Laser scanning yields digital as-builts

What do you do when an old plant system or infrastructure network needs upgrading but its dimensional documentation is missing or out of date? Call in the laser scanners. This relatively new technology is proving more accurate and less costly than using plumb bobs and measuring tape.

By Ken Wicker

Competition is challenging power plant owners to generate more electricity more efficiently and cost-effectively. At many plants, the means to those ends take one of two forms: running baseloaded units longer between outages or cycling peaking units daily to meet the needs of retail markets (see article on p. 40). In both cases, the result is increased wear and tear on the generating unit. Over time, any mechanical system will reach a point at which it can no longer tolerate stresses for which it wasn't designed; then the system has to be upgraded.

When a system upgrade is called for, it is imperative that the project be executed seamlessly. But "seamless" is a relative term, because upgrade projects seem more prone to problems than new projects are.

One challenge that often dogs plant managers seeking to upgrade an old system is inaccurate, incomplete, or missing physical (dimensional) documentation. Understandably, "as-built" documentation of systems that were installed decades ago and/or that have been upgraded several times over the years may no longer exist. The end result of missing or inaccurate plans is increased project costs, represented by more field rework, missed schedules, and longer outages. A typical solution has been to send in a team of technicians to manually measure equipment or facility dimensions using conventional tools such as tape measures, plumb bobs, and notepads. This process is usually time-consuming, expensive, and error-prone—not to mention tedious.

Space-age solution

Pittsburgh-based Quantapoint Inc. is one company that claims to have a better solution to this problem: laser scanning. "Laser scanning is a proven alternative to the tape measure and plumb bob," explains Eric Hoffman, the company's CEO. "The process we use quickly and accurately captures the existing or as-built conditions of a plant, reducing the need for rework by more than 80%." Laser scans can be accurate to within 1/4 inch (see box), and the process has proven capable of saving considerable amounts of time.

Quantapoint has completed more than 600 laser scanning projects since the company pioneered the technique in 1999. Most have been at refineries, but some of the more recent ones have been at nuclear plants. Among the more successful refinery projects was one for Shell Oil, which needed to upgrade the diesel-fueled generating units at five of its sites to comply with tighter emissions limits for SO_2. Common to each of the Shell facilities was a lack of accurate and up-to-date dimensional documentation for the units. Quantapoint's challenge was to provide highly accurate and detailed as-built documentation (Figure 1) for them in a fraction of the time that traditional surveying techniques require. Using laser scanning, in only a few weeks at each site the company generated almost 1,000 images that were then used for preliminary and detailed engineering of the upgrades.

Laser scanning's many benefits

Collectively, such laser images are known as the "digitized plant." Hoffman explains that one of the benefits of having a digital version of the plant's assets—everything from the largest piece of equipment to the smallest line of conduit—is the ability to "fit-up" new and old equipment the first time around. Another, he adds, is that "the

1. Shell game. Shell Oil hired Quantapoint to create laser images of five of its refineries to facilitate upgrading the emissions performance of Shell's generating units. Shown is a laser image of the equipment and pipes at one of the facilities in Houston. *Courtesy: Quantapoint Inc.*

digitized plant can be viewed as a set of interactive and photo-realistic 3-D laser models that can be rotated, zoomed, or cropped to focus on specific areas for construction planning." As you might expect, compared to 2-D images, 3-D images (Figure 4) enable plant and upgrade project managers and designers and maintenance personnel to better visualize what assets are in the field. And as modifications are made to the facility, the 3-D models can be easily updated to facilitate and speed subsequent planning and design activities.

In practice, the pictures and 3-D models comprised within the digitized plant are shared by every project team member and are used to support all phases of a project. According to Hoffman, "Project teams have used our laser documentation to develop traditional engineering design documents, including piping and instrumentation diagrams, piping isometrics, and plan and elevation drawings." In addition, the laser documents serve as a "system of record" for the entire facility that can be used in the planning of future projects.

The digitized plant also enables the integration of quality and work processes by allowing plant owner/operators to maximize the value of their assets through maintenance best practices. The results are improved designs and better decision-making based on more-accurate information. Among the tangible benefits of laser documentation are:

- Reduced costs, because everyone accesses a single source of dimensional data.
- The need to make fewer field trips to gather as-built information.
- Tighter scheduling, by reducing the time spent to collect data.

Laser scanning 101

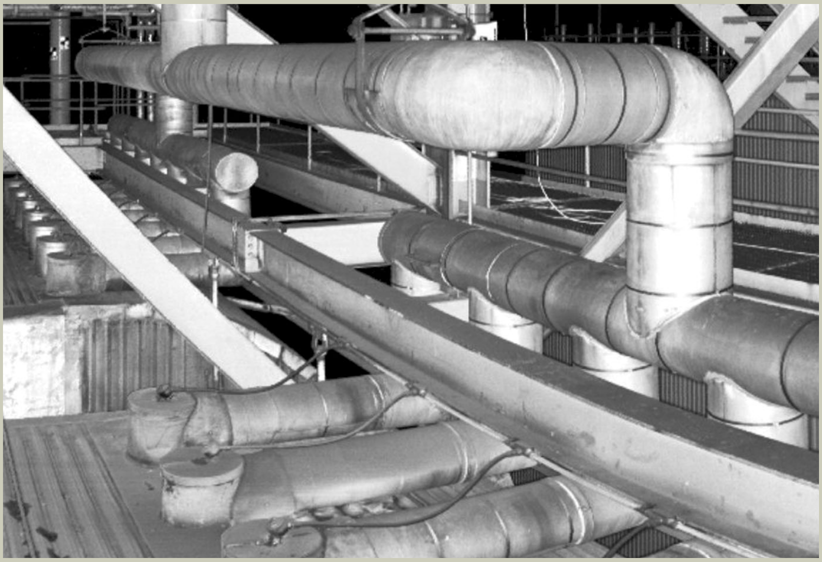
To create the "as-built" documentation of a system, a small field crew uses a laser scanner (Figure 2) to measure the dimensions of individual pieces of equipment. These scans are then integrated using special software that converts them into either two-dimensional images or photo-realistic three-dimensional laser models.

Tom Greaves, an analyst at Spar Point Research LLC (Danvers, Mass.) who follows the market for as-built capture technologies, explains that all laser scanners measure the dimensions of an object by shining laser light on it and detecting the amplitude of the reflections. "It's analogous to flash photography, which captures images taken one at a time," he says. But laser scanners repeat this process thousands of times a second, creating millions of measurements with a single scan.

According to Greaves, laser scanners for this kind of work are of two main types: time-of-flight (TOF) devices and phase-based devices. TOF scanners (also called pulse-based scanners) operate by emitting a pulse of light along a vector determined by two angles. The time it takes a light pulse to travel from the laser to the object and back is measured, divided by two, and multiplied by the speed of light, yielding the range to the object. By repeating the process over and over and changing the light's zenith and azimuth angles, a 3-D image can be developed. TOF scanners can measure distances over a wide range—from a few feet to thousands of feet—but at relatively low data rates of a few thousand measurements per second.

Phase-based scanners, by contrast, emit a continuous signal whose intensity is modulated by a sine wave or "chirped" with a more complex waveform. As with TOF devices, this signal is reflected by the object and the phase differences between the transmitted signal and the reflected signal are then measured. Compared with TOF, phase-based devices are much faster and higher in resolution—typically, up to 250,000 measurements per second with $^1/_8$-inch resolution. However, their range is limited to less than 150 feet. Quantapoint uses phase-based scanners in its projects for industrial facilities (Figure 3).

2. Not your typical camera. The Quantapoint laser scanner's small size and light weight make it ideal for working in cramped industrial facilities. *Courtesy: Quantapoint Inc.*



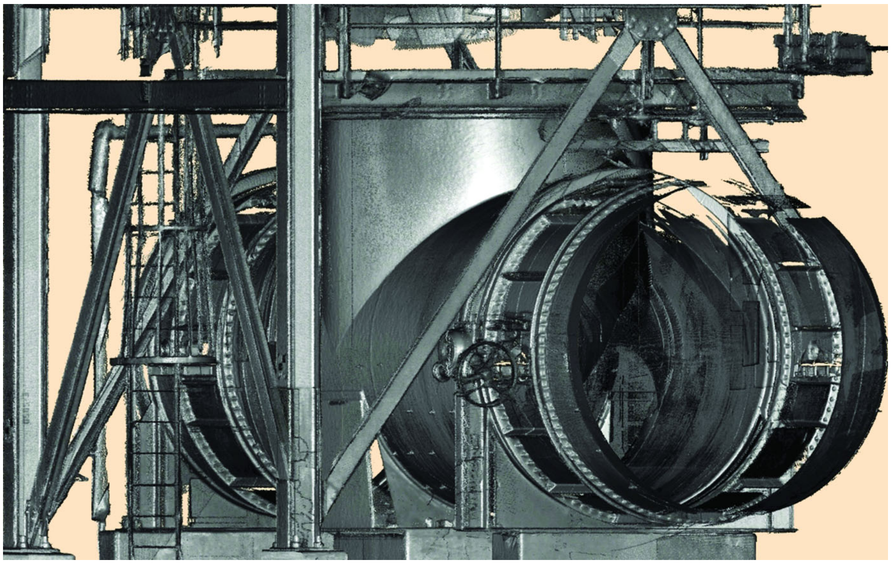
3. Prettier than a picture. In this laser scan (not a photograph) of power plant piping atop a baghouse, each point in the image represents a highly accurate measurement. *Courtesy: Quantapoint Inc.*

- Higher-quality designs, based on more-accurate information.
- The ability to prefabricate components.

Digitizing two power plants

For a concrete example of how laser scanning can benefit the upgrading of a power plant, consider how Quantapoint used the technique to help Parsons E&C (Reading, Pa.) shorten the timeline of an emissions-reduction project two years ago. According to Hoffman, "Two multi-unit power plants required retrofitting in anticipation of lower SO_2 emissions limits going into effect between 2005 and 2009." One plant has a rated capacity of 2,500 MW; the other, 400 MW. Upgrading the plants' selective catalytic reduction (SCR) units for controlling NO_x emissions also was part of the project, and that aspect had an even tighter deadline: One plant had to be running cleaner at the start of the ozone season that begins next month.

As the prime contractor of the project, Parsons E&C considered several options for capturing the existing units' dimensional data and defining the space available for the upgrade. The information to be gathered would be used in the design and construction of new duct systems, new structural support systems, electrical raceway systems, mechanical systems, and tie-ins to existing plant equipment at each station.



4. Easy 3-D. This 3-D laser model (as opposed to a CAD model) of ductwork contains all the dimensional information of all small pipes and conduit shown. *Courtesy: Quantapoint Inc.*

5. The nuts and bolts of laser scanning. Note the fine level of detail, including bolt threads, in this laser scan image of a power plant's structure and components. *Courtesy: Quantapoint Inc.*

According to Dan Biss, Parsons' engineering manager of the project, "The as-built data needed to support the design and construction of the upgrade wasn't available. We considered traditional methods, such as manually collecting dimensional data and attempting to track the history of mods to engineering drawings. But we realized that choosing either of these options would have taken too much time and produced too many errors."

Realizing that they were in a bind, Biss and Alan Smith, manager of engineering for Parsons E&C, called in Quantapoint to help. In the end, Quantapoint provided Parsons with laser images of various plant systems and subsystems, including the precipitators and boiler economizer and air pre-heater sections at both plants. Quantapoint was able to scan the internals and externals of the structures safely even in congested areas where access was nearly impossible (Figure 5). In some instances, the company's technicians even raised their scanning equipment into the air using hydraulic lifts to gain access to elevated parts of the systems.

Quantapoint delivered the scans within one month from the time Parsons E&C authorized the company to proceed. Quantapoint's teams of two or three men spent two weeks in the field capturing data at each plant. Biss and Smith estimate that it would have taken three months to research existing documentation and to field-verify measurements using manual procedures.

According to Smith, Quantapoint's laser scans made it much easier and faster for Parsons E&C to design the new emissions-reducing systems and integrate them into the two plants. He says, "Quantapoint enabled us to not only deliver an 'interference-free' design but do so on schedule as well. Quantapoint's high-quality, accurate scans were easy to view and manipulate, and they were even compatible with our Prism electronic document-management software and with our plant design system package from Intergraph." ■