SYSTEMS-LEVEL SIMULATION:
The New Imperative

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To create the complex products the market demands, organizations are turning to systems engineering to maintain reliability while shortening the development cycle.

Because of its incredible power to replicate how products perform in the real world, engineering simulation has revolutionized the product development process. By minimizing costly physical testing, accelerating time to market, and enabling game-changing design innovations in a low-risk virtual environment, simulation has helped businesses in every industry achieve significant competitive advantages. Leading engineering teams around the world use simulation software to fulfill customer promises, delivering high-quality products that perform as expected in real-world applications.

Since the introduction of engineering simulation more than 40 years ago, the global business climate has changed dramatically. Product life cycles have become shorter and shorter. Consumers have become more demanding. New product development competitors spring up seemingly overnight. And the volatile economy has created new pressures to cut costs wherever possible. As a result of these pressures, product designs have become much more complex — with added features, smaller sizing, novel materials, cost-saving production processes and other innovations.

For example, the new generation of "smart" products — including consumer offerings like phones, tablets and automobiles as well as industrial products such as wind turbines — are engineered to sense and respond to user needs and the surrounding environment. The influx of these products has created new challenges for engineering teams: They comprise many interconnected subsystems that rely on the performance of one another.

To keep pace, engineering teams in every industry must shift from a component or subsystem view to a higher-level perspective that considers performance at the systems level — applying multiple physics, multiple scales and a collaborative engineering approach. Today, simulation software must be leveraged in a higher-impact manner that reflects the new world in which we are doing business.

TRANSFORMING VISION INTO REALITY

Innovation leaders are now assembling multidisciplinary, cross-functional engineering teams to manage product complexity and predict systems-level performance at a very early design stage. By modeling systems-level interactions and product responses to multiple forces, these leading-edge engineering teams are able to rapidly and continually fine-tune the entire product system in a virtual environment, well before physical assembly and testing.

For many years, systems-level simulation has been viewed as the future of product design, a methodology not really feasible for the majority of
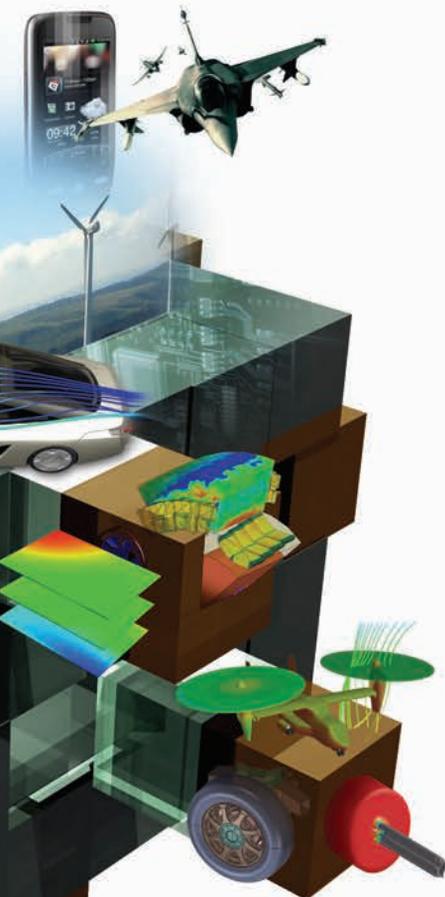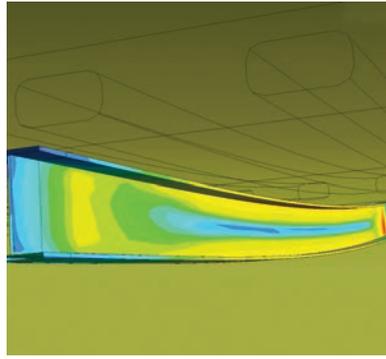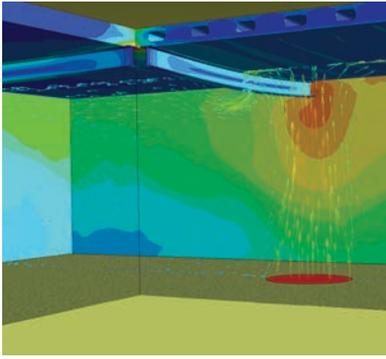
To determine the effect of a room fire on ceiling beams requires considering the entire system of air and heat flow, thermal radiation, heat conduction within the structures, structural deformation of the support beams, and elastoplastic material behavior. Using fluid–structure interaction, researchers can predict beam displacement over time.

companies. Building on its reputation for multiphysics leadership, ANSYS has recently created a number of technology advancements that deliver flexible fidelity, support a collaborative design environment, and offer new levels of scalability and speed. As a consequence, systems-level simulation is no longer a vision, but a reality that many engineering organizations can achieve if they leverage their software in the highest-impact manner.

MULTIPLE COMPONENTS ... MULTIPLE PHYSICS

Bringing disparate components together as a coupled system requires a new degree of multiphysics analysis. Systems-level engineering teams must consider the entire range of thermal, mechanical, electromagnetic and fluidic forces that each component — as well as the final product system — will be exposed to in the physical world.

Many product failures occur because multiple physical forces have not been considered, or because individual components fail to perform as expected when they are brought together. Unexpected electromagnetic interference may occur because an external antenna has not been positioned properly, for example. Novel composite materials used in one component may weaken the structure of the overall product system. Thermal overload can result when too many electronic parts are combined in a single assembly.

To maximize both component and system integrity, cross-functional engineering teams must assess the multiple physical forces and complex interactions that characterize a collection of working elements, brought together to fulfill a single product function. They need to perform sophisticated multiphysics simulations, whether they are assessing the impact of multiple physics on a single component or the complex interactions within a coupled system. Cross-functional engineering teams also need strong capabilities in data and process management, reduced-order modeling, and cosimulation that support rapid, reliable results.

FLEXIBLE FIDELITY FOR DIVERSE MODELING NEEDS

Because systems-level simulation spans a range of analyses — from individual parts and single physical forces to complex systems subject to multiple physics — engineering teams must take a customized approach.

Sometimes a high-fidelity 3-D study is required to verify performance at an exacting level of detail. At other times, 0-D models may be enough to predict functional performance at a coarse level, or to serve as control systems for functional models. By shifting the modeling approach and fidelity level in a customized manner, systems-level engineering teams can maximize speed and cost effectiveness while still ensuring the

appropriate degree of accuracy for each stage of product design.

Systems-level engineering teams require a flexible, comprehensive range of simulation fidelity to make systems-level simulation both time and cost effective. From the extreme high fidelity of 3-D modeling to the rapid broad view provided by 0-D and 1-D models, a diverse tool kit enables teams to choose the appropriate fidelity level for each incremental step in analyzing the complete product system.

THE SPEED AND SCALE DEMANDED BY SYSTEMS

Many design-intensive products, including automobiles and aircraft, combine a diverse range of physically large and small subsystems that must be evaluated together. This requires new software scalability as well as an intelligent solution that can model and solve extremely different problems simultaneously.

Numerically large problems naturally result from the simulation of multiple subsystems and multiple physics. In addition, iterative analysis is typically required to test the effects of changing design parameters on the system as a whole. This adds significantly to computation size and scale.

Systems-level engineering teams work in high-performance computing (HPC) environments built to manage these large-scale simulation needs. The technology tools they leverage must accommodate numerically large problems and deliver maximum performance benefits in today's HPC-powered workplace.

COLLABORATIVE DESIGN: A CULTURAL SHIFT

Even for companies equipped with the most advanced technologies and HPC environments, systems-level simulation can remain a challenge. Modeling performance at the systems level represents a completely new mindset for most engineering organizations.

To accomplish this successfully, teams of electrical, structural and fluids engineers must overcome their distinct functional silos and work together as a true systems-level team. Engineering staff at supplier organizations must also be involved, as needed, to integrate various component designs. Such large-scale cultural shift can
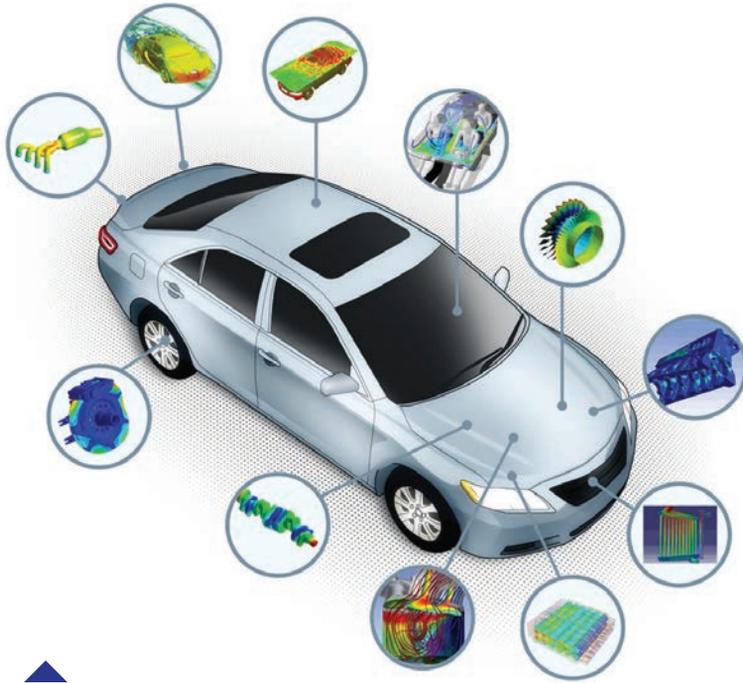
Many products combine a diverse range of physically large and small subsystems that must be evaluated both separately and together. This requires scalability, multiple physics and high-performance computing.

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represent an obstacle for even the most forward-looking business, especially in today's era of globalization — when engineering departments and supplier teams may be scattered across the world.

Facilitating collaboration across distinct engineering teams, different disciplines, and even multiple companies within the supply chain calls for utilizing a common technology environment. Working with a powerful shared platform such as ANSYS Workbench, cross-functional teams can leverage tightly integrated software applications and multiphysics solvers to conduct both component and systems-level analyses. Project schematics, drag-and-drop multiphysics, integrated parameter management and automatic project-level updates support the work of cross-functional teams all throughout the supply chain.

To support the need to share information across departments and companies, systems-level teams also require a software tool such as ANSYS Engineering Knowledge Manager (EKM), which directly facilitates cross-functional collaboration. Team members dispersed across time zones and geographies can seamlessly share product specifications, performance metrics and other critical engineering insights — so that they are informed by the same reliable, real-time information. Powerful capabilities for data backup and archiving, traceability and audit trails, process automation, capture of multiple engineering specs, and protection of proprietary data facilitate collaboration and openness, while still ensuring the security of critical product information.

CONQUERING THE NEXT FRONTIER

As companies in every industry move closer to the promise of systems-level simulation, ANSYS stands ready with the advanced technologies they need to achieve this goal.

In this issue of *ANSYS Advantage*, you'll learn more about how organizations are embracing capabilities within ANSYS software to reap the benefits of systems-level simulation. Baker Hughes, one of the world's largest oilfield services companies, is bringing teams together to reduce customer risk and developing reliable products using multiple physics, HPC, design exploration and systems-level thinking. Airbus uses fluids simulation and HPC to achieve regulatory compliance by performing transient analysis of a fuel tank during taxiing, takeoff, climbing, cruising, descent and landing. As part of a worldwide team, researchers at Politecnico di Milano are helping doctors to make surgical decisions for children born with a specific heart condition, employing multidomain modeling for the circulation system. Ramboll, a leading engineering design and consulting firm, employed ANSYS software's ability to handle differences in scale to model an innovative new building with integrated wind turbines within its urban environment.

Having realized tremendous benefits from their single-physics, component-level simulations, many other ANSYS customers are poised to conquer the next-generation challenge of engineering at the systems level. By providing customers with leading multiphysics tools, a robust and responsive knowledge management system, and a shared technology platform, ANSYS can help cross-functional engineering teams begin working at this newest frontier. ∧

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# MULTIDOMAIN SYSTEMS SIMULATION FOR MECHATRONIC DESIGN

More and more, manufacturers are integrating mechanical, electrical and software components into their products. While mechatronic products meet customer demand for better performance and "smartness," they introduce a new set of design challenges — most significant is predicting how the multitude of components from different disciplines will work together in a single integrated product. Each design element draws on different engineering disciplines with unique knowledge bases, processes and design tools. ANSYS simulation products can help sort through this mechatronic design difficulty.

For example, ANSYS Simplorer, a multidomain simulation tool, employs a schematic approach to represent and couple electrical, magnetic, mechanical, hydraulic, thermal and other multidomain types of models to rapidly and accurately simulate systems-level behavior. Simplorer offers multiple modeling techniques, including circuits, block diagrams, state machines and modeling languages, such as VHDL-AMS, SML (Simplorer Standard Language) and C/C++, that can be used concurrently. This enables engineers to easily create analog, digital and mixed-signal designs. Such flexibility eliminates the need for error-prone mathematical transformations and model analogies often employed by single-domain simulation tools.

To increase the fidelity of systems simulation, Simplorer leverages the accuracy of ANSYS Maxwell, ANSYS Rigid Dynamics, ANSYS Fluent,

ANSYS Mechanical and ANSYS Workbench. In many cases of systems modeling, a critical component — such as an actuator, motor, IGBT or bus bar — exhibits physical effects — such as force, torque, motion and temperature — that strongly impact system results. In these cases, Simplorer incorporates a physics-based model produced by the ANSYS solvers within the system simulation. Using the complete ANSYS portfolio, systems-level design no longer suffers from inaccurate model representations of critical components that can drastically affect results.

For industries whose products depend on precise interaction between electromechanical components, power electronic circuits, and systems-based electrical and mechanical control, Simplorer delivers usability and numerical power to accurately model these systems and capture the interactions between electromechanical components, electronic circuits and control logic — revealing the underlying physics that determine ultimate product performance.

Simplorer Design

Rigid Dynamics
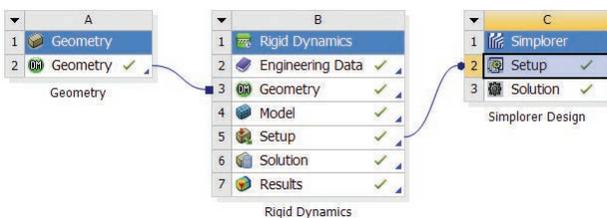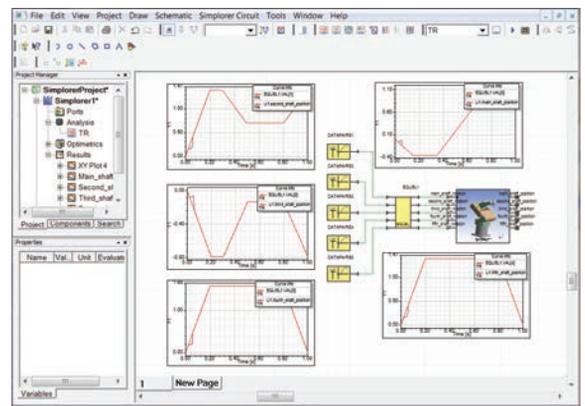
When modeling a system, critical components can exhibit physical effects, such as force, torque, motion and temperature, that strongly impact system results. In these cases, ANSYS Simplorer incorporates a physics-based model produced by the ANSYS solvers within the system simulation. Images illustrate a robotic arm (bottom right) and controller that were simulated with Simplorer and ANSYS Rigid Dynamics technology.