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Automotive design: **How AI is transforming** **the art of simulation**



Automotive design: How AI is transforming the art of simulation

The automotive sector is about to experience a major wave of innovation as artificial intelligence (AI) is applied to design simulation, according to experts.

The technology makes it possible to reduce the time needed to run the analyses for crash-test simulations—one of the most data-heavy exercises in automotive design—from several days to minutes, says Ilya Tolchinsky, lead product manager for AI at simulation specialist Ansys.

When AI is combined with simulation, crashes can be analyzed thousands of times faster than with traditional approaches has deep implications for the auto industry, Tolchinsky says.

Software-based simulation has long been used by automakers to reduce the need for physical testing, which is time consuming and expensive. The simulation allows automakers to predict the behavior of new designs and variants to guide the development process.

Although this is drastically more efficient than building real-life prototypes, it still requires significant resources. To begin with, a simulation expert must build a digital

model that faithfully reflects the conditions of a given test.

Once this has been created, the software must calculate the physical behavior of the vehicle under specified conditions. “To run these simulations requires enormous amounts of computing power,” says Tolchinsky.

DESIGN REQUIREMENTS

In the automotive sector, design exploration is complex because it is not driven purely by performance but must also consider the aesthetic desirability of the products.

In this respect, says Tolchinsky, automotive design presents interesting challenges not seen in industries such as aviation, where design is largely dictated by physical constraints.

“For car designs, manufacturers have to take into account the aerodynamic performance—but they also have to make the car look cool,” he says. “If the designers want to create a different shape, it’s not just about engineering performance but also aesthetic appearance.”

In this environment, he says, designers “don’t want to be constrained by a fixed set of parameters to define the design, because from one design to the next they might completely redefine how they describe the geometry.”



With traditional simulation, this means starting from scratch for every new geometry. AI, however, makes it possible to create surrogate models using historic simulation data.

This enables designers to assess the performance of new designs within minutes, without requiring an expert to build and execute a simulation.

Automakers can use these AI surrogates to rapidly test masses of new designs, discarding options that would not work in practice and focusing on those that offer the greatest promise.

GROWING ADOPTION

Ansys' SimAI AI-assisted simulation software has been in use for more than a year and is garnering interest from major automakers, says Tolchinsky. "I know there are cars that are being designed right now that will be impacted by this," he says.

While there is interest in AI-assisted simulation across a range of industrial sectors, "automotive, in particular, is demanding this," he adds.

SimAI was formally launched in January 2024 as "a physics-agnostic, software as a service (SaaS) application that combines the predictive accuracy of Ansys simulation with the speed of generative AI," according to a press release.¹

"Instead of relying on geometric parameters to define a design, Ansys SimAI uses the shape of a design itself as the input, facilitating broader design exploration even if the structure of the shape is inconsistent across the training data," said the release.

The application can reduce the amount of time it takes to evaluate the performance of a new design by a factor of 10 to 100, across all automotive design phases, for computation-heavy projects, Ansys added.

Early SimAI adopters include Renault Group, which has been working with Ansys on autonomous vehicle design since 2019.²

"With Ansys SimAI, we will be able to easily test a design within minutes and rapidly analyze the results, ultimately redefining our digital engineering workflow and reshaping our perception of what is possible," said William Becamel, expert leader in numerical modelling and simulation at Renault.³



"By enhancing simulation speed, we can explore more technical possibilities during the upstream phase of our projects and reduce the overall time to market."

Besides working with Renault, in March 2024 Ansys was named preferred supplier for Hyundai Motor Company's next-generation vehicle body system analysis.⁴

SIMPLE REQUIREMENTS

Ansys's SimAI software is designed for users with no coding or deep-learning expertise and its availability under a SaaS model means automakers can use it without having to worry about hosting, installation and integration.

And while most generative AI systems require massive data sets for training, Tolchinsky says SimAI can build models with exposure to as few as 30 software simulations. This assumes the simulations are all closely related, for example focusing on a particular vehicle type.

More generic models, still sufficient for the development of conceptual studies, might require hundreds of simulation data sets. "We've seen an OEM will take all their vehicles—pickup trucks, sports cars, sedans, SUVs—and throw all that together into the model," says Tolchinsky.



Automakers have access to lots of potential training data following years of software simulations, he says. “The obvious direction is to create one model that can do all cars without needing training data,” he adds. “There you’re talking about much larger data sets.”

The Ansys software is surprisingly nimble in terms of computing requirements, unlike AI systems used for other applications.

In March, consultancy firm Dell’Oro predicted AI would require \$200 billion of extra capital expenditure on data centers by 2028⁵, yet Tolchinsky claims the Ansys software could be trained with a single graphics processing unit running for a couple of days.

NEW DESIGNS

Traditional simulation has already demonstrated its value in areas such as automotive safety, where fatalities have decreased by 78% in 60 years⁶ thanks to technology innovation.

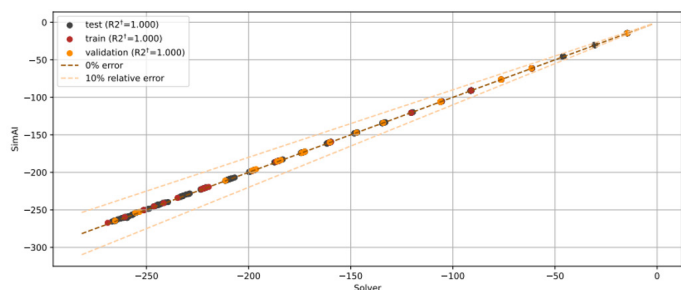
Early reductions in vehicle fatality rates came from the introduction of physical features such as seatbelts and bumpers. But further improvements were aided by the introduction of crash testing in 1978.⁷

Today, software simulations can help determine the safety performance of new materials and vehicle configurations, a process that could be enhanced with the addition of AI to explore many more options in much less time.

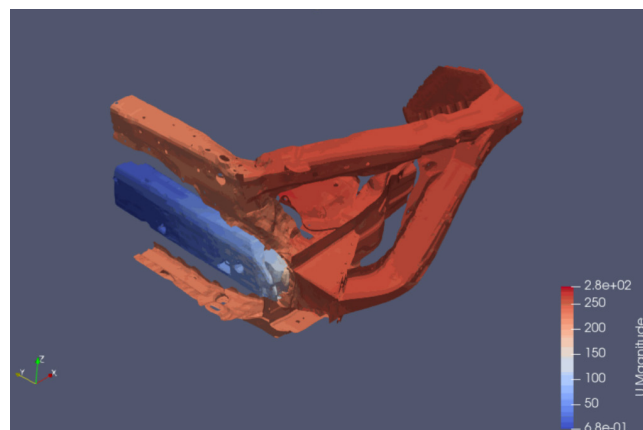
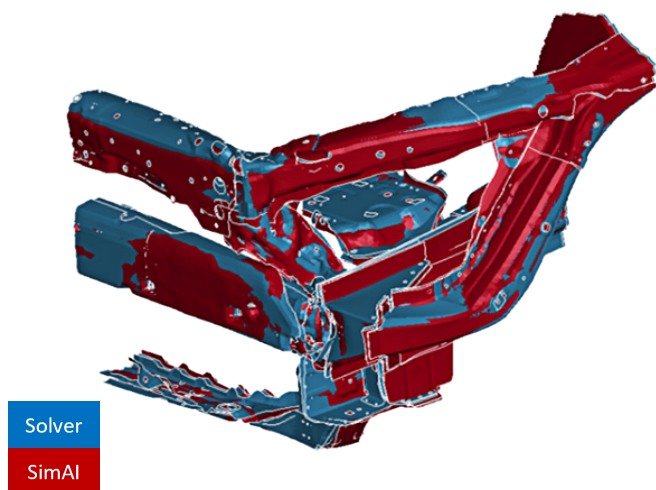
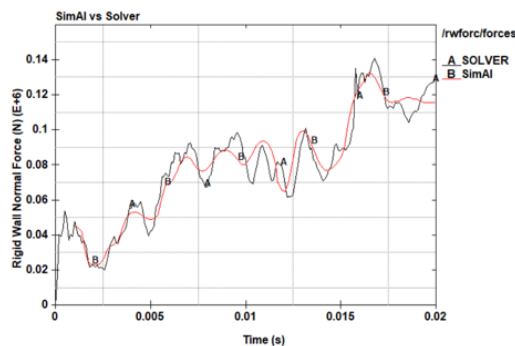
There has always been a trade-off between speed and accuracy when running simulations, says Tolchinsky. “This is what we’ve always done with simulation—made it faster and more accurate,” he says. “AI provides a new outlier in this trade-off. This is just a big leap forward.”

AI-assisted design optimization could also help carmakers come up with completely new designs by creating original geometries that are not constrained by a human-fixed set of parameters.

Overall Crush Prediction Accuracy



Rigid-wall Force Prediction



SimAI **crush prediction** on new bumper thickness in less than 1 minute

“Today, to do design optimization, we typically have to define how to represent the geometry by a set of parameters,” Tolchinsky says. “When we do that, we fix the scope of what is possible. With AI, we don’t need to parameterize our design space to do automated design exploration.”

SIMULATION EXPERTS

It is unclear how AI might change the role of simulation experts. For the first time ever, applications such as SimAI will allow non-experts to test new designs without requiring help from simulation experts.

Instead, SimAI and similar applications can take care of the manual processes required to build a simulation model, potentially reducing the need for human specialists—although they will still be needed to generate training data sets.

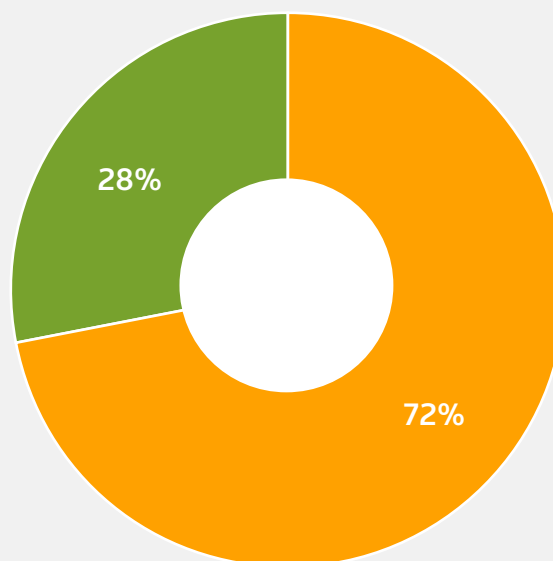
Furthermore, Tolchinsky believes most carmakers will use the expert skills freed up with AI to increase the extent of simulation work rather than scaling back the role of experts. “We can use these models to evaluate more designs, so the value simulation brings is greater now,” he says.

“What will happen is we’ll have spare capacity—of computing and simulation experts—to explore more advanced topics. Simulation can now go into areas that we just haven’t had the capacity to do before. This is just speeding up innovation. I see new applications for simulation coming out of this.”

Analyst forecasts for the automotive simulation market also point to considerable growth.

Global Market Insights claims the market was worth more than \$2 billion in 2021 and is set to see more than a 10% compound annual growth rate (CAGR) up until 2030, hitting more than \$5 billion by the end of the decade.⁸

This growth will largely be driven from rising demand for automated vehicles and could push the software segment of the simulation market to a CAGR of more than 20%, with safety engineering growing by more than 15%, Global Market Insights says.



● SOFTWARE ● SERVICE

Global automotive simulation market share, by component, 2021.
Source: Global Market Insights.⁹

CHANGING MARKETS

AI-assisted simulation is emerging at a point when the auto industry is undergoing deep changes, emphasizing the need for rapid, large-scale innovation.

The most immediate of these is vehicle electrification, in response to government-backed phaseout dates for internal combustion engine models and growing consumer demand for EVs.

Even though the Environmental Protection Agency in March slashed its target for U.S. EV adoption from 67% to 35% by 2032, after industry and autoworker backlash,¹⁰ Consumer Reports said in February that electrified vehicles were becoming more desirable than their gasoline counterparts.¹¹

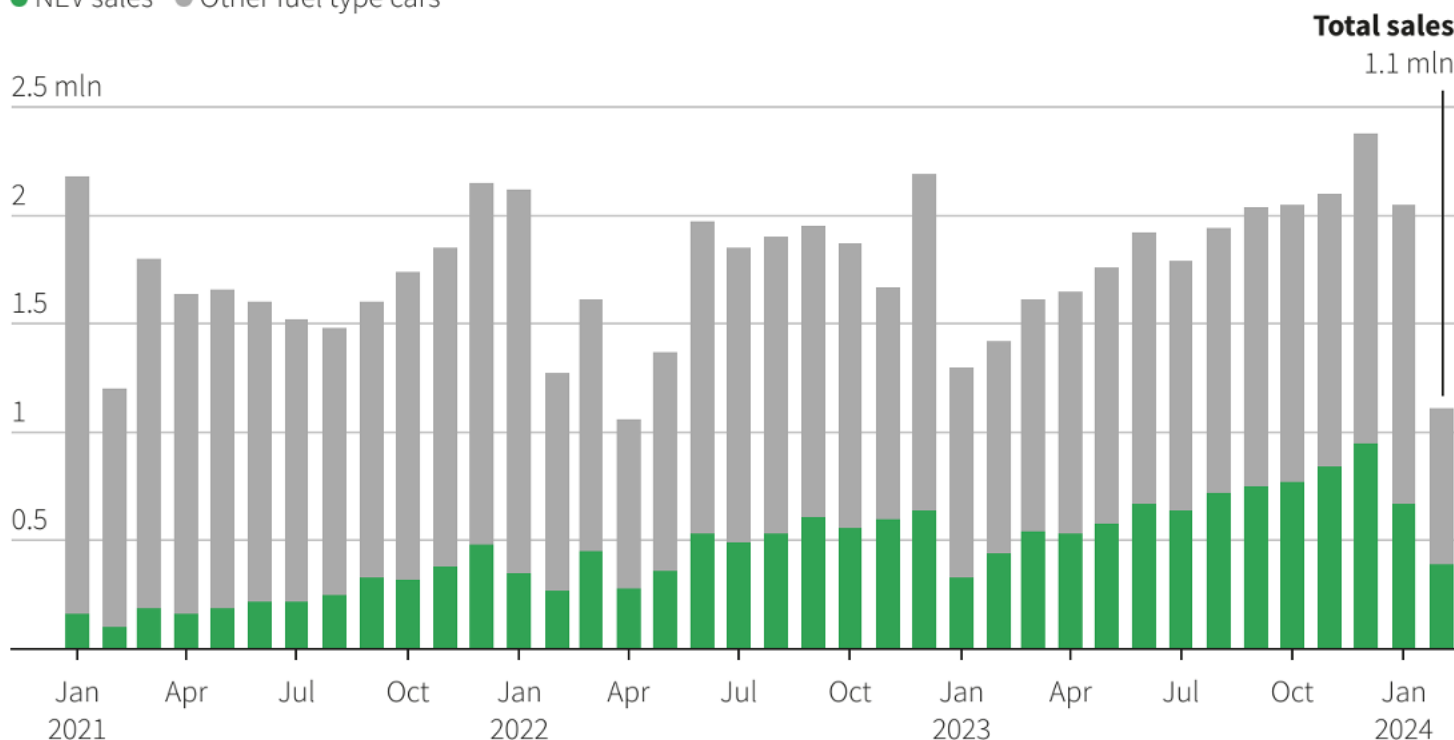
Meanwhile in December the European Automobile Manufacturers Association said sales of electric cars in the European Union were almost half of all new passenger car registrations between January and November 2023.¹²

Meeting this growing demand requires radical changes to automotive manufacturing processes and designs.

Car sales total 3.16 million units in January and February

A total of 3.16 million passenger cars were sold in China in the first two months of 2024. NEV sales rose by 37% in the first two months of 2024 compared to Jan-Feb 2023.

● NEV sales ● Other fuel type cars



Source: CPCA | Reuters, March 8, 2024 | By Sumanta Sen

Because of its batteries, a typical EV weighs around 2 tons, or about 25% more than an average internal combustion engine vehicle,¹³ which creates a need for design changes such as reducing rolling resistance to increase energy efficiency.

This weight differential means test results for internal combustion engine vehicles are no longer valid when models are converted to battery power. Hence, automotive manufacturers may need to run simulations not only on new EV designs but also on electric versions of existing models.

CHINESE THREAT

While western carmakers look to adapt their ranges to an electric future, they also face increasing competition from Chinese EV makers.

EV sales in western markets are for now dominated by European and U.S. OEMs, and particularly Tesla, which took a 56% share of its home market in the fourth quarter of 2023, followed by Ford with less than 9%.¹⁴

Tesla also boasted the world's number one and number three bestselling EVs globally in 2023. However, the other eight models in the top 10 were all Chinese, with six belonging to a single carmaker, BYD.¹⁵

BYD overtook Tesla as the world's top-selling EV maker in the last quarter of 2023 thanks to booming domestic sales. EV penetration in China is expected to top 40% in 2024, with local brands commanding 78% of the market. In comparison, EVs account for just 12.5% of the U.S. auto market.¹⁶



Western OEMs are bracing for fierce competition in 2024 as Chinese EV makers look to foreign markets in the face of softer domestic demand.

Although China saw an 18.2% rise in EV sales in January and February, this was below the 20.8% average for 2023 and saw BYD slashing prices on popular models.¹⁷

In March, BYD launched a new version of its best-selling model, the Yuan Plus crossover, at an 11.8% discount compared to its predecessor.¹⁸

An influx of low-cost Chinese models poses a quandary for western OEMs at a time when many are scaling back EV production in the face of over-optimistic EV sales forecasts.

Some western OEMs are hoping for protection from policymakers, with the president of the Association of European Automobile Manufacturers, Luca de Meo, calling for European coordination on ten initiatives, from smart charging to green economic zones, in an open letter in March.¹⁹

In the long run, however, it seems likely many OEMs may have to scale up innovation to counter the threat of a shrinking market share, prompting the need for increased simulation testing.

And as EV systems gain complexity, auto suppliers are facing extreme pressure to achieve and exceed OEM requirements.

To safeguard a design's robustness, suppliers need intelligent engineering workflows to virtually explore, test and optimize electrical and electronic components and mechanical sub-systems for passenger and commercial vehicles.

"Leveraging AI-powered analyses before the design and product Validation phases is a breakthrough for any automotive company looking to accelerate innovation," says Anthony Matarazzo, sales director for AI and simulation at Ansys.

"Product vitality will depend on creating better products faster with less resources, winning more programs in less time. It's about doing more with less. Traditional engineering isn't enough, and companies can't afford to wait and see."



AUTONOMOUS VEHICLES

A final important trend affecting the auto industry is the rise of autonomous vehicles.

Driverless vehicles covered almost 3.3 million miles in California during 2023, five times the distance traveled in 2022, as ventures such as Alphabet's Waymo and General Motors' Cruise pressed ahead with autonomous vehicle tests despite persistent concerns over the technology.²⁰

A transition to autonomous driving would represent a major shift in automotive design by radically changing the nature of the customer experience.

Current car designs give priority to driver road awareness and aesthetic features related to driving, such as aerodynamics in sports cars or ruggedness in off-roaders. When driving is taken out of the equation, design is likely to pivot to considerations such as in-car comfort and infotainment.

This tends to result in box-shaped vehicles rather than today's sleek designs.²¹ Studying how such fundamentally reshaped vehicles function in practice will likely require large amounts of simulation testing, which AI could help deliver at scale.

Even more important is the need to test how these vehicles react to real-life situations from a safety perspective, extending advanced driver assistance systems to the driverless realm.

"Simulation based testing provides the luxury of conducting a large number of iterations in a relatively small amount of time, compared with real-world testing," says Professor Siddhartha Khastgir, head of safe autonomy at the University of Warwick's WMG research and education group.

"However, for systems like self-driving vehicles, the system interaction configurations to explore are potentially infinite. As a result, we need an intelligent approach to explore this enormous interaction space, which is where AI-based search solutions stand out, making it more efficient for us."

Currently, Khastgir says, "It is very difficult for self-driving vehicles to experience all the situations and learn how to respond. With the restriction of trialing in the real world, simulation supports the industry and research organizations to test self-driving vehicles and their systems virtually."

But with AI, "Engineers and researchers can create numerous road scenarios and test if their systems can respond safely," he says. "In virtual simulation, there is also no limitation on what you want to include in a scenario; many different situations and incidents can be included to train this technology."

As OEMs face challenges such as how to build self-driving cars, AI-assisted simulation is "really a game-changer in terms of speed [and] ease of use," says Tolchinsky of Ansys. "This will give one car manufacturer advantages over another. They can't afford not to get in the game."



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