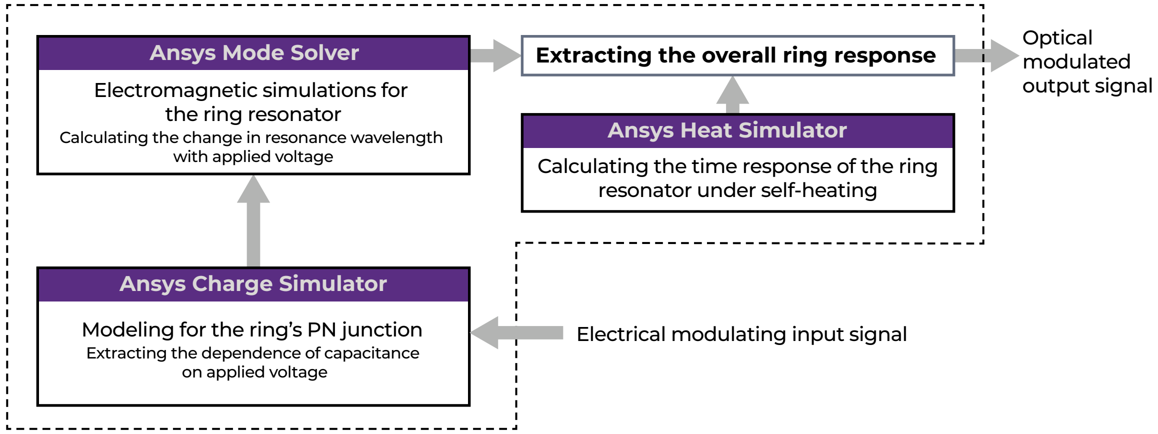
"Our mission is to enable data connectivity inside next-generation AI data centers — meeting market demands for ultra-high-speed, low-power integrated optical engines with state-of-the-art bandwidth density and energy efficiency," says Botros George,

"With such multidisciplinary simulation flows, coupled with accelerated computational capabilities of Ansys tools, our models led to a better understanding of the problems and enabled the development of novel, highly optimized solutions. It's a game changer for our product development cycle."

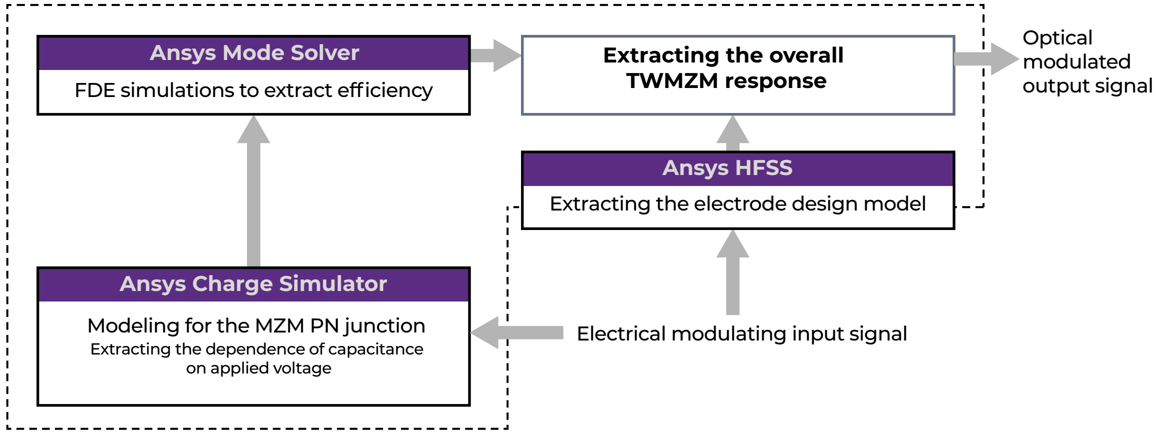
— **BOTROS GEORGE**, Chief Technology Officer and Co-Founder, InfiniLink



InfiniLink's integrated optical transceiver chiplet (IOTC) in co-packaged and pluggable optics applications.



Simplified modeling flow for high-power nonlinearity and self-heating effects in micro ring modulators (MRMs)



Multiphysics modeling of Traveling Wave Mach-Zehnder modulators (TWMZMs)

chief technology officer and co-founder of InfiniLink.

InfiniLink is developing highly integrated optical transceiver chiplets that combine silicon photonics and analog mixed-signal components through advanced packaging technologies. Realizing these sophisticated optical engines relies heavily on multidisciplinary modeling and simulation for design optimization and system-level verification.

FINDING THE RIGHT TOOLS FOR THE JOB

In 2022, with support from Fluid Codes, a Middle East-based Ansys Apex Channel Partner, InfiniLink joined the Ansys Startup Program, gaining access to industry-leading simulation tools at a cost-efficient scale and leveraging the power of Ansys optics, photonics, and electromagnetics software. Through the program, InfiniLink used products such as Ansys HFSS high-frequency electromagnetic simulation software, Ansys Lumerical FDTD advanced 3D electromagnetic simulation software, and Ansys Lumerical INTERCONNECT photonic integrated circuit design and simulation software.

These tools proved instrumental in designing a wide range of active and passive photonics components, enabling the team to build custom photonics process design kits (PDKs) to optimize, replace, or complement missing elements in standard foundry PDKs.

ADDRESSING COMPLEX MULTIDISCIPLINARY DESIGN PROBLEMS

George and his team further explain that the

> ***"Our mission is to enable data connectivity inside next-generation AI data centers — meeting market demands for ultra-high-speed, low-power integrated optical engines with state-of-the-art bandwidth density and energy efficiency."***
>
> — **BOTROS GEORGE**, Chief Technology Officer and Co-Founder, InfiniLink

Ansys, part of Synopsys, tool set has proven essential for modeling highly complex, multidisciplinary problems. An example of this is the modeling of high-power nonlinearity and self-heating in micro ring modulators (MRMs) and assessing the impact on complex modulation formats like PAM4. With such comprehensive models, novel solutions were devised.

Another key use case involved the design optimization of Traveling Wave Mach-Zehnder modulators (TWMZMs), combining Lumerical software and HFSS software to capture the interaction between the electromagnetic performance of the modulator electrodes with the optical performance of the modulator output.

ACCELERATING DESIGN CYCLES WITH HPC

Beyond complex multidisciplinary modeling, Ansys tools brought powerful HPC capabilities, including GPU-accelerated simulations. This computational edge enabled extensive design space exploration of different architectures and yield optimization of individual designs, drastically reducing simulation times by orders of magnitude while providing deeper insights both at the component and system levels.

DRIVING THE FUTURE OF OPTICAL CONNECTIVITY

"With such multidisciplinary simulation flows, coupled with accelerated computational capabilities of Ansys tools, our models led to a better understanding of the problems and enabled the development of novel, highly optimized solutions. It's a game changer for our product development cycle," says George.

As AI workloads and cloud infrastructure continue to grow, the demand for high-speed, low-power data connectivity solutions is only accelerating. Powered by simulation tools and Fluid Codes' continued support, InfiniLink is pushing the frontier — engineering the next generation of integrated optical engines that will power tomorrow's AI-driven data centers.

LEARN MORE

Explore the benefits of the Ansys Startup Program.

ansys.com/startup-program

NASA's X-59 quiet, purpose-built supersonic aircraft will validate simulation results that predict a dramatically quiet sonic thump. In this Ansys simulation, streamlines are colored by velocity magnitude. The exhaust plume is a volumetric CFD temperature data field. Temperatures are rendered with a black body color scale, in which higher temperatures are more emissive and opaque.

How SIMULATION Is Helping To Make Quiet Supersonic Travel a Reality

By **LUKE MUNHOLAND**, Principal Application Engineer, Ansys, part of Synopsys

The NASA X-59 Quesst recently soared into the sky for its maiden voyage. This unique aircraft was carefully designed using computational fluid dynamics (CFD) to mute the thunderous double-boom of traditional supersonic aircraft. Popular movies often depict futuristic aircraft reaching speeds far beyond expectation on their first flight. A stirring soundtrack builds suspense as a heroic test pilot ignores orders to stop and impulsively pushes the throttles to the max. The control room cheers as the craft streaks across the horizon.

In real life, the NASA control room still cheers, and test pilots are definitely heroic. But NASA test pilots are not impulsive — in fact, they are much more careful than most cinema depictions. The X-59's first flight was significant, but it purposefully did not break the sound barrier. Test pilots follow meticulous incremental protocols to safely validate aircraft performance, and data from each flight is reviewed before the next slightly more aggressive maneuver is planned. Eventually, aircraft performance is validated throughout the entire flight envelope, and the aircraft receives a safety certificate.

Ansys has a tradition of simulating aircraft at extreme limits and is a longtime participant in NASA's High-Lift Prediction Workshops (HLPWs).

The first flight was one of many carefully planned steps that began years ago to ensure that the X-59 can safely carry out its mission: Introduce the American public to quiet supersonic travel.

ENSURING SAFETY WITH SIMULATION

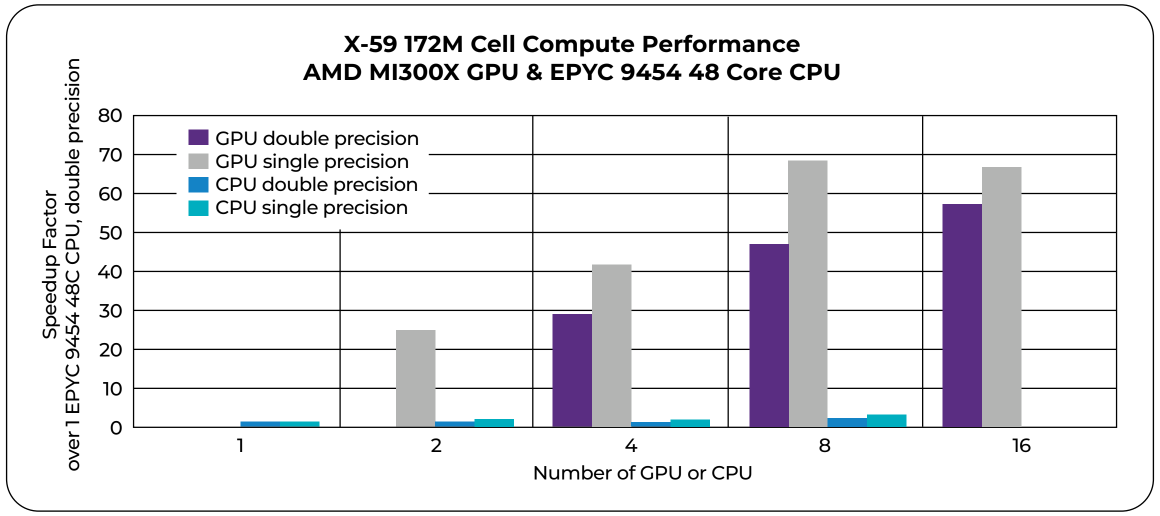
One of the incremental tests NASA pilots work up to are high-lift maneuvers. In emergency situations, pilots must be able to retain control at high angles of attack up to and exceeding the critical angle of attack. NASA test pilots will carefully approach this point, in which the aircraft stalls and begins to fall from the sky. Loss of lift occurs when airflow above the wing becomes turbulent and streamlines dramatically separate from the wing's upper surface. For many aircraft, the stall critical angle of attack is in the 15-to-18-degree range.

Thankfully, advanced CFD simulation tools can help pilots and engineers understand exactly the conditions in which stalls begin. In fact, there is an entire community of simulation leaders who meet regularly to share new information on achieving flight with a high angle of attack. Better understanding and control in this flight regime is critical for all aircraft to take off and land safely.

MODELING HIGH PITCH RATES WITH THE ANSYS FLUENT GPU SOLVER

Ansys, part of Synopsys, has a tradition of simulating aircraft at extreme limits and is a longtime participant in NASA's High-Lift Prediction Workshops (HLPWs). Ansys was at the first meeting in 2010 and has participated for over 15 years. At these meetings, representatives from industry, academia, and government meet to discuss lift and drag predictions on increasingly complex aircraft geometries. The goal is to collaborate on best practices, but there is also friendly competition to see who most accurately matches previously unpublished wind tunnel test data. CFD codes become faster and more accurate every year, and better tools produce safer aircraft — including the X-59.

The updated HLPW workflow from 2025 was applied to an X-59 aircraft geometry Ansys has studied for the past six years. In the first step, the Fluent meshing capability created a rapid octree mesh around the c608 variant of the X-59. This high-quality hexahedral mesh was refined at the aircraft boundary and contained 172 million elements. The meshing tool generated the mesh in only 11 minutes using 192 CPU cores. The minimum orthogonal



quality of the mesh was above 0.3, which is considered very good.

The mesh was read by the Fluent GPU solver to produce high-fidelity flow results. The pressure-based segregated solver included an ideal gas air material and included the energy equation to accurately describe engine intake and exhaust flow rates and temperatures. The freestream velocity around the aircraft was set to Mach 0.2. Turbulence was described by the wall-modeled large eddy simulation (WMLES), which allows excellent resolution of flow separation above the wing.

The X-59 was oriented in progressively steeper angles of attack up to 20 degrees using a sliding mesh approach. For this test, an airshow-worthy pitch rate of 20 degrees per second was implemented. After pitch-up, the aircraft was held at 20 degrees to enable flow to fully develop.

The image below shows flow behavior as the X-59 rapidly pitches upward. The isosurfaces of the normalized q-criterion at a value of 50,000 are colored by velocity magnitude. Q-criterion surfaces help identify areas of high turbulence and illustrate vortex structures. The q-criterion isosurfaces would normally cover the entire aircraft body, but they have been clipped to focus on the largest vortex structures. Note how the canards just ahead of the main wings redirect airflow along the wing root. The exhaust plume may look like an "afterburner," but it actually represents a volumetric CFD temperature field. Higher temperatures are depicted as more yellow-white in color, emit more light to the scene, and are more opaque.

The Fluent GPU solver simulation ran on AMD Instinct MI300X GPUs. Peak throughput was at single precision on eight GPUs requiring only 0.27 seconds per iteration. Five seconds of flow time were simulated in just 3.7 hours on the wall clock. Although this case ran well with single precision, double precision is recommended for most sliding mesh simulations. With twice as many decimal places, this case scaled to 16 AMD MI300X GPUS. Results were still ready in less than 4.4 hours.

These premium AMD MI300X GPUs are 22X faster than the equally top-quality AMD EPYC 9454 48-core CPUs. It is safe to say that GPU computing is changing the way engineers do simulation — just a year or two ago, simulations like these would have taken several weeks and required thousands of CPU cores.

USING HIGH-FIDELITY CFD TO MEET DESIGN GOALS

Highly accurate simulation data is critical for new aircraft such as the X-59. Performance goals like quieting sonic booms are important, but they are useless if the aircraft is unstable in flight. Ansys tools like Fluent fluid simulation software help engineers quickly create reliable, robust designs that fulfill their missions.

Simulation results have already been used to ensure that the X-59 has good handling characteristics despite its long nose. They influenced the placement of the canards to ensure stability and have even been incorporated into an X-59 flight simulator. Test pilots already have a very good idea of how the aircraft will handle as they push it toward the most extreme flight conditions.

Once NASA has verified handling and safety, the X-59 will fly over U.S. cities to demonstrate the quiet supersonic technology. These tests will confirm what we in the simulation community already know: An aircraft traveling faster than a speeding bullet will make the unremarkable sound of a car door closing in a parking lot. Over the next few years, the American people will decide how they feel about the adoption of overland supersonic flight based on this new quiet technology. The benefits speak for themselves — for example, a 6.5-hour flight from Boston to Los Angeles would take only 3.25 hours.

LEARN MORE

Explore Ansys Fluent fluid simulation software.

ansys.com/products/fluids/ansys-fluent

Disclaimer: The simulation images were created from a geometry that Ansys redrew from the public domain model. NASA was not involved in their creation.

Why Simulation Is Step One to Simple and Sustainable Aviation

By **SUSAN COLEMAN**, Senior Director Academic and Startup Programs, Ansys, part of Synopsys; and
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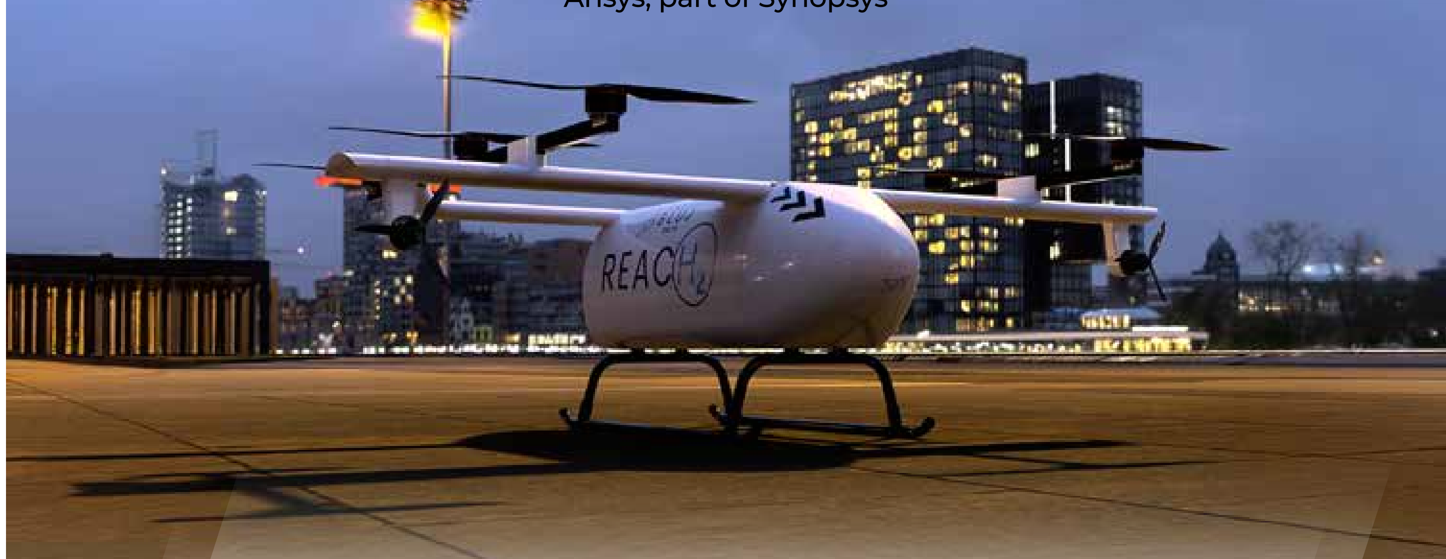


It's not every day that you come across a company with a product that has the potential to improve the lives of a large group of people. But that's exactly what BluJ Aero — a company building vertical takeoff and landing (VTOL) aircraft — intends to do.

Utham Kumar Dharmapuri, co-founder and chief technology officer of BluJ, says the company "reaches people of every walk of life" by making flexible, world-class aviation products with potential applications ranging from regional air travel and same-day deliveries to uncrewed emergency evacuation. BluJ's products address some of the key challenges facing the aviation industry today, including high costs and inefficiencies in regional transportation and the need to keep pace with increasing demand for delivery services.

As for how the company is achieving this, "BluJ was formed with the vision of making aviation simple and sustainable," says Dharmapuri. This sustainability comes in two parts:

1. **Environmental sustainability:** BluJ relies on hydrogen-powered fuel cells that reduce emissions.
2. **Economic sustainability:** BluJ focuses on creating versatile designs that enable a wide range of applications in different geographies, ensuring that its aircraft are affordable to a large group of people in the long term.

As part of the advanced air mobility (AAM) industry, BluJ is also diverging from traditional aviation solutions and increasingly using autonomous technology, nontraditional propulsion systems, compact designs, and customized areas for landing and takeoff, such as vertiports or skyports.

"The idea is to get closer to the doorstep of whoever wishes to fly on these aircraft or even move their goods to the end destination," says Dharmapuri. "You don't need a runway. All you need is a safe space for something to land and take off from."

Already, BluJ has taken to the skies and flown its first VTOL prototype. "Science fiction is closer than we thought," says Dharmapuri. Continuing its path forward will require overcoming a few hurdles common in the AAM space.

> ***"Simulation is what cuts down time and is able to produce things at a much faster rate."***
>
> — **UTHAM KUMAR DHARMAPURI**,
> Co-Founder and Chief Technology Officer, BluJ Aero

WHAT'S NEEDED TO GROW IN THE AAM SPACE

Turning science fiction into reality is no easy task. First, there's the financial part of the equation. There is the need for a "large capital requirement and appetite of investors globally to bet on such long-term ideas," says Amar Sri Vatsavaya, co-founder and CEO of BluJ. And after this money is successfully raised, there is the challenge of commercialization and demonstrating the importance of this technology to potential clients.

Second, there's regulation. "Regulators or even the general community are not used to having things flying next to their apartment windows," says Dharmapuri. "That's what we imagine in the near future with these vehicles. So, regulation will be a big part of that." Here, BluJ has worked with the Directorate General of Civil Aviation (DGCA) from the beginning to help address this challenge.

Finally, AAM relies on new technology and uses existing technology in new and innovative ways. While this opens up new possibilities, it also comes with new technical challenges — for instance, designing a VTOL that can travel for hundreds of kilometers before quietly landing back in a dense urban environment.

At the end of the day, these challenges are multifold, and AAM designs "need to be built responsibly to address the tech, as well as the regulation," says Dharmapuri. To find an answer that works technically and for investors, regulators, and potential users, the BluJ team turns to simulation from Ansys, part of Synopsys.

EFFICIENCY: A SOLUTION TAILORED FOR STARTUPS

While reducing costs is important for all companies, this goal is particularly important for startups. Here, the BluJ team turned to the Ansys Startup Program and gained support from Telled Marketing.

By joining the startup program, BluJ gets access to "a bundle of all the simulation solutions that are required for a company like ours," says Vatsavaya. By having a variety of Ansys solutions in one place, the bundle not only is affordable but helps with budget planning.

"It let us focus more on how we are going to use these tools rather than looking at how we can afford them or how we can buy them in the most efficient token or license combinations," says Vatsavaya. "That's been the biggest positive surprise with the Ansys Startup Program. … The startup bundle for the first year was much more affordable than what we would have had to invest without the program, so that's very helpful in the early journey."

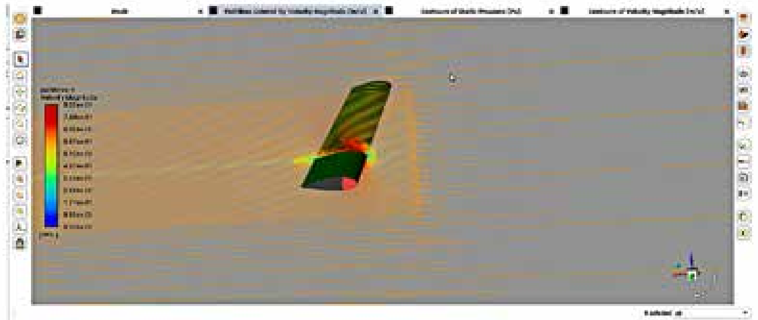
Importantly, the bundle also includes high-performance computing (HPC), which is a unique offering for a startup package.

ACCURACY: THE ANSYS PRODUCT SUITE

Through the Ansys Startup Program, the BluJ team has access to the advanced software that it requires, including Ansys Fluent fluid simulation software to study flow interactions inside and around aircraft. This includes analyzing how air and fluids are recirculated within the VTOL, how aerodynamic BluJ's VTOL designs are, and if they maximize energy use. Meanwhile, Ansys Mechanical structural finite element analysis (FEA) software helps the team build an optimized VTOL design that meets all requirements and regulations.

A render of a BluJ vertical takeoff and landing aircraft at a charging station

A BluJ vertical takeoff and landing aircraft on a vertiport



Velocity magnitude flow simulations on a vertical takeoff and landing aircraft wing

VELOCITY MAGNITUDE FLOW SIMULATIONS ON A VTOL WING

The team also relied on the Ansys Composite PrepPost (ACP) tool for composites to design Type IV composite pressure vessels for hydrogen storage and Ansys LS-DYNA nonlinear dynamics structural simulation software to help it solve its models more seamlessly. The BluJ team is also beginning to integrate the Ansys Maxwell advanced electromagnetic field solver into its processes.

As one example of its use of simulation software, consider BluJ's propellers, which it makes from scratch. Propellers are a notoriously challenging design component, and Ansys software enables BluJ "to quickly check to tell what's working and what's not working," says Dharmapuri. "Once you have ideas, you can cycle through them quickly."

After running its simulations, the BluJ team compared the results from its high-fidelity Ansys models with existing propeller designs. In doing so, "we could verify and cross-validate with the tool, and we found that Ansys (software) could predict the actual real-world results within 5% of variation, which is a very close correlation for a propeller," says Dharmapuri. "If you're within 5% of an actual (propeller) made by a reputed vendor, that's a good place to start."

And propellers are only one of the many ways that BluJ uses simulation in its work. With simulation software, engineers can rapidly analyze iterative design changes and performance in a large variety of environmental conditions. In doing so, "you cut down the time to production, and you cut down the time to iterate and try out designs, which would otherwise take a longer time," says Dharmapuri.

Performing simulation analyses is imperative for modern-day engineers. "You will not be able to test all aspects of any structure in the real world," says Dharmapuri. "The only way to do that is to fly, but it's too late if you want to test it at that stage." Instead, simulation must be used from the start.

No matter what the team's current goal is, "simulation is a big part of anything we develop," says Dharmapuri. "I've been in this industry for 18 years, and I don't design anything without simulation anymore. … It's a compliment to the simulation tools themselves that you don't even design without them."

FROM SKETCH TO THE SKIES

BluJ has come a long way in just about three years. From a team of two and a professor with initial sketches of their aircraft to a flying prototype, the sky is not the limit but an opportunity for BluJ. The company intends to enter the market in 2026 and introduce its aircraft as a solution for moving goods.

Looking to the future, BluJ plans to continue to scale and take on new potential applications for its technology. Further, "we would love to automate the complete workflows as much as possible, and with Ansys moving toward a Python scripting layer, it's going to be really helpful," says Vatsavaya. This development will aid BluJ in further cutting down its design time.

Additionally, the team will continue to work toward certification. Ansys software "is a certified and accepted tool in the aviation industry," says Dharmapuri, and "that is going to contribute to us being able to certify our products faster."

The team also plans to use multiphysics simulations to solve for multiple goals at once, such as designing a VTOL that is not only aerodynamic but fuel-efficient and quiet. Throughout it all, "simulation is what cuts down time and is able to produce things at a much faster rate," says Dharmapuri.

LEARN MORE

Watch the "Digital Engineering for Advanced Air Mobility" webinar.

ansys.com/webinars/digital-engineering-advanced-air-mobility

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