

HIGH DEFINITION SCANNING

Uses of Scanning in **Construction and Fabrication**

Geoff Jacobs

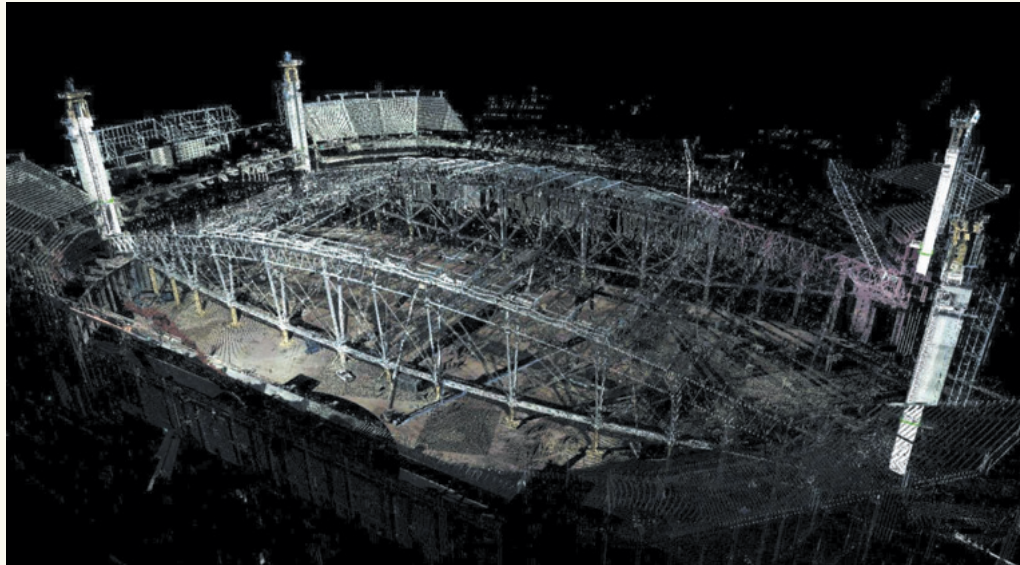
Many professionals are aware of the beneficial use of laser scanning for creating as-builts for use by engineers or designers. However, scanning is used successfully in all stages of a capital asset's lifecycle, not just the "design stage." These other uses include the Proposal Stage, the Construction/Fabrication Stage, and the Asset Management (or maintenance & operations) Stage.

This article is the second in a series that looks at the use of scanning in various stages of an asset's lifecycle. The January 2006 *Professional Surveyor* article examined uses in the Proposal Stage; this article focuses on beneficial uses of scanning in the Construction & Fabrication Stages and what the latest trends are in this area. A future article will cover in-depth looks at uses in Asset Management.

Overview

The use of high-definition surveying during the Construction Stage has become virtually commonplace for certain types of civil, architectural, and plant projects. For many projects, scanning can be more cost-effective than traditional survey methods, while also providing more accurate and complete information. Uses of laser scanning in construction & fabrication include:

- Quality assurance (QA)
- Designing temporary structures
- Quantity surveys
- Path planning



Laser scanning is commonly used in construction projects. Image Courtesy: 3D Laser Imaging

- Final as-built deliverables
- Pile & crane locations
- Construction & demolition sequencing
- Design verification
- Deformation monitoring
- Litigation protection
- Construction craft training
- Clearance evaluations for assembly personnel and tooling

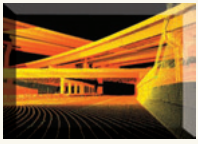
The notion here is that for "construction" applications, the specific client of the as-built survey is a Construction Contractor or the Construction Department (as different from a Design/Engineering Consultant or Dept.). For the purposes of this article, as-built surveys that are conducted for engineering/design clients or departments—even if these engineering/design plans will eventually be implemented via construction—are considered as being part of the "Engineering or Design Phase" of a project

(not for direct use during the "Construction Phase"). This article focuses on direct Construction Phase uses.

Risk Reduction: A Key Benefit for Contractors

One of the primary drivers for the rapid growth of high-definition surveys in construction is the fact that contractors place a high value on services that can significantly reduce risk to their construction budgets and schedules. High-definition surveys have proven over time to sport three advantages over traditional methods that can provide valuable risk reduction benefits for cost- and schedule-conscious project managers. These construction risk-reducing advantages are:

- Higher level of completeness
- Better accuracy
- Quicker availability of as-built data



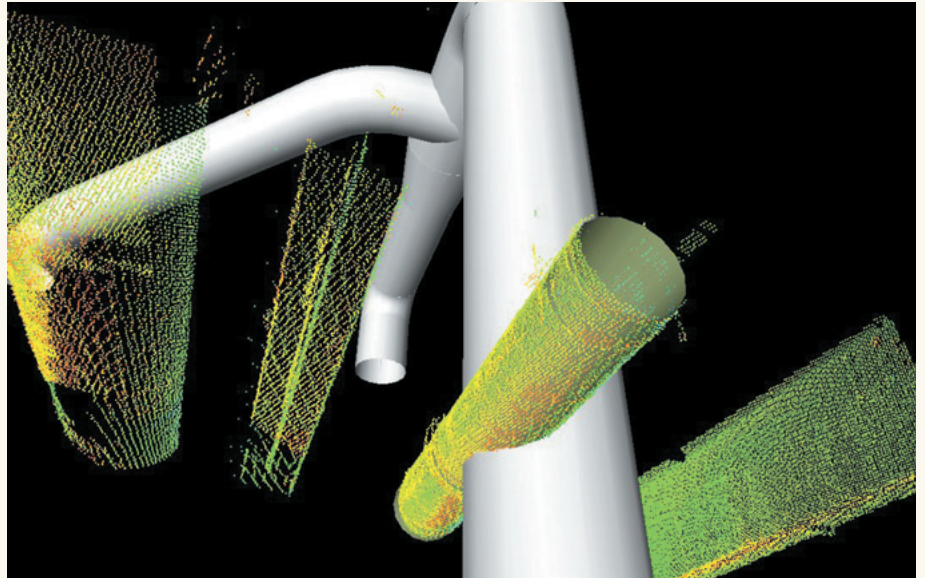
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Reduced Risk of Interferences

For complex structural projects, scanning's *higher level of completeness* translates into less construction risk in the area of "construction interferences." A construction interference is a case where a structure, such as piping or steel framework, is in the process of being installed and the contractor makes an ugly discovery that the planned layout physically clashes with existing structures. When this discovery is made, construction halts. Designers and project managers scramble to figure out on-the-spot workarounds. Welders break out their torches to cut existing structures or modify new piping, etc. The construction budget takes a hit. The schedule takes a hit. The project manager can't sleep. And the end client—the owner/operator of the asset—may become very upset if it affects their project cost. They may become absolutely irate if it delays their facility from becoming available for commercial use.

Reduced Risk of "Fit-Up" Problems

For many projects, the *higher overall accuracy* of a high-definition survey translates into less risk of "fit-up" problems. A fit-up problem is one in which during an installation, the contractor makes the unpleasant discovery that some element does not quite fit-up exactly with another element for which it was intended. Some fit-up problems can be easy to fix on-the-spot with minor changes to either the existing structure or to layout plans. However, some fit-up problems can be just as disastrous to project budgets and schedules as construction interferences can be. What happens if a new 16" pipe doesn't quite fit up with an existing 16" pipe flange? It's not nearly as easy to bend 16" pipe to tie-in as it is to bend 1/4" tubing for a tie-in. It's not surprising, therefore, that high-definition as-built surveys are often focused on capturing large elements, such as large piping, structural steel, HVAC conduit, large vessels, and concrete



High-definition surveys reduce the risk of construction interferences on retrofit projects. Image courtesy: WGI

elements, rather than capturing elements such as tubing and wooden structures that may be easy to modify in the field.

Construction Project Examples

Several projects/firms that have successfully taken advantage of high-definition surveys in their Construction & Fabrication Stage are discussed in the following pages. In some

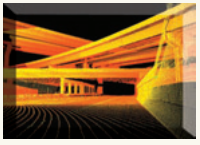
cases, these same projects/firms may have also used high-definition surveys for the Proposal Stage, Design Stage, and/or Asset Management Stage. These Construction Stage examples cover civil, architectural, and plant projects.

Civil Construction Projects

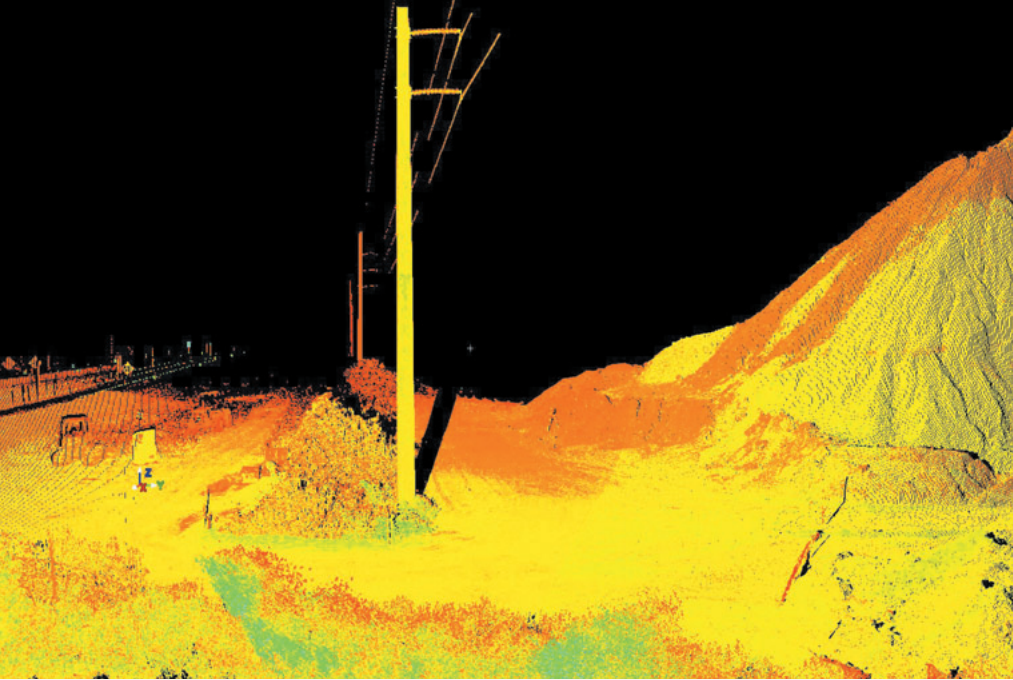
A common use of high-definition surveying in construction projects



For quantity surveys, scanning is often more economical. Image Courtesy: G&T Conveyor



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Point clouds provide more complete data for more accurate quantity surveys.
Image courtesy: G&T Conveyor

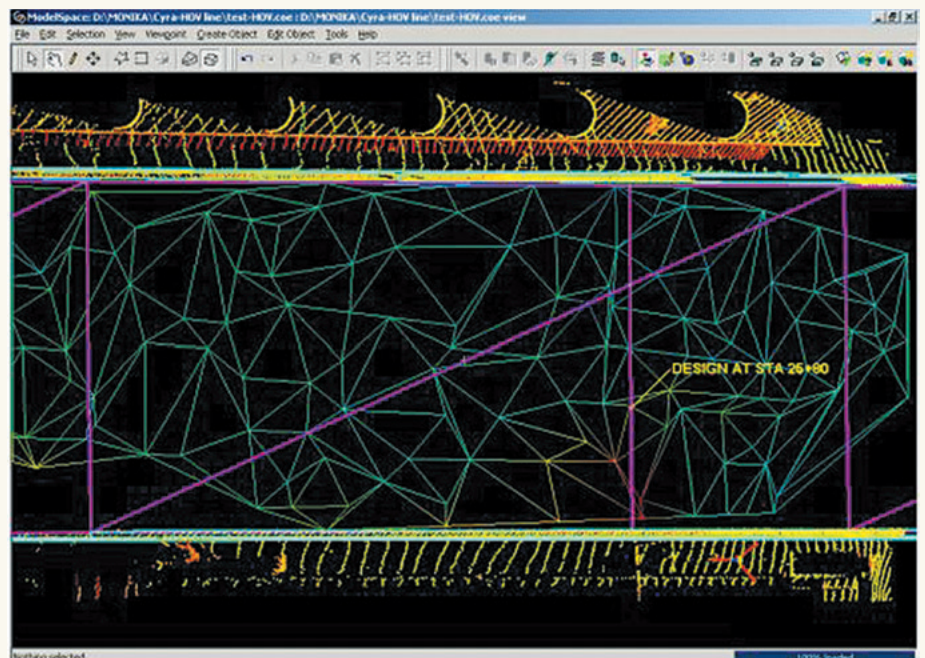
that involve moving dirt or rock is a quantity survey. For this application, laser scanning can often be more economical than traditional methods thanks to its fast, remote data capture. Other benefits include more accurate quantities, safer data capture, and faster turnaround of survey results to the contractor client.

The survey department of G&T Conveyor (FL) primarily uses high-definition surveys in the design stage of conveyor projects in which conveyors are to be installed in existing, congested facilities, such as in airport baggage handling areas. G&T Conveyor's survey department also provides surveying services to the general market. One such recent high-definition survey was a quantity survey of several large, geometrically complex dirt piles for a contractor building a new highway cloverleaf interchange. On this project, the cost of deploying high-definition surveying was estimated to cost less than the cost of conducting the quantity surveys traditionally. Quantities were also considered to be more accurate from scanning, thanks to the high density data capture of the irregularly shaped dirt piles.

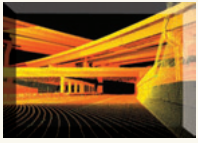
Another common Construction Stage application of scanning on roadway projects is pavement surveys. BSC/Cullinan has used high-definition surveying extensively on

Boston's BigDig project for quality assurance (QA) surveys of newly paved roadways and tunnels. Several high-accuracy laser scanners have been used simultaneously on this massive project over a period of several years. The use of laser scanning for pavement QA surveys has been estimated to provide cost savings on the order of 75% or more over traditional methods. In addition, pavement QA surveys done with scanning have caught localized low- and high-spots that would otherwise be very difficult to capture traditionally. In addition to pavement QA surveys, laser scanning has also been used extensively on this project for "final as-built surveys" that are part of the overall project deliverables. It has been estimated that the use of scanning just for final as-built surveys for the BigDig project will save the project more than \$2 million in survey costs.

Another interesting use of laser scanning in civil construction projects is construction monitoring related to excavations near existing structures. Dasan Engineering, a Korean civil/survey firm, has used high-defi-



Laser scanning has proven highly cost-effective for pavement QA surveys.
Image courtesy: BSC/Cullinan Associates



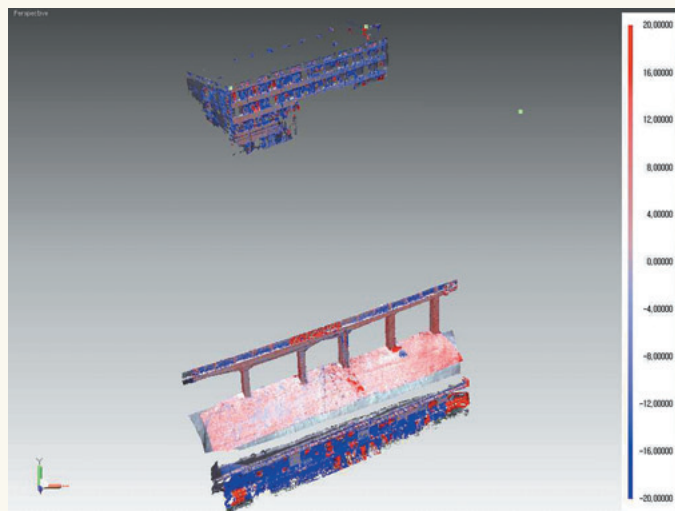
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High-definition surveys are used for monitoring structures near excavations. Image Courtesy: Dasan Engineering

High-definition surveying to accurately assess the movement of road piers and retaining structures adjacent to an excavation project. In contrast to discrete point surveys, scanning offers the advantage of monitoring entire

surfaces for movement and deformation. A challenge with the use of laser scanning for this application is that monitoring must be done in reference to some fixed points or structures that are not affected by the



Scans of excavation area, monitored road piers, and reference building structure. Image courtesy: Dasan Engineering

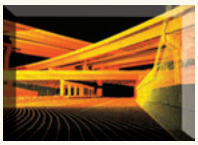
excavation. Such reference structures may be a fair distance (e.g., >300' or 100m) from the excavation area, hence it is very important that the scanning system be able to achieve high accuracy results (e.g. <math><1/2''</math> or 12mm positional accuracy), even at such ranges.

Architectural Construction Projects

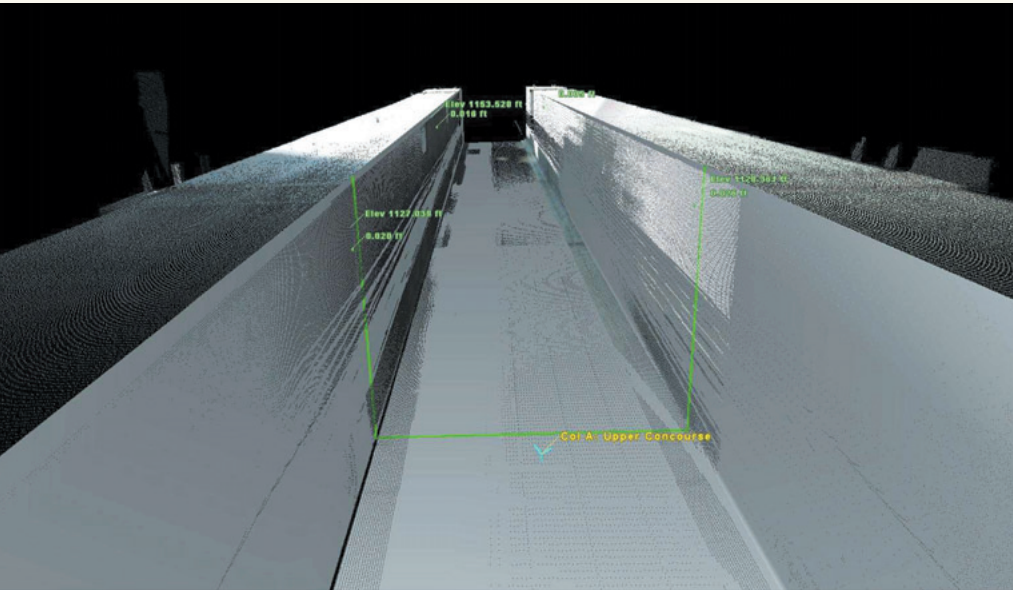
3D Laser Imaging (AZ) is a good example of firm that provides high-definition surveying services extensively during the construction phase of projects involving buildings.

The 2005 construction of the new Cardinal Stadium involved a heavy lift of a roof structure onto a set of four large columns. Each of the four columns features a slot that runs the length of the column; the slot was designed to accept the roof structure once it had been lifted into place. The Hunt Construction Group retained 3D Laser Imaging to provide critical on-site construction QA measurements to help ensure that the heavy lift went without incident. The first QA task was to measure the center-lines of each column to ensure that they had been built in the correct geometry to receive the new roof. Accurate measurements were also needed from the inside notch of the super columns to verify if the steel structure (i.e., the roof) was going to have enough spatial clearance as the contractor lifted it into its final resting place. An advantage of high-definition surveying over traditional methods for measuring the notch is the ability to pick up localized geometry changes along the full surface of the notch. Another advantage of scanning was the ability to analyze the notch surface survey on-site, providing virtually real-time feedback to the contractor. This avoided any construction delays that may have otherwise resulted from a traditional survey and the time needed in the office to reduce and analyze its data.

3D Laser Imaging has similarly provided cost-effective construction QA services with laser scanning on



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Scan of super column notch at Cardinal Stadium construction. Image courtesy: 3D Laser Imaging

the Phoenix Civic Plaza & Symphony Hall Expansion Project. The objective was to see how far the project's complex steel structure was deviating from its proposed design. On this project, the 3D point cloud allowed them to easily model and depict ornate building overhangs, cornices, and facades. After the initial scan was complete, 3D Laser Imaging was able to import the proposed design directly into the laser scan data and give the contractor a real time, as-built referenced to design.

Other service providers equipped with suitable high-accuracy scanners have also used them extensively in the Construction Stage of projects that involve building claddings. In this application, scanning is used to accurately extract the location of tie-point clips that have been installed on new steel. The clip locations are then used to accurately fabricate framework for the external cladding to ensure smooth installation.

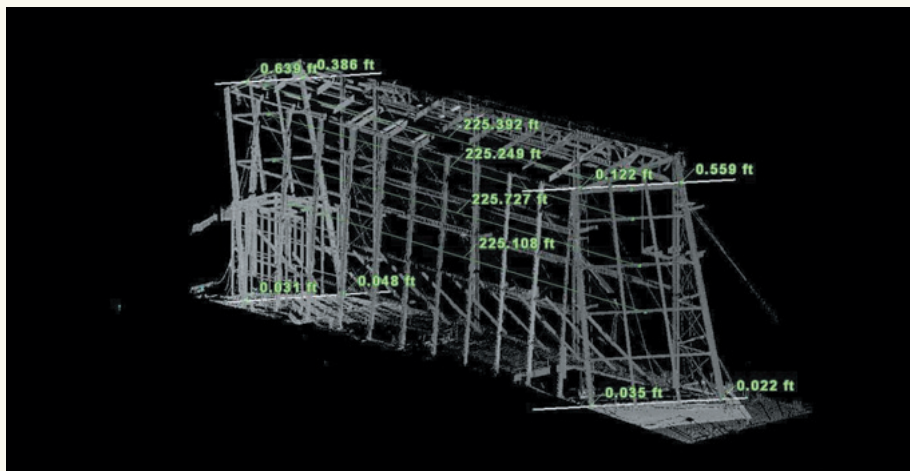
Plant Construction Projects

High-definition surveys are used extensively worldwide in the Construction & Fabrication Stages of plant projects. Plants were one of the very first application success areas for laser scanning, in general, back in 1990s when the technology was first commercially introduced. Thus, it's not surprising that its use has spread extensively from its initial use in the Design Stage into the Construction and Fabrication Stages.

A good example of an organization that uses high-definition surveying extensively for plant Construction & Fabrication is the Metrology Services Department of Framatome ANP (VA), an AREVA (France) and Siemens (Germany) company. Framatome specializes in providing services to the nuclear power plant industry.



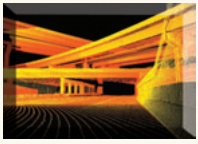
High-definition surveying is used heavily in the power plant industry. Image courtesy: Framatome ANP



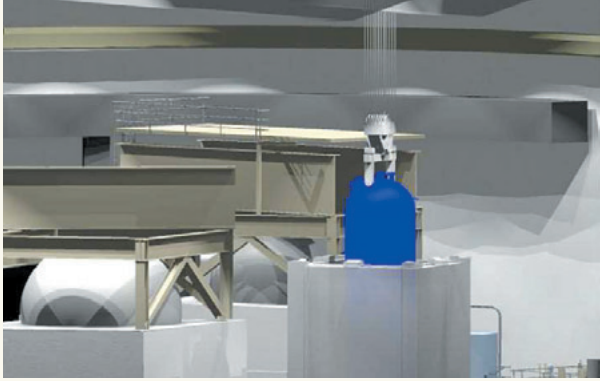
Steel structure scan for construction QA at Phoenix Civic Plaza project. Image courtesy: 3D Laser Imaging

These services include project design, specialty construction, and fabrication. For a recent reactor head replacement project, Framatome used high-definition surveying for three different applications to support the construction phase of the project:

- Interference Detection
- Simulate component load-path movement sequences
- Identify interferences
- Mock-up Training
- Create welding & machining mock-ups to train craft on actual geometry
- Tool Clearance evaluation
- Ensure sufficient clearance for safe operation of automated welding and machining tooling

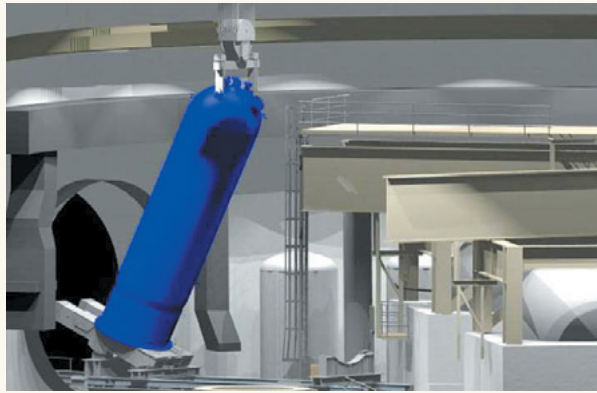


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Laser scanning is commonly used for equipment removal path planning. Image courtesy: Framatome ANP

3D models created from scans can be used for construction animations. Image courtesy: Framatome ANP



construction is making contractors, especially project managers, aware of the benefits of the technology.

Although the technology delivers Construction Stage benefits everyday worldwide, many project managers are still unaware of the technology and these benefits. My observation is that when service providers take the time to explain these benefits to project managers, these professionals are quick to recognize the significant value of the project benefits in contrast to the relatively low cost of deploying the service. To be sure, project managers will likely want to use the technology primarily on critical-path aspects of the project and not on every detailed task. Nevertheless, it has been my observation that such efforts to educate project managers have met with a good pay-off for both the service provider and the client. Firms that have successfully provided laser scanning services to construction project managers report that these clients return for repeat business and repeat benefits.

Summary

High-definition surveys are regularly used during the Construction and Fabrication Stages of capital construction projects. They have proven to save money on as-built and quantity survey costs. In addition, scanning has also proven to reduce construction budget- and schedule-risk—a major benefit to contractors. Over time, it is expected that this application of the technology will continue to grow rapidly as more and more project managers become aware of these benefits. ▽

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In addition to these applications, Framatome has also used high-definition surveys for the design of temporary structures needed during construction. These temporary structures have included scaffolding and temporary radiation shielding. When speaking with users worldwide who provide services with their scanners, I often hear of its use for accurately locating and designing scaffolding that is used during construction. A similarly popular application is its use for the design of specialty derricks and the location of cranes for construction.

Fabrication QA

Just as scanning is widely used in the Construction Stage of plant projects, it is also widely used in the Fabrication Stage. Here, the most common application is to check the fabricated geometry of complex structures, such as piping “spools” or large vessels with multiple nozzles. The QA check is intended to make sure that such structures have been accurately

fabricated according to plans and that they will fit-up properly on site when they are installed.

Many users will scan both the site/structure where the installation will take place and the fabricated structure in the fab shop. The two scans are then merged together on a computer and an “electronic fit-up” check is performed before the actual structures are physically brought together. The benefit to the contractor is that if there are potential problems, it’s a lot less expensive to fix them while the structure is still in the fab shop than it is to fix it on-site in the field. If these problems are not caught until the fabricated structure is being installed in the field, then costly construction crews and equipment are often standing idly by while the fixes are being implemented.

Marketing the Benefits of Scanning to Contractors

One of the keys to the successful use of high-definition surveying in