3D Modeling With Autodesk Inventor, Autodesk 3ds max Speeds Federal Nuclear Waste Project

Engineers at the U.S. Department of Energy's Hanford Site used Autodesk Inventor to accelerate the design process for a radioactive waste storage system. When the components were finished, animations created by Autodesk 3ds max were used as a training aid to show crane operators the installation steps before a single piece was lifted.

The U.S. Department of Energy's Hanford Site, a complex of facilities located on 586 square miles of shrub and grassland north of Richland, Washington, began producing plutonium for the nation's first generation of nuclear weapons in 1943. During the following years, Hanford operated nine different nuclear reactors, several production facilities and a warren of underground storage complexes. By 1989, all the reactors had been shut down and production stopped, leaving radioactive material and waste to deal with—the legacy of years of producing plutonium.

In 1989, several federal and state agencies drew up a long-term plan to clean up the Hanford Site and transfer its toxic nuclear wastes and spent nuclear fuel to permanent repositories in Nevada and New Mexico. Even after most of Hanford's dangerous wastes are either moved or "vitrified"—turned into glass-parts of the site will need to remain sealed off well into the 22nd century.

Two massive underground storage pools built at Hanford in the 1960s are called the K Basins. Here, approximately 2,100 metric tons of corroding nuclear fuel rods are stored in hundreds of containers underwater. Though girded by several feet of reinforced concrete, the K Basins are only 400 yards from the Columbia River. Moving the fuel and the layer of radioactive "sludge" that has accumulated, and then draining and dismantling the basins, have become some of Hanford's highest priorities. The sludge consists of sand and dirt, as well as metal corrosion products that have resulted from degradation of the spent fuel. Fluor Hanford, the Department of Energy's (DOE) Hanford Site prime contractor, and its commercial affiliate, Fluor Federal Services, employed three-dimensional (3D) modeling and rendering tools to engineer and design a storage system for the sludge from the K Basins. These new methods saved considerable design time, enabled team collaboration and planning, and helped us complete the project on schedule and within its budget.

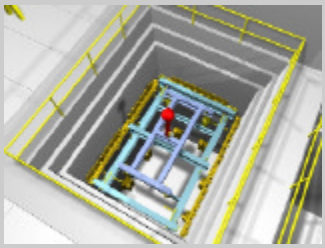
From K Basins to the T Plant Canyon

The complex effort of cleaning up the K Basins is separated into several individual projects. The Sludge Removal Project will remove the sludge and transport it away from the river to another Hanford facility (known as T Plant, built in 1944). The sludge will be vacuumed from the floor of K East Basin, placed in a series of large, heavy containers, and transferred to a long-term storage facility at T Plant. T Plant has rows of square cells that are 23 feet deep and lie beneath the main floor cover of the plant's 40-foot-deep "canyon."

For the containers to fit properly within the T Plant cells, Fluor designed a storage system—a rack that fits inside each cell and holds six containers, each weighing nine tons when fully filled with sludge. Each rack is braced against the walls and floor of the cell. Fluor also designed lifting devices, pumps, a leak-detection system, and another system that determines if water is evaporating out of the vented containers, and replenishes it if it does.

Operators installed the components using a remote-controlled crane and cameras. Like many Hanford waste storage areas, T Plant's canyon is sealed off because of the risk of contamination. Direct visibility and maneuverability are limited, and many of the necessary views are relayed by video screens to a monitoring room. These factors required the new container storage system to fit the cells properly, meet a range of design demands, and be installed accurately the first time—even though engineers would have virtually no direct access to the installation.

To accelerate the design process and engineering reviews throughout design, Fluor Federal Services modeled key elements of the project using Autodesk



As a result of the efficiencies, first-time accuracy and savings that Fluor realized with 3D modeling on this project, Fluor Federal Services is now training more designers on Autodesk Inventor and expects to incorporate 3D modeling into projects at other nuclear facilities and decommissioning activities.

Inventor®, a 3D modeling program for mechanical design. When the components were finished, animations created by Autodesk 3ds max™ were used as a training aid to show crane operators the installation steps before a single piece was lifted. The 3D models that Fluor ultimately created for the T Plant project were so exact and complete that they required virtually no late-stage design changes, and only nominal refinements during fabrication and installation. Such precision is rare in projects based on traditional 2D drafting.

As a result of the efficiencies, first-time accuracy and savings that Fluor realized with 3D modeling on this project, Fluor Federal Services is now training more designers on Autodesk Inventor and expects to incorporate 3D modeling into projects at other nuclear facilities and decommissioning activities. This approach rose out of Fluor's commitment to use new technologies to constantly raise the bar on performance.

Modeling the Cell Pools First

The design phase of the project began in September 2000 and finished June 2001. Fluor completed construction of the T Plant storage structures in October 2002, working in tandem with a separate Hanford subcontractor who designed the containers that will hold the sludge from K East Basin. AutoCAD® is the design format mandated for all final drawings; therefore, Autodesk Inventor was selected because of its ability to easily import and export 2D AutoCAD data. Fluor designers and engineers, principally Richard Christensen, were able to import 2D sketches to make parts. The designers also relied on the software's capacity to handle large assemblies and accommodate multiple users working on the same models simultaneously.

The learning curve for Autodesk Inventor was short because its interface is intuitive, allowing designers to be productive quickly. The other 3D modeling programs reviewed either appeared less intuitive, did not leverage adaptive technology (the ability to have design changes ripple through the program automatically, updating all affected features and dimensions), or did not offer sufficient interoperability with AutoCAD.

The Fluor team began by modeling the concrete-lined cells in T Plant that would house the new storage system. The "operating envelope" that engineering and construction had to operate in had to be constructed in 3D, because the potential for exposure to high levels of radiation in the cells made it impossible take measurements, even in protective suits. Designers developed as-built drawings of the cells. To ensure clearances were adequate, "go/no-go" gauges made of wood were lowered into the cells to check dimensions and clearances. Because the containers to be stored were not yet finished, Fluor built container mockups based on sizes, weights, and other limits provided by the contractor fabricating the containers. The mockups were used to develop and verify the 3D models.

Other Systems Designed with Autodesk Inventor

After the physical operating constraints were modeled, Fluor designed a leveling frame to be placed inside the cell, including an impact wrench, jacks and wall braces used to level the frame. Once in place, this frame formed the cradle for the storage system, which in turn would house six sludge containers. Additionally, to meet federal regulations for spills, a sump pump installation was designed, along with leak-detection and response systems to feed data to the monitoring room.

Autodesk Inventor was used for 3D modeling of mechanical parts sent to fabrication shops, as well as for interfacing the new mechanical parts with the existing structures to ensure everything would fit. Fluor found 3D modeling espe-

The learning curve for Autodesk Inventor was short because its interface is intuitive, allowing designers to be productive quickly.

cially advantageous for making plant modifications in tight areas where constraints were a challenge. Two-dimensional AutoCAD drawings were developed for electrical and control systems design.

The project featured complex devices and assemblies for which 3D modeling was particularly useful. For example, in addition to monitoring leaks, operators must also know when to add water to the sludge containers. (The water evaporates through vents in the containers.) To address this issue, Fluor designed a stress-measuring load cell lifting assembly, allowing the fully filled 9-ton containers to be lifted by crane and weighed periodically. The weight of the containers will determine if water needs to be replenished.

The station for adding the water comprises a stand, water container, nozzle and a spring-loaded ball valve to fill the canisters. Autodesk Inventor was particularly helpful in designing these assemblies because of its adaptive, parametric and interference-checking features. As a result, the fabricated assemblies worked perfectly the first time.

In the unlikely event a container leaks, Fluor used 3D modeling to design an "overpack," a cylindrical vessel in which a leaky container can immediately be placed.

Using 3D at Design Review Meetings

Having a lifelike 3D model of the project proved particularly beneficial during the engineering reviews held at regular intervals during the design process—one each at 30, 60, and 90 percent completion. At these reviews, several DOE and facility operators, fabrication contractors and engineers reviewed the proposed designs using 3D graphics projected onto a large screen from a laptop computer.

The Inventor model was imported into Autodesk 3ds max, and used to create videos for review sessions showing dynamically how various components fit together. In addition, Fluor used a shareable 3D viewing application called SpinFireTM, by Actify Corp., to create 3D views on Web pages. SpinFire allowed the model to be viewed and rotated, and was even used to identify dimensions, thus allowing project clients, managers and team members to look at the 3D model together in real time, instead of separately, which saved time. In addition, the Web pages allowed people to examine each model carefully in 3D on their own, back in their offices or at other locations.

Using the 3D presentation for reviews made it possible for the reviewers to visualize the design better than using traditional flat drawings, technical documents and flow diagrams. At project completion, there were no surprises; the assemblies and installation were executed as expected from the design reviews.

Bidding and Error-Free Fabrication

The same 3D animations Fluor used for these "constructibility" reviews were useful when the design was complete and it was time to bid the project for fabrication. All the bidders for fabrication were invited to an on-site meeting and shown the 3D presentation, along with the requirements and tolerances. The bidders were then given a presentation of what was critical and why the critical points were important.

When fabrication was complete, only eight changes to design were required, and these were to facilitate fabrication. The water-addition system worked perfectly. The container alignment systems all lined up and fit together with no modifications. The errors that used to occur with 2D drawings were gone.

The water-addition system worked perfectly. The container alignment systems all lined up and fit together with no modifications. The errors that used to occur with 2D drawings were gone.

Using Autodesk 3ds max to Simulate Installation

After the various fabricated parts of the storage system were assembled, they were rigged and hoisted by a 10-ton crane into the cells at T Plant. Fluor used Autodesk Inventor to determine the "pick points" for each item's center of gravity (CG). A simulation of the lifting sequence using Autodesk 3ds max was developed before hoist operations started.

Some details will show why this installation had to be done carefully. The storage rack, a very large and heavy piece, had to be lowered 23 feet into a tight space by a crane operator, who was using cameras and monitors for guidance. The viewing area was very small, and some cameras were mounted on rails that rode up and down the crane itself, looking down at the hook. Rather than create a mockup, Fluor designed an animation of the hoisting operation to show the storage rack from the crane operator's perspective, with simulations providing the view the camera would provide.

The crane operator, reviewing the simulation, was able to position the camera trolleys to see the brackets properly. After four days of planning using 3D model run-throughs, the actual installation only took two days. Using a simulation to work through the installation allowed Fluor to develop realistic and achievable work plans.

From initial concepts and the "nuts-and-bolts" of engineering through important milestones like collaborative reviews, bidding, and installation, 3D modeling tools helped Fluor complete this complex and critical nuclear waste project efficiently, accurately, and cost-effectively. A major factor in this success was the DOE's support for using 3D innovations, and the project managers and engineers who participated, including Wally Rutherford, Fluor Hanford's Sludge Treatment/Disposal Program Manager, who approved the use of this latest technology. At Fluor Federal Services, Project Manager John Viita was an early advocate of 3D design, and Project Engineering Manager Dave McShane, envisioned 3D as a tool to complete the engineering and design effort faster and more effectively.

Fluor's objective is to be the customer's benchmark for expertise, dependability, and safety, which also includes meeting the needs, expectations, and challenges with the right solutions at the right time. With training in 3D technologies, Fluor Federal Services expects to realize time and cost savings in engineering and design, thus completing projects faster, and saving dollars for the "ultimate customer"—the taxpayers.

Bruce Nielsen is Design Services Manager and Richard Christensen is the 3D Design Lead at Fluor Federal Services.

The U.S. Department of Energy's Hanford Site Autodesk solutions were implemented and supported by PacifiCAD, Inc. of Spokane, Wash. Call 800-722-2621 for information or visit www.pacificad.com.

This case study was prepared by DLT Solutions of Herndon, Va., Autodesk's master government sales and marketing partner. DLT and Authorized Autodesk Resellers deliver the complete family of Autodesk and companion products to federal, state and local government agencies nationwide. For a free demo CD, call 888.447.ACAD (2223) or visit www.autodeskgovernment.com GSA schedule # GS-35F-4543G.