Digital engineering: Controlling costs for megaprojects

Digital engineering, which uses advanced technologies to capture data and optimize design in a digital environment, is being applied for the first time to a DOE nuclear project and has already realized substantial benefits.

By Paul Menser

With a new generation of nuclear reactors in the works, Idaho National Laboratory has embraced digital engineering (DE) as a means of achieving the same efficiencies that companies in the private sector have been able to realize in everything from concert halls to aircraft engines.

DE—using advanced technologies to capture data and craft design in a digitized environment—has been evolving since the 1990s. For Mortenson Construction, a worldwide construction firm, using virtual design and construction resulted in a cumulative 600 days saved over 416 projects and a 25 percent increase in productivity. By building digital twins for assets, systems, and processes, DE has avoided more than $1.05 billion in customer, production, and mechanical losses.

Leaders at INL recognized in 2018 that DE could be useful in the design and construction of new commercial and test reactors. Managing construction costs, timing, and performance will be essential to maintain U.S. competitiveness.

In addition to accurate information that enables better decision-making, gains in productivity, operational efficiencies, and lower costs, the benefits of DE and building information modeling include the following:

- 3D models to help analyze geotechnical elements and enable the development of virtual and augmented reality solutions.
- A value chain that is connected, collaborative, and efficient, contributing to improvements in performance.
- A single source of truth agreed upon and shared by key players before, during, and after the asset creation process.
- 3D and 4D (3D plus time sequencing) models that enhance constructability reviews and stakeholder engagement and buy-in.

The Versatile Test Reactor

The first Department of Energy nuclear project to which DE has been applied is the Versatile Test Reactor (VTR). Planned for completion by the mid-2020s, the proposed 300-megawatt, sodium-cooled, fast spectrum reactor is intended to be the United States' leading facility for advanced nuclear reactor research and development (see *NN*, Feb. 2020, p. 9).

To support INL's use of DE, the entire platform has been loaded onto the cloud, the first in the DOE's national lab system. It has given the VTR team, spread out across other national labs, industry, and university partners, the ability to collaborate seamlessly in real time. Team members were able to develop a 3D model of the reactor in the first three months of the project, 10 times faster than similar past efforts.

Instead of modeling and running simulations independently, DE integrates modeling codes to increase the efficiency of the process and quickly optimize the design. The cloud allows real-time collaboration and quick access to data, minimizing technical barriers such as latency. Requirements Information Management, a tool that uses data to generate documentation, helps ensure that a program can collect requirements, risks, and tests in a fully integrated database to plan for any changes that might be necessary.

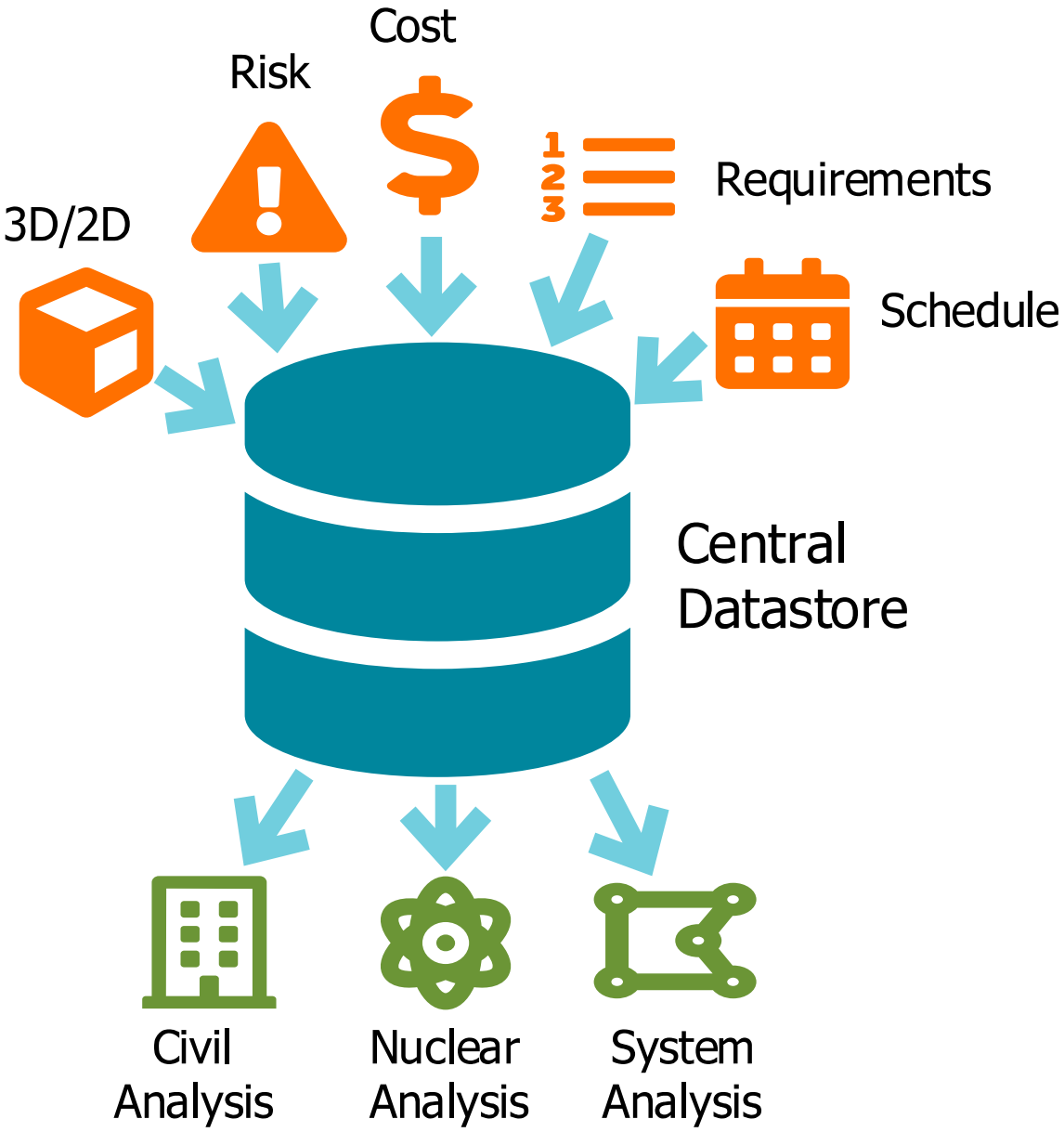
INL seeking collaborators

While INL is the DOE's lead nuclear energy research laboratory, it is offering its DE expertise to other partners, said Chris Ritter, who came to INL in 2018 to start a digital engineering program for integrating systems engineering, software development, and database management. With a strong pool of software designers and engineers, the lab is already expanding its scope and seeking new collaborators.

Ritter said that he sees INL's DE expertise expanding to nonnuclear projects in the same way the INL-developed Multiphysics Object Oriented Simulation Environment, or MOOSE, originally intended for nuclear projects, has been adopted by other industries that can benefit from high-performance computing. "We'd like people in industry and at the other national labs to know that we're available to partner with them," he said.

Starting with the VTR offers a great opportunity to demonstrate the benefits that DE can bring. By using DE strategies,

Paul Menser (<paul.menser@inl.gov>) is a freelance science writer.



INL/Vanessa Godfrey

To power the analytics, the central database stores working data, configuration management, latest approved data, concept requirements, and calculations.

designers can predict reactor performance and identify design issues early in the process, minimizing the possibility for cascading risk.

What makes INL unique is its open approach, Ritter said. Many companies use digital technologies, but groups inside a company can get siloed and not communicate well with each other. "It's difficult to power any analytics that way," he said. "The question you want to be asking is not, 'What document should I create?' but, 'What's the data that is actually involved?'"

Whether a document is in Word or AutoCAD, DE makes it possible to look beyond the page or screen and link all information to data codes in a central database. This is what is known as an authoritative source of truth (AST), a system that validates data as originating from a legitimate source.

The overall arrangement is for the AST to serve as the hub, with different organizations connected to it by their unique individual spokes. The VTR may use a different program to link to the AST. But the hub and all the spokes are open, enabling access to data regardless of its source.

"As a national lab, we don't want to be picking winners or be beholden to a single vendor," Ritter said. "We just want to enable the best tools for each particular job."

Current DE partnerships

DE partners in the VTR program include U.S. universities and industries. North Carolina State University has developed a method to automate 3D modeling for advanced structural analyses of building facilities. This makes it possible to automate seismic and pipe stress analysis, boosting accuracy and efficiency. Virginia Commonwealth University, meanwhile, is conducting research aimed at automating traditionally manual processes, allowing for the discovery of missing links and incorrect object types. To integrate modeling codes and increase the efficiency of experimental design, TerraPower has developed the Advanced Reactor Modeling Interface, a software framework that will be integrated into the VTR's DE database.

Virtual design and construction processes are intended to be used throughout the life cycle of any project, from concept to operations and maintenance. Ritter said that he sees INL's DE initiative as very much a work in progress. The processes inherent in DE are evolving all the time. Technologies that are considered cutting edge today may soon be out-of-date, replaced by faster and more efficient tools that change the way projects are designed and delivered. "It's in an evolutionary stage," he said. "But we know this will make a big difference." NN