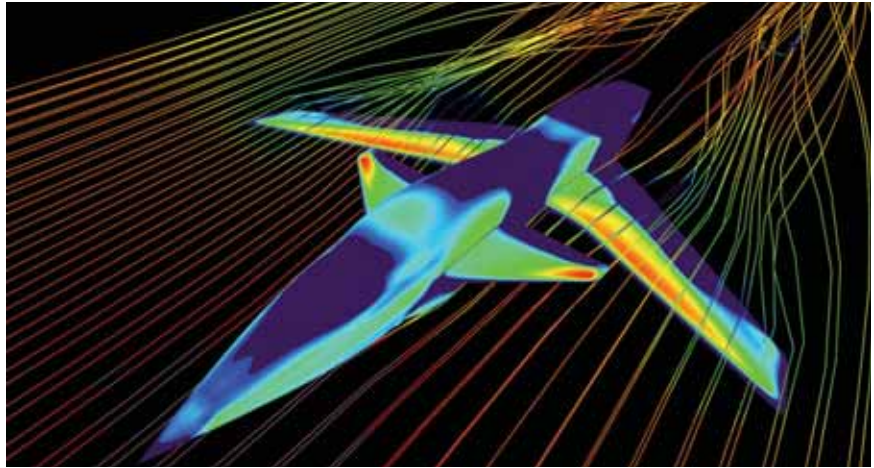


Computers in engineering

Virtual engineering for design today

One of the key advantages to physical prototyping is the design collaboration it fosters. Project and process engineers, stylists, managers, and even customers can gather around a physical mockup, and opinions and input naturally follow. However, physical prototyping is expensive and is increasingly being displaced by computer-generated simulations in many stages of the design process. While cost-effective, the collaborative element so helpful to design decision-making can suffer in the new age of CAE.

Researchers at **Iowa State University** with commercial software providers such as **Acuitiv Software** are at the front of an emerging field that seeks to re-establish if not revolutionize the collaborative nature of engineering design. Virtual engineering (VE) is a user-centered process that provides a collaborative framework to integrate all of the models, data, and decision-support tools needed for good engineering design. Using established virtual reality (VR) visualization hardware, VE is pushing the application of



Virtual engineering tools such as Acuitiv can be used to optimize component design locally or to evaluate a complete system.

that hardware from interactive post-processing of computational data to virtual design, analysis, operation, and optimization.

The goal is to integrate a broad spectrum of engineering tasks into a virtual environment. In doing so, the collaborative spirit of physical proto-

typing is recreated around a prototype that is almost as real. Beyond this benefit, VE can layer more data into the process than any physical prototyping process could. Imagine a prototype that can be interactively colored according to simulation or experimental data. The next step is to be able to change shapes and properties and immediately analyze the design impact, and optimize component design locally and as part of a larger system.

For this imagined process to become fully realized, at least five key components must be brought together as outlined in Table 1.

While most of these components are not fully developed today, the first foray into VE has been the development of the VE workspace. Virtual-environment hardware has been successfully combined with software to bring engineering data into the virtual world. Applications are currently used in automotive design, medical and chemical research and development, aerospace engineering, and many other industries.

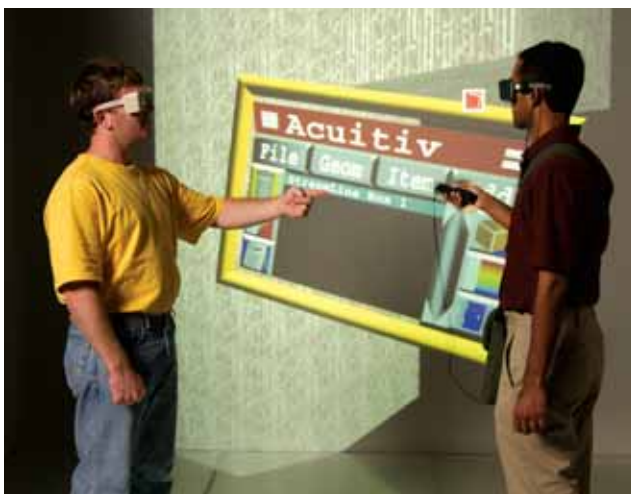
VE environments today can include desktop systems as well as specialized immersive VR environments, with the eventual goal of collaborating across heterogeneous systems. The costs of

**Table 1
Key Components of Virtual Engineering**

Virtual reality (VR) visualization techniques	In a first-person, immersive interface, complex data become more understandable and usable. Visualization in VR recreates the intuitive understanding and collaborative spirit of the physical prototyping experience.
Real-time analysis	Today, nearly all aspects of engineering simulation require offline setup, calculation, and iteration. Advances in simulation tools to enable real-time "what-if" analyses will establish a dynamic thinking process and speed decision-making.
Coupling and integration of numerical models	A complete engineering analysis can employ a substantial number of simulation tools. These tools should be integrated and coupled to inform a collaborative design process.
Remote collaboration infrastructure	VE should include an infrastructure that allows team members to work separately and still maintain efficient, effective, and continuous communication. Remote VE team members will interact with others in a VR environment.
On-demand information handling	A method for storage and rapid access to analyses, measured data, geometry, and all other qualitative and quantitative engineering data is required to fully realize the goals of the VE process.

Table 2
Milestones Expected in VE Development

Level 1	VR interaction with engineering data	The foundation of VE is the ability to interact naturally with design model and geometry data. Though available today, refinements to user interfaces and expansions to the types of data displayed will continue.
Level 2	Model manipulation in the VR environment	Seamless interaction between the visual environment and computational resources will enable design teams to enter the virtual workspace, load and view data, and request new analyses or optimization directly.
Level 3	On-the-fly model recalculation	To increase the interactive nature of the VE workspace, new techniques will provide approximate solutions to "what-if" scenarios quickly and with sufficient accuracy.
Level 4	Integration of models	Engineering components are designed as part of larger systems. Models exist for both the into-systems parts and the whole, and will be linked in VE so the impact of component design changes on the system is readily apparent.
Level 5	Fully realized VE	As a standard design tool, VE will include the ability to track and interact with field data and component analyses throughout the product lifecycle as needed.



The foundation of VE is the ability to interact naturally with design model and engineering data in a first-person, immersive interface.

these systems have fallen dramatically with advances in computing and graphics power, with VR hardware now a viable everyday tool. A desktop system can be augmented for stereoscopic viewing for a few hundred dollars. A stereo projection wall can be built for under \$20,000, including the computer to drive it.

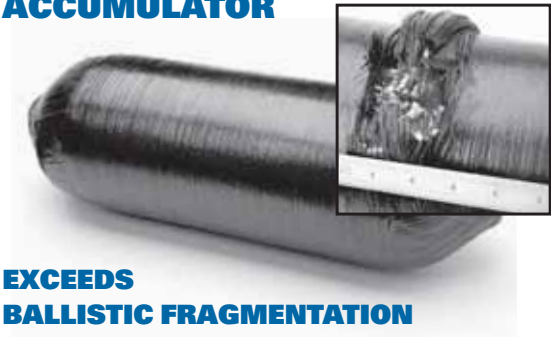
The software needed to display and analyze engineering data in virtual environments is also available today both commercially and in the academic community. Many familiar engineering application developers have retrofitted their software for display in virtual environments, and other new applications have been built from the ground up to maximize the benefits of immersive technologies. The best applications include a user interface that is accessible in the virtual world so that the user's engagement and presence in the virtual world is not interrupted.

Realizing the larger goals of VE will require further development of its key components. Starting with the current ability to visualize high-fidelity models like CFD and FEA data and ending with a cross-industry standard in VE, five levels of success can be envisioned (Table 2). As each new level is

achieved, increasing benefits to engineering design are expected. VE holds the promise of recreating the collaborative experience of physical design reviews but at much earlier stages and throughout the design process. With more information and responsive analysis tools available for collaborative decision-making in an intuitive virtual environment, faster and higher-quality design engineering will naturally follow.

This article was written for *Aerospace Engineering* by **Mark Bryden**, Assistant Professor, Iowa State University, and **Karen Ringel**, Manager, Applied Computing, Acuitiv Software.

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