# A CHANGING SIMULATION PARADIGM *FOR A* CHANGING AUTO INDUSTRY

Geometry courtesy PTC.

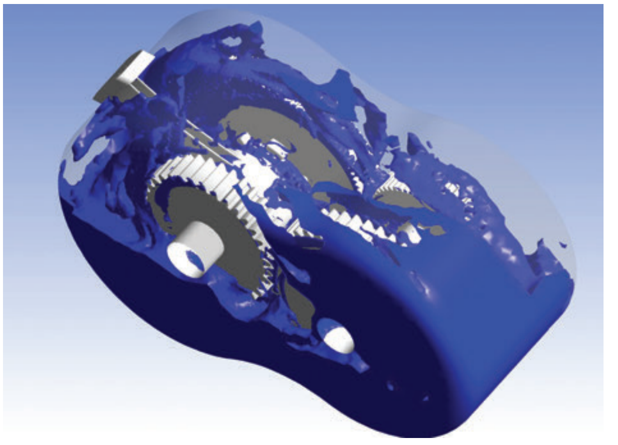
▲ The latest ANSYS release assessed thermal effects of the engine and exhaust manifold on other vehicle components using a new mapped interface approach. The meshes for each component can be created separately, which is simpler and quicker than generating them with matching mesh between fluid–solid and solid–solid regions.

**The automotive industry must fully embrace complete virtual prototyping with multidisciplinary simulation and multiphysics — and use it thoughtfully and systematically throughout the product development cycle — to see the real promise of technical innovation. Can vehicle companies shift the paradigm from simulation-in-silos to deploying a common, scalable enterprise-level simulation platform that enables thorough systems engineering?**

**By Sandeep Sovani**, Director, Global Automotive Industry, ANSYS

A hundred years ago, Henry Ford promised customers that their car could be painted any color so long as it was black. Today, color is the least of the auto industry's challenges. The car of the 21st century must be fuel-efficient and robust, technologically savvy and affordable, and manufactured quickly on the line without defects. It must meet increasingly stricter government regulations. And the vehicle must incorporate fast-evolving electronic, communication and software technology that hardly existed a few years ago.

Automakers and their supply chain already apply engineering simulation to address some of today's problems: fuel-efficiency standards, potential warranty issues (with reputation and financial consequences), and the transition to hybrid and electric vehicles (H/EVs). They also embrace big ideas — disruptive technology — like self-driving cars. But the key to success is how the industry leverages the big-picture power of simulation to innovate, fulfill consumer demands, comply with stringent regulatory demands, and meet development time, cost and performance targets. Said another way, how effectively are companies deploying a common enterprise-level simulation platform?



▲ Gear box simulation is useful in predicting flow pattern to ensure proper lubrication, computing temperature distribution in fluids and solid components, and predicting viscous losses. ANSYS offers tools that analyze not 20 or 30, but many hundreds of, vehicle shape variants with high-fidelity, detailed simulations.

**The key to success is how the industry leverages big-picture power of simulation to satisfy consumer wants, comply with regulatory demands, and meet development time, cost and performance targets.**

## TODAY'S DRIVING FORCES IN AUTOMOTIVE INNOVATION

### Fuel-Efficient, Cleaner Cars

It's no surprise that the industry's overriding trend is fuel efficiency and emissions reduction. Governments worldwide have established fuel-economy/greenhouse-gas emissions standards. By 2025, U.S. CAFE standards will jump to 54.5 mpg, a move backed by 13 major automakers. China and India, the world's largest automotive markets, have followed suit. The global initiative will cut emissions, save oil and take outdated cars off the roads.

Meeting these targets involves exploiting every opportunity for re-engineering. Using simulation sheds insight to quickly resolve a variety of trade-offs, such as reducing aerodynamic drag without sacrificing cooling/cabin quietness, or reducing vehicle weight while still meeting strength/durability specs.

**ADDRESSING ENGINEERING CHALLENGES OF INCREASINGLY COMPLEX AUTOMOBILES**
ansys.com/92auto1

### Rising Vehicle Complexity and Disruptive Technology

Consumer appetites, government regulations and advancing technologies are transforming cars from mechanical machines to complex electronic ones. For instance, the door lock apparatus, once a small mechanical device, is now an electronic passive-entry system that comprises electronic sensors, controllers, actuators and advanced software algorithms.

Seven automotive companies have announced plans to sell or market some form of autonomous or self-driving car. Players are investing heavily in this application, achieving major milestones. Internet giant Google logged 125,000 miles in autonomous vehicles in its first year of testing alone, a mere five years ago. While these innovations intrigue consumers, they unnerve auto executives who confront the rising complexity of vehicle engineering — along with its effect on time and cost of development. The chance of an engineer failing to uncover and address potential catastrophes is directly proportionate to a vehicle's design complexity.

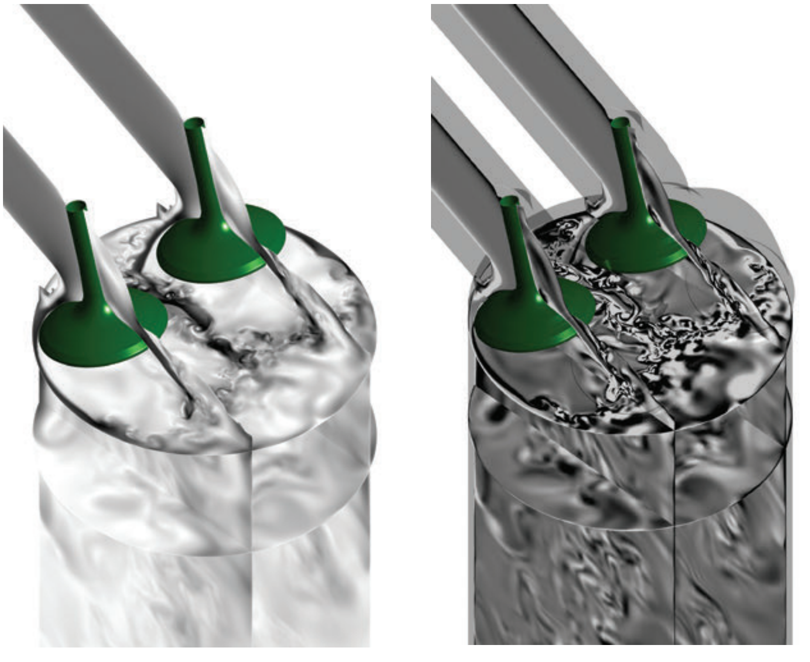
How can the industry accomplish such dramatic leaps in product technology in a short time? How can car makers ensure thorough safety of autonomous driving systems? Simulation is the product development tool of choice to tackle these mounting challenges, enabling engineers to model the entire vehicle as a single system. Furthermore, since a company typically employs thousands of engineers around the globe to design various aspects of a vehicle, providing a common collaborative simulation platform is a key enabler. Visionary companies are developing and deploying a common enterprise-level simulation platform — a best practice that delivers rapid testing for hundreds, even thousands, of operating conditions; achieves safe operating modes; and exploits hard-to-see optimization and innovation opportunities.

### The Electronics of Things

With smart electronics usage in general on the rise, demand dictates more smart interfaces in vehicles. Infotainment comes in the form of satellite radio, GPS units, and touch-screens built into dashboards and headrests. Automakers now offer in-car 4G LTE Wi-Fi (along with the antennas that make it possible).

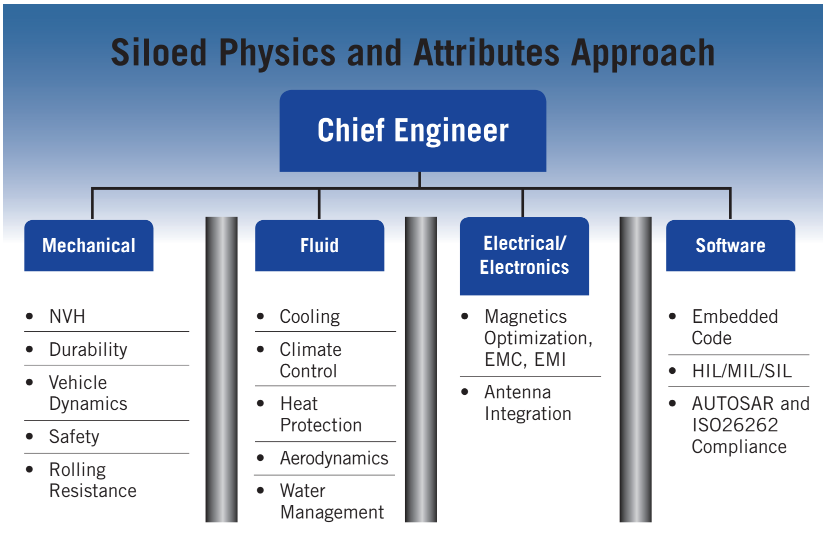
Components like keys and window/door locks are operated by software, as are gauges that read fuel consumption, mileage and emissions. Software controls rear-view cameras, batteries, acceleration and braking functions, to name a few. These systems together create a complicated network of embedded software and electronic signals that grows more complex as technology advances. The modern car is nothing short of a large computer cluster on wheels.

Such Internet of Things (IoT) functionality requires high-fidelity simulation tools for complex tasks — antenna and radar development, EMI–EMC prediction, signal integrity, chip–package system design and electronics cooling — in tandem with embedded code modeling and generation tools. The ANSYS software combination ensures reliable systems-based engineering across hardware and software, in a competitive time frame.



Courtesy Stefan Buhl, Chair of Numerical Thermo-Fluid Dynamics, TU Freiberg, Germany.

▲ Joint research indirectly advances the interests of industry. ANSYS engaged with TU Freiberg to study IC engine flow. The results show how HPC can deliver outstanding results in a time frame that fits into the product launch schedule.




▲ Most automakers focus on single-physics analysis, which lengthens the product development cycle and can result in disastrous consequences as the vehicle's various subsystems interact. Complex systems require best practices that break down the silos and span all physics/engineering disciplines.

## STAYING ON TOP OF THE TRENDS: BREAKING DOWN THE SILOS

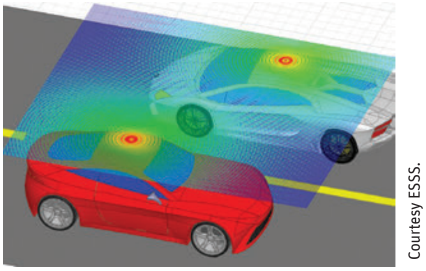
The automotive industry was an initial adopter of engineering simulation; it has leveraged this technology for several decades. The industry realized early on that simulation delivers virtual testing and analysis of an entire vehicle and its parts even before any prototypes are assembled. It's less expensive than physical testing and reveals results in a fraction of the time. Yet today, more than 85 percent of computer-aided engineering performed by automotive companies is single-physics simulation, which studies a sole physical effect in isolation. For example, mechanical strength of a brake rotor is studied separately from air flow that cools the brake. This approach will not recognize potential failure modes when the phenomena intersect — and the consequences of product failure can be disastrous. It also impacts development time, as simulation in various disciplines is performed sequentially instead of in parallel.

As vehicles become electrified, the interplay of multiple physics increases. In an electric traction motor, for example, electrical, magnetic, thermal, fluid, structural and acoustic aspects are all tightly coupled: Coolant flow affects temperature; temperature affects electromagnetics; these, in turn, affect motor efficiency as well as structural vibrations that result in noise. For such systems, making these trade-offs in a silo-like approach is suboptimal.

To make effective trade-offs, the ANSYS simulation suite incorporates coupled solvers, detailed models, submodels, methodologies and best practices across all prominent physics for analyzing key vehicle systems and components. The tools enable car companies to truly optimize designs, performing thousands of what-if, coupled-physics analyses that would be prohibitive via any other means. It serves as an exceptional common enterprise-level simulation platform due to its unparalleled breadth and depth of simulation solutions that are seamlessly hosted in a shared user framework.

**SYSTEMATIC DEPLOYMENT OF SIMULATION AT AN R&D CENTER: EVOLUTION OF AUTOMOTIVE SUB-SYSTEM SIMULATION AT VALEO**
ansys.com/92auto2

**Since automotive products must perform reliably the first time, every time, engineers leverage simulation to address challenges in a risk-free manner.**



Courtesy ESSS.

Without simulation, there is no way to properly design a car's antenna so that it is best prepared to deal with Wi-Fi.

**SAFE AUTOMOBILE CONTROLS**
ansys.com/92auto3

## BROADENING DESIGN EXPLORATION AND USING OPTIMIZATION TECHNIQUES

Since automotive products must perform reliably the first time, every time, engineers leverage simulation to address challenges in a risk-free manner. ANSYS tools build in robustness while speeding design time. Parametric design exploration and parameterization enable a thorough view of a wide design space to uncover potential failure modes and quality issues; the methods incorporate design of experiments (DOE) analyses, response surface investigation and input constraint analysis in pursuit of optimal design candidates. Topology optimization takes bulk material out of components, reducing weight without sacrificing strength and durability. The adjoint method, which automatically shows exactly where and how to change a part's shape to improve performance, is especially beneficial in optimizing aerodynamics and duct flows. These methods maximize the ability to sort through thousands of product design concepts by testing for specific parameters, then adopt and refine only the best design candidates. High-performance computing (HPC) and the cloud's space and flexibility of storage ensure that wide design spaces are explored in short time.

## LEVERAGING MODEL-BASED SYSTEMS ENGINEERING AND HARDWARE/SOFTWARE COSIMULATION

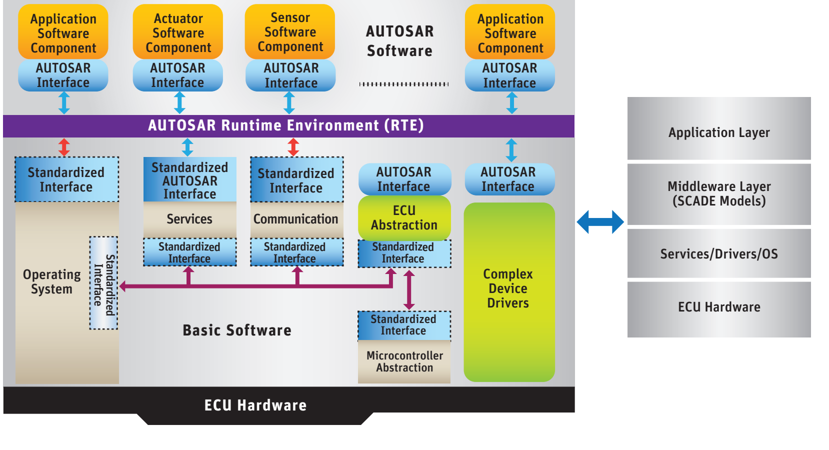
Auto companies must go even further to address complexity, employing simulation that combines high-fidelity component analysis with holistic system behavior models. The focus is on model-based systems engineering (MBSE), in which systems and components are simulated together. The solution includes reduced-order methods (ROMs) that enable effects of a subcomponent to be represented within an assembly without loss of accuracy — while greatly increasing computational speed. This approach accurately captures behavioral characteristics of individual components under real-life operating conditions as part of a bigger system.

Modern cars incorporate dozens of microcomputers that perform control and computational functions, with embedded software programs running them. Just like hardware components, embedded software must be tested for a variety of operating conditions to ensure flawless performance, especially in the case of safety-critical systems such as airbags. To ensure that hardware and software operate flawlessly in unison, they must be cosimulated. ANSYS advancements in MBSE and certified embedded code generation drastically reduce development time for embedded software while meeting the highest safety standards, such as ISO 26262 ASIL-D.

## THE NEXT GREAT IDEA

Simulation is not new to cars, but it has become such a crucial element of automotive engineering that visionary companies are making the paradigm shift of deploying a common enterprise-level simulation platform. It helps automakers keep pace with trends in everything from fuel efficiency to self-driving cars. Tomorrow, the trend-setters will look to simulation to set the pace.

This issue of *ANSYS Advantage* details exemplary practices that launch more-reliable products faster. "On Top of the World" (page 10) relates how DENSO engineers use the mechanical suite to expedite product development, cut costs and boost competitiveness across its product portfolio. "In the Loop" (page 22) addresses the role of embedded-code simulation tools in designing vehicle automation and driver assistance concepts. Insights into designing better onboard vehicle electronics appear in "Test Drive for EMI" (page 13). And Tenneco in China utilizes fluid dynamics to address emissions (page 29). Enjoy this automotive edition of *ANSYS Advantage*.




ANSYS SCADE was deployed for the hybrid vehicle management system named electric brain unit (EBU) for a Subaru production vehicle. Software architecture in EBU control software is layered to comply with the AUTOSAR standard.