THE CONSTRUCTION RESOURCE

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4D SCHEDULING'S TIME MACHINE

Construction managers zoom back and forth through combined activity plans to reduce risk by resolving conflicts of time, space and safety

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SEEING IS BELIEVING

Interest heats up for risk-reducing tools that marry highly detailed schedules to design and construction models By Tom Sawyer

ENR Future Tech Special Report

Software that can show a video of a construction project assembling itself has been around for years, but an important change is afoot, say a wide range of industry leaders. Some of them say 4D technology—that is, 3D plus time—is finally poised to bend upward the long-stagnant construction productivity curve by significantly improving efficiency and reducing waste and risk.

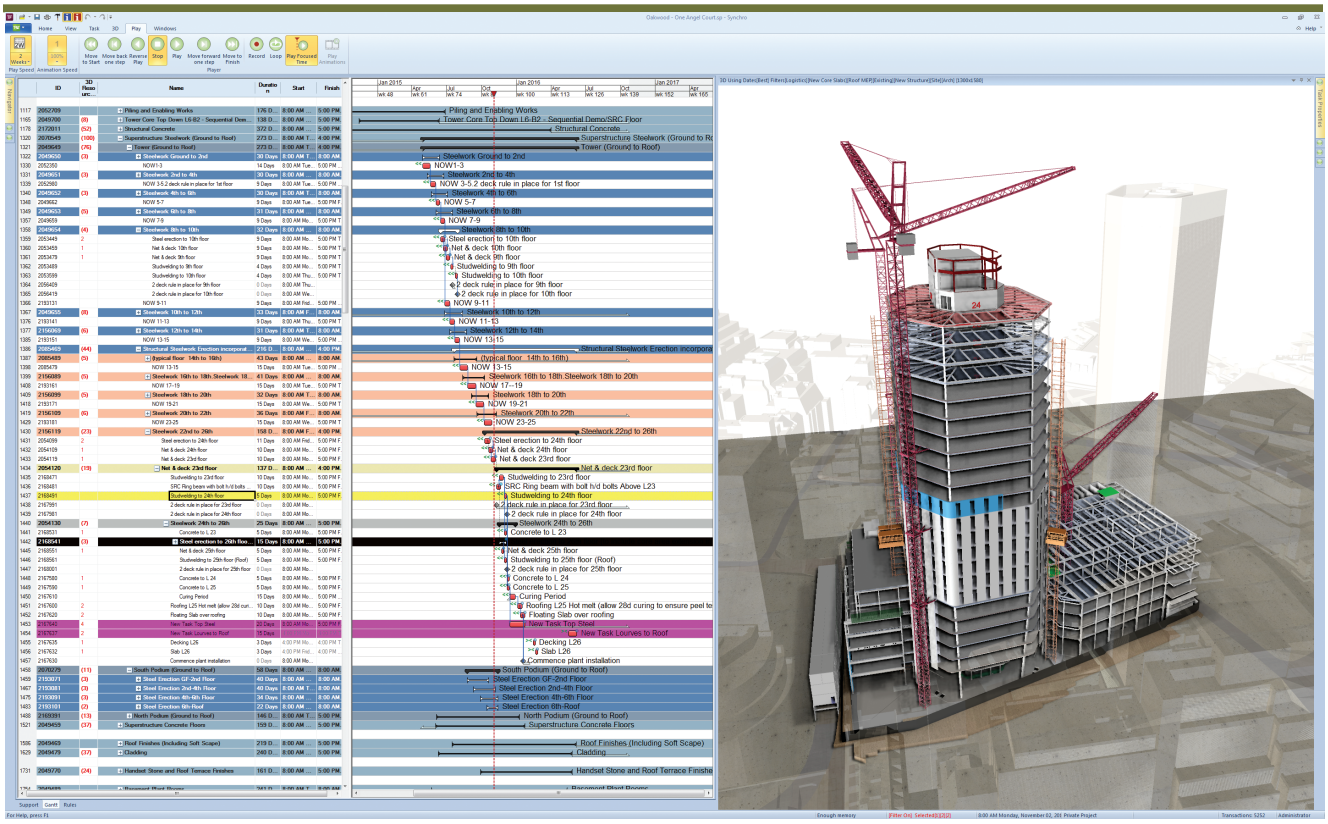
Two flavors of construction sequence visualization are in use. One consists of schedule simulators, such as Autodesk Navisworks and Bentley Navigator, and custom services, such as Visual5D, that link an exported 3D project model to a schedule—imported from Oracle Primavera P6 or Microsoft Project, for example—and play the sequence as if it were a movie. Those tools are well suited for tender presentation, stakeholder outreach and initial construction planning.

Other 4D sequence visualizers, including Asta Powerproject BIM, Synchro Pro and Trimble's Vico Office 4D Manager with its partner, Tekla, interactively integrate models and scheduling in a way that can support detailed, day-to-day planning. Construction managers particularly note use of Synchro Pro by teams building major projects. Many attribute the growing use of the software to its compatibility with 3D models in many formats, a flexibility that becomes vital during the construction phase as subcontractor models and schedules are integrated, they say.

But, in general, users say the increasing application of lean project management, which emphasizes nearly constant refinement of schedules during construction to meet the evolving reality of jobsites, makes 4D planning a great fit.

Whatever the driver, 4D is spreading. Projects recently implementing 4D include retrofits on nuclear power plants, performed by Duke Energy; a sustainable apartment building in Kansas City, Mo.; use on water projects by MWH; a California sanitation district that is building a sprawling treatment facility; a mixed-use neighborhood in London, created by Lendlease; and a 1970s-era London high-rise, being rebuilt by Mace. Many other leading construction firms report recent implementations of 4D planning, as well.

The 8-year-old 4D planner Synchro, which seems to be the leader for now, reports that its 500-customer base has added 23 new clients since April 1, the beginning of its fiscal year. Its li-



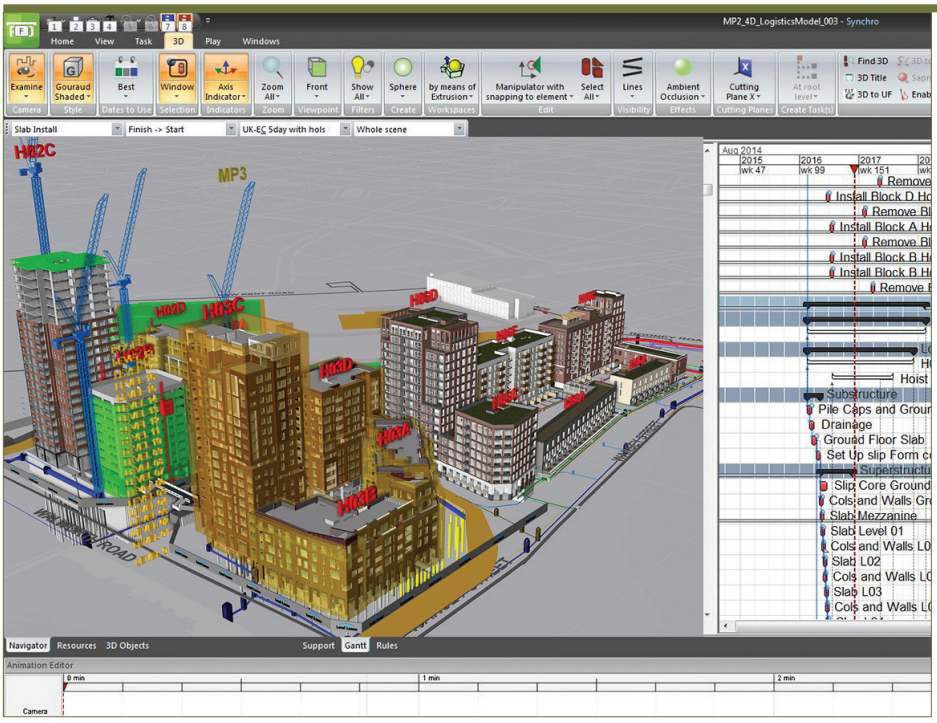
'PLAY' BUTTON Synchro's model and schedule view of Mace's Angel Court project in London (top) are linked in real time and can be filtered, navigated and adjusted in fine detail. A MWH team (left) studies, critiques and rehearses a complex plan of action at a water utility. One participant says the common understanding and confidence led to "a remarkable sense of calm" when the actual work commenced.

IMAGE: TOP, COURTESY OF SYNCHRO. PHOTO BY TOM DEINGENIS

cense sales are up by 35% overall compared to the previous year, and its new customer sales growth is up by 90%. Synchro reports growing use in EPC, up 25%; global ACE, up 60%; and owner-client use, up 10%. The company says adoption is concentrated at the top end of the ENR's 2015 Top Contractors and includes nine of the top-10 U.S. contractors and 33 out of the top 50. Adoption is similar among the top international contractors.

Mark Hedges, digital asset creation manager at MWH, says his firm started exploring use of Synchro on a project in March 2015. He says the results led him and a colleague to develop a strategy quickly for progressive deployment both internally and on external projects.

Hedges says the tool's process visualizations are powerful on the jobsite. Project teams, including foremen and craft workers, are able not only to see the schedule in action but, because Synchro has both an integrated CAD functionality and a critical-path-method scheduling engine, they can critique and correct the view and schedule in real time as deficiencies are observed. The sequence can be played again and again until the team is convinced it is right. Using what Hedges calls "digital rehearsals," team members learn their roles and timing.



PROJECT MESH
In London, Lendlease is developer and builder of Elephant & Castle, a mixed-use community of urban infill. Synchro is the schedule planning tool used to merge multiple models and schedules and resolve conflicts of time and space.

"Synchro forms the absolute core of our digital rehearsal strategy," says Hedges. "It's all about practice makes perfect. We use the analogy of a theatrical performance. All theatrical performances are rehearsed. Yet, we expect to deliver massive construction projects—in an inherently dangerous environment with all kinds of hazards and risks—perfectly, without any rehearsal or practice whatsoever. Crazy."

"Digital rehearsal, for us, is to simply rehearse and practice our operations in a safe environment until we are as sure as we can be that it will be 'all right on the night,'" Hedges says.

In Kansas City, Jonathan Arnold—principal of the Arnold Development Group, which specializes in urban infill and adaptive reuse of historic buildings—is constructing what Arnold says is the world's largest passive house. The project is the company's first using Synchro's 4D planning.

Arnold sees 4D planning—and especially its ability to portray the future state of the work at locations—as a complement to lean construction. "You can't intelligently talk about an area unless you can see it, and if it isn't built yet, you can't see it," he explains. Without 4D and a detailed visualization of the state of the construction site at any moment in the future, it's hard to perceive all the constraints that present themselves in the real works, he says. "4D visualization is a dress rehearsal for the foremen, and catching [conflicts] weeks ahead of time means you can be that much more efficient when the labor and the foremen are on the jobsite. Its the human capital equivalent of clash detection," Arnold says.

"As you use Synchro, you have this rich amount of data you can use on your next project—that's what we are looking forward to. The hope and attraction is that we are going to build on this data set and improve our company," Arnold adds.

Industrial Strength

"4D builds a better schedule sooner," says Charles Wray Dunn Jr., who is in charge of 4D and project controls at Duke Energy. "The process of animating the model from the schedule forces an attention to detail that is often missing from schedule reviews," he says. Dunn calls this "the detail gap" and says that, ordinarily, you can't close the gap "until the work is staring the craft in the face—generally, two weeks out." By using 4D to bring the work to them sooner—even years ahead of time—managers gain huge opportunities to improve the schedule and drive down cost with alternate strategies, he says.

Unlike traditional CPM scheduling, which is managed by a silo of specialists, 4D visualization provides a common understanding of the project, Dunn says, adding, "Based on a background in lean process, I'm convinced that quality comes from the source. You have to have good input from the guys doing the work, and CPM mechanics and reports are often misunderstood or ignored by the experts I need to get engaged in order to build a solid schedule.

"4D visually manages the project," Dunn continues. "It also supports lean principles, and it pays huge dividends in safety, efficiency and quality. 4D creates belief. I didn't expect this, but I've seen it over and over. As a team reviews the 4D model, they believe that the work can be done as the schedule and model show."

With a nod to the work of 1960s-era media theorist Marshall McLuhan, Dunn says, "CPM schedules are cold. They tribalize knowledge for the specialists. 4D is hot. It unifies and creates common understanding."

Regional San, a regional sanitation district in Sacramento, is another recent adopter. It is launching construction of the EchoWater Project, a $1.5-billion to $2.1-billion compliance upgrade to its wastewater treatment system. To be completed by 2023, the work

IMAGES COURTESY OF LENDLEASE

is divided into 14 major contracts, including some simultaneous work on adjacent sites. Concerned about conflicts among contractors' activities, material deliveries and equipment moves—particularly in an area in which two sites are separated by a utility corridor that also will be undergoing construction activities—the program managers decided to federate multiple construction models and schedules into a program model and use 4D to search for conflicts. The managers concluded that two adjacent projects could not be constructed independently, but the risk was discovered early enough that combining them could be done without impact.

"A 4D Synchro model was used to manage any conflicts over time that couldn't be planned from a static view," says Serelle Corn, project scheduler for Echo-Water. One part of the project is a biological nutrient-removal facility that is about the size of 20 football fields and is expected to cost $414 million to build, says Corn. The schedule has more than 233 slab-on-grade concrete placements, but planners realized the cure times would prevent adjacent pours and greatly extend the project schedule. Planning the pours in a systematic manner that allowed feasible exiting of the site and equipment moves turned into kind of a Rubik's Cube puzzle. It was judged to be practically impossible without a 4D model. A key plan was built and loaded into the schedule and modeled in Synchro. Errors quickly showed up, and the puzzle was solved.

Long Run

Bechtel is one of the longest-running users of Synchro. The firm is providing program management services for Crossrail, the upgrade to London's underground transit system. "We have people in place at each of the stations, working with them on the tunneling and managing track-install and installation of all the systems," says Steven Smith, virtual project delivery operations lead.

Navisworks and Navigator worked well for schedule visualization during planning, but, as the

TRICKY SHIFT
On the second of two swap-outs of 1.1-million-pound stators at a Duke Energy plant, the team turned to 4D planning to choreograph 11 teams working in a tight space. They credit use of Synchro with cutting 20 days off the job.

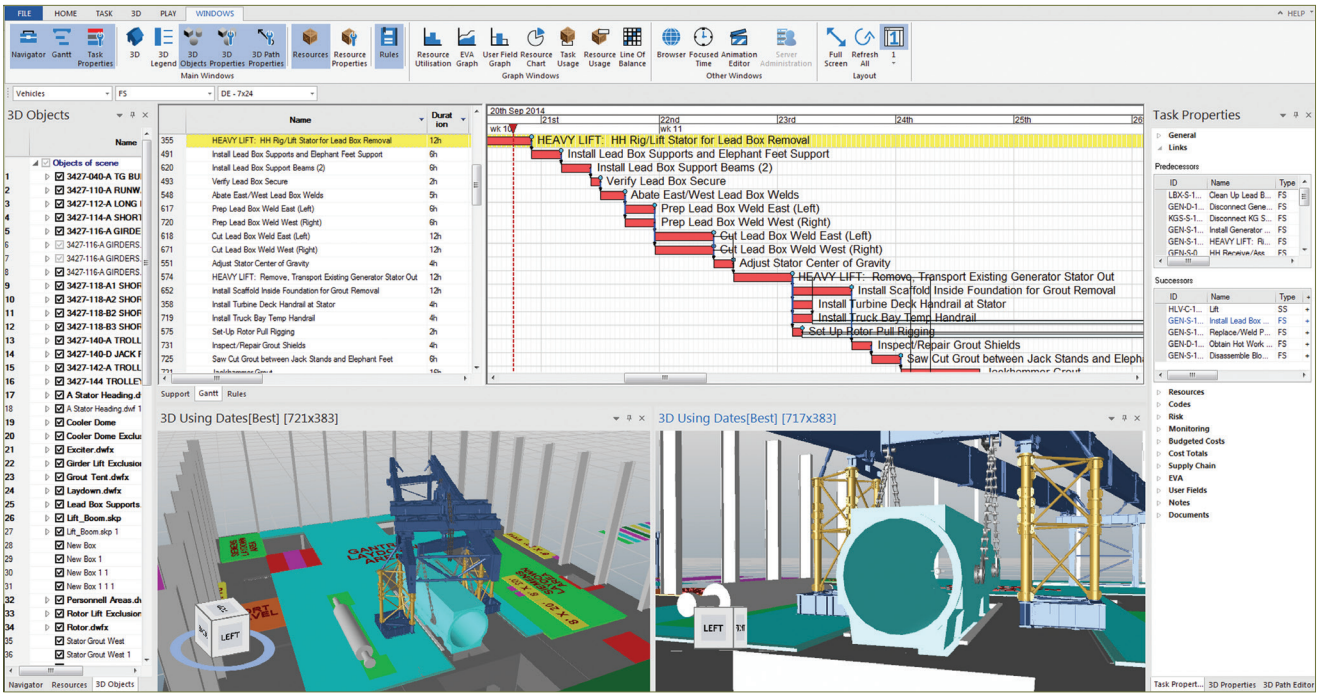
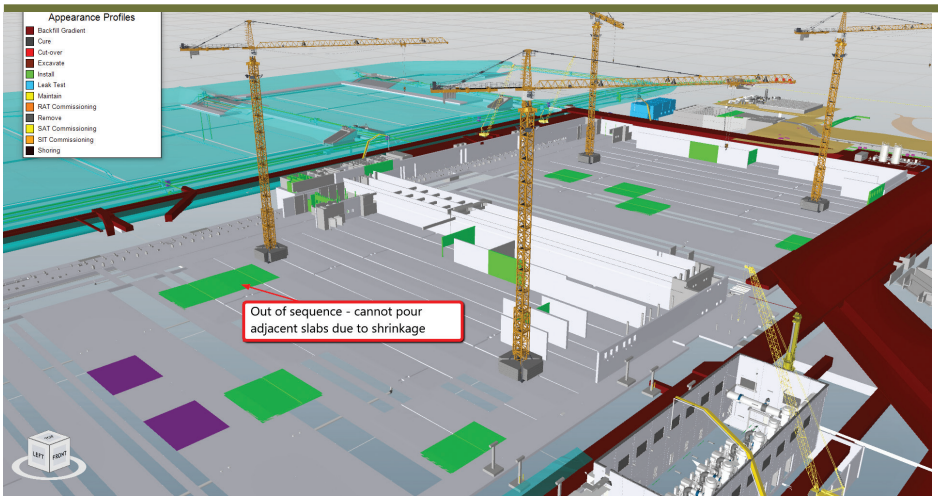


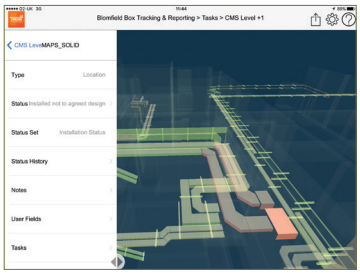
PHOTO AND IMAGE COURTESY OF DUKE ENERGY



FORESIGHT In Sacramento, the regional sewer district's plan for system upgrade involves 14 major contracts and significant potential conflicts. Planners have turned to 4D to spot and fix them.

project approached the construction phase, the level of detail began to explode with the integration of the schedules and specialty models of the trades, Smith says. Bechtel decided to try Synchro to coordinate one of the project's more complex stations, the Liverpool Street station.

"At some point, the construction team needs to own the plan and break it down to a level of installation detail," Smith adds. "With the new approach, you pull the data in once and then adjust it in the 4D environment. When you are working in a complicated construction environment, you may have multiple models that impact on each other, and the ability to adjust them quickly is really important to have a smooth and efficient workflow.



STATUS CHECK Duct runs are notorious for deviating from the model, says Bechtel's Smith. Engineers check them against the model on an iPad and color-code them as correctly placed, out of place but acceptable or needing rework.

That is really the shift."

After Bechtel's typically exhaustive vetting process, enterprise adoption of Synchro is underway for all its engineering and construction sectors, including nuclear, infrastructure, oil and gas, and mining, Smith reports. "Usually, things aren't led by the tool, but the Synchro tool was built from a planning engine. It was designed from the bottom up, so it understands dependencies and successors and predecessors, and it understands construction. It's starting to break down the gap between planners and the construction team. That's the significant difference," Smith says.

"The confidence you can get from a 4D simulation de-risks the notion that something will go wrong. Run through the sequence with all the stakeholders so that, when you get down there and play it on site, it's all really familiar," he says.

Bechtel is starting to use a new mobile feature, Synchro Site, "which is an iPad app that allows us to take the model to the field," Smith observes. "We can capture the actual status of installation and note any issues. You have a view of the fabrication-level-detail model, and the field engineers can … do a visual comparison and … progress it by tapping on the individual elements of the work and take photos and add notes.

"The shift to 4D planning is one move, and the ability to get that model into the field and into the hands of the construction team is another. That's the big overall story: It's a much more data-centric work process. We are going to see some major efficiency gains come from that," Smith predicts. ■

IMAGE (TOP) COURTESY OF REGIONAL SAN; PHOTO AND IMAGE (BOTTOM) COURTESY OF CROSSRAIL AND BECHTEL