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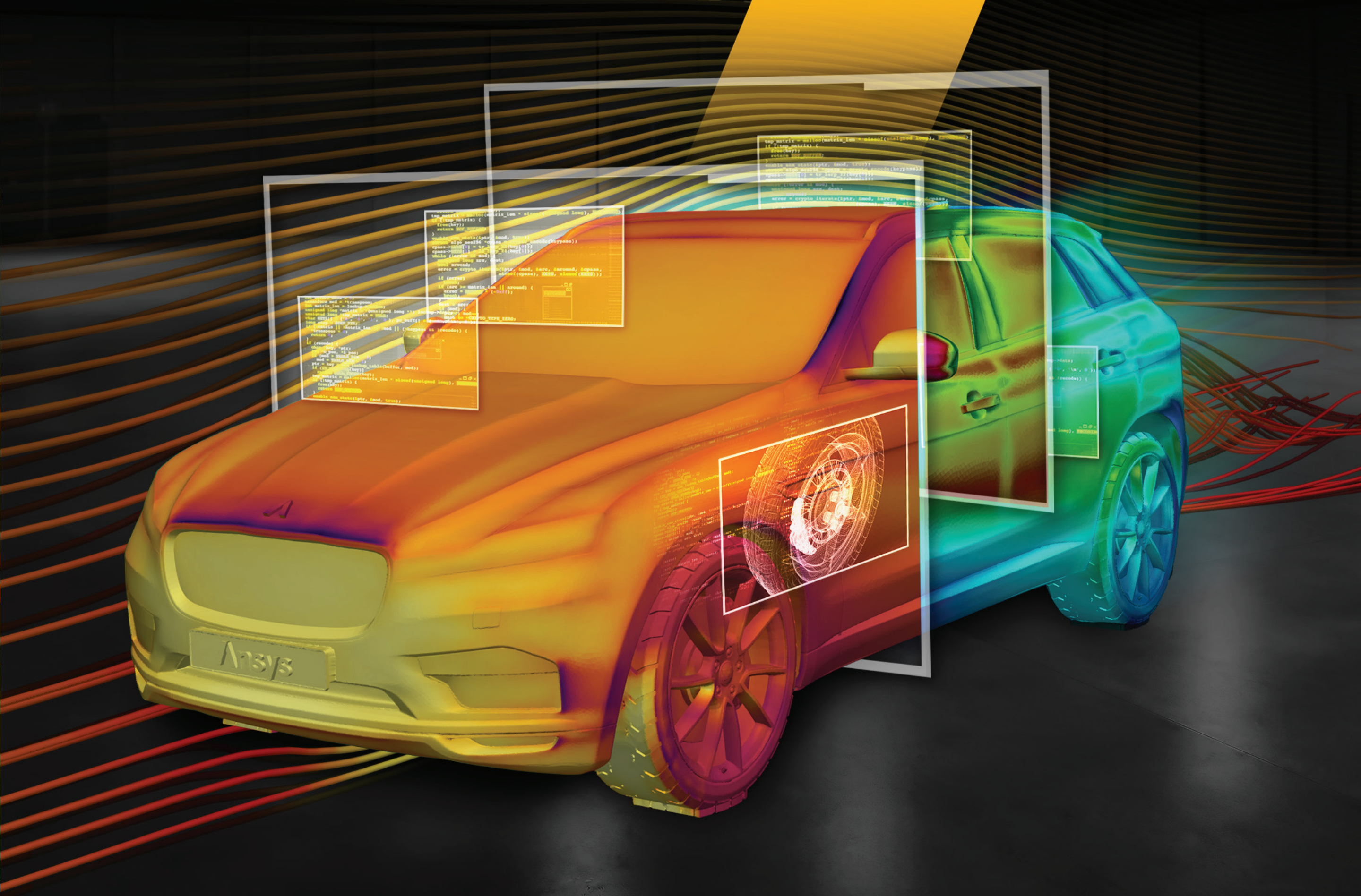
POWERING INNOVATION THAT DRIVES HUMAN ADVANCEMENT

ISSUE 2 / 2024

SIMULATE AT THE SPEED OF AI



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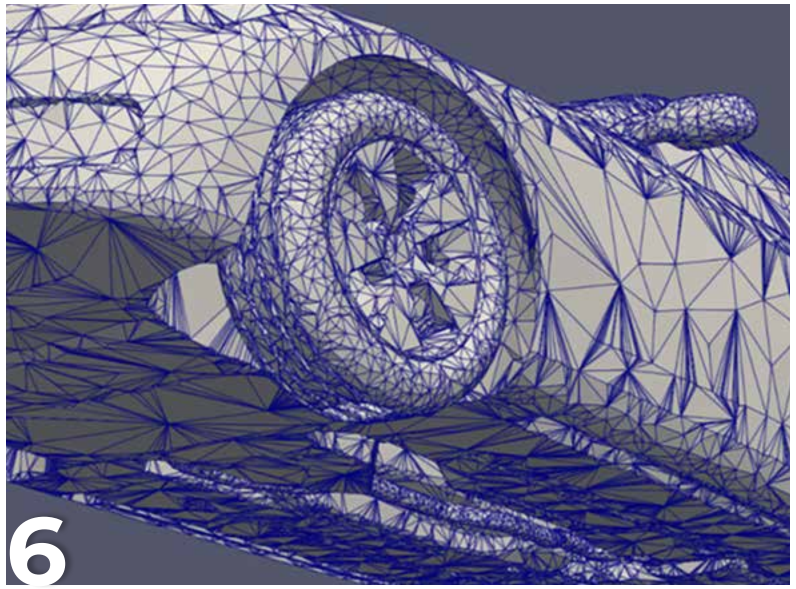

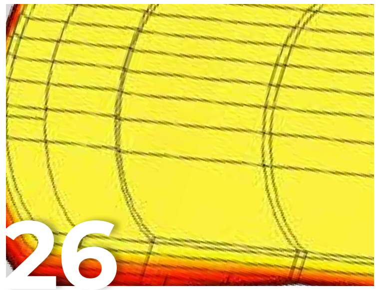

Focus on AI

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ADVANTAGE

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Issue 2 / 2024

Combining the Power of Simulation and Artificial Intelligence

By **PRITH BANERJEE**, CTO, Ansys

Simulation has steadily become faster and more accessible, but with the addition of artificial intelligence (AI), that steady progress takes a great leap forward. The predictive power of simulation that enables engineers to revolutionize the way we understand phenomena we can't even see is being supercharged by AI. In turn, simulation data is being used to accelerate the pace of AI training.

Simulations can use AI techniques to run models faster and easier. The more AI is trained, the faster and more accurate those simulations become. Providing enough good data to properly train AI models has been a significant challenge. Simulation data helps solve that challenge. AI can be trained using simulation data from a variety of industries and applications. It's an upward spiral that results in faster, easier to use, more comprehensive, and continually improving workflows.

ACCELERATING THE SCIENCE OF INNOVATION

So how can we train AI to ensure that it really does what we need it to do? Simulation data is full of information that can be used to inform AI across disciplines. Real data can be pulled from past simulations and fed into an AI model, thus creating a starting point for further advancements.

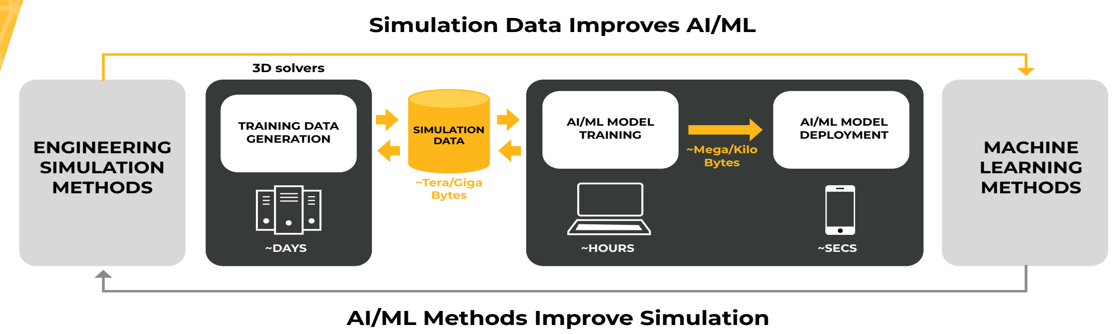
An important enhancement in data-driven training of AI is the reduced-order modeling (ROM) approach that Ansys uses to speed up many types of simulations. Essentially, ROMs are simplifications of complex models that capture the behavior of source models, allowing engineers and designers to use minimal computational resources when examining a system's principal properties. ROMs have become a staple for industries that demand high-quality end products with shorter design life cycles.

In addition to ROMs, AI large language models (LLMs) allow further training of automatically generated solutions. LLMs give engineers the ability to write a statement requesting a desired outcome, which then automatically generates results. This sort of AI training gives experts the power to obtain outcomes beyond what the human mind might think of or consider on its own.

Quickly obtaining complex results is undoubtedly a central feature of AI, so much so that anyone using it has the possibility of becoming too reliant on its capabilities. How can we, as pioneering engineers in the field of AI, ensure that our findings are properly informed and accurate? It is important to know that AI is not perfect. It can pull from thousands of resources, some of which may be unreliable or even proprietary and legally protected. To guarantee that data generated by simulation is truthful and as accurate as possible, explainable AI (XAI) and human monitoring are crucial to the functionality of AI in any field. XAI is the technique of using processes and methods that can be applied to a system, allowing human users to understand and trust results from AI algorithms.

More interaction. More exploration. More innovation.

Combining artificial intelligence (AI) and simulation promises amazing benefits for engineering.



How AI/machine learning and simulation work together: Ansys is combining the power of AI and simulation to provide groundbreaking technology through many AI products and platforms.

TRANSFORMING SIMULATION AT THE SPEED OF AI

Ansys continues to work on advancing technology through its AI platforms. The iterative engineering process enabled by AI and simulation enables engineers to improve their designs with far fewer constraints. As you'll see in this issue of *Ansys Advantage* magazine, engineers are already leveraging the power of AI to generate reliable simulations across many industries, including aerospace, automotive, electronics, optics, and healthcare. The combination of AI and simulation makes data actionable, which continuously improves the iterative engineering process to advance designs with fewer constraints.

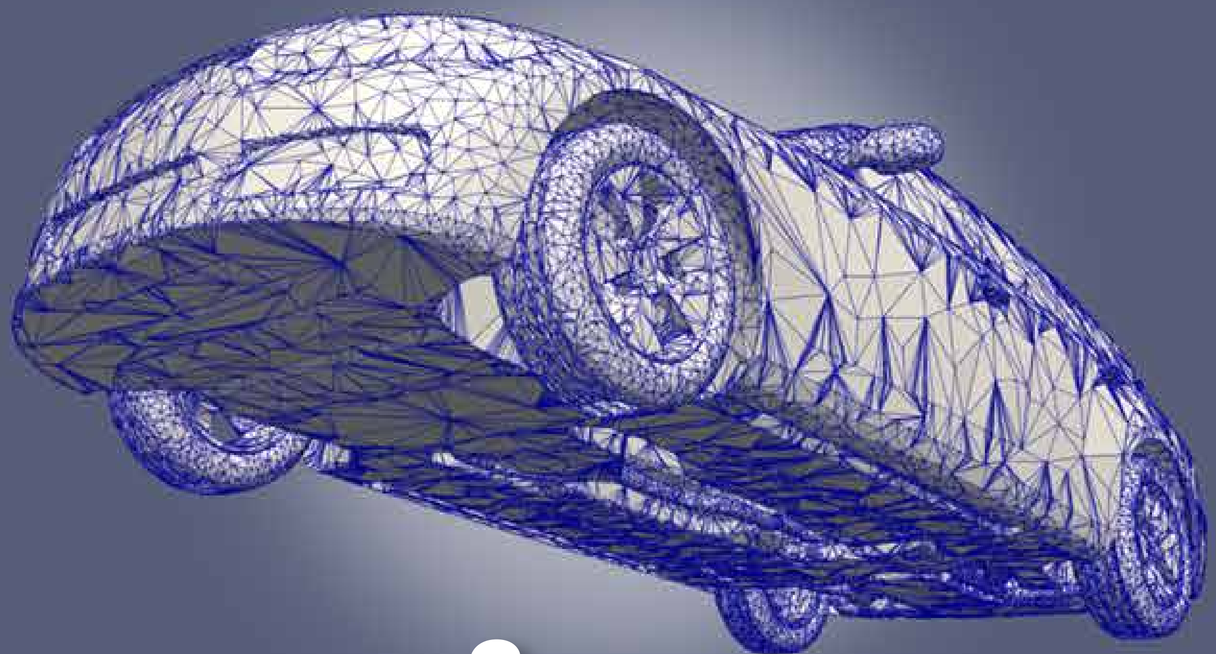
The Ansys SimAI cloud-enabled generative AI platform and Ansys Twin Builder simulation-based digital twin platform are just two of our innovative AI solutions that harness the power of AI/ML combined with simulation. SimAI software enables you to rapidly test design alternatives — around 10x to 100x more — without the constraints of traditional solvers across all design phases. It makes simulation accessible to designers and non-experts. Ansys TwinAI software is a digital twin solution that integrates the accuracy of physics models with insights from real-world data, powered by AI techniques.

Many of the Ansys products you already use can also be augmented with AI. We call these AI+ add-ons. They employ a rich set of machine learning capabilities across various physics to deliver more accurate results, capture more details, and make our solutions even easier to use.

Finally, AnsysGPT is your AI-driven virtual assistant that uses AI and the Ansys support documentation training to answer your questions in many languages, with links to the source materials.

We hope you enjoy this issue of *Ansys Advantage* magazine. As you'll see, when intelligence and powerful simulation tools are brought together, the possibilities are endless. /\

The Ansys SimAI cloud-enabled generative AI platform uses past data to predict performance of new designs.



SimAI Explained

See How AI Is Applied to Numerical Simulation in Practice

By **JENNIFER PROCARIO**, Senior Marketing Communications Writer, Ansys, and **ANTOINE REVERBERI,** Application Engineer II, Ansys

Simulation continues to transform workflows around the world, regardless of industry. Product development teams are constantly challenged to produce better designs at a faster pace. By incorporating simulation earlier into design and development, these teams accelerate production and inform design with critical insights that improve efficiency, accuracy, and product quality. But as impactful as this "shift to the left" is — that is, using simulation earlier to inform design rather than as a late-stage verification or post-analysis tool — artificial intelligence (AI) technologies present another opportunity to drastically shift production and simulation workflows.

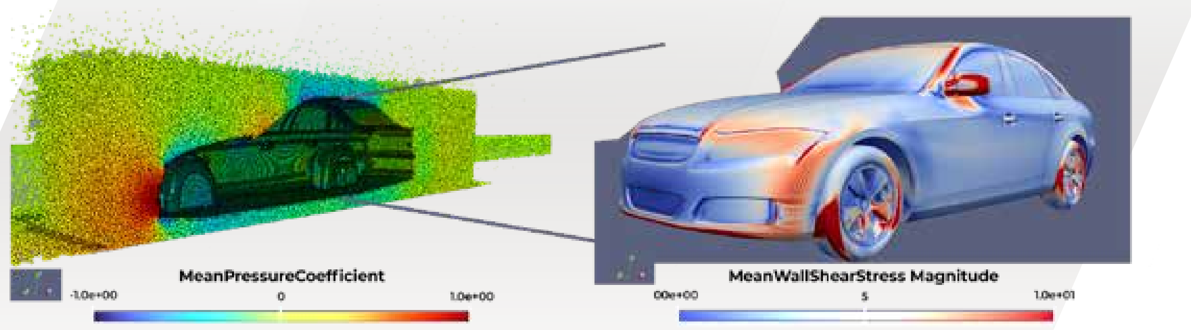
To assess automotive aerodynamics, engineers often incorporate computational fluid dynamics (CFD) simulation to analyze the flow field around a car.

By combining the power of AI and multiphysics simulation, the Ansys SimAI cloud-based platform enables organizations to reach even greater levels of innovation at a rapid pace.

With the SimAI physics-agnostic and cloud-native platform, you can train an AI model using previously generated Ansys or non-Ansys data and assess the performance of a new design within minutes. The software as a service (SaaS) application combines the predictive accuracy of Ansys simulation with the speed of generative AI via the cloud — a combination that boosts model performance by 10 to 100X across all design phases for computation-heavy projects.

to calculate and iterate system-specific quantities more easily and efficiently. For example, to assess automotive aerodynamics, engineers often rely on computational fluid dynamics (CFD) simulations to analyze the flow field around a car.

Governing equations play a crucial role in the analysis of physical systems because they enable models that can be used to analyze and predict behaviors that are otherwise unobservable. By employing mathematical approximations, numerical simulations solve these governing equations through computer algorithms. Some of the most well-known governing equations in engineering are the Navier–Stokes equations, which are used to express the motion and flow of incompressible fluids. In the case of automotive aerodynamics, Navier–Stokes equations help describe the relationship



For automotive aerodynamic assessments, the Ansys SimAI cloud-based platform enables a continuous representation of the surface and volume fields like pressure and velocity. In addition, global coefficients can be derived from the predicted fields as postprocessing.

So, how do AI and machine learning (ML) methodologies integrate with and extend upon numerical simulations and solvers? Let's explore the inner workings of the SimAI platform to learn how this technology both expands and enhances traditional simulation without compromising accuracy for speed.

INFORM MACHINE LEARNING WITH NUMERICAL SIMULATION

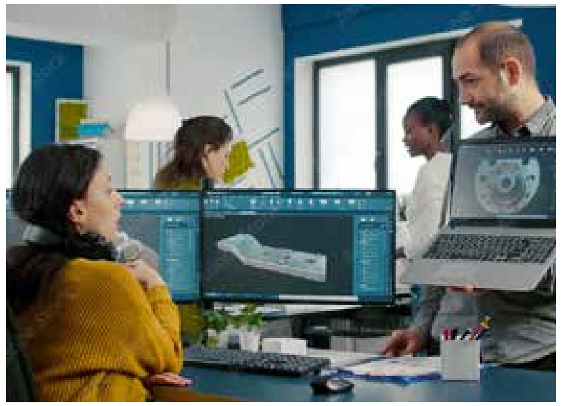
To appreciate the technology behind the SimAI platform, you must first understand the nature of numerical simulations and their complexities and purpose. Numerical simulations model the behavior of physical systems in various engineering domains without needing to conduct lab experiments. This enables engineers

between the velocity and pressure of moving fluid around a car.

When employing ML techniques, the goal is to enable an algorithm to learn a task or general rule, given a set of examples. There are several ways to do this when integrating ML with numerical simulation.

$$\frac{\partial \rho U}{\partial t} + \nabla . \emptyset U - \nabla . \mu \nabla U = -\nabla p$$

The Navier–Stokes equations, shown here in their incompressible forms, describe the relationship between velocity and pressure of the moving fluid.



With the SimAI platform, data from previous simulations can be used to accelerate new designs.

Here are two categories of such methods:
Physics-aware method: The most straightforward approach is to replace the bottleneck in standard solvers with ML techniques that can output predictions faster — for example, to accelerate the inversion of a large linear system of equations. However, most of these methods remove the solver involved in the computation while keeping information about governing equations — for instance, by injecting penalization terms implied by the equations into the loss function (the amount of error in your training data). In other words, physics-aware methods focus on a particular physical task and get the job done, but they might sacrifice some predictive accuracy.

Physics-agnostic method: The other approach is for the ML algorithm to learn a latent representation of the physics directly from the solutions of numerical solvers. These methods are agnostic to the underlying equations and solvers. For example, by using examples from previous computations, ML algorithms can learn a data-driven representation of the Navier–Stokes function and use a new geometry and freestream condition as inputs (like the speed of a car) to deliver its flow field as the output. In this way, physics-agnostic methods offer both speed and predictive accuracy.

$$\mathcal{S}(\underline{x}) = \mathcal{N}(\underline{x}, BC)$$

By using examples from previous computations, the physics-agnostic machine learning (ML) techniques used on the SimAI platform can learn a data-driven representation of the underlying governing equations of your system — for example, the Navier–Stokes functions.

The SimAI platform takes a physics-agnostic approach, accelerating your simulation workflow without compromising its predictive accuracy. Instead of relying on geometric parameters to define a design, SimAI software uses the shape of a design itself as the input. This facilitates broader design exploration even if the shape's structure is inconsistent across the training data.

Essentially, the SimAI platform is engaged in three simple steps: upload data, train the AI model, and predict. As mentioned, customers can train the AI model using previously generated Ansys or non-Ansys data.

DISCOVER WHAT'S UNDER THE HOOD

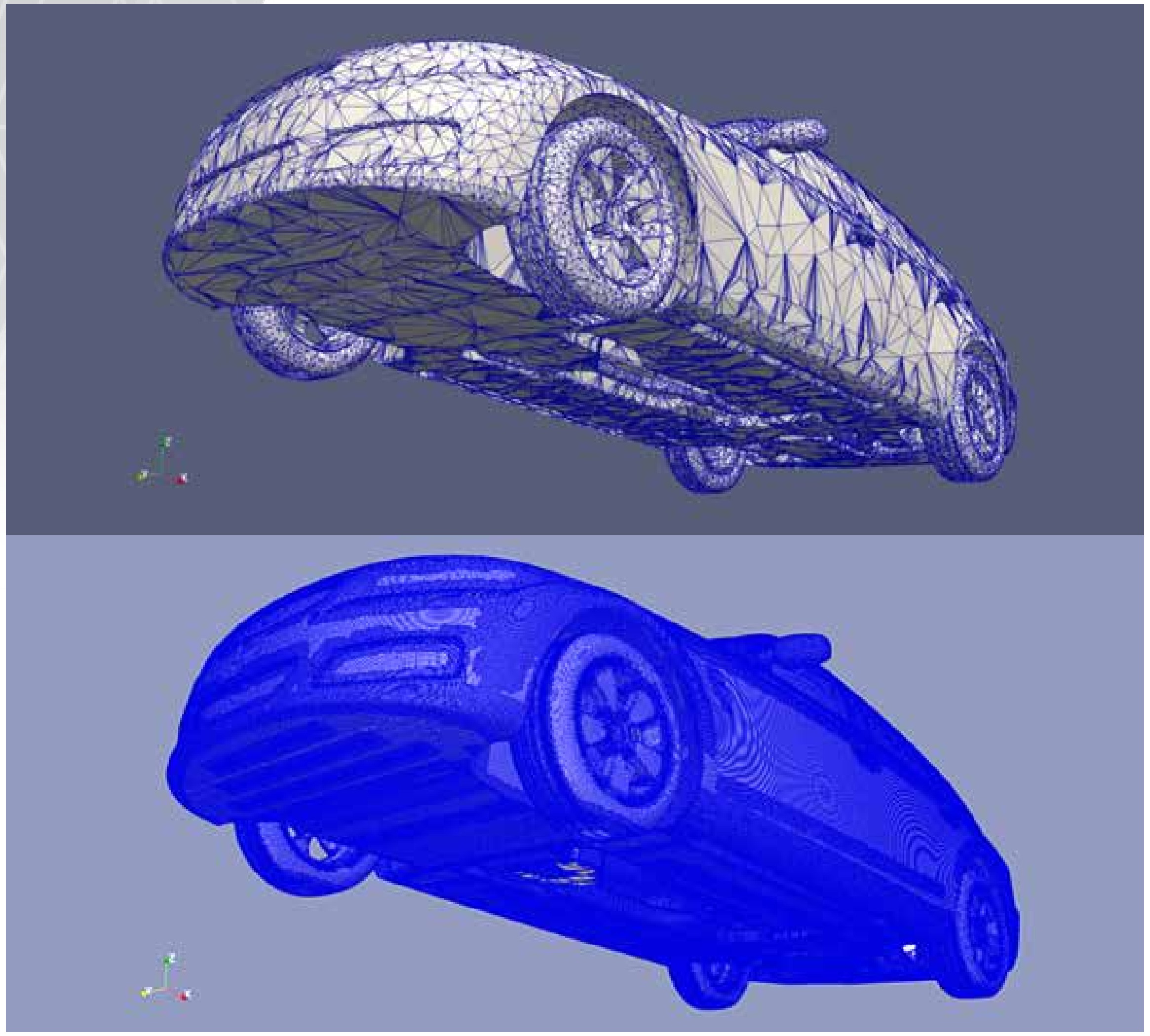
The generic architecture of the SimAI platform is based on a fusion of different techniques that combine multiple deep-learning neural networks. This type of architecture makes it possible to capture all the important scales of physics. The architecture is composed of a significant number of nonlinear layers, including multiple parameters and complex interactions between variables.

Instead of explicitly storing data points like pixel values in an image, the SimAI platform uses an implicit neural representation to learn a continuous function that can generate these data points. This means that SimAI software can take a set of points obtained from previous computations and generalize well to new geometries and freestream conditions.

Keeping with the example of automotive aerodynamic assessment, this capability enables a continuous representation of the surface and volume fields — for example, pressure and velocity. This makes it possible to request a prediction at a desired resolution. Additionally, global coefficients can be derived from the predicted fields as postprocessing.

In fact, one of the SimAI platform's strongest assets is its use of regularization techniques to prevent overfitting and improve generalization for new geometries. What does this mean? Basically, overfitting is when an AI model's predictions are too narrowly focused on its training data and included geometry, lacking any generalization or scope to learn or generalize new geometries. Regularization techniques are designed to reduce overfitting. The SimAI platform uses regularization techniques, including local methods that are embedded directly in the structure of the model and lead to a more stable and expressive model. It's the reason SimAI software can work with new geometries so quickly and easily.

Similarly, the SimAI platform uses an adequate representation of 3D shapes to describe arbitrary or irregular meshes with complex geometric variations that do not follow a specific distribution — for example, unparameterized geometries. To help quantify the uncertainty in the prediction, SimAI software uses a unique confidence score to calculate the distance from the nearest known geometry in a very high-dimensional space.



Regardless of a new geometry's mesh resolution, the SimAI platform will return the same confidence score because it adopts an underlying representation of the shape, therefore producing the same output.

EXPAND SIMULATION WITH THE SIMAI PLATFORM

While it's good to know the basics of SimAI software's technology behind the scenes, the best part about the platform is that you don't need to know any of this to use it. It is intuitive and designed for users without coding experience, AI/ML familiarity, or deep learning expertise.

By catering to a broad engineering audience, the SimAI platform empowers product engineers, designers, and nonexperts across all industries and engineering domains to easily leverage previous simulation and measurement data to assess the performance of new designs within minutes instead of hours.

LEARN MORE

Watch "Introducing Ansys SimAI: Cloud-Native Generative AI for Simulation."

ansys.com/webinars/introducing-ansys-simai-cae-platform-powered-by-generative-ai

From Chips to Ships:

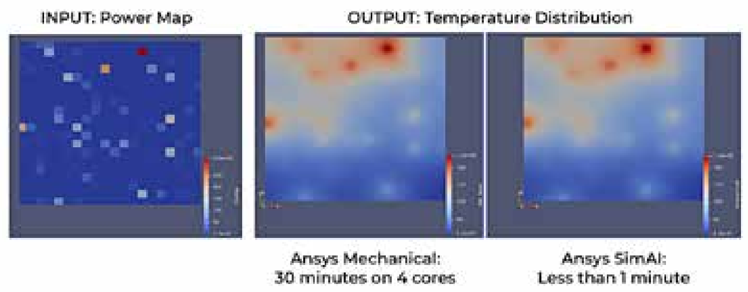
Optimize Design With the Ansys SimAI Platform

By **JENNIFER PROCARIO**, Senior Marketing Communications Writer, Ansys

Regardless of your occupation or industry, there's a modern-day unifying truth: Artificial intelligence (AI) has the potential to transform your workflow, if it hasn't already. Particularly for engineers, designers, and others who incorporate simulation into design and development to optimize products, AI presents a unique opportunity to enhance this optimization even further.

By combining the power of AI with cloud computing, Ansys' latest AI-based technology, the Ansys SimAI platform, enables you to reach greater levels of innovation at a rapid pace. With the SimAI physics-neutral and cloud-native platform, you can train an AI model with previously generated Ansys or non-Ansys data and assess the performance of a new design within minutes across a wide range of engineering domains, including electronics, structures, and fluids.

The software-as-a-service (SaaS) application combines the predictive accuracy of Ansys simulation with the speed of generative AI via the cloud. The combination boosts model performance by 10 to 100X across all design phases for computation-heavy projects. Let's explore how the SimAI application optimizes design from chips to ships in four different scenarios.



The SimAI platform optimizes chip thermal reliability assessment, including a consistent prediction of temperature maps 20 to 80X faster across design alterations than conventional simulation techniques.

"By integrating Ansys Mechanical Parametric Design Language (MAPDL) and the SimAI tool, the team was able to overcome hurdles, assess chip thermal reliability earlier in the design process, and speed up their workflow."

ENHANCE CHIP DESIGN

Chip design requires complex engineering that frequently involves nonlinear, unexpected behavior. Simulation analyses often provide critical insight into electrical, thermal, and structural characteristics to not only inform design but improve efficiency, accelerate development, and ensure verification. Still, for fast design iterations, even the most robust simulation workflow can feel like it's holding you back and is just too time-consuming.

That was the case for a recent team seeking a faster way to explore chip design. The team's existing approach slowed it down due to a dependence on domain discretization and the number of elements required in chip modeling. It also offered limited scalability. A slight change to the model or hiccup in the process significantly increased simulation time. In addition, it was difficult to efficiently represent and map spatial distribution uncertainty and variations in chip parameters, including die size and heat transfer coefficient (HTC) values.

The SimAI platform optimizes chip thermal reliability assessment, including a consistent prediction of temperature maps 20 to 80X faster across design alterations than conventional simulation techniques.

By integrating Ansys Mechanical Parametric Design Language (MAPDL) and the SimAI tool, the team was able to overcome hurdles, assess chip thermal reliability earlier in the design process, and speed up their workflow. MAPDL is a scripting language that interacts with the Ansys Mechanical finite element analysis (FEA) solver to automate simulation tasks and streamline workflows.

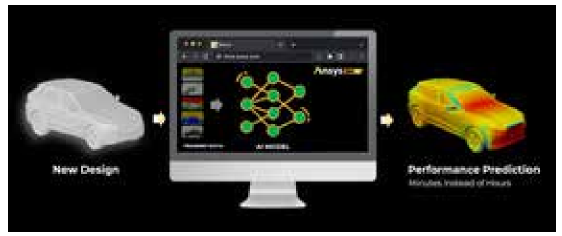
Essentially, the SimAI application is engaged in three simple steps: Upload data, train an AI model, and predict. Using simulation results from Mechanical software, the team created an AI model based on 2,250 diverse chip thermal simulation datasets. With this insight, the application swiftly predicted a temperature distribution map within one minute. The maximal temperature difference between ground truth and prediction is less than 0.5%. The AI prediction accurately pinpointed the thermal-critical locations.

Key benefits of the SimAI tool for chip design and thermal reliability assessment include:

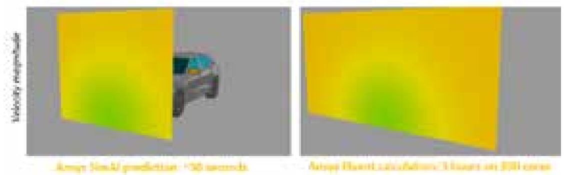
- Quick evaluation of an on-chip thermal solution that is approximately 20X faster than conventional simulation techniques, as well as expedited analyses of various system scenarios.
- Accelerated and consistent prediction of temperature maps across design alterations, approximately 20 to 80X faster.
- Elimination of tedious adaptive volume meshing tasks.
- Expedited development life cycle for next-generation chip design.

REV UP AUTOMOTIVE AERODYNAMICS

As environmental concerns grow, car manufacturers must meet more requirements to reduce carbon dioxide (CO_2) emissions. Many reduction plans and guidelines, such as the Worldwide Harmonized Light Vehicles Test Procedure (WLTP), require automotive manufacturers to assess the aerodynamics of design variants in new car models.



The Ansys SimAI application boosts the prediction of model performance by 10 to 100X across all design phases — delivering simulation results in minutes, not hours.



SimAI platform capabilities speed up automotive aerodynamic design by up to 10 to 100X faster.

The AI model provides a confidence level with each prediction. As shown in the graph, the confidence level increases with the number of training samples.

Unfortunately, wind tunnel tests are a slow and costly solution, and speeding up development time to advance the next generation of electric cars is important. Faster simulated predictions of aerodynamic performance are crucial to meeting requirements, staying competitive, and keeping costs down.

The SimAI platform was used in tandem with Ansys Fluent computational fluid dynamics (CFD) software to assess the aerodynamic performance of a sport utility vehicle (SUV). Using approximately 50 CFD results, the team created an AI model that included car exterior shape variations and topological changes, such as a rear mirror, ski rack, and spoiler. With the support of the AI-based application, predictions for new SUV geometry took less than one minute. In addition, the application's drag error results compared to CFD results showed less than a 0.5% difference. Accurate predictions were also generated for flow characteristics, including skin friction field and wake topology.

The SimAI capabilities speed up automotive aerodynamic design by up to 10 to 100X.

The top benefits of the SimAI platform for automotive aerodynamic assessment include:

- Increased design alternatives assessment — 20X more compared with traditional simulation methods — and quicker design optimization.
- Accelerated and consistent prediction of aerodynamic performance across design changes that is 10 to 100X faster, even when the geometry structure is inconsistent, by leveraging CFD simulations used in earlier design phases or previous car generations.
- A quicker design process and reduced costs by "shifting simulation left" to incorporate simulation earlier in the process. This enables designers to incorporate fast and meaningful aerodynamic predictions throughout all design stages.

BOOST ENGINE BRACKETS

In aerospace applications, structural analysis can be just as important as aerodynamic assessment, even for the smallest parts. Consider jet engine brackets, also known as loading brackets. They may seem minor compared with the engine itself, but they are essential components because they support the weight of the engine.

Consequently, developing new jet engine bracket designs that meet weight and structural requirements, as well as constraints is a challenging process. It's helpful to reference existing designs, drawing knowledge from previous projects. The SimAI application helps with this workflow too.

Using a multitool workflow, including the capabilities of Ansys Discovery 3D design modeling and Ansys optiSLang process integration and design optimization software, one team built an AI model using about 250 training samples, which included different and topologically diverse bracket designs. With insight from past simulations, the application predicted the behavior of a new shape in less than a few seconds. For future projects, the same AI model can be retrained using different designs to capture new insights.

Discovery 3D modeling software can accurately and rapidly simulate any design on the first attempt without training. The SimAI application can provide very rapid predictions within an already simulated design space to aid in optimization, sizing, and selection for applied scenarios. Leveraging both the Discovery and SimAI platforms, engineers can generate accurate data, enrich the training process, and produce pervasive insights into future product behavior.

The primary benefits of the SimAI application for jet engine bracket design include:

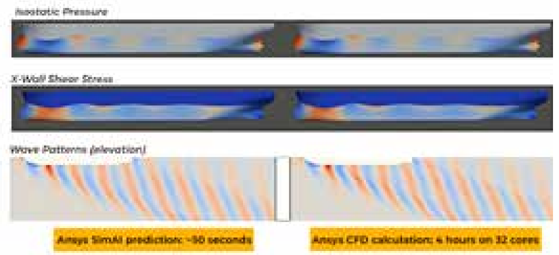
- Zero scraps and reduced material usage. Past designs are valuable, as even a failed design is a source of knowledge.
- Reduced workflow of up to 90%, with the ability to shift effortlessly between computer-aided design (CAD) and multiphysics simulation.
- Accessibility for 100% of the team, including people who are not specialists. Supported by AI guidance, team members no longer need a deep knowledge of physics.

The AI model provides a higher confidence level with each prediction.

INFORM AND ACCELERATE SHIP HULL DESIGN

Similar to the automotive industry, shipping companies are being encouraged to reduce emissions. One example is the push from the International Maritime Organization (IMO) to reduce emissions from international shipping. To achieve this, one method is to improve ship resistance by optimizing the hull form, which directly translates into energy efficiency and fuel savings. However, fast and efficient simulations are needed to evaluate several hull designs at once with many different variables.

Employing the SimAI tool, engineers created an AI model using 288 CFD results that included hull shape variations and operational conditions, such as draft and boat speed. In less than one minute, the tool predicted new and optimized hull geometry. In addition, the tool's resistance error results were less than 5% compared to the CFD simulation results and the wave pattern prediction was fully accurate.



By combining traditional simulation methods like computational fluid dynamics (CFD) with the SimAI tool, you can predict new geometry for ship hull design in less than a minute.

The main benefits of the SimAI tool in ship hull design include:

- Accelerated performance assessment of new hull designs in a few minutes instead of days.
- Informed decision making in the early stages of design.
- Time savings for value-added tasks like design exploration, which creates more time to innovate.

By combining traditional simulation methods with the SimAI tool, you can predict new geometry for ship hull design in less than a minute.

EMBRACE AI-POWERED SIMULATION

AI and machine learning (ML) methods are being applied to design and development in a range of industries, from semiconductors and aerospace to automotive and maritime. By integrating AI/ML with simulation and computer-aided engineering (CAE), teams from diverse fields can solve multiphysics and engineering challenges more quickly and accurately, enhancing design exploration and optimization. As illustrated in the previous scenarios, this AI/ML-powered optimization leads to more efficiency, cost savings, and, ultimately, better products.

The SimAI application enables both engineers and designers to leverage their previous simulation and measurement data to train and build a surrogate AI model. By using this AI model, they accelerate the design process with assessments that take minutes, not hours or days.

LEARN MORE

Register for the webinar series "Accelerate Your Simulation with AI."

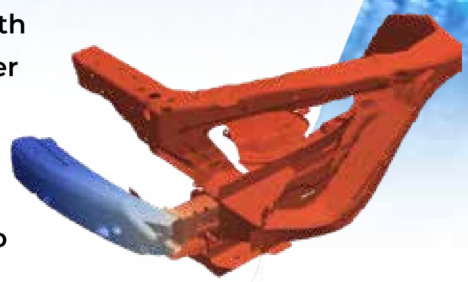
ansys.com/events/accelerate-your-simulation-webinar-series

OPTIMIZE AUTOMOTIVE SAFETY THROUGH AI-POWERED DESIGN

By **SRIKANTH ADYA**,
Lead Application Engineer,
Ansys

Designing safety into vehicles isn't just good business or a regulatory requirement for the automotive industry: It's a moral imperative. Accidents will happen. When they do, vehicle design can be the difference between life and death for drivers, passengers, and pedestrians. Safer designs also mitigate the economic burdens of crashes on individuals, healthcare systems, and society.

In essence, a lot rides on the industry's ability to make every vehicle as safe as possible.



Ansys engineers recently used the Ansys SimAI cloud-enabled generative AI platform to speed up simulation of a car bumper deformation during a crash.

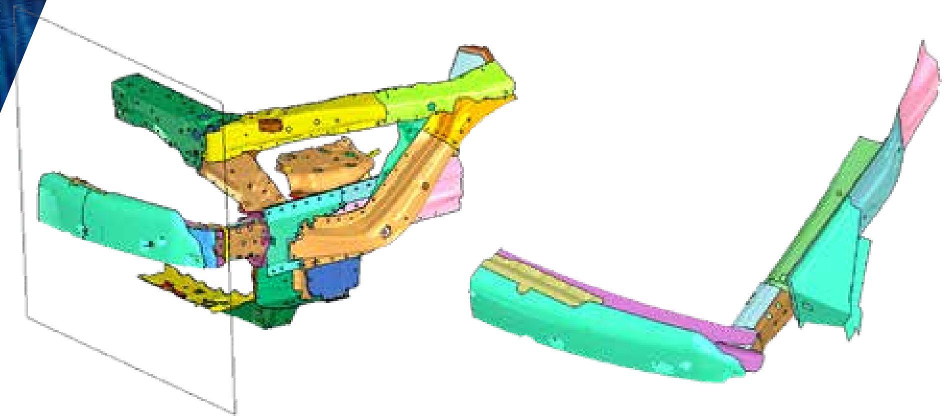
"Speeding up the simulation process enables more design exploration, letting automotive engineers try out additional ideas and innovations and focus on promising designs earlier in the process."

While "safety at any cost" is an ideal, automotive engineers face countervailing pressures, mostly in the form of reduced developmental timetables and budgetary limitations. As a result, engineers may be forced to prioritize safety aspects thought to most reduce accident severity or to seek more cost-friendly strategies, such as the phased implementation of safety features.

To balance safety and time to market, computer-aided engineering (CAE) has become an integral part of the vehicle design process. Virtual analysis enables designers to reliably assess a vehicle's crash and safety performance while reducing costly physical testing.

Ansys application engineers recently used the Ansys SimAI cloud-enabled generative artificial intelligence (AI) platform to quickly predict how a car bumper would deform during a high-speed, front-end car crash.

Their efforts demonstrated that the software, which has proven effective in predicting how fluids move, especially in constant motion simulated by computational fluid dynamics (CFD) solvers, also can handle other physics, such as nonlinear, transient structural simulations.



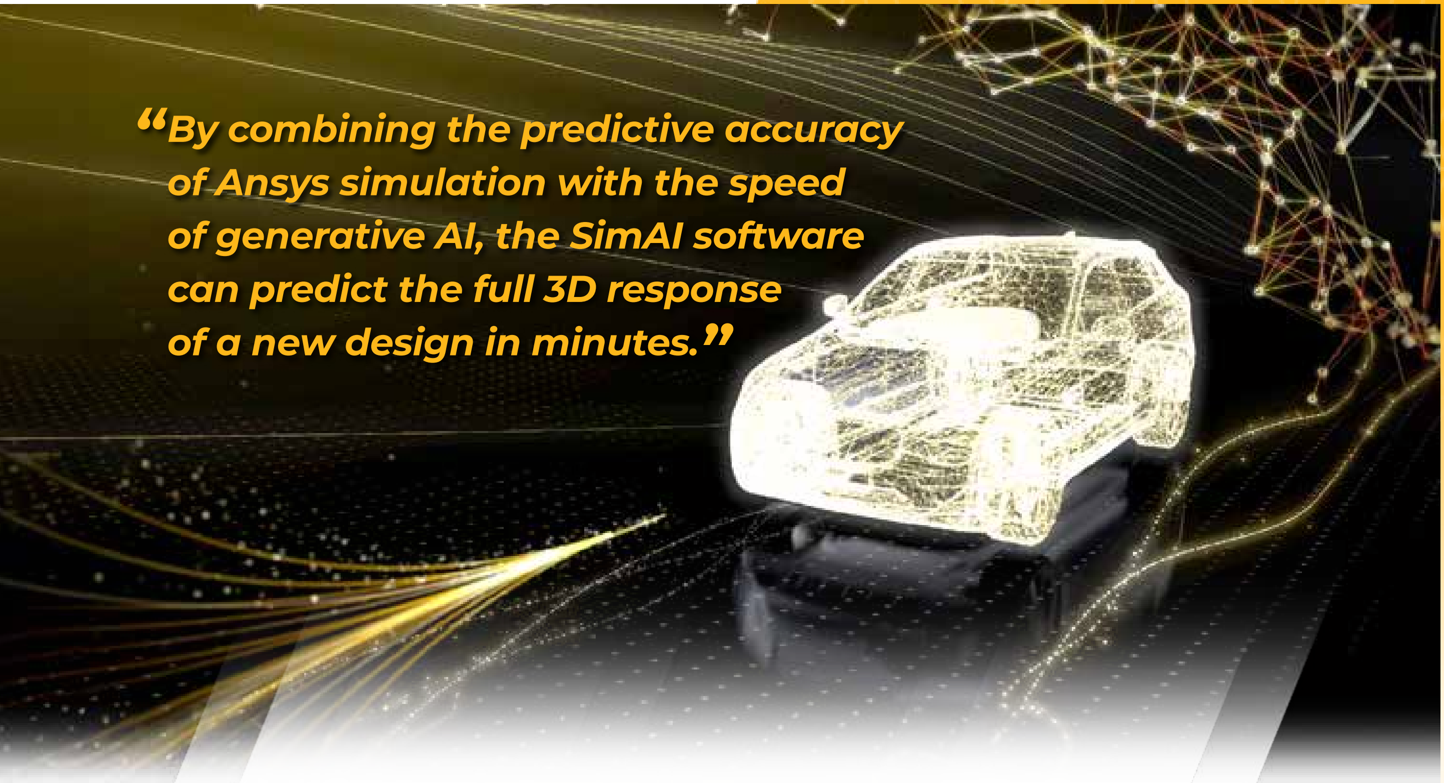
Part thickness of the highlighted parts varied in this bumper crush model.

ACCURACY AND SPEED

As vehicles have become more complex, the digital models used in their design have grown in complexity as well. Models are also larger than ever, requiring more compute resources and substantially longer simulation times.

Today, it's not uncommon to see full-vehicle models with 40-million to 50-million elements, requiring 25 to 30 hours to solve a complete crash event on a modern-day high-performance compute cluster of 700 to 1,000 CPUs. That's on top of the months engineers already have put in clearing the new computer-aided design (CAD) — removing intersections (overlaps) and penetrations (gaps) that remain after parts and subsystems from legacy programs are reused, a common practice during the early concept phase — meshing the CAD, adding all the necessary connections and materials, debugging for any errors, and establishing a baseline performance.

Even then, CAE models often fail to keep up with all the design changes, unless engineers have clearly defined them and created parameters for each key aspect of the model being changed. Because parameterization is difficult and time-consuming, especially for complex design



> ***"By combining the predictive accuracy of Ansys simulation with the speed of generative AI, the SimAI software can predict the full 3D response of a new design in minutes."***

changes, only a few designs are ever evaluated thoroughly.

That's where the power of the SimAI platform comes in. By combining the predictive accuracy of Ansys simulation with the speed of generative AI, the SimAI product can predict the full 3D response of a new design in minutes. For complex, computation-heavy projects, it can predict outputs 10 to 100X faster than a finite element solver.

Speeding up the simulation process enables more design exploration, letting automotive engineers try out additional ideas and innovations and focus on promising designs earlier in the process.

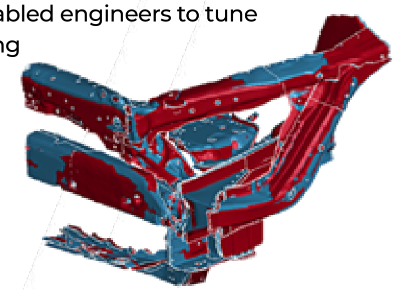
TRAINING DAY

SimAI technology is physics-agnostic, cloud-based software that can be trained to work with fluids, structures, electromagnetics, and more.

To show how it could predict a transient event like a car crash, when everything is rapidly and constantly changing, Ansys application engineers started with a "sled" — a simplified vehicle model in Ansys LS-DYNA nonlinear dynamics structural simulation software. In this case, the sled simulated the bumper impacting a rigid wall at 15.6 meters (16.4 yards) per second.

To produce enough data points to accurately predict the transient response, Ansys engineers introduced design variations. Changing the thickness of seven parts within minimum and maximum boundaries generated 98 different designs, each with 21 states — crushed, bent, folded, and so on — for 2,058 training data points.

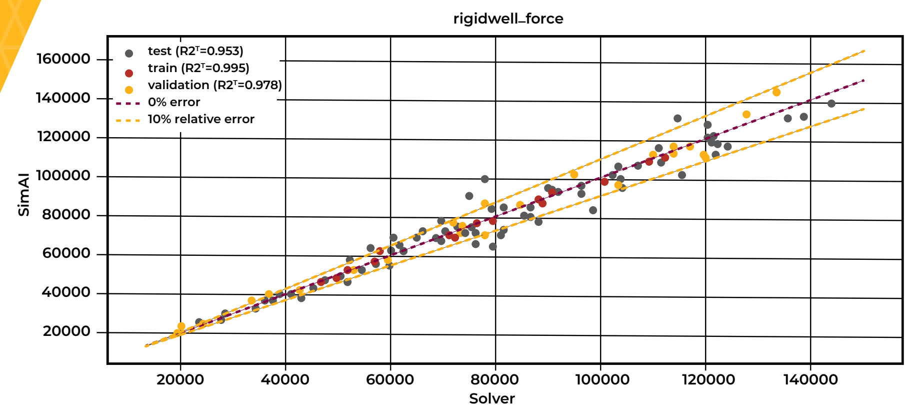
Ansys engineers then uploaded the data to the SimAI platform, where it was automatically divided into training, validation, and test sets. The validation set enabled engineers to tune the model's underlying structure to improve its performance while the test set determined how well the model could handle unfamiliar situations.



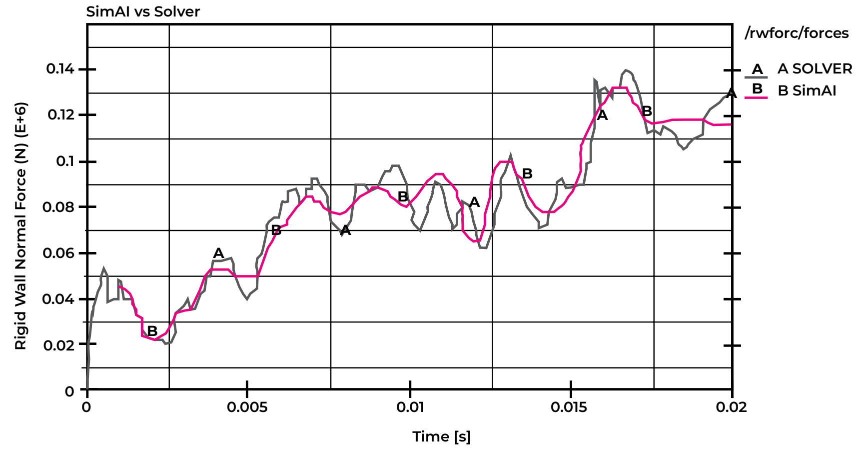
Comparison of the deformed shape between the solver and the SimAI platform

Configuring the model came next. That included determining the:

- Boundary (or crash) conditions.
- Inputs — in this case, different points of time during the crash and the thickness of several parts.
- Outputs, rigid wall force (or how much force the wall would experience), and nodal displacement (how far a point marked on the bumper would move up, down, to the left, or to the right).
- Precision level, which directly affects the time required to train the model. "Precise" models take up to two days to train while "very precise" models typically require a week. In this case, the model took about 21 hours to train.



An Ansys SimAI trend plot for the global coefficient rigidwall_force. The SimAI predictions mostly lined up, but indicated where the AI's training could be improved even more.



A comparison of rigidwall_force prediction between the solver and the SimAI platform shows good correlation and was much faster than the traditional solver.

Ansys engineers assessed the accuracy of SimAI software by comparing how well it calculated the force exerted by the wall during the crash with the results of a traditional solver.

LINED UP

Plotting the predictions made by the solver and the SimAI product revealed a slight discrepancy. While both predicted the bumper's shape and wall force at the same time steps, the points were not perfectly matched. The AI's hypothetical points didn't land exactly on the same straight, diagonal line of the graph as the solver's.

This was actually a good thing.

A perfect match isn't always the best outcome. It might mean that the AI overfitted the training data — that the AI just memorized the specific examples it was trained on, not the underlying rules. An overfitted AI wouldn't be good at predicting entirely new designs that it hadn't seen before.

However, because the SimAI software predictions mostly lined up well with the solver's predictions, it suggested that the SimAI model was accurate without overfitting. The plot also indicated areas where the AI's training could be improved for even better results.

SAFETY, FASTER

In the end, SimAI technology proved to be orders of magnitude faster than the traditional solver. It predicted the force on the wall in less than a second and the entire movement of the bumper in about 10 seconds.

Speed isn't the only advantage over traditional simulation, however. Because the SimAI solution can predict what would happen at every point during a crash (within the limits of the data it was trained on), it provided a more detailed picture of how the bumper deformed — including intermediate states, not just the outcome.

This means it's possible for automotive engineers to have a single, accurate model for transient, nonlinear events, leading to safer cars that make it to the market faster and with less strain on development budgets.

LEARN MORE

Download the white paper.

ansys.com/resource-center/white-paper/simai-predicts-transient-vehicle-crash

Maximize Simulations With Secure, Cloud-native AI

By **DON FERGUSON**, Ansys Fellow, and **JENNIFER PROCARIO**, Senior Marketing Communications Writer, Ansys

Across industries, product development teams are constantly challenged to produce better designs at a faster pace to meet consumer demands. For this reason, running high-performance computing (HPC) simulations in the cloud has become a desirable solution for getting optimal designs to market on schedule. At the same time, emerging artificial intelligence (AI) technologies have presented another opportunity to accelerate production and enhance simulation workflows.

By combining the power of AI with cloud computing on Amazon Web Services (AWS), Ansys' latest AI-based technology, the Ansys SimAI cloud-enabled generative AI platform, enables organizations to reach even greater levels of innovation at a rapid pace. With the SimAI platform, you can train an AI model using previously generated data from Ansys products or other sources and assess the performance of a new design in minutes, increasing the potential for your projects, products, and workflows.

Still, does AI in the cloud give you pause? Do you worry about data security? It's a fair concern, but the reality is that with robust cybersecurity systems and protocols in place, your data is often more secure in the cloud than on local machines or on-premises servers. In the same way, Ansys customers can trust that their SimAI platform data is secure, from initial upload throughout model building and prediction runs. Let's explore the benefits of a cloud-native platform and the stringent security measures in place with the SimAI platform.

USE AWS TO ENHANCE AI

The SimAI platform is a physics-agnostic software as a service (SaaS) application that combines the predictive accuracy of Ansys simulation with the speed of generative AI via the cloud. In fact, the combination boosts product development performance by 10 to 100 times across all design phases for computation-heavy projects. You can rapidly test design alternatives without the constraints of traditional solvers, which can include parametrization challenges, complex user interfaces, extensive learning curves, and long wait times for results.

The SimAI platform is intuitive and easy to use. It is designed for users without coding experience or deep learning expertise. This makes AI-powered simulation more accessible to nonexperts. But what are the advantages of its cloud-native infrastructure?

By removing hardware barriers, cloud-enabled platforms increase simulation throughput, which accelerates data generation and enables you to run deep-learning inference with ease. As the term suggests, deep-learning inference is the stage when an AI model infers what was learned during training. On-premises platforms, in contrast, slow down the AI pipeline orchestration, which includes data conversion, model adaptation, training, and inference serving.

Similarly, the cloud offers greater storage, portability, and scalability than on-premises platforms. In addition, cloud computing encourages collaborative workflows with easier, shared access to organizational data. In short, cloud benefits are especially helpful when training AI models.

However, in some organizations, cloud migration can pose challenges, including adjusting to new workflows, financing cloud technology, and hesitation for noncloud users.

The SimAI platform provides a turnkey solution with a more secure infrastructure. First, cloud computing is inherent to the platform and included automatically. This reduces the time, cost, and adjustment of typical cloud implementation. Here are the typical steps for using the platform:

- **Data upload:** Upload your training data to the SimAI platform, where it is stored on remote servers to ensure smooth integration.
- **Model training:** Select variables of interest, set your desired wait time, launch the training process in the cloud, and receive notifications upon completion.
- **Prediction:** Upload your 3D geometry, run the prediction with a single click, and access results in minutes, including volume, surface, evolution curves, and coefficients.

The Ansys SimAI cloud-enabled generative AI platform can significantly speed up simulation predictions, especially computation-heavy projects.

The SimAI platform is architected on AWS by keeping in account the security and architecture best practices from the AWS Well Architected (WA) Framework. The AWS WA Framework describes key concepts, design principles, and architectural best practices for designing and running workloads in the cloud. It is based on six pillars: operational excellence, security, reliability, performance efficiency, cost optimization, and sustainability.

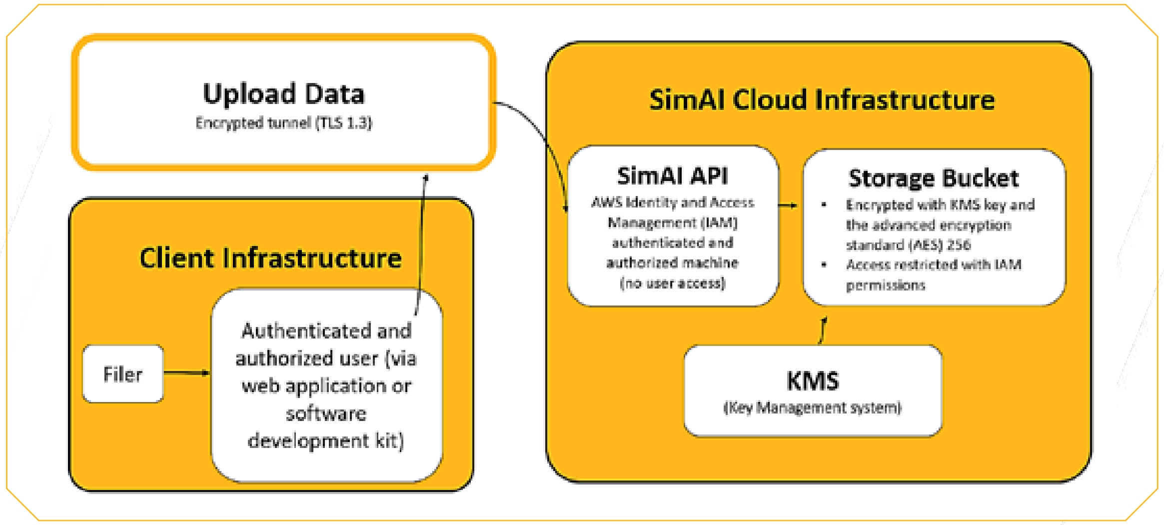
SECURELY TRAIN AI

To get started on the SimAI platform, simply select the files that you wish to use and upload them to the platform — either by using a web application directly through your browser or by using a Python software development kit (PySimAI SDK) compatible with Python version 3.9 or higher. PySimAI is publicly available with documentation. Your data is securely stored in an encrypted data bucket in Amazon Simple Storage Service (S3) and transferred through an encryption tunnel protected by transport layer security (TLS) 1.3 — the most recent and strongest version of the TLS security protocol.

Once your data is uploaded to the SimAI platform, you can configure a model and initiate training with confidence that your data remains secure throughout all stages of the workflow. The architecture performing training and inference is hosted in the AWS Europe region (eu-west-1, Ireland), using the best security practices.

KNOW YOUR INFRASTRUCTURE

The SimAI platform is multitenant with logical separation through tenant- and user-based ownership. In other words, customers have access only to their own data. In a similar



SimAI data passes through multiple layers of security — from the client to the cloud — helping to safeguard data more effectively than most organizations could do locally.

manner, simulations are run on tenant-exclusive, ephemeral-allocated instances and all read objects are copied, used, and then destroyed.

As another layer of security, the SimAI platform infrastructure is managed using an infrastructure as code (IAC) model on Kubernetes (k8s) clusters using Amazon Elastic Kubernetes Service (EKS). What does this mean? Put simply, k8s clusters are groups of nodes that run containerized applications. This enables multiple applications to run securely in a more efficient, scalable way. As a result, the benefits of the IAC model are maximized.

In addition, Ansys' internal services are secured by a firewall and virtual private network (VPN) while client-accessible web applications and application programming interface (API) endpoints use an industry-grade authentication and authorization service. Accordingly, SimAI platform user accounts are managed through this service, which verifies access to the platform using a customer identity provider (IdP). For example, the platform may delegate authentication to a client's IdP to ensure that the client controls who has access to the service. Data transfer is possible only after authentication and authorization.

The AI training and inference on Amazon EC2 use the robust, secure foundation provided by the AWS Nitro System. It includes a highly secure hypervisor designed to deliver strong resource isolation and performance that is nearly indistinguishable from a bare metal server. Postprocessing tasks on Amazon EC2 also benefit from the enhanced security and efficiency of the Nitro System, ensuring that data integrity and processing speeds meet the rigorous demands of modern AI applications.

Also, your storage — that is, your Amazon S3 data bucket — is protected with AWS Key Management Service (KMS) encryption owned only by ephemeral compute instances, which use the advanced encryption standard (AES) 256. AES-256 is considered the strongest encryption method available, requiring a 256-bit key. Additionally, access is filtered and restricted by AWS Identity and Access Management (IAM) permissions, including guardrails and access controls.

EMBRACE AI ON AWS

Cybersecurity systems and protocols not only protect data but ease user concern about cloud computing and build confidence in cloud-native solutions. Leading cloud providers, such as AWS, have superior cybersecurity and encryption resources to safeguard data more effectively than most organizations can manage alone.

By using AI in the cloud, engineers and designers can amplify the power of simulation, transcend previous compute limitations, gain relief from AI pipeline IT complexity, and maintain data security.

LEARN MORE

"Understanding Data Security for Ansys Cloud Workloads"

ansys.com/blog/understanding-data-security-ansys-cloud-workloads

How To Deploy Your Digital Twin With AI

By **CHRISTOPHE PETRE**, Manager and Product Specialist, Ansys

Ansys has introduced the Ansys TwinAI digital twin solution, which integrates the accuracy of physics models with insights from real-world data, powered by artificial intelligence and machine learning (AI/ML) techniques. TwinAI software delivers unmatched precision and speed.

This addition to the Ansys Digital Twin offering allows the creation, validation, and deployment of a digital twin model in an environment that is closer to what can be found in cloud infrastructures, with respect to simulation engine and operating system data streams. It benefits you in three ways:

1. Creating digital twins with reduced-order models (ROMs) or functional mock-up units (FMUs), possibly extended with Python code.
2. Enhancing the accuracy of twins with hybrid analytics — for example, calibrating existing twins with new data coming from the field or filling the gap between prediction and measurement using ML-based models.
3. Simplifying and streamlining the process for cloud and/or edge deployment.

CHALLENGES IN DIGITAL TWIN DEPLOYMENT

When deploying digital twins, a few challenges are commonly encountered.

First, digital twin creation and validation, which consist of creating a sufficiently accurate representation of the asset and effects that we want to track with the twin, typically happen in a modeling environment that is not necessarily consistent with the environment used for deploying and executing the twin. These differences might come from multiple aspects, such as different mechanisms to feed the input data used by the twin, different solvers used to simulate the models, or different operating systems. TwinAI software provides you with a graphical environment to import the generated twin, cross-compile the models when required to execute on different operating systems,

"TwinAI software provides you with a graphical environment to import the generated twin, cross-compile the models when required to execute on different operating systems, and test and validate twin simulation to ensure that its execution performance and accuracy are as expected before deploying."

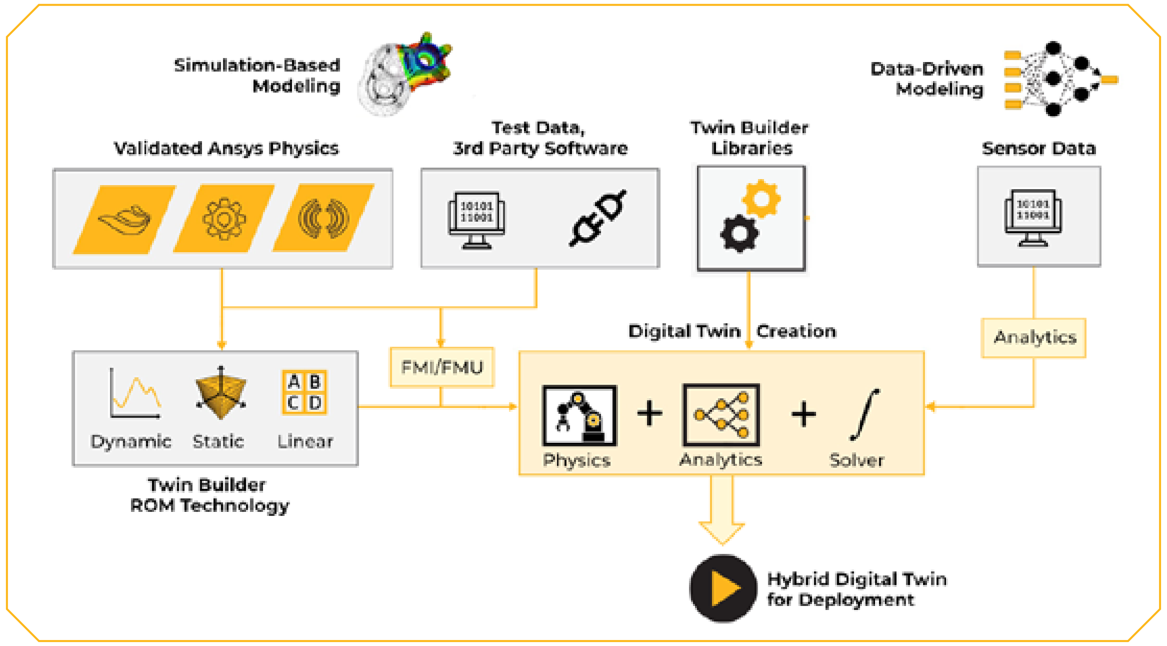
and test and validate twin simulation to ensure that its execution performance and accuracy are as expected before deploying.

Creating a performant, accurate twin model is one step, but deploying a digital twin requires additional considerations. In particular, how can the twin execution be integrated in a larger deployment workflow connected to other applications — for example, to pass the acquired data from the connected assets to the twin, to collect prediction from the twin in the form of time series and/or 2D and 3D field data visualization, and to use these predictions to derive key performance indicators that are relevant to the consumers of the twin? For those aspects, TwinAI software has capabilities to package twin models in the form of portable, scalable runtime applications, with direct application programming interfaces (APIs) available to manipulate and execute the twins. It also makes it possible to generate scaffolding deployment application code, which the user can directly use and extend to integrate the twins in the deployment environment.

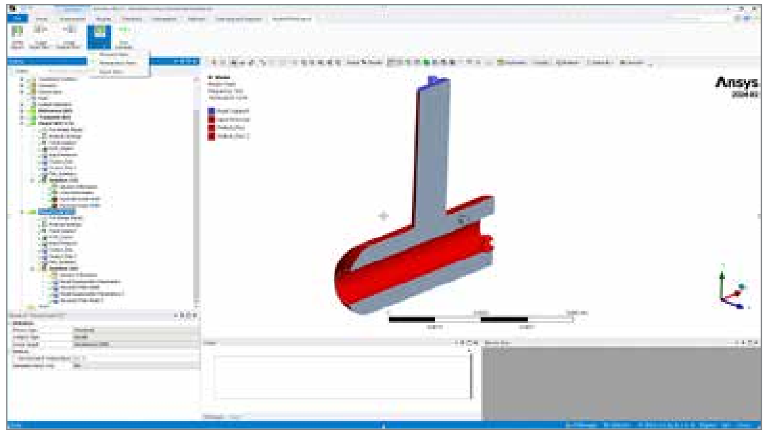
One Ansys PyAnsys package, the Ansys PyTwin offering, provides access to a Python version of these APIs that you can integrate with any Python-based workflow. Beyond Python and web application scaffolding code, there are options to deliver a containerized version of the twin application, coming with a set of REST APIs exposed, which typically is better suited for cloud and Internet-of-Things applications integration. The container has the advantage of packaging not only the twin application but all the dependencies required to properly integrate and execute it so it can be deployed easily at scale in the cloud.

HOW TO SUCCESSFULLY DEPLOY YOUR DIGITAL TWINS

Several examples can be used to illustrate digital twin deployments and their benefits. For instance, we have been working with a leading flow equipment manufacturer, which wanted to provide a monitoring solution to its customer, a public utility. However, diagnostic sensors could not be added due to cost and feasibility. Using Ansys products and hybrid digital twins, the equipment manufacturer has built physics-accurate representations of the utility's flow networks, with prediction by virtual sensors as accurate as actual flow rates.



Hybrid digital twin solution architecture



Reduced-order models (ROMs) are simplifications of complex models that capture the behavior of source models so engineers and designers can quickly study a system's dominant effects using minimal computational resources.

Another example can be found in heavy energy industries like steel or glass manufacturing, in which installation of physical sensors generally is not feasible due to high temperatures and harsh conditions. Being able to create digital twins from physics-based models and ROMs enables you to get accurate, fast predictions of various quantities, which helps control manufacturing processes and maximize production quality.

Finally, we have had the opportunity to collaborate with global automotive suppliers to demonstrate the possibility of deploying detailed, simulation-based digital twin models of electric vehicle systems so their ranges can be accurately predicted based on user-selected comfort-levels.

TwinAI software capabilities are key for all these different use cases to help create digital twin models and extend them with hybrid analytics capabilities, as well as streamlining the deployment process through scaffolding code and container generation.

FACILITATING COLLABORATION FOR SEAMLESS DEPLOYMENT

Digital twin creation and deployment activities involve several steps that typically are handled by different people and teams. On one side are the modeling creation and validation steps, which involve application modeling and simulation experts who look at things like model and prediction accuracy, robustness, and execution performance. On the other hand, deployment activities involve people closer to information technology and operations, who are more concerned about APIs and application integration and deployment.

As explained earlier, it is very important to ensure that the models created and validated by the application experts can be reused in a consistent way when deployed in operations. TwinAI software bridges the gap between the sides, helping you to bring their models and digital twins together and validating the models and twins in an environment that uses the same technologies as the environments used to deploy and execute twins elsewhere. TwinAI software generates self-contained, portable applications that can be integrated with provided APIs.

FUTURE DEVELOPMENTS

We are considering multiple areas for future developments and will continue to support your digital twin creation and deployment journey.

One important upcoming benefit is to bring in more and more digital twin creation capabilities from a modeling perspective to streamline the full process of twin creation and execution. As an example, starting with the Ansys 2024 R2 product release, we are launching ROM capabilities in TwinAI software so that users easily can build and deploy twins based on ROMs using a single environment.

Another important area is to keep adding capabilities related to hybrid digital twins and AI/ML so our physics-based twins can be more accurate with data and be updated when deployed in the field. We also will continue supporting our IoT partners and deployment ecosystem by providing more deployment and API-related capabilities to facilitate integration and overall deployment.

LEARN MORE

See how Ansys TwinAI software enhances the accuracy of digital twins with hybrid analytics and simplifies deployment

ansys.com/products/digital-twin/ansys-twinai

Exploring Hybrid Digital Twins With Ansys Experts

You've likely heard of digital twins: "virtual representations of real-world entities and processes, synchronized at a specified frequency and fidelity," according to the Digital Twin Consortium. But what are hybrid digital twins, and how do you create them? Essentially, hybrid digital twins increase the value of digital twins by blending data and physics. Through artificial intelligence/machine learning (AI/ML) integration, you can create them using the Ansys Twin Builder simulation-based digital twin platform and Ansys TwinAI AI-powered digital twin software.

Asmaa Lapouge, a senior product marketing manager at Ansys, discusses hybrid digital twins on Ansys' interview series "The Twin Talks" (https://ansys.me/twintalks). Recently, she sat down with two Ansys experts to get an overview of hybrid digital twins, including common applications and use cases. Here are some highlights and excerpts from those interviews.

DISCUSSING DIGITAL TWINS

Q: Can you provide a brief overview of what hybrid digital twins are and how they differ from a traditional digital twin?

MANZOOR TIWANA,
lead product manager at Ansys:

The traditional digital twin, or traditional approach for these models, has been that either it's a pure simulation — for example, in Ansys' case we are very strong in physics and in simulation, so we have this model based on simulation and physics — and a lot of other people had it based on ML techniques like AI/ML analytics techniques. A hybrid digital twin allows you to combine the best of both worlds from simulation and physics and from AI/ML.

Q: Are there specific industries or applications where hybrid digital twins have shown significant impacts, such as optimizing operations, improving decision making, or enhancing overall performance?

MT: At Ansys, we have customers across almost all industries. We have customers from aerospace, automotive, manufacturing, healthcare, energy, and oil and gas, to name a few. And the things these customers are doing, or the challenge they are facing, is how they can represent these assets or processes in a very accurate way, at the same time, making it very quick and scalable.

We have a customer who is using this hybrid digital twin in flow networks with systems consisting of palms, valves, piping — vessels that help them predict the failure in the components and then help them optimize the operation for energy efficiency. So, that could be a goal to optimize the operation and to predict a failure if there is some. We also have published a paper in IEEE with that use case that demonstrates that with a pure analytics approach, they were getting an accuracy of about 80%. And this could be different from case to case, but in that case they had an accuracy of around 80%, and they used the simulation and were getting an accuracy of around 90%. But when they combined both things, they had an accuracy of 98%. ... And then we have a customer who is using this technology to predict the emissions from their engines, and they're using this hybrid approach to limit how many simulations they have to perform. They can combine the simulation and the real data to get these results very quickly so they don't have to do that many simulations to get to a very higher accuracy, but they can combine these two to get there very quickly.

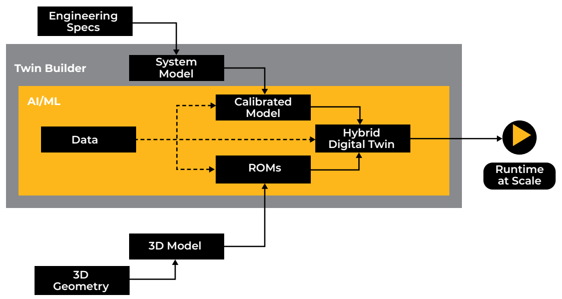
Q: And from an Ansys perspective, can you tell us how does the company integrate hybrid digital twins into its solutions and the role of simulation in analytics in creating a holistic representation of physical assets?

MT: Twin Builder software is our product that helps build the physics-based digital twin, and then we have the TwinAI platform that performs this AI/ML integration. The TwinAI platform allows the engineers to blend the data and physics to create this advanced digital twin. So, users can also perform things like parameter calibration and fusion to create their model, which combines both the physics and the sensor data into their models.

Q: In what ways are digital twins used during product stages? What are the use cases?

VITOR LOPES,
senior product sales manager at Ansys:

The interesting aspect about digital twins, like any good technology, is that it's very, very flexible and applicable to a variety of scenarios. So, if you're talking specifically about operations or environments where you already have an asset and you're connecting it to twins, you may be using this — one of my favorites — as a virtual sensor to take what you can measure to then measure what you cannot measure as the asset is being operated. And you can take this into different scenarios. You may use it initially for monitoring. You may use it for control. You may use it for optimization. You may then even use it to predict behavior like, "Hey, when are assets going to fail so that I can service it ahead of time and minimize costs associated with unplanned downtime?" That's the operational world.



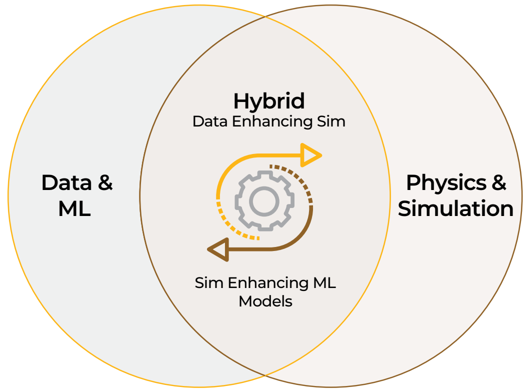
There are two approaches when building a hybrid digital twin: top-down and bottom-up.

Now, imagine you are in a scenario where you have a project designed. You want to bring it to the real world, but you're still at that commissioning stage. You may use it more as an offline twin to minimize the commissioning times and risks. Because before the product is even built, you can start understanding, "Hey, how am I going to use this product? In which conditions that may happen in the field (or) that may happen on manufacturing lines?" There are all sorts of different use cases.

And, finally, as early as product development, you may just have a digital prototype. At that stage, the asset doesn't really exist, you're still designing it, but you're using the models to be able to validate designs, to optimize designs, and to understand better ways to be running in different performances. It's the concept of virtual prototyping, virtual validation, and deciding where to place sensors.

Q: Can you share some specific examples to illustrate the impact of digital twins in the various sectors?

VL: Industries such as energy, metals, and mining — industries where they have very harsh conditions, but at the same time they need a very tight control of operations. They may be using these twins to understand specific points in the assets or the systems, the so-called virtual sensors, where operations were happening before in a more blind way. You don't really know what's going on, and until you actually connect the twins, you now then have the ability



Hybrid digital twins combine data, physics, and artificial intelligence/machine learning (AI/ML) techniques to provide the most accurate representation of an asset.

to start seeing, "Oh, our temperatures are too high here, pressures are too low," things like that, and that may drive your operation to increase yields or minimize risks, costs, or performance degradation.

Now, that may happen in a manufacturing setting, but for instance, we see a lot of this happening also in the aerospace and defense industry where people are actually connecting these twins to aircraft and being able to understand when services are due ... in a lot more refined way. Because now with this concept of hybrid, you have the data there, but you also have the physics giving you an element of what is really going on and, if things are going to break, why are they breaking and where.

LEARN MORE

Watch "Ansys TwinAI: Combining Physics Accuracy with Data-Driven Insights."

ansys.com/webinars/ansys-twinai-physics-data-driven-insights

SIMULATION Takes the Heat off Tata Steel Nederland

By **GRAZIELLA ALVES**, Manager, Product Marketing, Ansys

Most of the processing steps in steelmaking involve high temperatures. It is these incredibly high temperatures that can drive up energy demand and maintenance for steelmakers and pose inherent safety risks for steel workers. Combating these competitive pressures requires a thoughtful tweaking of manufacturing processes and installation design optimizations that lead to safer, more price-performant production scenarios.

THE IJMUIDEN STEELWORKS OF TATA STEEL NEDERLAND

Image copyright Tata Steel, 2022

"INNOVATION FUELS PROGRESS, and at Tata Steel Nederland we're pioneering a transformative journey toward sustainability. By harnessing the power of simulation and AI, we're optimizing our production processes, minimizing energy loss, and driving toward our decarbonization goals. Ansys TwinAI software seamlessly combines simulation and data with AI to revolutionize steel manufacturing for a cleaner, greener future. With CO_2 reduction targets of 30% to 40% by 2030 and being carbon-neutral by 2045, Ansys TwinAI software is instrumental in leveraging Tata Steel Nederland's energy efficiency and achieving our decarbonization goals."

— **DR. PAUL VAN BEURDEN,** *Knowledge Group Leader of Research and Development at Tata Steel Nederland*

Setting aside uncertainty, Tata Steel Nederland (TSN) — one of Europe's leading steelmakers and part of the Tata Steel group, which is one of the world's most geographically diversified steel producers — scrapped a "trial-and-error" approach to production for a more reliable one based on digital technologies. Ansys is an important partner in this process.

Dr. Paul van Beurden, knowledge group leader of the Materials Engineering and Mathematical Modeling Group (MEM), coordinates a team of skilled researchers and specialists in materials and numerical modeling for high-temperature applications. Dr. Bruno Luchini and van Beurden walk us through Ansys simulation tool usage in such a harsh environment.

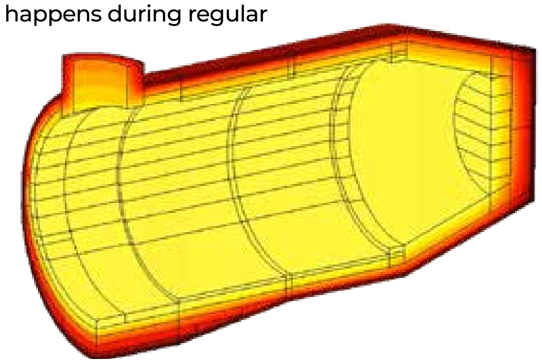
"Part of our simulation activities involves assessing several scenarios for process and installation optimization, as well as root cause analysis," says Luchini, principal researcher and project leader, R&D Ironmaking, Steelmaking, and Casting for Tata Steel Nederland. "The possibility of simulating multiphysics problems with Ansys products enables us to better evaluate failure mechanisms of the distinct materials/equipment present in the plant."

"Ansys Mechanical software is used to develop sophisticated thermomechanical finite element method (FEM) models to investigate the relationship between temperature change rates and stresses occurring to the refractory lining. Modeling these relationships enables optimization of heat treatment procedures while minimizing damage risks," says van Beurden.

TIME FOR A TEMPERATURE CHECK

An inherent challenge for Tata Steel is in maintaining the slab reheating furnaces. During longer maintenance stops, the furnaces must be cooled. Operating at 2,370 degrees Fahrenheit (1,299 degrees Celsius), this is no small task, as simply turning them off results in thermal shock that can effectively crack the furnace lining. The same is true for reheating the furnace. Any temperature changes must happen gradually to avoid any costly damage. At the same time, cooling or heating the furnace too slowly can also result in the loss of a significant amount of production time.

Ansys simulation played a critical role in understanding the relationship between furnace temperature rates and refractory lining damage and stress. Tata Steel Nederland measures the material properties of its refractories in the lab, then measures the temperatures of their furnace lining using thermocouples. Integrating these into a thermomechanical model of the furnace enabled the steel manufacturer to calculate the stresses that occur to better comprehend what happens during regular



Inside view of an empty torpedo ladle cooling down

> ***"Taking this approach, we were able to examine the derivation of maintenance rules for cooling plate replacement in the blast furnaces. Using an FEM model meant we could easily prioritize cooling plate replacement for safer, more reliable operation."***
>
> — **DR. PAUL VAN BEURDEN,** *Knowledge Group Leader of Research and Development at Tata Steel Nederland*

A torpedo ladle car being transported from the blast furnaces (visible in the background) to the steel plant. *Image copyright Tata Steel, 2022*

heating-up and cooling-down procedures.

In this scenario, Mechanical structural finite element analysis software is used to investigate what happens when heating or cooling rates are increased or decreased. By doing so, cooling and heating times could be minimized. As a result, the MEM team reduced furnace downtime by 400 hours annually, increasing steel product capacity by more than 5% while significantly reducing fuel gas consumption and CO_2 emissions.

In an upstream part of the production process, liquid pig iron (or hot metal), an intermediate product in the production of steel, is produced and transported. To improve process control and increase reliability of the production of the liquid hot metal, it is necessary to be able to predict its temperature at any moment in time. Using an FEM thermal process model developed in Mechanical software and validated by thermocouple measurements, the temperature field of the production installations can be simulated and used to derive the liquid metal temperature. However, the application of such an FEM model in real-time process operation is limited due to lengthy computation times.

Instead, a reduced-order model (ROM) based on the FEM model simulation results was used — as a reference, 1 second (ROM) versus 2 hours (FEM), with less than 0.1 °C in terms of temperature difference. ROMs are a key component in digital twin solutions that can leverage high-fidelity simulations to optimize process operations in real time.

ANSYS SIMULATION BECOMES ROUTINE

Tata Steel relies on several Ansys products in total, including Ansys SpaceClaim 3D computer-aided design (CAD) modeling software, Ansys Fluent fluid simulation software, Ansys CFX computational fluid dynamics software, the Ansys Maxwell electromagnetic field solver, and Mechanical software. For a long time, the group also used Ansys Parametric Design Language (APDL) scripting for thermomechanical applications, and it still maintains several models with complex features running in APDL. More recently, the team began using the Ansys Workbench simulation integration platform and the Ansys Twin Builder simulation-based digital twin platform. The team parsed out this product usage into three distinct workflows for root cause analysis, process and equipment optimization, and new installation design.

ROOT CAUSE ANALYSIS

MEM routinely uses simulation software for root cause analysis workflows to better understand why a certain installation is behaving in a specific way in the plant or to assess the failure of a component. Simulation enables information gathering involving the geometry, material properties, and boundary conditions. The data is then used to virtually replicate the scenario that the equipment is facing during operation that leads to failure. Once the model is validated, design dimensions, materials, and process conditions can be modified to explain the current performance of a design and to subsequently arrive at the appropriate design improvements.

"Taking this approach, we were able to examine the derivation of maintenance rules for cooling plate replacement in the blast furnaces," says van Beurden. "Specifically, maintenance limitations did not allow for all the cooling plates to be replaced simultaneously. Using an FEM model meant we could easily prioritize cooling plate replacement for safer, more reliable operation."

PROCESS AND EQUIPMENT OPTIMIZATION

Tata Steel Nederland also relies on Ansys products to optimize processes and equipment. In this scenario, virtual models of equipment are created. Using a parametric approach, the team identifies key parameters, then fine-tunes the process parameters needed to fully optimize both their key processes and equipment. It is the versatility of these virtual models that enables the team to explore many scenarios while reducing the need for costly physical experimentation in the operating plant.

NEW INSTALLATION DESIGN

New installation design is the third workflow in which Tata Steel Nederland relies on Ansys products. For this purpose, simulation is used to check supplier designs by running numerous scenarios before proposing improvements. This process was critical in the design of TSN's new reheating furnace. The team used the information gathered to better comprehend the impact of high temperatures several times over before the furnace was put into operation. During the project's evaluation phase, several FEM models were used to assist in material selection, as well as for the accurate prediction of temperature distribution and heat losses.

DIGITAL TWINS LEVERAGE SIMULATION TO IMPROVE OPERATIONS IN REAL TIME

In addition to losing energy during the manufacturing process, a lot of energy is lost during the transport of liquid pig iron in what is called a torpedo ladle (that is, a specialized transfer container roughly shaped like a torpedo). To negate energy loss during transport, a digital twin is used to model the entire process to determine how fast, as well as what process parameter, the team can tune to evaluate the best transport scenario.

To van Beurden's team, digital twin technology has become a natural evolution of their engineering simulation use. In the past, they were building separate models for individual equipment in the plant. Therefore, its optimizations were, by definition, suboptimal (local optimizations). With the digital twin technology, the steel manufacturer will be able to globally optimize the process to connect the equipment in its production chain and evaluate its processes in greater detail. Such testing can illuminate the impact of changes on certain pieces of equipment on other pieces, leading to a cleaner, greener production chain.

"Combining a digital twin with other technology innovations like smart sensors will help us leverage the energy efficiency of the plant and, in turn, help us achieve our decarbonization targets," says Luchini.

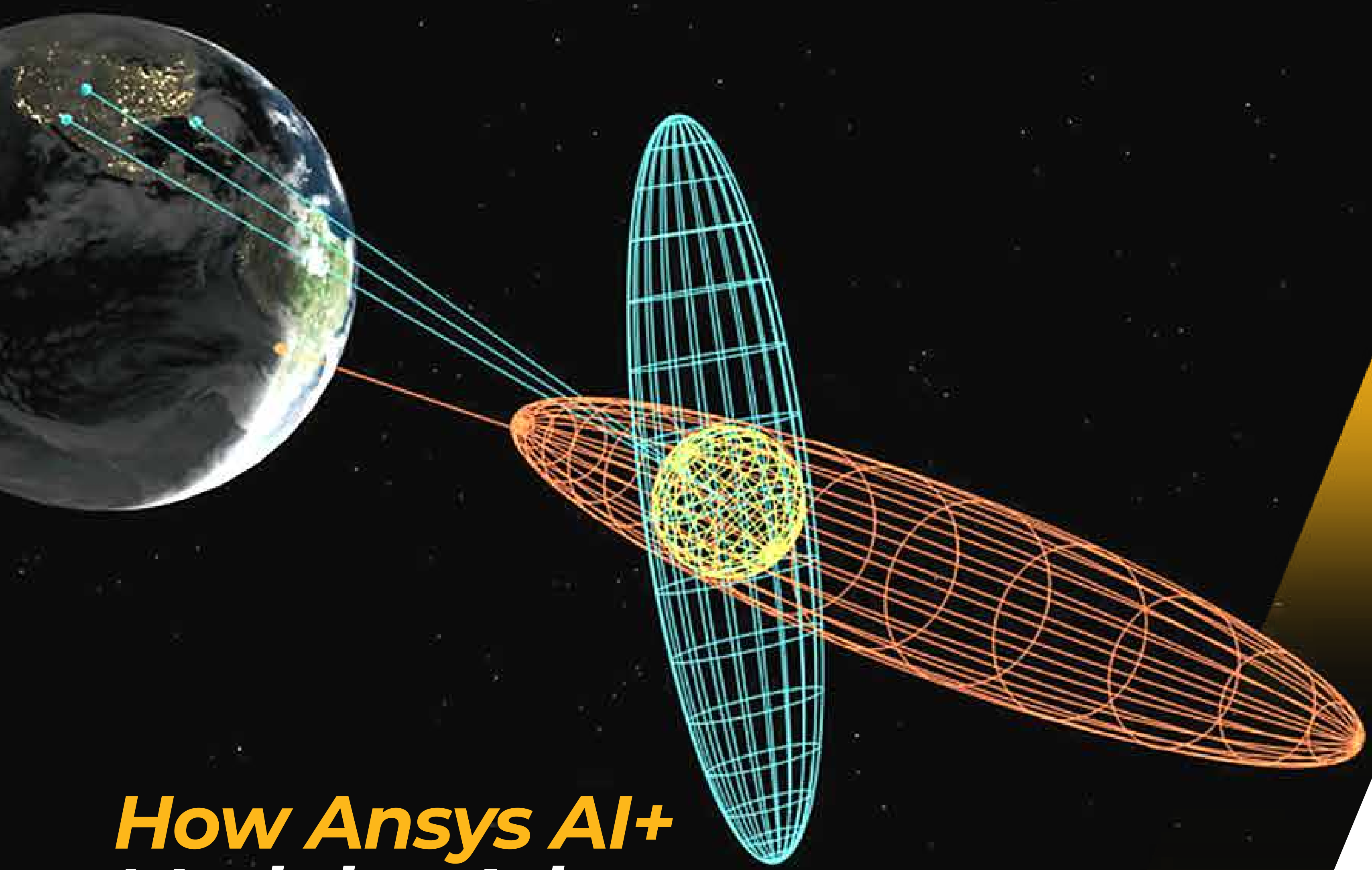
Tata Steel Nederland is passing through an unprecedented transformation in its production processes whereby hydrogen will replace coal. By 2030, TSN will have implemented a direct reduction plant (DRP) and a reducing electric furnace, saving around 30%-40% in CO_2 emissions.

"Planning the commissioning of such equipment and decommissioning of others is no easy task. It is like changing tires while the car is moving. Again, simulation technology is crucial in designing the new processes," says Van Beurden.

LEARN MORE

Watch the webinar.

ansys.com/webinars/how-digital-twin-is-a-game-changer-for-tata-steel-nederland-to-achieve-their-targets



How Ansys AI+ Modules Advance Simulation and Analysis

By **ILYA TOLCHINSKY**, Lead Product Manager, Ansys

Engineers in all industries use simulation to evaluate the quality of their new designs. Before such analysis tools were available, engineers had to build physical prototypes and test their designs in the real world. With simulation tools, the need for physical testing is reduced by providing a quicker, easier way to analyze new designs. Innovation depends on the ability to try out new ideas. The more designs that an engineer can consider, the faster that he or she can find something that works better than the current state of the art.

An ideal analysis tool takes the definition of a product, along with its operating conditions, and instantly delivers an exact prediction of performance for the new design. Although this is a dream, simulation tools are evolving in this direction. Over the years, simulation has become easier to set up, faster to run, and more accurate.

In recent years, mathematical techniques known as artificial intelligence (AI) have helped us make leaps and bounds toward these ideal analysis methods. If we look at Ansys tools, some of our most advanced capabilities are powered by AI. Wherever possible, we have isolated these in dedicated AI+ modules. This allows Ansys to provide AI capabilities to users no matter which license packages they have. Ansys also is able to turn off AI capabilities in products if users are not yet comfortable with these advanced features. And very simply, AI+ options allow Ansys to highlight the latest and greatest AI-powered capabilities.

To date, Ansys has seven such modules available:

- CFD AI+
- Structures AI+
- Missions AI+
- SynMatrix AI+
- Granta MI AI+
- optiSLang AI+
- Electronics AI+

CFD AI+

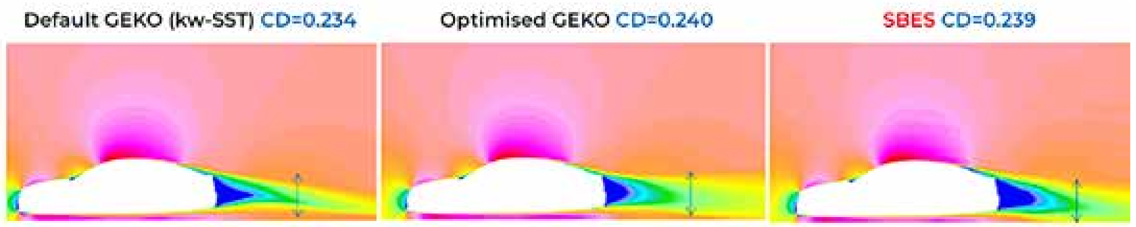
The Ansys CFD AI+ module enables you to predict fluid behavior with steady state simulations only previously possible with more costly transient simulations. By fine-tuning the Ansys Fluent turbulence model on a reference result from transient simulations, you then can run a suite of less expensive steady state simulations with increased fidelity but with far fewer computational resources.

SYNMATRIX AI+

The SynMatrix AI+ module brings AI techniques into the design of radio frequency (RF) filters, helping engineers find the optimal configuration for new RF filters.

GRANTA MI AI+

Using Granta MI AI+ technology, materials engineers can gain insights into factors affecting material properties by better understanding the process-property relationship. This enables the optimization of existing material and manufacturing processing parameters and aids in defining new materials.



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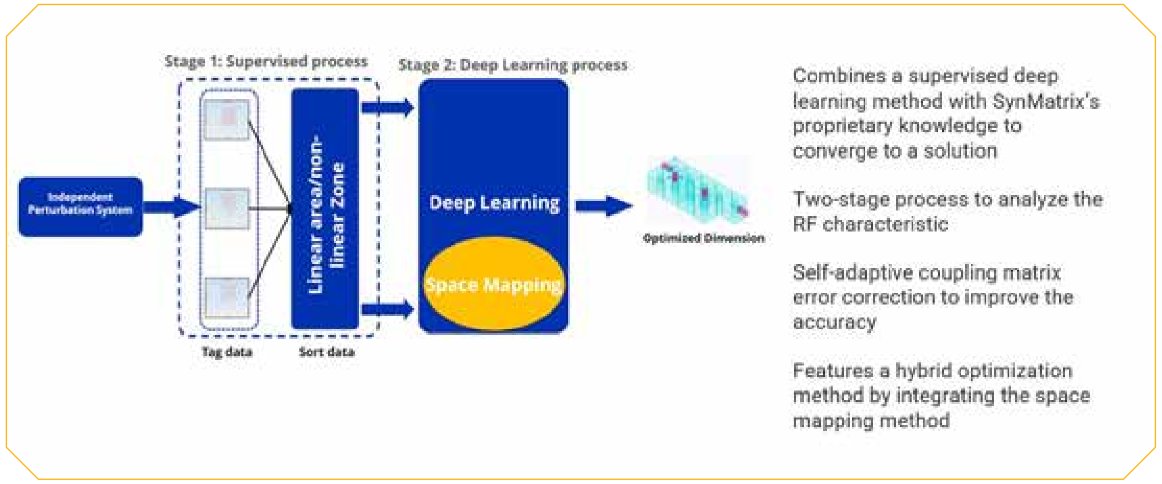


The SynMatrix AI+ module brings AI techniques into the design of radio frequency (RF) filters, helping engineers find the optimal configuration for new RF filters.

MISSIONS AI+

An AI-based tool is available in Ansys Orbit Determination Tool Kit (ODTK) orbit simulation software to automatically evaluate the quality of resulting orbits. This quality assessment tool is offered as part of Ansys Digital Mission Engineering (DME) software's Missions AI+ module. Combining tuned models with AI algorithms allows users to confidently assess the quality of their resulting ODTK orbit solutions.

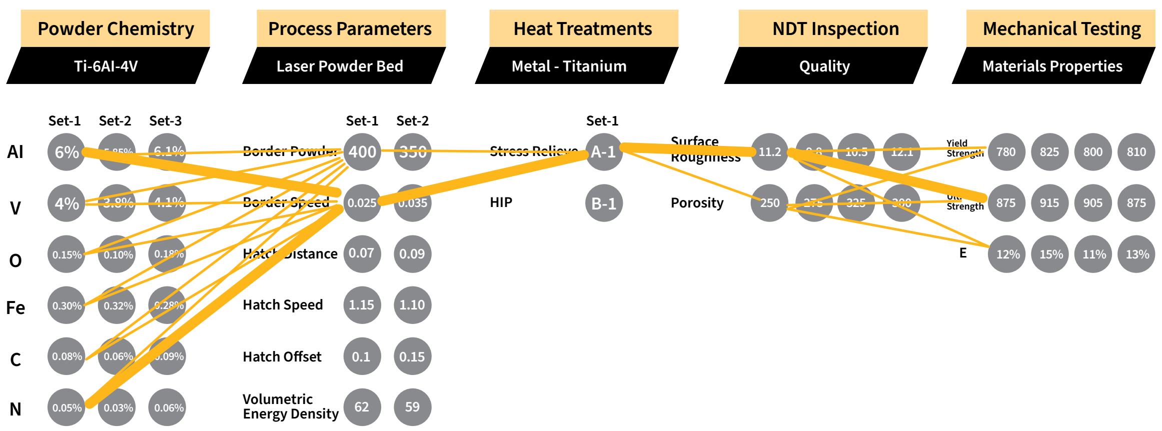
OPTISLANG AI+

The optiSLang AI+ module allows Ansys users to create surrogate models, which provide a way to explore possible designs even faster than with numerical simulation tools. There are even techniques that give AI the ability to search through potential designs and provide optimal choices to users. Human operators simply specify desired performance characteristics, and the AI-powered algorithms perform the tedious task of considering all the possible product configurations, identifying and presenting only the best options.

STRUCTURES AI+ AND ELECTRONICS AI+

Both the Structures AI+ and Electronics AI+ modules contain tools to predict the amount of computing power that is required to run simulations for Ansys Mechanical structural simulation software and Ansys SIwave printed circuit board (PCB) and package electromagnetics simulation software products. Machine learning predicts how long a simulation will take (given the available resources), how much memory it will need, and what happens if a user throws more computing power at it. This capability will be even more important as Ansys continues to enable customers to use the virtually unlimited compute capacity in the cloud. Ansys users will need to know how much it will cost them to burst simulation into the cloud.

These AI+ capabilities are a sampling of what's to come. Ansys recently brainstormed on all product lines. We came up with about 150 ideas of how to use AI to further enhance Ansys products. Now we are busy identifying top-priority items and determining how to implement these ideas. The future of AI at Ansys is bright.



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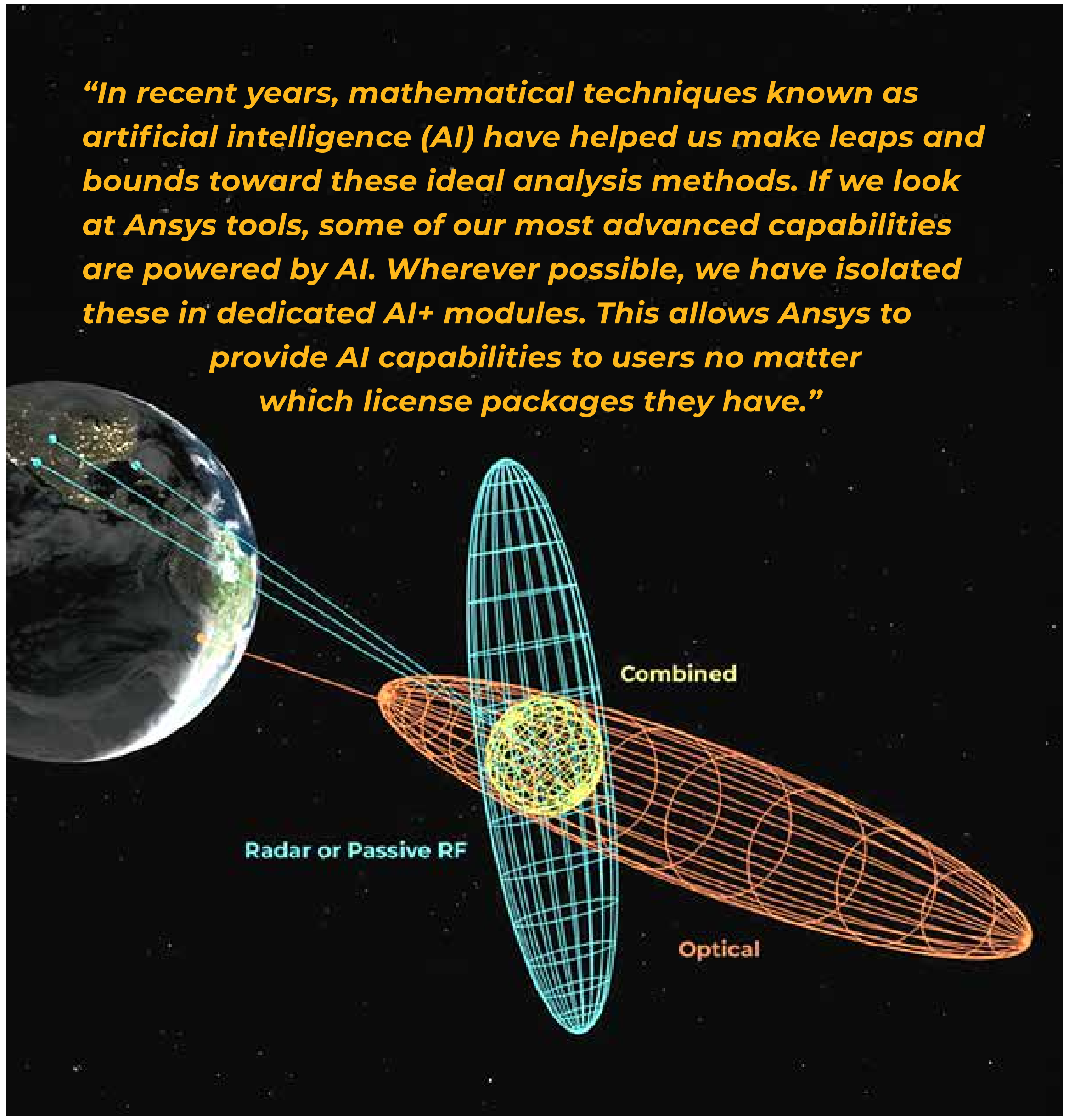
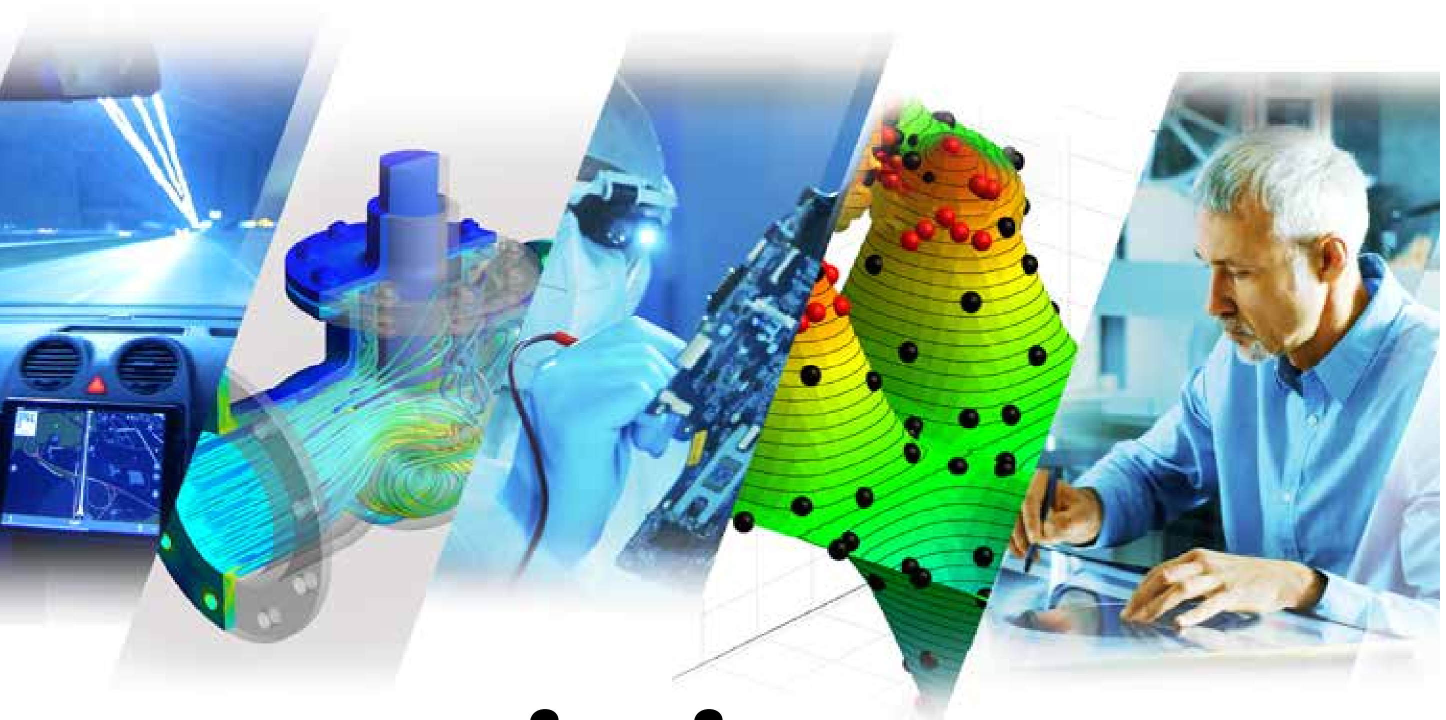


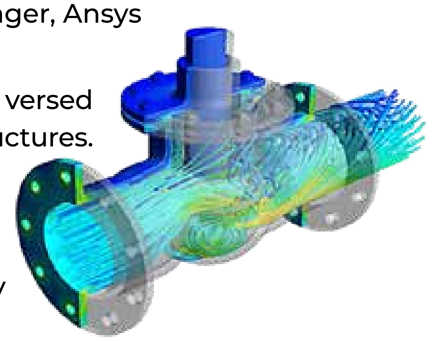
Combining tuned models with artificial intelligence (AI) algorithms allows users to confidently assess the quality of their resulting Ansys Orbit Determination Tool Kit (ODTK) orbit simulation software solutions.



Optimize CFD Simulations With Just a Click

By **DAVID SCHNEIDER**, Lead Product Manager, Ansys

Computational fluid dynamics (CFD) experts are well versed in fluid mechanics, numerical analyses, and data structures. They frequently analyze different properties of fluid flow, such as temperature, pressure, velocity, and density, and then apply these insights to engineering challenges across industries, from aerospace and automotive to energy and healthcare. However, while CFD experts are masters of fluids, they're usually not optimization specialists, which requires them to seek outside assistance or software when optimization needs arise.



Computational fluid dynamics (CFD) experts now can optimize their simulations directly in Ansys Fluent CFD software.

The latest release of Ansys Fluent CFD software eliminates this hurdle by offering built-in features from Ansys optiSLang process integration and design optimization software. Now CFD experts can stay in the software they know best while optimizing their simulations with just a click. Artificial intelligence (AI) and machine learning (ML) algorithms, including a one-click optimizer (OCO) and an adaptive Metamodel of Optimal Prognosis (AMOP) tool, empower CFD experts to try their hands at optimization easily and efficiently. Let's explore how these optimization capabilities enhance the Fluent simulation experience.

LET ALGORITHMS DO THE WORK FOR YOU

Reduced-order modeling (ROM) is a key feature of optiSLang software and enables metamodeling. Put simply, a metamodel is a model of a model, and optiSLang software builds metamodels for rapid feedback and robust design analysis.

Typically, engineers need to run large quantities of simulations to conduct parametric studies like optimization. However, the algorithms in optiSLang software guide simulations, supporting easier and faster optimization with increased efficiency. In addition, the algorithms encourage deeper design insights, including parameter influences, coherences, and output selections.

> ***"Typically, engineers need to run large quantities of simulations to conduct parametric studies like optimization. However, the algorithms in optiSLang software guide simulations, supporting easier and faster optimization with increased efficiency."***

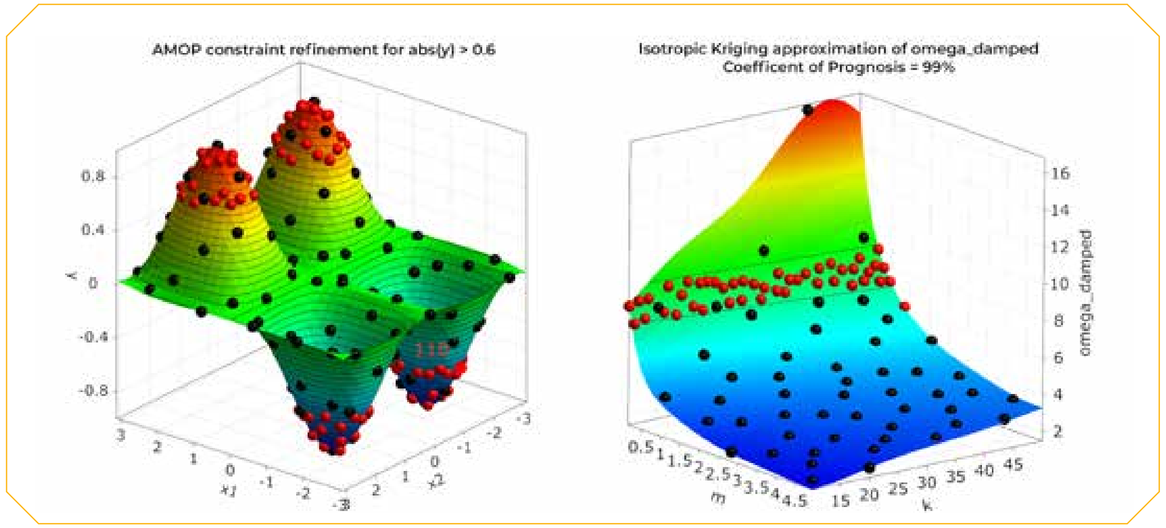
AMOP is built from the Metamodel of Optimal Prognosis (MOP), an automatic machine learning (AutoML) algorithm in optiSLang software that finds the best metamodeling approach and prepares its settings. As its name suggests, AMOP is adaptive. This means that after the initial design of experiments (DOE), AMOP automatically creates MOP for the outputs. AMOP finds regions where the metamodeling is favorable and regions where new observations could improve quality. Based on this insight, AMOP automatically runs new simulations for future iterations. In this way, AMOP redefines the DOE where needed to achieve the best metamodel quality, requiring less manual input and fewer simulations.

Similarly, OCO uses MOP philosophy to select not only the best metamodel but the best optimization approach. Like MOP's competition of metamodels, OCO places optimization strategies against each other to determine the ideal approach.

For this reason, CFD engineers and designers do not need extensive AI/ML knowledge or any optimization know-how to use AMOP or OCO and can benefit from their automated optimization and parametrization without leaving the Fluent platform.

ACCESS OPTIMIZATION WITH EASE

Both OCO and AMOP — the most widely used and sought-after algorithms in optiSLang software — now can be accessed directly from Fluent software. Simply click on the Optimization Options dialog box and select the OCO or AMOP algorithm. If you're selecting



The adaptive Metamodel of Optimal Prognosis (AMOP) algorithm concentrates value searches on the most relevant parameters, accelerating simulation time and increasing efficiency.

"Now CFD experts can stay in the software they know best while optimizing their simulations with just a click. Artificial intelligence and machine learning algorithms, including a one-click optimizer and an adaptive Metamodel of Optimal Prognosis tool, empower CFD experts to try their hands at optimization easily and efficiently."

OCO, you need to enter only one setting: the maximum number of design evaluations. Once you've entered that value, just click on "configure settings."

OCO automatically selects the most suitable optimization algorithms with the most appropriate settings. It's a hybrid, surrogate-assisted optimization strategy that uses MOP capabilities for function approximation to significantly speed up optimization.

If you're selecting the AMOP algorithm, it is almost as simple as employing OCO but requires an additional step. For AMOP, you need to enter the maximum number of samples and then select either local or global refinement before configuring the settings. Due to AMOP's adaptive ML nature, it will generate the rest of the data by running Fluent simulations with several parameter combinations.

With local refinement, AMOP adapts where the quality of the metamodel is most promising to improve while global refinement is more explorative. With global refinement, AMOP will add new design points until a certain level of prediction quality is reached or the maximum number of calculations is exceeded.

ENJOY THE BENEFITS OF OPTIMIZATION

The main benefit of OCO and AMOP is their convenience.

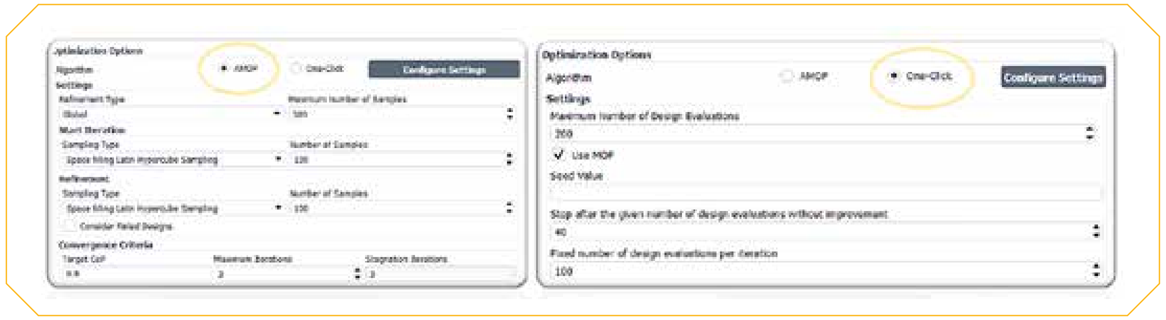
Additional benefits include the ability to:

- Optimize without any optimization or AI/ML expertise. It all happens behind the scenes.
- Enlist the AMOP function to achieve an optimal set of parameters using fewer simulations by using response surface modeling (RSM) for surrogate models or metamodels.
- Select the best metamodel and optimization approaches through automatic algorithms.
- Pit optimization approaches against each other through OCO to determine the ideal approach.
- Accelerate Fluent CFD's pre- and post-processing workflows with both AMOP and OCO.
- Improve CFD multiphase flow modeling with more accuracy and faster setup.
- Access the full optiSLang software more quickly if needed for deeper analyses.

AMOP and OCO optiSLang software algorithms are also available in Ansys' other flagship products, including the Ansys Workbench simulation integration platform and the Ansys Electronics Desktop (AEDT) suite of electronic products.

NO AI EXPERIENCE REQUIRED

Ansys is constantly integrating new AI/ML algorithms to optimize simulation and related workflows. Now, in the latest release of Fluent software, CFD experts can easily optimize fluid flow simulations with minimal settings and without any optimization or AI/ML background.



You can access the AMOP and one-click optimizer (OCO) algorithms easily from the Fluent platform.

AnsysGPT:

YOUR VIRTUAL ASSISTANT FOR SIMULATION QUERIES

Discover how the AnsysGPT tool can help you get fast, accurate answers to simulation questions using GPT technology.

By **ANTHONY DAWSON**, VP, Worldwide Ansys Customer Excellence

If you use simulation, then you know how challenging it can be to find the right information and guidance for your specific needs. You may have to search through many sources, such as product documentation, training materials, blogs, videos, and forums, to get the answers you seek. This can be time-consuming and frustrating, especially when you are working on a tight deadline or a complex problem.

"The AnsysGPT solution is a secure AI tool that generates content from trusted Ansys resources, such as courses, the Learning Hub, and technical materials. It ensures accurate, nonproprietary responses with strict controls and follows responsible AI practices."

WHY DO YOU NEED THE ANSYSGPT SOLUTION?

What if you had a virtual assistant that could answer your simulation questions in seconds using the power of artificial intelligence (AI)? That's what AnsysGPT technology is: a cloud-based tool that uses GPT, or generative pretrained transformer, technology to provide real-time, on-demand support for simulation questions. GPT technology is a form of AI that can generate natural language responses based on large amounts of data. The AnsysGPT tool is built using GPT-4 technology by integrating a large language model with Ansys' extensive knowledge base, which covers numerous products and physics. The AnsysGPT solution can quickly summarize lengthy documents, provide concise answers, and refer you to the original sources for more details. This way, you can save time and effort by accessing the most relevant, reliable information for your simulation needs.

HOW TO USE THE TOOL FOR YOUR SIMULATION QUERIES

Using the AnsysGPT solution is easy and intuitive. You can access it anytime, anywhere, from any device. All you need is standard, active Technical Enhancements and Customer Support (TECS). You can ask the AnsysGPT tool any question related to Ansys products, physics, simulation setups, and other engineering topics. You also can use different languages, as the technology can recognize and reply in multiple languages to meet the needs of our global user community.

The AnsysGPT tool will respond to your question in seconds, with a text response and a link to the original source. It also will recommend related tutorials and learning opportunities that match your unique needs. For example, if you ask, "What are the different ways to connect the parts of my model in Ansys Mechanical structural FEA analysis software?" the tool will tell you about the two methods available — shared topology and contacts — and provide you with links to training courses, instructional videos, and other expert resources. You can ask follow-up questions as well or provide feedback to the solution to improve its performance and accuracy.

WHAT ARE THE BENEFITS FOR YOUR SIMULATION WORK?

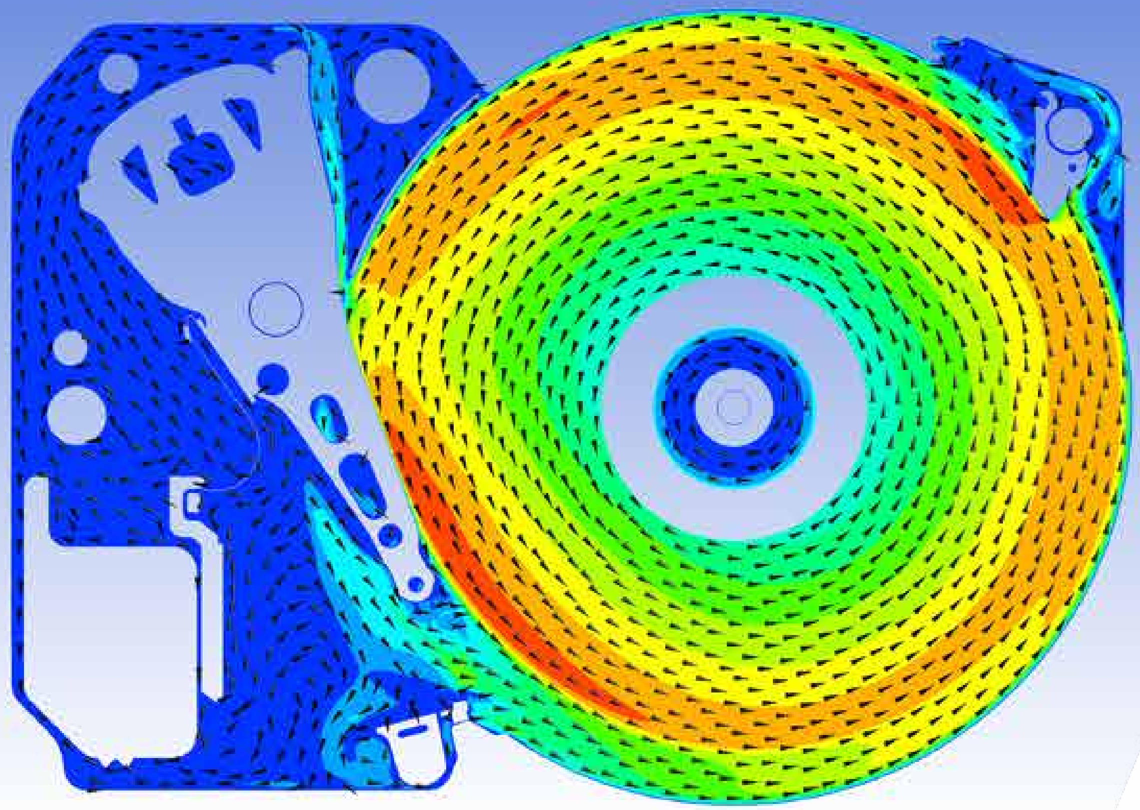
AnsysGPT technology is not a replacement for the traditional support available to customers, such as one-on-one technical support, self-help knowledge materials, and community-based support on the Ansys Learning Forum. Rather, it is an additional avenue for accessing real-time, on-demand support. It can help you in several ways, such as:

- Reducing the time and effort required to find the right information and guidance for your simulation questions.
- Increasing your confidence and productivity by getting fast, accurate answers from reliable Ansys sources.
- Enhancing your learning and discovery by accessing relevant, diverse content from Ansys' extensive knowledge base.
- Supporting your globally diverse needs by offering multilingual, multiphysics support.

ENSURING QUALITY, SECURITY, AND CONTINUOUS INNOVATION

The AnsysGPT solution is a secure AI tool that generates content from trusted Ansys resources, such as courses, the Learning Hub, and technical materials. It ensures accurate, nonproprietary responses with strict controls and follows responsible AI practices, including robust data governance and cybersecurity to protect user privacy. The technology does not save or monitor customer inputs, record queries, or use personal or intellectual property data for AI training.

The tool operates on the Microsoft Azure platform, benefiting from its high performance and security features. The solution enhances simulation experiences and is part of the Ansys AI and Ansys AI+ solutions designed to improve design and optimization for product development. It is customer-focused and continuously improved through user feedback, and Ansys encourages sharing of experiences to further refine the product. We strive to evolve AnsysGPT technology into your virtual assistant to ensure that you can dedicate your efforts toward advancing engineering breakthroughs rather than searching for information.



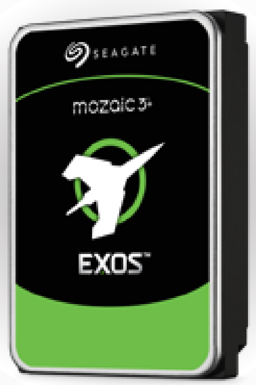
A computational fluid dynamics (CFD) simulation of a hard drive's internal flow velocity in the Ansys Fluent platform. Image: Seagate Technology.

READY FOR AI:

Seagate Expands Scalable, Sustainable Data Storage Solutions With NVIDIA-powered Ansys Simulation

By **JENNIFER PROCARIO**, Senior Marketing Communications Writer, Ansys

Data is essential to artificial intelligence (AI). It's used to train, maintain, and validate AI models. Consequently, as AI becomes more prevalent across industries around the world, the need for greater data storage is rapidly increasing. It's projected that about 181 zettabytes (ZB) of data will be generated in 2025, with forecasts ranging between 175ZB and 200ZB. To put that into perspective, 1ZB is equal to 1,000 exabytes (EB), 1 billion terabytes (TB), or 1 trillion gigabytes (GB). That's a lot of data. In fact, it's far more data than we can store. Global data storage capacity is expected to reach only about 16ZB next year.



Exos Mozaic 3+ hard drives hold up to 32 terabytes (TB) of data.

To meet growing demands sustainably, Seagate Technology, a leader in mass-capacity data storage solutions, is leveraging Ansys simulation and NVIDIA technology to develop future generations of its Mozaic hard drive technology. The current platform, Mozaic 3+, delivers mass-capacity storage at unrivaled areal densities of 3TB per platter. Anticipated models Mozaic 4+ and Mozaic 5+ will store 4TB and 5TB of data per platter, respectively. The Mozaic 3+ platform currently powers Seagate's Exos hard drives, which boast a capacity of up to 32TB.

With the support of Ansys and NVIDIA, Seagate enables its Mozaic technology to store data at previously unachievable levels without increasing power consumption. By integrating Ansys Fluent fluid simulation software and NVIDIA's accelerated compute power, Seagate optimizes and accelerates designs up to 50 times faster, increases efficiency, and drives down costs, enabling greater mass data storage solutions for emerging AI-related data needs.

OPTIMIZING CFD WITH GPU COMPUTE POWER

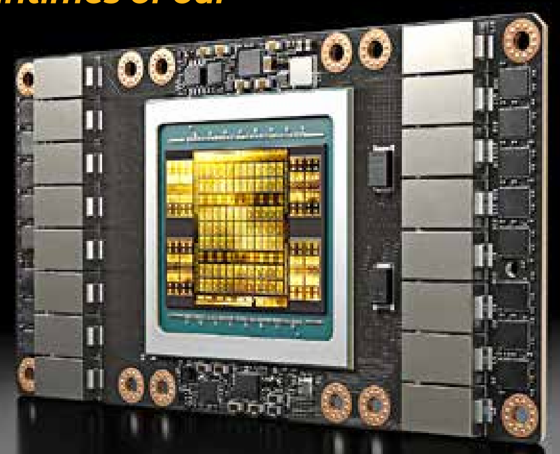
Since its founding over 45 years ago, Seagate has produced more than 4 billion TB of data capacity and currently offers a full portfolio of storage devices, systems, and services. Recognizing today's storage demands in the face of expanding AI technologies, Seagate uses simulation and accelerated compute power to amplify design and development.

Specifically, by combining Fluent software computational fluid dynamics (CFD) simulation and an NVIDIA DGX system, Seagate dramatically reduces model solve times for significant design optimization and increased productivity.

Fluent software simulation offers a transformative feature for engineers seeking to speed up CFD simulations with accelerated computing: a native multi-graphics processing unit (GPU) solver. A native implementation harnesses the full potential of NVIDIA accelerated computing for CFD by running the solver code resident on multiple GPUs. With this capability, Fluent CFD software drives impressive savings in simulation time, hardware costs, and power consumption compared with traditional central processing unit (CPU)-driven solvers.

Before adopting Ansys and NVIDIA technology, Seagate's hardware included a workstation comprising 40 core CPUs, resulting in a time-consuming, cumbersome workflow. Seagate's CPU-based workstation runtimes were approximately one month for chassis-level aeroacoustics models with a mesh size of about 50 million cells while finer, higher-quality mesh containing up to 100 million cells took even longer.

> ***"With NVIDIA DGX and Ansys Fluent software, we are able to reduce the runtimes of our internal drive flow models from hours to minutes, approximately a 50X improvement."***
>
> — **KENT FORBORD**, Senior Director of Advanced Mechanical Development at Seagate



"Through more upfront modeling and design optimization, Seagate engineers reduce prototyping and physical testing. This helps them meet the ultimate goal of shortening our design cycle."

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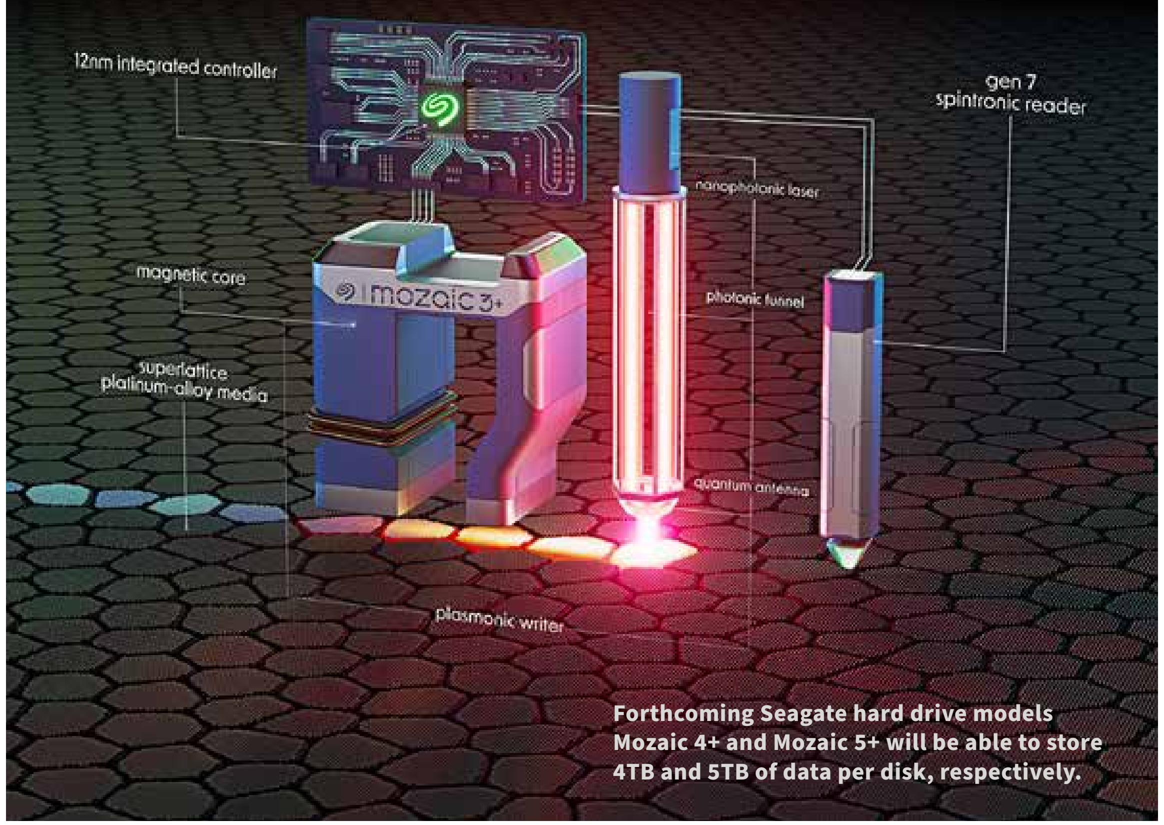


Forthcoming Seagate hard drive models Mozaic 4+ and Mozaic 5+ will be able to store 4TB and 5TB of data per disk, respectively.

Today, the company runs Fluent software models on an NVIDIA DGX system.

"With NVIDIA DGX and Ansys Fluent software, we are able to reduce the runtimes of our internal drive flow models from hours to minutes, approximately a 50X improvement," says Kent Forbord, senior director of advanced mechanical development at Seagate. "With NVIDIA DGX and Ansys Fluent software, we are able to reduce external aeroacoustics model runtimes from one month to less than one day. The end benefit of reduced solve times is the ability to evaluate more designs over a shorter period of time, ultimately achieving a more optimal design."

BUILDING A FUTURE GENERATION OF HARD DRIVES

Seagate is developing future generations of its Mozaic hard drives, which are standouts when it comes to areal density and incorporate the company's unique implementation of heat-assisted magnetic recording (HAMR). Also referred to as area or surface density, areal density is essentially a measurement of the storage capacity per square inch of an object's surface.

According to Seagate, although adding more disks to a hard drive could increase capacity, it's not efficient. For starters, each disk in a hard drive requires many materials. This not only increases overall material usage but raises power consumption. On the other hand, increasing areal density enables each disk to hold more data without using more material or disks, offering a more efficient approach. Basically, it's about storage quality, not quantity.

Tracks are the circular rings, or bands, on a hard disk that store data. Achieving higher track densities is a critical target for Seagate's forthcoming HAMR-enabled platforms Mozaic 4+, which is in development, and Mozaic 5+, which is being demonstrated in lab tests.

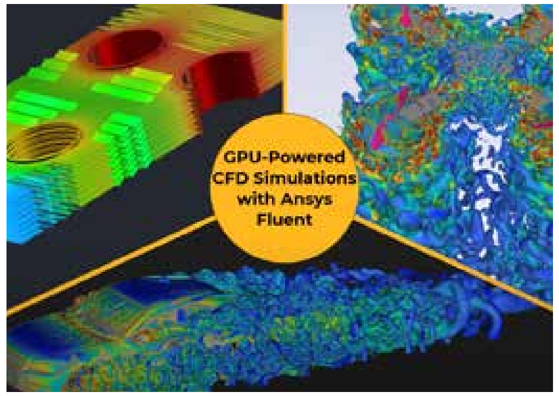
To increase track densities, Seagate engineers use Fluent software simulation to assess and optimize key airflow metrics in the drive, such as particle transport, windage drag, and structure excitation.

At the system level, they model the dynamic excitation on the outside of the drive, temperature, and pressure drop to assess cooling flow throughout the system. Thermal analysis is important in designing efficient, safe hard drives. The team also performs aeroacoustics simulation — the modeling of sound generated from a flowing fluid — to improve system chassis and fan designs.

Mozaic drives enable data centers to store more data in the same space, offering more compute power with a smaller footprint and reduced total cost of ownership (TCO) for customers. Keeping things compact, the drives bear the same 3.5-inch form factor as Seagate's earlier hard drives and use the most advanced materials, including a superlattice platinum-alloy media that combats magnetic instability at the nanoscale.

Additionally, the GPU-powered simulation workflow reduces material and power usage while speeding up design.

"Through more upfront modeling and design optimization, Seagate engineers reduce prototyping and physical testing," Forbord says. "This helps them meet the ultimate goal of shortening our design cycle."



SPEEDING UP DATA STORAGE FOR AI BOOM

Mozaic-enabled drives are making a substantial difference in the industry. With greater areal density, the hard drives store more data in the same space, and with an upgraded workflow, Seagate produces more drives at a faster rate.

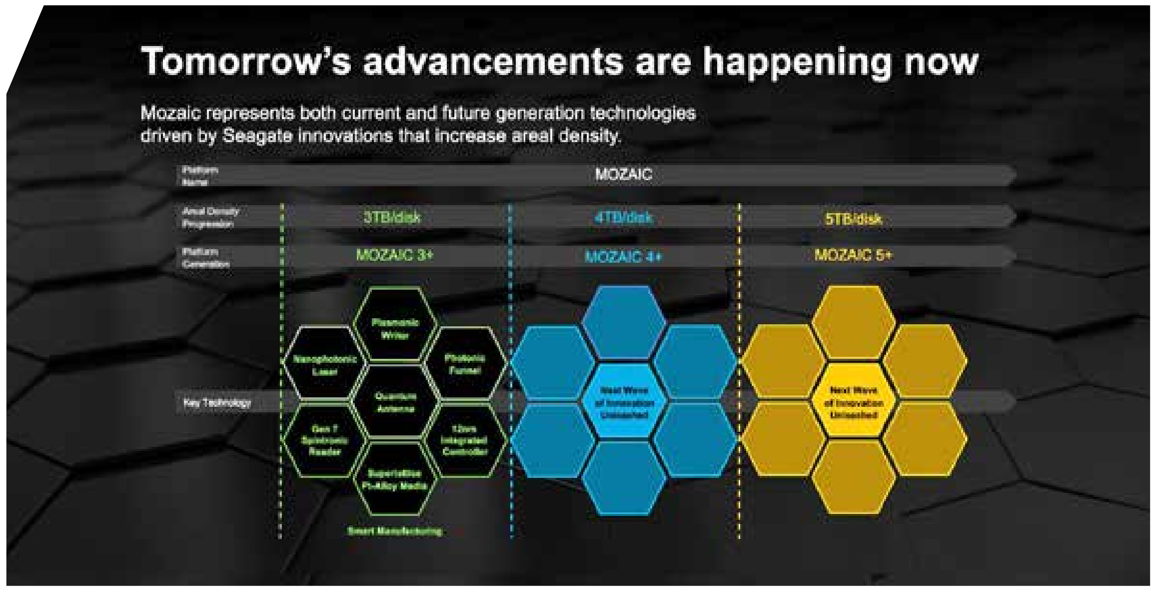
"When the models ran about one month, that made them impossible to use as a design tool," Forbord says. "Integrating Ansys and NVIDIA technologies enables our team to streamline the innovation process and meaningfully speed up time to market."

With regard to the AI-related data explosion, Seagate is ready.

LEARN MORE

Explore the capabilities of Ansys Fluent fluid simulation software.

ansys.com/products/fluids/ansys-fluent



Designed with the most advanced materials and structures, Seagate's Mozaic drives enable data centers to store more data in less space more efficiently.

The Role of AI and Multiphysics in the Future of Optical Design: Ansys Optics and Edmund Optics

Incorporating AI can significantly accelerate optical design.

By **KERRY HERBERT**, Senior Product Marketing Manager, Ansys, and **CORY BOONE**, Technical Marketing Manager, Edmund Optics

In the ever-evolving field of optical design, artificial intelligence (AI) is enabling advances in multiphysics simulations that will reshape the way engineers approach their work. This technology has the potential to produce innovations previously unimagined by providing insights that yield a better understanding of the real performance of optical systems. It also provides the computational power to explore design spaces faster and more efficiently than ever before.

Edmund Optics, based in New Jersey, is a leading supplier of optics, imaging, and photonics products, offering a wide range of optical components and systems. The company is investigating ways to improve design efficiency with AI. Meanwhile, Ansys Optics is pursuing innovative ways to incorporate AI into its multiphysics design and simulation software. Seeking similar solutions, the two companies are working to shape the optical designs of the future.

"By integrating multiphysics simulations into the design workflow, engineers can evaluate the impact of environmental conditions, material properties, and manufacturing tolerances on optical performance. This holistic analysis ensures that optical designs are robust and reliable under real-world operating conditions."

USING MULTIPHYSICS SIMULATIONS FOR COMPREHENSIVE ANALYSIS

Multiphysics simulations enable engineers to simulate the complex interactions among optical, mechanical, thermal, and other physical phenomena. This comprehensive approach enables a deeper understanding of how factors impact the performance of optical systems.

By integrating multiphysics simulations into the design workflow, engineers can evaluate the impact of environmental conditions, material properties, and manufacturing tolerances on optical performance. This holistic analysis ensures that optical designs are robust and reliable under real-world operating conditions.

However, conducting multiphysics simulation accurately and efficiently can be a challenge. AI has the power to address this challenge in several ways.

Much of an optical designer's time is spent at the beginning of the design process. This includes figuring out the overall form of the lens assembly, determining how many elements to include in the assembly, and other initial steps. After being trained by many input designs, AI neural network models can speed up this process to predict what initial design would be a good starting point, based on the desired end specifications of the optical system.

A collaboration among AI, subject matter design experts, and end users could significantly reduce the total time needed to arrive at a final design. Using technologies like machine learning (ML) lets designers explore wider solution spaces using traditional design optimization routines. These are the AI applications that Edmund Optics are investigating to improve the efficiency of product design and analysis.

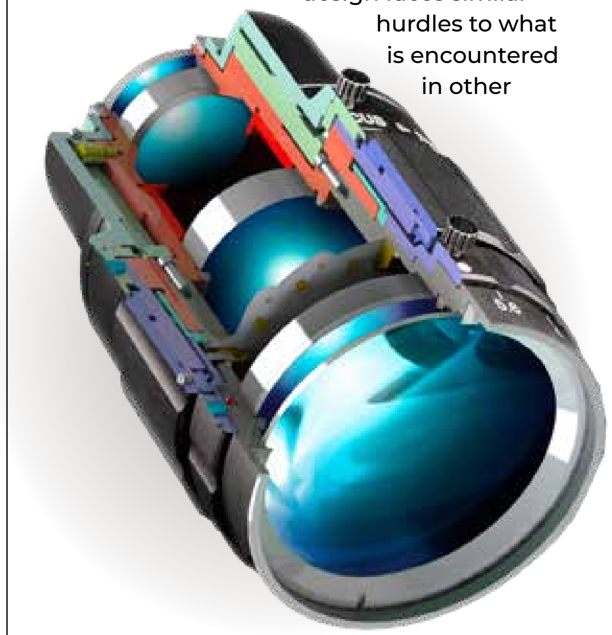
OPTIMIZING AI-POWERED DESIGN

Ansys Optics is exploring how to leverage AI algorithms to optimize optical designs with unprecedented speed and efficiency. While traditional design processes often involve manual iterations and extensive computational resources, Ansys Optics' AI-driven approach would accelerate this process by quickly exploring a vast design space to identify optimal solutions.

The services provided by Edmund Optics are perfectly situated for improvement through AI. The large catalog of existing Edmund Optics designs provides a great library for training ML algorithms to generate new starting designs, speeding up the overall design process.

By harnessing ML techniques, Ansys Optics products learn from past designs and simulations to continuously improve optimization algorithms. This iterative learning process enables engineers to explore innovative design concepts and achieve performance targets that were previously unattainable. When this knowledge is applied to physical components, the possibilities for improvement are endless.

The task of integrating AI into optical design faces similar hurdles to what is encountered in other



AI neural networks can generate optical design starting points based on desired end specifications after analyzing existing designs in training.

> ***"Similar to previous technological advancements, the strength of AI will mainly be in the efficiencies it creates for optical designers. However, the need for skilled designers and subject matter experts is not going anywhere. Instead, AI technologies will augment designers' capabilities and streamline their workflows."***

fields. These include intellectual property (IP) concerns, limited access to sufficiently large training datasets, and the risk of overdependence — and subsequent overengineering — when simpler solutions are sufficient for the application. Achieving an appropriate level of AI integration into optical design requires collaboration and access to large datasets of existing designs to train the models. Customized AI integrations may be needed when addressing specific applications requirements and ensuring compatibility with existing supply chains.

WILL AI REPLACE HUMAN DESIGNERS?
Similar to previous technological advancements, the strength of AI will mainly be in the efficiencies it creates for optical designers. However, the need for skilled designers and subject matter experts is not going anywhere. Instead, AI technologies will augment designers' capabilities and streamline their workflows. In fact, neural networks and other AI technologies have the potential to increase participation in the field of optical design because they lower the barrier to entry and facilitate a quicker learning curve.

These AI-based design tools could quickly and efficiently iterate designs, investigate alternatives, and analyze end performance to accelerate the whole design process while encouraging rapid experimentation. While AI promises a transformation of the design process, its role will be complementary instead of serving as a substitute, ultimately driving innovation at a more accelerated pace.

The cost and manufacturability of components and assemblies is often an area that can strongly drive the design decision-making process. The long feedback loop between design concept, generating models and manufacturing prints, and waiting for a quote can be greatly shortened through AI-enabled predictive modeling and simulation from past data. If engineering teams can rapidly iterate designs across wider solution spaces, identify cost-saving opportunities, and make informed decisions early in the design and development cycle, AI can greatly streamline the design process and provide a significant competitive advantage in today's dynamic markets.

Engineers can save time with AI-generated design starting points.

A holistic analysis ensures that optical designs are robust and reliable under real-world operating conditions.

Edmund Optics will continue to investigate the potential of applying AI to product development and optical design processes, including manufacturability, cost estimations, and predicting the feasibility of designs.

AI-based advancements in multiphysics simulations let designers much more accurately predict how their designs will perform in real systems. In the coming years, we can expect to see continued collaboration and integration between these technologies, further accelerating the pace of optical design innovation.

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Explore Ansys Optics solutions.

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A Winning Team

Leverage SPDM To Enhance AI Training

By **TOM MARNIK**, Senior Business Development Executive, Ansys,
ILYA TOLCHINSKY, Lead Product Manager, Ansys, and
JENNIFER PROCARIO, Senior Marketing Communications Writer, Ansys

Despite the inference drawn from its name, artificial intelligence (AI) is based on very real data. In fact, data is fundamental to AI training. Typically, an engineer feeds an AI model with data to train it to perform tasks. As you might imagine, data accuracy is essential for successful AI training, which generally requires a large volume of data. In this regard, simulation offers significant support, including predictive accuracy, a large capacity for data, near-limitless analysis capabilities, and speedy results.

“SPDM enables teams to manage simulation, data, workflows, and resources throughout their organization, spanning various departments and engineering disciplines, from one central database. With an SPDM solution such as Minerva software, companies can create a digital thread throughout all stages of the product life cycle, increasing productivity, design success, and collaboration.”

Ansys’ latest AI-based technology, the Ansys SimAI physics-agnostic, cloud-native software as a service (SaaS) application, combines the predictive accuracy of Ansys simulation with the speed of generative AI. Customers can train the AI using previously generated Ansys or non-Ansys data. For simulation process and data management (SPDM) users, such as Ansys Minerva SPDM software customers, this is great news. In SPDM platforms, an abundance of data is already organized, managed, and ready to go. This makes it even easier, faster, and more efficient to supply data to the SimAI platform. Let’s explore how you can leverage SPDM to enhance AI training.

UNDERSTAND THE PLAYERS

SPDM enables teams to manage simulation, data, workflows, and resources throughout their organization, spanning various departments and engineering disciplines, from one central database. With an SPDM solution such as Minerva software, companies can create a digital thread throughout all stages of the product life cycle, increasing productivity, design success, and collaboration.

What does this have to do with the SimAI platform? In relation to AI training, it means Minerva software users have quick and easy access to well-organized, robust data from every corner of their organization.

Now, let’s get to know the SimAI platform a bit better. Designed for users without coding experience or deep learning expertise, the application is intuitive and easy to use. Instead of relying on geometric parameters to define a design, the platform uses the shape of a design itself as the input, facilitating broader design exploration even if the shape’s structure is inconsistent across the training data. In addition, the application can boost the prediction of model performance throughout all design phases by 10-100X for computation-heavy projects. Training and predictions are hosted on a state-of-the-art cloud infrastructure to ensure that user data is secure.

Essentially, the SimAI platform is engaged in three simple steps: upload data, train the AI model, and predict. As mentioned, customers can train the AI using previously generated Ansys or non-Ansys data. This gives SPDM users an advantage because their data is already compiled, sorted, and accessible in a few clicks.

SimAI software boosts the prediction of model performance across all design phases by 10-100X for computation-heavy projects — delivering simulation results in minutes, not hours.

ENHANCE THE POWER OF AI WITH SPDM

So, how do we move our Minerva software data into the SimAI platform? First, you can connect with SimAI software using a web application directly through your browser. Next, from Minerva SPDM software, select the files you wish to use and drag them over to a dedicated folder in your file system. Run a script in this folder to convert the simulation data into a Visualization

"We've already established that SPDM is a secure repository for simulation results that are categorized, organized, and easy to find, but Minerva software also stores important information about these results so users can understand them better."

Tool Kit (VTK) file, an open-source format that SimAI software can understand. Then drag the files from your local file system into the SimAI web application and you're all set.

In the SimAI platform, you can now configure a model using your data and initiate AI training. You can even assess the quality of your data by using an existing SimAI model to evaluate the performance of geometry within your computer-aided design (CAD) files, then automatically download the results into Minerva software.

Conveniently, with the cloud-first approach of SimAI software, your original results for training are stored on remote servers. This eliminates unnecessary uploading or downloading between local and remote file systems as you continue to train your AI.

SimAI software relies on simulation results to undertake the learning and training needed to complete tasks or generate design recommendations. For this reason, it is critical to keep track of simulation results when preparing to train AI — something that Minerva software does inherently. But the benefits of SPDM don't stop at the onset of training.

As you continue to train your AI and run more simulations, you will create more results that need to be categorized, organized, and managed so that SimAI software can learn and make even better recommendations. In this way, Minerva software provides continuous support throughout AI training — which is often an ongoing, evolving process. Similarly, in the SimAI platform, you can tag your prediction results with metadata, including global coefficients or values, making your results easier to locate later.

MAKE THE TOOLS WORK FOR YOU

We've already established that SPDM is a secure repository for simulation results that are categorized, organized, and easy to find, but Minerva software also stores important information about these results so users can understand them better. This insight encourages better decision-making when selecting data input for AI, accelerates the AI training process, and makes it more efficient.

Other advantages are that Minerva software supports cloud deployment and offers native interoperability with popular CAD and computer-aided engineering (CAE) tools, as well as product life cycle management (PLM) systems. It also integrates easily with other Ansys Connect products, including Ansys Granta MI Enterprise materials data management software, Ansys optiSLang process integration and design optimization software, and Ansys ModelCenter model-based systems engineering (MBSE) software. This means that your SPDM data is likely chock-full of insights from a variety of Ansys and non-Ansys solutions, ready to provide comprehensive training to your AI model.

In addition, a multiphysics simulation workflow works seamlessly with SimAI software because it is physics-neutral. As a result, customers can leverage Minerva and SimAI software across all engineering disciplines, simulation products, and industry segments.

HOW SPDM ACCELERATES PRODUCT DEVELOPMENT

To better understand the simulation data management challenges that engineering and manufacturing organizations now face and how simulation process and data management (SPDM) solutions address their concerns, research firm Lifecycle Insights conducted the "2024 Simulation Data Management Study." This market analysis of SPDM surveyed 200 companies and included interviews.

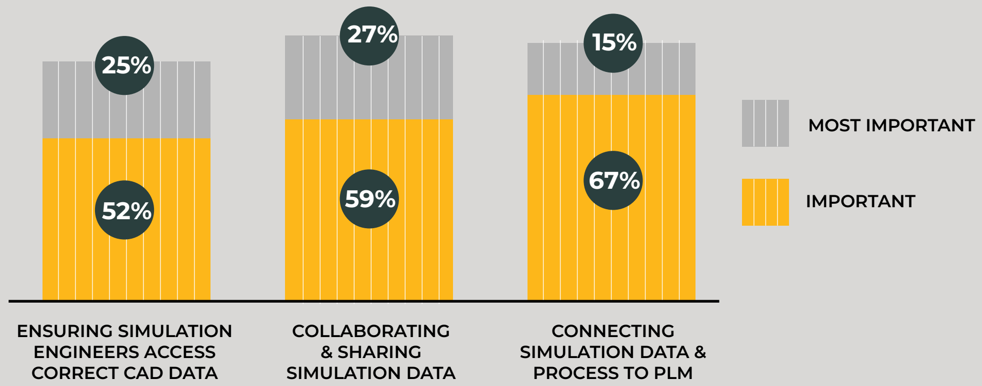
Findings indicate that the tools and processes used by many companies to manage simulation data are insufficient for their needs. The report also suggests that SPDM solutions deliver capabilities that improve product development by enabling companies to extract maximum value from their investments in simulation.

Simulation plays an important, ongoing role in improving product development in every industry. The kinds of improvements that simulation enables — reducing prototyping and testing costs, shortening design timelines, and increasing product quality — are crucial for companies as they work to keep pace with competitors in complex marketplaces. When organizations integrate a dedicated SPDM solution with their existing product life cycle management (PLM) software, they can accelerate product development, more effectively use simulation throughout the product life cycle, reduce communication errors, and maximize the return on their investment in simulation.

Companies seeking to achieve these kinds of product development improvements should:

1. Examine the company's current product development process and how effectively it manages simulation-related data and processes.
2. Identify broken links in the simulation processes and data in the existing digital thread to determine whether those processes and data are connected throughout the product life cycle.
3. Implement SPDM and integrate it with the company's current PLM solution to ensure that simulation is available throughout the product life cycle.

MOST VALUABLE CAPABILITIES OF SPDM



Study participants say simulation process and data management (SPDM) provides several valuable capabilities to product developers related to finding and sharing accurate, up-to-date simulation data.

LEARN MORE

For more information, read the "2024 Simulation Data Management Study."

ansys.com/resource-center/white-paper/maximizing-the-value-of-simulation

Mission Engineering and Machine Learning

A Collaboration To Improve Your Analysis

By **NOVARAH KAZMI POLICHT**, Senior Application Engineer, Ansys, and **TERESA BROOKS-MEJIA**, Principal R&D Engineer, Ansys

Artificial intelligence is a powerful tool for solving problems. When coupled with mission simulation, you can explore solutions to novel problems for a fraction of the cost of development and testing in the physical world. Specifically, you can improve your analysis by using a workflow that combines mission simulation and machine learning (ML) models in Ansys Systems Tool Kit (STK) digital mission engineering software.

UNDERSTAND THE PROBLEM

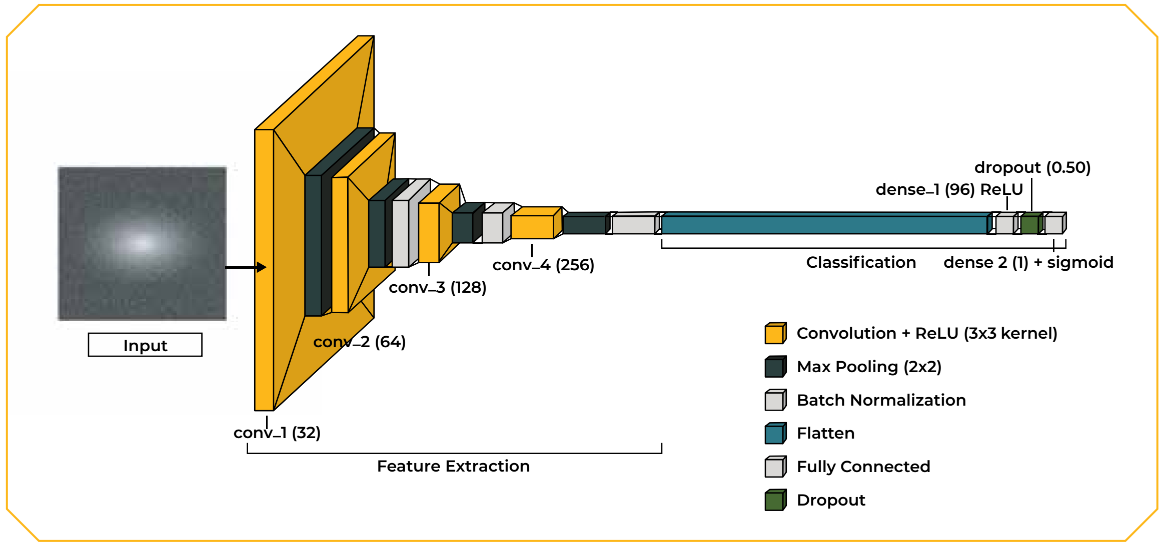
ML is a data-driven approach to solving problems because the problem that you want to solve is modeled in the data used to train and validate your models. When applied thoughtfully, ML can extend your ability to understand and solve problems using that data. For example, an ML model trained on well-designed datasets can learn hidden features and relationships, and it can allow you to scale and automate tasks in an operational setting. So the question is, how do you get these datasets? You could start the expensive, multiyear process of conducting an operation, or you can turn to commercial off-the-shelf (COTS) tools like STK software to generate datasets for use in ML models.

You can answer a few questions to help you start modeling your mission and generating datasets.

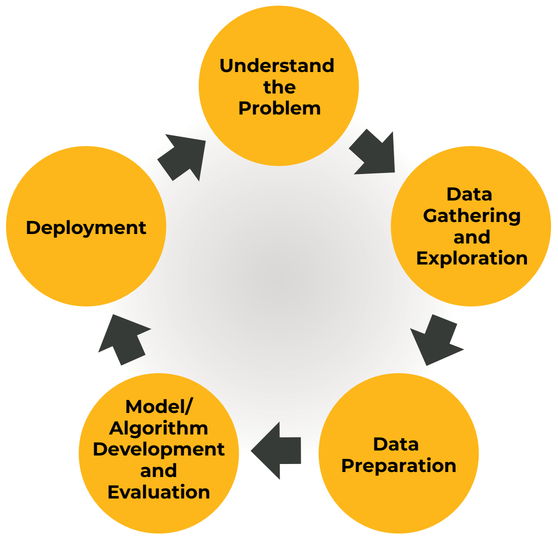
1. **What kind of ML problem are you trying to solve?** For example, is it a classification or identification problem, or is it a regression problem in which you are trying to predict a numeric value from an input? The image on page 54 depicts the typical ML development life cycle, and the process always begins with understanding the problem you are trying to solve.
2. **What kind of data do you need to train your model, and what features should be included in the data**? For instance, if you are trying to identify a satellite using distinguishing characteristics from an optical sensor, you would need images of the satellite to train and validate your model, as well as labels for each example in the dataset, in which the labels describe the satellite in the example.
3. **How many examples do you need in your training dataset, and how closely do these examples represent the problem in the physical world?**

GENERATE THE DATASET WORKFLOW

Once you have a handle on the problem, the next step is diving into the tools to generate datasets. Generating datasets with physics-based tools like STK software gives you traceability in understanding where your data comes from, and it gives fine-grained control over how you model the problem in your datasets. Simulation tools also provide the benefit of modeling and exploring



Convolutional neural network model architecture from the 2024 AIAA SciTech Forum published work



Typical machine learning (ML) development cycle

solutions for which datasets do not exist. For example, simulation is especially helpful for developments taking place in the future or if a solution is too costly to launch and iterate in real life.

With STK software, you can build a design reference mission (DRM) to model the problem that you are investigating. Your DRM can include all the assets and complex systems in the context of the mission. Whether those be on the ground, in the air, or somewhere in space, you can model your assets in one cohesive tool. There is the added flexibility of making changes to your DRM to generate new results without affecting the operational cost. In a live mission, you might have a wide selection of parameters but only get to test one configuration at a time. With simulation, however, you can sweep through unique configurations to test multiple approaches and generate the data you need.

You can generate results from your DRM by modifying the scenario, but you also can connect your tools to external ones to make automating easier. Ansys ModelCenter model-based systems engineering software or custom scripts are common tools to automate and run trade studies on your DRM. Once the data has been generated, it's time to explore ML approaches to find the best fit for your problem space.

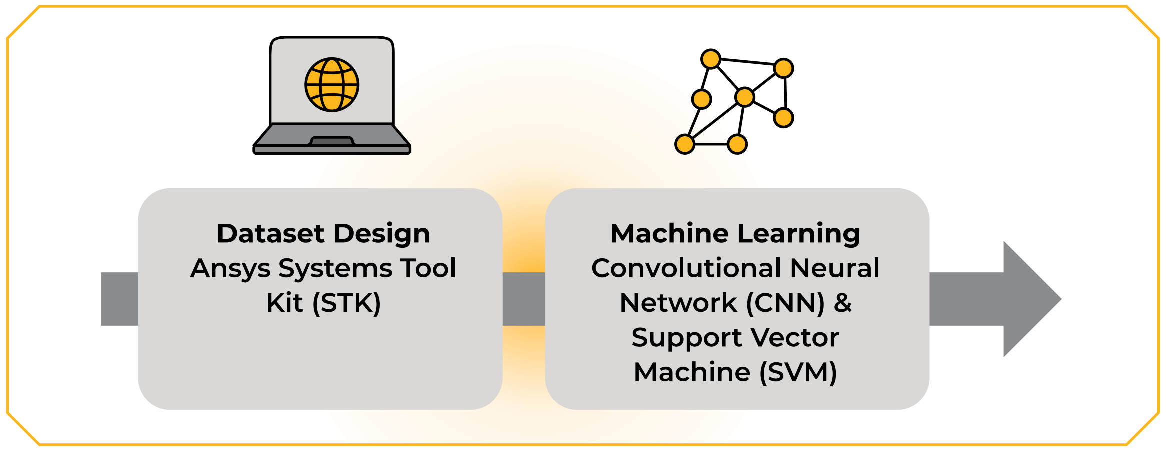
HOW TO IMPLEMENT A MACHINE LEARNING PIPELINE

The ML development life cycle is an iterative process. A substantial part of that process involves implementing a pipeline that includes the following steps:

1. Data ingestion and preprocessing.
2. Exploratory data analysis. This step is all about understanding the dataset that you have generated. Specifically, you want to understand how well this data represents the problem.
3. Data preparation. In this step, you perform any preprocessing required to transform the data into a format for training and model evaluation. This includes splitting the data into train, test, and validation sets, as well as feature reduction.
4. Model selection, training, and evaluation.

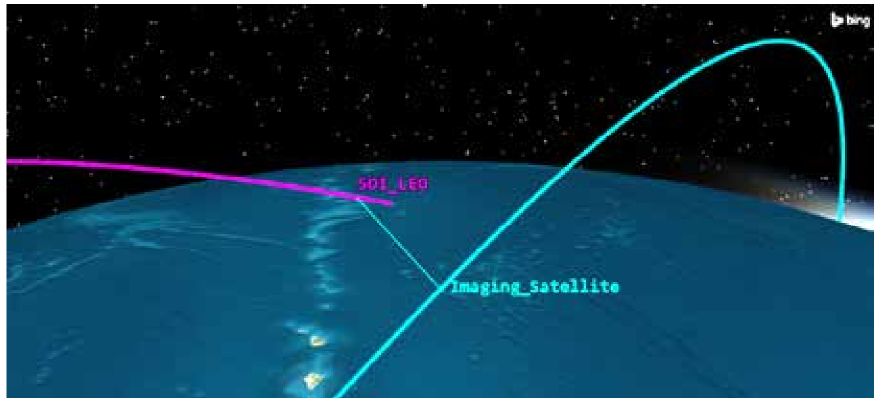
EXPLORE THE WORKFLOW IN ACTION

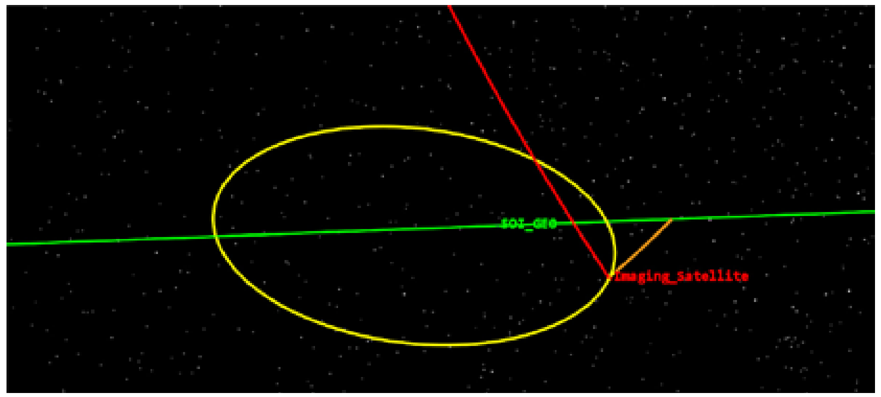
When used together, STK software and ML can help you achieve new levels with your mission analysis. Let's talk about some research work that demonstrates the approach we just discussed. At the 2023 and 2024 AIAA SciTech Forums, we presented "Electro-optical Fiducial Markers on Satellites for Identification and Characterization" and "Characterization and Classification of Low-resolution LEO and GEO Satellites With Electro-optical Fiducial Markers," respectively.



Depiction of the workflow for using Ansys Systems Tool Kit (STK) digital mission engineering software to generate data for training ML models

> ***"You can generate results from your DRM by modifying the scenario, but you also can connect your tools to external ones to make automating easier. Ansys ModelCenter model-based systems engineering software or custom scripts are common tools to automate and run trade studies on your DRM."***





STK software scenario views in the 2024 study. At the top, SOI_LEO is indicated in fuchsia and the observing satellite is in teal.

Below, SOI_GEO is indicated in green and the observing satellite's trajectory stages are in orange, yellow, and red.

In these experiments, we used STK software to simulate the mission and design our dataset. We wanted to test whether unique spectral markers, also called electro-optical fiducial markers, on the body of a satellite could be detected and characterized by neighboring satellites or from the ground. Could our ML model tell whether a marker is or isn't present? We modeled the cameras' systems on each asset and let STK software generate the data for us. In our follow-up work, we made the problem harder by using cameras with decreasing resolution to capture images of our satellite of interest. We wanted to see how far we could degrade an image and challenge our ML classifier model.

In both studies, we followed the data generation process with the ML pipeline. We first ingested and preprocessed the data, then we conducted an initial exploratory analysis, prepped the data, and trained and evaluated our model.

TAKE THE NEXT STEPS

Our research shows that collaboration between simulation and ML greatly improves analysis. We hope that this workflow and our research inspire you to model your missions with STK software and explore generating datasets to train your ML models.

LEARN MORE

Explore Ansys digital mission engineering software.

ansys.com/products/missions