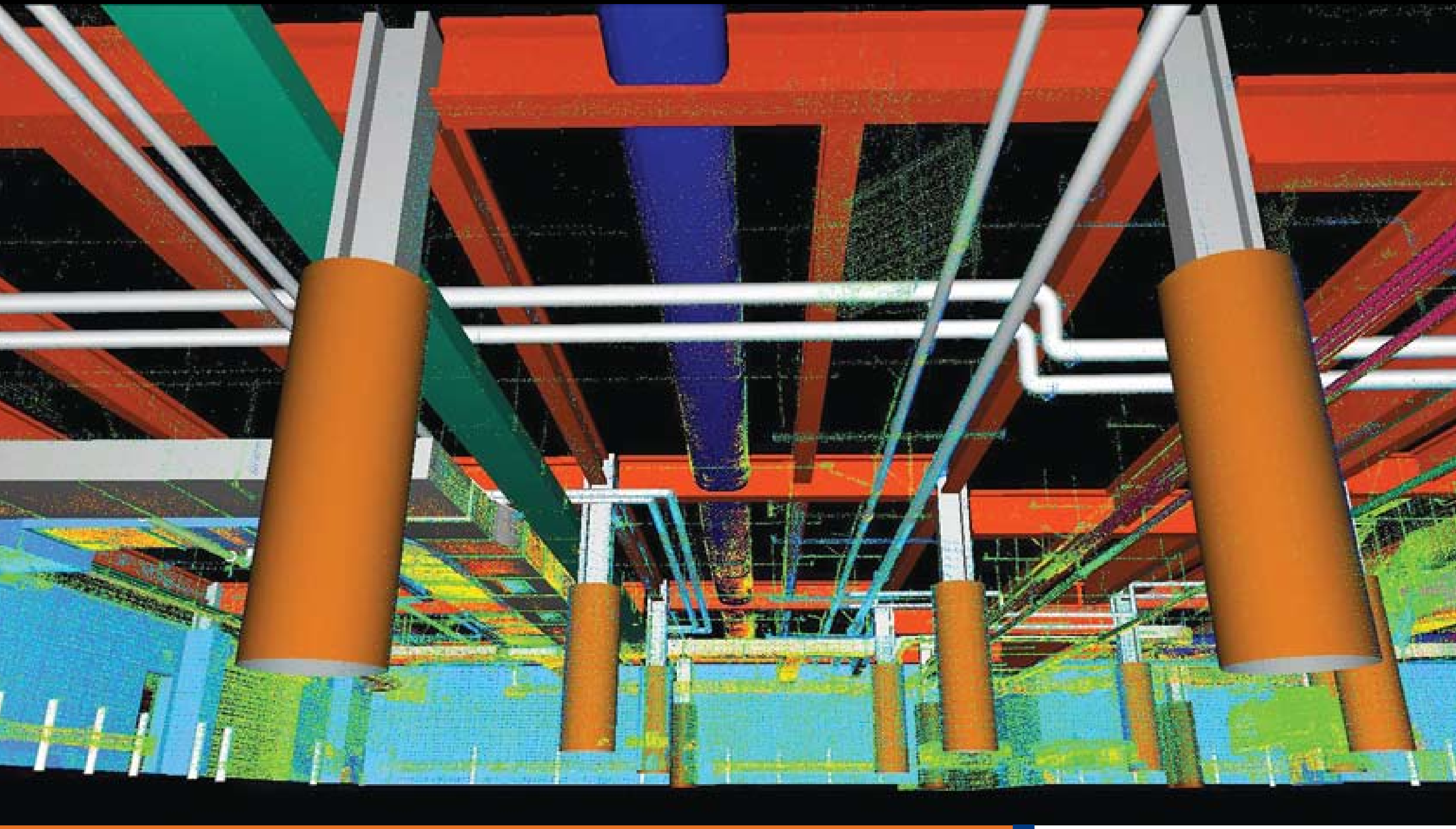
Scanning PDX



Finding the right solution to create an as-built BIM of Portland International Airport's baggage handling facility

Above
This laser scan shows ceiling beam details from above PDX's baggage claim area.

By Brad Longstreet

The Portland International Airport (PDX) serves about 18,000 flights and 14 million passengers annually, and the baggage for all of them is handled in just one underground facility… a facility that requires major renovation in order to meet new Homeland Security standards. The $100-million project will automate baggage screening, implement inline explosive detection systems, remodel 225,000 square feet and install more than two miles of new conveyor lines. Amazingly, the facility is continuing to work at full capacity during the entire three-year project.

To keep luggage moving, while working around—and under, over, and through—existing equipment and conveyor lines, lead contractor Hoffman Construction determined that a building information model (BIM) was needed. With an accurate 3D model of the baggage handling area, designers could check for clashes virtually and avoid costly surprises during construction. They could

Above
The final renovation will involve more than two miles of luggage conveyor lines.

also figure out which existing features had to be removed or rerouted, plot access for bulky equipment being moved in, and efficiently plan construction phasing so that ongoing work was disrupted as little as possible. "The key to success," says Hoffman operations manager Dale Stenning, is, "'if it fits in the model it fits in the building,'—but only if the model is accurate."

A Complex Proposition

Getting the model right turned out to be a major project all by itself. "We had to start from scratch," says Stenning. "We had a few CAD files and a lot of paper as-built documents provided by the Port of Portland, but they weren't very useful." Stenning is understating things; the facility has been in continuous use since the 1950s, and updates and additions haven't been recorded in any consistent way. Complicating matters is what's above the baggage handling area—PDX's mall and food court. All the water, gas, sprinkler, electrical, wastewater, and even soda lines for the food court have been installed above baggage handling conveyors with almost no documentation. "It's like spaghetti up there," says Stenning. And because the facility ceiling has to be used for conveyor line attachment points, all the lines had to be located and then moved, rerouted, or avoided. Many of the installed utilities aren't even active—they've been abandoned but left in place to avoid disrupting work.

Hoffman Construction's preferred solution for BIM creation is laser scanning. The company has been using high-definition surveying (HDS) laser scanning equipment from Leica Geosystems since 2003 and has successfully performed hundreds of large-scale scanning projects. Given the complicated structure of the handling facility and the need for very precise clash detection, Stenning was sure that scanning was the right technology for PDX. But airport authorities weren't convinced. "They hadn't considered scanning before, and they weren't sure about the expense," Stenning explains.

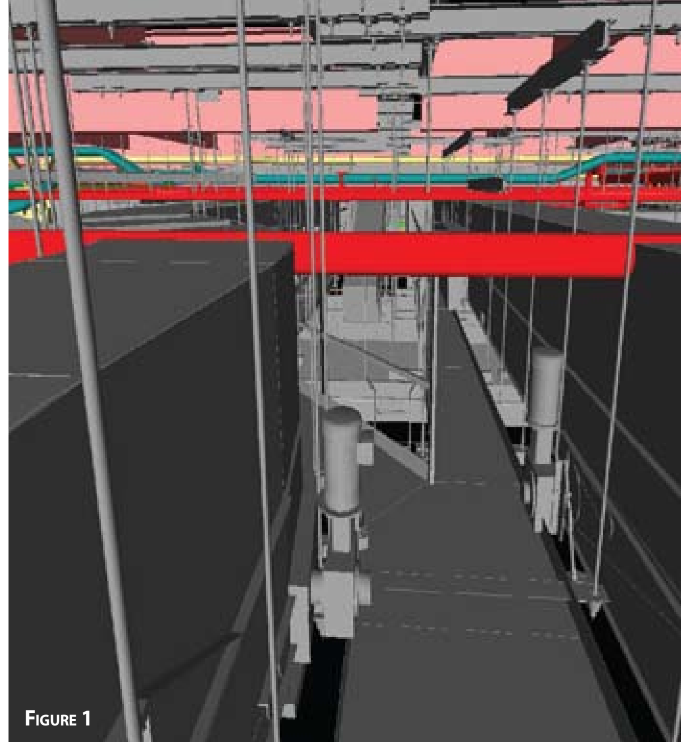


Figure 1

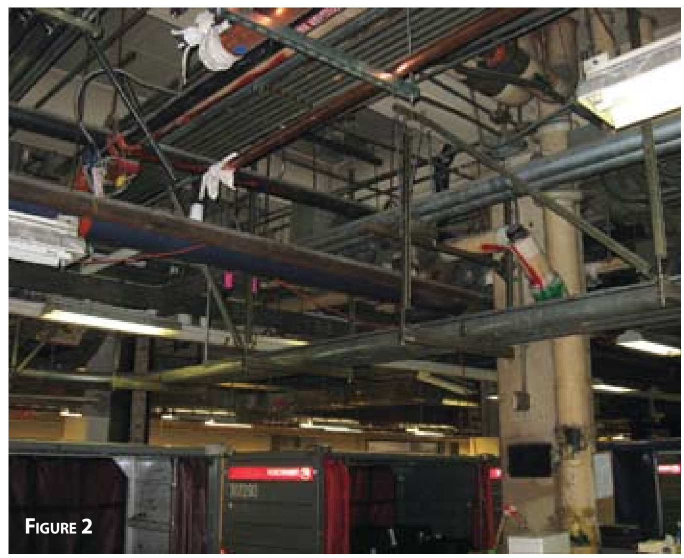


Figure 2

Figure 1
Scans were used to locate potential conflicts prior to the installation of new equipment.

Figure 2
Many of the existing pipes were no longer in use and had been abandoned in place.

To overcome the resistance, Stenning agreed to a test that demonstrated scanning's potential. "We carved out a small area and went in on a limited basis and laser scanned. Then we took that data and went through our entire proposed workflow to demonstrate the value delivered. That test project helped them see how the end product becomes a valuable tool for facilities management, long after construction is done. Now, they're really thrilled with what we're giving them."

With scanning accepted as the right way to create the needed as-built BIM, scanning teams got to work. A control network was established on the Port of Portland's (the port district that oversees PDX) coordinate grid and benchmarks and was extended underground to the facility. Hoffman uses standard survey methods when scanning, so physical control points were set for about 50 scan setups. To further aid registration, about 150 spherical and paper targets were set and were also tied in to the control network with a conventional control survey. This enabled confident, precise registration and geo-location of multiple scans. This coordinate system was also passed to subcontractors, such as steel detailers, so everyone worked on the same basis. "That may not seem like such a big deal," says Stenning, "but remember, this is a 24/7 facility, and all the available workspaces are filled with running carts. We don't have the luxury of snapping lines on the floor and using plumb bobs—we have to quickly get to the exact point needed."

To further increase confidence in the scanning work, one crew member was dedicated to processing scan data with Leica Cyclone and CloudWorx so that each day's work could be checked immediately. Work was completed in two, two-week phases, with the second phase devoted to filling in more detail in critical areas. Much of the work was done during night shifts, when less baggage was being processed. The most commonly used scanner was Leica's time-of-flight scanner, the

ScanStation. Don Ming, who supervised about half of the scanning work says, "the scanner had a good combination of distance and resolution for this project." A Leica HDS4500 was also used for highly detailed work. In some cases, small diameter lines were physically traced for absolute certainty about their type and location, and on occasion a Genie lift was used to scan from higher vantage points.

Because all work on this project is in secure areas, Hoffman employees and subcontractors had to meet special requirements. "Anyone who works in secure areas has to have a background check and has to be badged," says Han-Mei Chiang, a project engineer now working on installing new equipment, "We also have to attend airport training classes, bus people in, take precautions with tools, and, because we're working around so many airport employees, we have to keep crews small. And we're not even working with TSA yet—that won't happen for a couple of months!" Ming says that there was another unexpected security factor: "There are actually sensors that detect lasers in the airport, and we had to meet with airport officials to make sure our equipment wouldn't set them off—thankfully, it wasn't a problem."

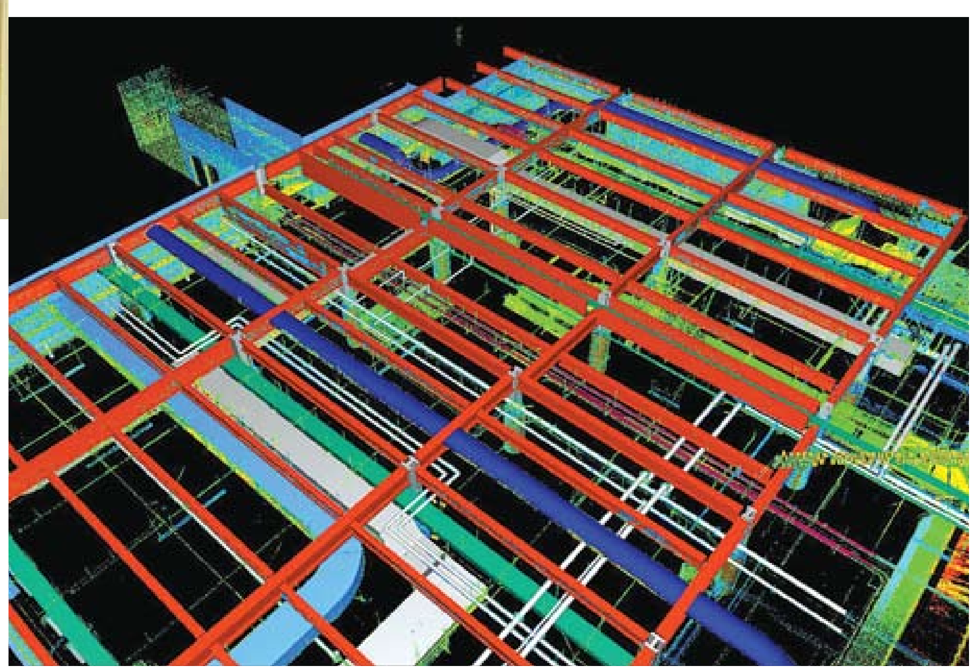
Making Sense of Spaghetti

With the scanning completed, designers could begin to make sense of the tangle of utilities and equipment. Utility lines were color coded by type, and different color intensities were used to designate lines to be moved and lines to be rerouted. Because Portland is in an active seismic zone, bracing for new, rerouted, and temporary lines had to be planned along with other construction information.

Hoffman Construction has developed an innovative approach to dealing with one of BIM's perennial challenges: the conflict between the real world and the world that parametric design software likes to work with. As Stenning says, "Nothing in reality is level, true, straight or planar—it's all deflected, skewed, or twisted in some way. But the parametric tools are based on predictable geometry." File sizes are also an issue. Point clouds are made up of millions of points and can be unwieldy to work with—on this project, more than billion points were gathered, and total data file sizes were around 38 gigabytes.

So when creating the BIM, Hoffman designers used the point clouds as guides to create accurate, geometrically true representations of existing features. For example, a section of pipe would be modeled as a cylinder for use in the model and for design purposes. The downside to this is that even small deflections from the definable cylinder (like sagging) could be important when resolving intricate interference challenges. So when this was the case, designers had the option of turning on the point cloud and using it to perform high resolution clash detection. This approach combined the speed and efficiency of design tools that use predictable geometry with the security of clash detection performed on accurate, real-world shapes.

Checking installation paths is another useful feature of the BIM. "For example," says Stenning, "the x-ray machines we're bringing in are really big. With the laser scanned model, we're able to previsualize the path that the machines will



Above
The facility has been in continuous use since the 1950s, and updates and additions haven't been recorded in any consistent way.

Right
Utility lines were color-coded by type, and different color intensities were used to designate lines to be moved and lines to be rerouted.

travel to get into position. We actually 'walked' the modeled object [the x-ray machine] down the hallways and aisle to check for conflicts."

During construction, the BIM is used constantly to compare the existing facility with the new equipment being installed. Crews typically receive printed 3D visualizations as part of daily work packets. And because the scanning resolution is so fine, even details like bracing attachment points can be provided within tolerances of a quarter-inch. With the project about half completed, Hoffman has experienced no major delays or conflicts with ongoing operations. "It's a fascinating project," adds Chiang, "rerouting all the utilities and managing all the phases has been like a big Tetris game—this would have been a lot harder without the model."

"I suppose we could have done the as-built survey with conventional techniques or even a tape measure," says Stenning, "but the results wouldn't be nearly as good. We're really getting amazing results, and the client recognizes the benefits."

Scanning Value Recognized

"We believe that BIMs built on scanning data are the next wave in facilities management," says Stenning, "and the stakes are really high, because many thousands of dollars are spent improving and upgrading a building during its lifespan. The value of implementing BIM increases exponentially as a project unfolds, but today we're still focusing on the use of BIM in design."

But Stenning says that things are changing. Customers are beginning to write more sophisticated BIM requirements into RFPs, which is significant because, "we need owners to articulate what they need as a deliverable for project closeout, so that we can impose those requirements on subcontractors throughout the process. And we don't want to over model, because that's a waste of money. Expectations are still in flux, but we're starting to see some standards emerge."

Stenning also points out that airports everywhere have to comply with new requirements for digital modeling of critical secure areas, so there may be a boom in airport work in particular. In fact, many factors are converging to make laser scanning and BIM a new standard in the construction and management of large facilities.

Brad Longstreet *is a freelance writer specializing in land surveying, GIS, and laser scanning technology.*

Above
Recently installed baggage screening equipment