Successful Adoption of Engineering Simulation

In the realm of engineering simulation, the most important point is NOT whether a company uses the tool, but how the organization applies it. A survey of leading companies reveals that good practices for successful engineering simulation deployment include:

- → Systematic use of the technology, especially early in the design process
- → Parametric investigations to challenge and optimize any solution
- → Integration of resources and protagonists
- → Centralized, controlled storage of simulation data

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Xerox Corporation

Systematic Use

Initially, organizations used engineering simulation to understand product behavior — usually to detect malfunctions or failures during the prototype phase of product development, at the end of the development cycle. Although a valuable approach, this usage of simulation tools — troubleshooting — has moved upfront in the design process to address potential problems from the earliest stage. Korhan Sevenler, director of product lifecycle management at Xerox Corporation, confirmed: "All Xerox products are developed using leading-edge analysis tools for advanced simulation, particularly in multiphysics applications in which multiple physical factors must be evaluated."

Systematic use of simulation early in the design process, when more design variables can be adjusted with minimal impact on cost and time to market, will greatly minimize problems late in the design process — or in the worst-case scenario, after the product is released. Bob Tickel, director of analysis at Cummins, reported, "The ease of using simulation tools has helped to transform our organization from a test-centric culture to an analysis-centric culture."

The use of engineering simulation is a natural next step for the newest generation of project leaders, who are being exposed to this technology through academic courses. Unfortunately, this approach is not yet systematic for every organization. However, many companies have formally imposed the use of engineering simulation during the design process to ensure a systematic investigation early in the design process. The powerful U.S. Food and Drugs Administration recommends the use of simulation and specifies protocols to properly conduct simulations. Similarly, Fereydoon Dadkhah, senior engineer for mechanical analysis and simulation at Delphi Electronics Safety System, revealed, "Today, the company has incorporated structural mechanics simulation into the Delphi Product Development Process (PDP) as a requirement."

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Andreas Vlahinos
Advanced Engineering Solutions

Parametric Analysis

Accurately predicting parts, products or systems behavior early in the design process is a challenging task, but many companies will not develop a product without engineering simulation. The practice is complex, requiring proper modeling and relevant simplifying assumptions so engineers, managers, executives and other stakeholders can fully understand product behavior — without neglecting any important aspects. After an initial design phase, the engineering team subjects the design to a range of virtual scenarios, sometimes to predict product behavior under service or extreme conditions and other times to explore what-if scenarios to optimize product performance and determine operational tradeoffs. When used this way, engineering simulation can be an extremely cost-effective practice. At General Motors, technology makes it possible to quickly evaluate hundreds of designs in batch processes to explore an automobile's complete design space. This way, the GM team — engineering and otherwise — knows that they have developed the best possible design.

→ **What-If Analysis — Modeling Uncertainties**

"Companies often focus on time to market, but the advantages of fast product introduction may be quickly overshadowed by the huge cost of poor quality, resulting in product recalls, rework, warranty payments and lost business from negative brand image," explained Andreas Vlahinos, president of Advanced Engineering Solutions. Products that meet integrity targets and fulfill consumers' expectations are key to success. Using tools that accurately predict product behavior, it is straightforward to modify a product's virtual environment to reproduce situations it might experience throughout its lifecycle. This helps to ensure that the product will behave appropriately and safely no matter the circumstances — for example, a building that must sustain the blow of a major hurricane, a phone that can be dropped or crushed but still work.

Since real-world product dimensions, material properties and operating conditions vary slightly from an average value, the accumulation of these small variations could lead to dramatic impact on whole-product behavior. Pioneering companies have started to use engineering simulation to ensure that, despite such variations, the product will behave as expected throughout its life cycle. This new discipline called robust design.

Dyson Fan

→ **Design Optimization**
If good design is a clear competitive advantage, a company will not maintain market leadership if the design is not "best the first time." In our fast-paced global economy, good ideas are quickly identified, mimicked and improved. How does a company stand out? By incorporating virtual optimization into the design process, Dyson engineers have been able to test up to 10 different designs per day, whereas a physical prototype took a few weeks. The R&D team tested 200 different configurations — 10 times more than their previous practice — releasing a robust and completely innovative design with their bladeless fan.

The cost of doing parametric optimization on a few selected parameters has become so inexpensive that companies cannot afford to bypass the opportunity to strengthen the competitive advantage that accompanies first-to-market designs.

→ **Smart Tradeoffs**
In most cases, design parameters do not trend in the same direction. Cost and quality, for example, can be opposite forces. In Formula 1 race car design, the BMW Sauber Team must trade off downward force for reduced drag. Such a strategic decision is difficult and risky without a clear and quantified understanding of its consequences.

Furthermore, once a satisfying robust design is reached, alternative solutions can be found to meet more efficient manufacturing processes or to substitute cheaper, more sustainable materials without greatly compromising product performance and quality. This strategic decision is often made by executives who define the most meaningful tradeoff — the one that will fit company strategy, initiatives and values. Without an accurate assessment of consequences, such a strategy is very risky.

Integration
At one time, entrepreneurs created great innovations in their garages, and engineers worked in silos. Not so anymore. Modern engineering simulation requires integration in terms of physics, people, hardware and software resources. Integration brings these components together for quick and cost-effective success.

→ **Integration of Physics**
Products today are very complex. For example, good performance may require interaction of solids, liquids and gases within an electromagnetic or acoustic field. Whatever the combination of interactions, they must all be properly managed to avoid undesired interference within a product, between products or with consumers. Properly predicting product behavior requires reliable modeling of meaningful physics as well as their interactions. Neglecting important physics can lead to the wrong conclusion.

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Martin Lehmann
MANN+HUMMEL

→ **Staff Collaboration**
Today's world-class engineers can be found on every continent, and modern telecommunications tools enable companies to leverage the best resource wherever they are located. Consider this example: A leading turbine manufacturer can't risk losing the experience accumulated by its long-term designers based in in Europe and North America — but at the same time the company would welcome people working in all corners of the globe in a 24-hour cycle to speed up the design process. One solution is close interaction between experienced designers (who can quickly perform advanced modeling) and skilled analysts (who might be based in a low-labor-cost developing country). This allows work to be performed efficiently around the clock through different time zones. The company can leverage accumulated experience and seize the opportunity to employ specialists in other regions, delivering the product earlier.

→ **Centralization of Software Resources**
Consolidating resources can help an organization deliver more robust designs within a shorter timeframe. For example, ABB is centralizing its software acquisitions while distributing cost on a per-usage basis. This policy facilitates both scaleup and efficient exploitation of licenses that can be employed broadly. By concentrating its efforts with a few software vendors, the company acquires more influence with each vendor and facilitates the entry of new employees, who find an environment of experienced people able to assist them through the initial learning curve. ABB is reinforcing this strategy by setting up its own software global technical support team to deliver first-level support. In addition, centralizing software needs and resources allows the company to gain access to low-volume/special-purpose codes that would not be affordable using an isolated, location-centric approach.

Engineering Knowledge Management
To succeed, integration must include a proper environment for managing controlled access to project files, simultaneous collaboration on projects, and formal archiving and access to past simulations. "We have engineers in Europe and in India who frequently needs to share models, CAE data and simulation results. They also need to collaborate in real time while performing CAE analysis," said Martin Lehmann, head of simulation filter elements, MANN+HUMMEL.

Although the process is inexpensive and easy to put in place, recent surveys from the Aberdeen Group reveal that a limited number of organizations centrally manage their existing analysis results and best practices. Similarly, even fewer track simulation's shortcomings or develop methods to refine current work for application to future study. In most cases, analysts work in a silo, often without considering similar models that they ran in the past. These practices have a significant impact on time and quality: Results are better/quicker if your foundation is an existing, similar investigation that yielded reliable results, one that might contain insight for further improvements. Data management tools such as engineering knowledge management (EKM), process data management (PDM) and product lifecycle management (PLM) are available. Adopting and deploying tools that integrate with existing software improves efficiency.

System and Balanced Complexity

Modeling any system — whether it's an analysis of the 9/11 tragedy, study of the human body modeling (HBM) or aerodynamic behavior of a Formula 1 car — can take a great amount of time. Including geometrical details that may not affect results stretches computational time further, especially if performing parametric analysis and optimization. Alternatively, oversimplifying a model in terms of dimension, physics or scope may lead to misleading conclusions. Engineering and modeling engineering skills are still required to make proper assumptions regarding the target model, available computational power and goals.

A reduced-order model (ROM) locally reduces the size of a model and computational task, applicable to areas in which details of the result are less important. This technique is used increasingly for systems models, in which detailed models are required only in the regions of interest. Consider these examples: Walls of a skyscraper are modeled as 2-D shell elements or arteries of the cardiovascular system as 1-D element. This allows modeling of the entire building or full human body, respectively, enabling parametric simulation in a reasonable timeframe.

Alternatively, for some detailed analyses, in-depth troubleshooting investigations or marketing demonstration, very high-end simulations can be required of the entire system. Extreme software scalability combined with several thousand cores of supercomputing power provide the necessary infrastructure to support and balance the problem complexity.

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