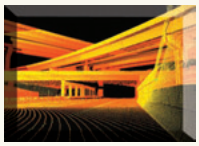


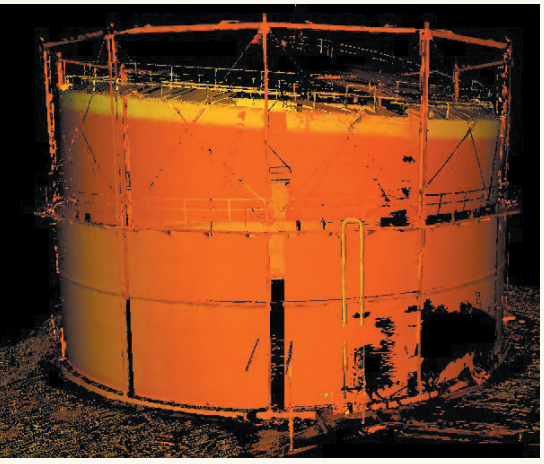
Forensic and Damage Assessment Surveys

Geoff Jacobs

Surveyors and other measurement professionals often find themselves "on-call" for certain types of clients. In addition to providing valuable services for planned projects such as land, infrastructure, commercial, and industrial development, surveyors are periodically called on to respond to both natural and man-made incidents. With Hurricane Katrina and the flooding of New Orleans as a recent, sobering reminder of both natural and man-made incidents, this article examines the rapidly growing role of high-definition surveying as a valuable tool for better servicing these types of needs.

Forensic Advantages

Fundamentally, forensic and damage assessment projects are almost a perfect fit for high-definition surveying technology. In the very first article in this series (*Professional Surveyor*, May 2004), I described a set of five characteristics that define high-definition surveying or laser scanning:



This collapsed 100' diameter tank was scanned to assess whether it could be saved or should be demolished. Image courtesy: North Surveys

- High point density
- Ultra-fast data capture
- Remote, reflectorless measurement
- 3D visualization
- Informative imagery

Since that article, I've now added a sixth fundamental characteristic: unattended, robotic operation. Each of these features brings value to forensic and damage assessment projects.

High Point Density for Mapping Irregular Surfaces

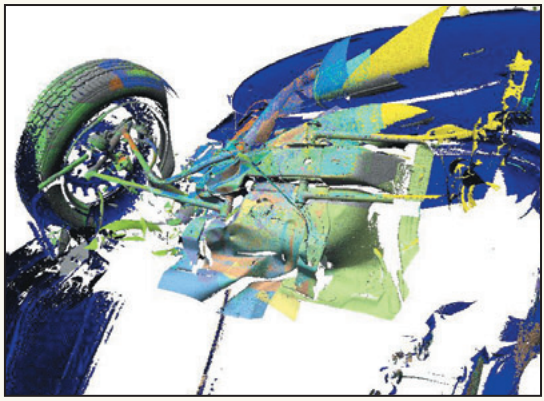
In virtually all forensic and damage assessment surveys, someone is capturing geometry of surfaces. Moreover, these surfaces—especially ones that have been damaged—are characterized by very irregular geometry. Laser scanning's inherently high-density data capture is ideally suited for accurately capturing and characterizing surfaces, especially irregular surfaces.

One of the more common examples of this use is in automobile accident reconstruction for use in legal cases. By accurately modeling the geometry of a damaged vehicle, forensic professionals can better reconstruct exactly what happened during the accident. Another common use is in assessment of the geometry of large storage tanks that have started to deform over time. These complex deformations can be analyzed and recommendations can be made regarding retrofitting such tanks to avoid future catastrophic failures.

While high-definition surveys are ideal for accurately capturing the geometry of highly irregular surfaces, there are some challenges as well for these types of surveys. For automobile body surveys, highly reflective surfaces and some specific colors can create problems in obtaining usable data. A practical fix for this challenge is to apply powder to a damaged car surface.

A second, more difficult challenge, is to process the scan data into appropriate deliverables. Cross-sections of

Scanning is used to capture geometry of vehicles that have been in severe accidents. Image courtesy: Infinity Digital Group, LLC



Laser scan of damaged vehicle. Image courtesy: Berding Surveying

damaged surfaces are fairly straightforward to create, but nice-looking 3D computer models of highly irregular surfaces require highly specialized software and often a lot of time in the office to create. These types of software tools and processing skills are sufficiently specialized that some organizations have developed specific expertise in this area and offer their services in conjunction with others who have laser scanners and collect laser scan data.

Completeness

Another significant advantage of high-density data capture for such incidents is its completeness. In contrast to the sparse data capture inherent in

single point measurement methods (*e.g.*, tape, total station, and GPS), the completeness of a high-definition survey offers genuine benefits for forensic and damage assessment surveys. Often the damaged structure must be quickly removed from a scene or perhaps even demolished. There are often no "second chances" to capture the original scene with site revisits; thus, capturing as much data as can possibly be captured from the original scene is invaluable for investigators who want to know exactly what was there at the time of the incident.

This benefit of completeness is, of course, why photographs are also invaluable for capturing incident scenes. Just as photographs have high pixel density, a high-definition survey has high geometric density. For this reason, *i.e.*, completeness of data capture, close-range photogrammetry has long been a tool also used in forensic and damage assessment surveys. An advantage of a high-definition survey over close-range photogrammetry is that a high-definition survey is much better suited to accurately capturing the geometry of irregular surfaces. From a measurement standpoint, close-range photogrammetry actually morphs into a single point measurement method in the office, so it's not particularly well-suited for mapping irregular surface geometries.

The combination of completeness and high single-point accuracy of each scan point (*e.g.*, $^1/_4$" or 6mm) has made high-definition surveying a favorite in the legal community. Laser scan data from high accuracy scanners has already been accepted in court in the U.S. and internationally. Legal staff have quickly come to consider high-definition survey data as the best geometric record of the site or structure, the "ultimate archive record," if you will. High-definition surveys have already helped to win or quickly settle numerous legal cases.

Sites captured by high-definition surveys are sometimes converted ino 3D computer models for court cases. Image courtesy: David Evans and Associates.

The geometry of collapsed buildings can be captured in detail with a high-definition survey.

Unobtrusiveness

Yet another advantage of high-density data capture for forensic and damage assessment surveys is that it enables surveyors to collect useful data even when people or equipment are active around the scene. For example, laser scanners can capture accurate, detailed geometry of recovery sites with construction/demolition crews around; intersections with people walking and vehicles in motion; and, damaged underpasses with traffic flowing beneath the damage area. The captured data is so dense that data collected from cars and people passing by the scanner's field of view is usually "minor noise" compared to the full, high-definition data sets collected. In the office, it's straightforward to remove this type of noise from scan data sets.

Ultra-fast Data Capture

As noted above, in many incident surveys, the site or scene needs to be cleaned up quickly. For automotive accidents on busy roads, the need to clean up the scene quickly to resume traffic flow is a very high priority, so clients place a premium on tools that can quickly capture complex geometry of these scenes. Organizations that have used laser scanning for forensic surveys and vehicular accident scenes, in particular, typically report at least a 50% reduction in field time when using laser scanning versus traditional single-point methods.

Remote, Reflectorless Measurement

Another very common aspect of forensic and damage assessment surveys is the client's desire to capture the geometry without disturbing the scene and evidence at the scene. Thus, remote measurement methods are ideal. Laser scanning, reflectorless total stations, handheld EDMs, and photography/photogrammetry are all valuable tools for such surveys thanks to their ability to capture the geometry of a scene without having to touch objects or walk within the scene to make measurements.

In addition to a client's desire to not disturb the scene while measuring it, often it's not safe to walk within many forensic and damage assessment sites. By definition, something has been damaged and there's a need to assess the extent of damage before making a determination of whether or not it's safe to physically occupy the site.

Even for scenes that have already been cleaned up, the scene may simply be hazardous to occupy most of the time, which is why the accident occurred in the first place. This is the situation for busy, urban intersections. Such intersections are frequent locations for accidents; the same aspects that make them hazardous to drive or walk through also make them hazardous to survey. Who wants to stand in a busy intersection to survey it? Even with lanes closed, such intersections can be hazardous to occupy. Remote measurement methods, including laser scanning, are well-suited to this task. In fact, busy intersections are ideal for the combined capabilities of (a) laser scanning's safe, remote measurement feature plus (b) its dense data capture, which lets surveyors capture accurate, detailed geometry

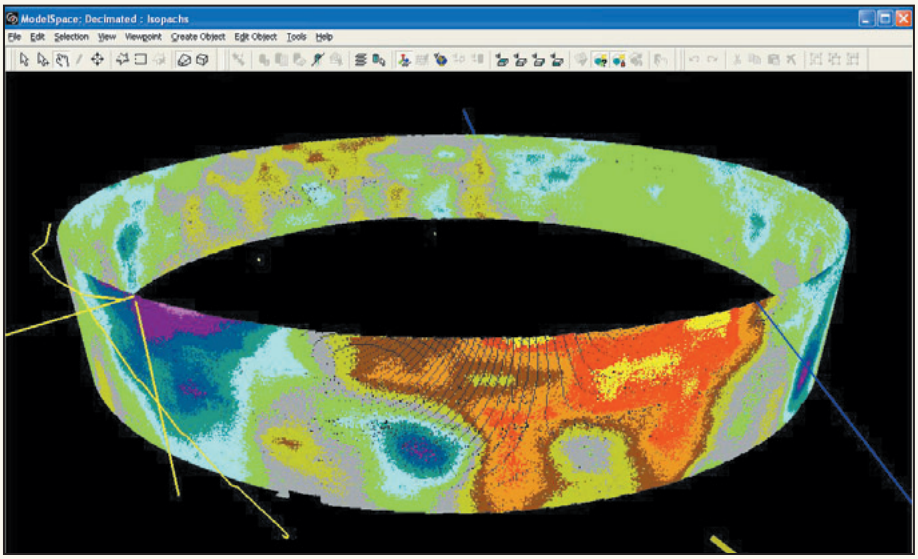
of such intersections even with moving traffic and people going by.

3D Visualization

When forensic professionals and damage assessment experts review and analyze data collected at the scene/site, they often prefer to be able to view the scene/site in 3D. Three-dimensional representations allow them to view a scene from visual perspectives that he/she would not otherwise be able to see. Such bird's eye views or elevated, oblique views can provide valuable insights as to what actually happened in the incident. For high-end court cases, 3D visualization tools have become increasingly common. Laser scanning is inherently a 3D data capture method. Point clouds can be viewed in 3D and animations can be made of point cloud data directly using point cloud processing software (provided that the software has this capability). Third party software is also commonly used to create 3D animations for forensic and damage assessment surveys.

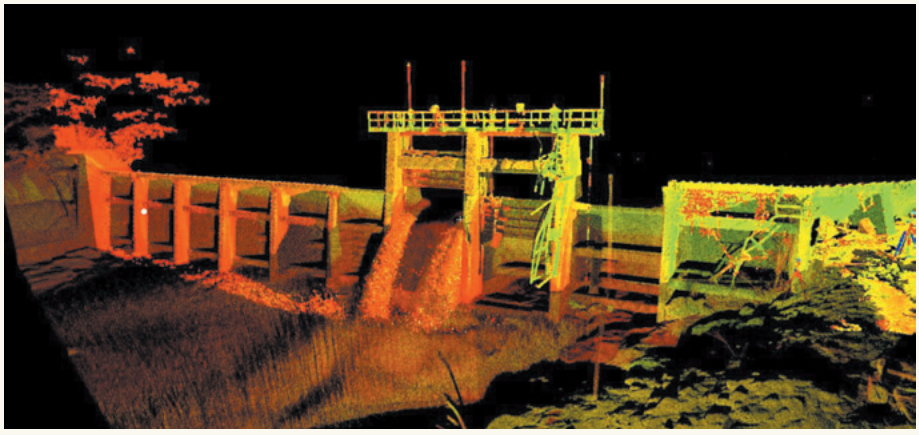
Informative Imagery

Just as 3D visualization is useful for providing additional insights for professionals tasked with analyzing the data, imagery can also provide valuable insights. Photographs are the most obvious sources of imagery data. However, sometimes good photographic images can be difficult to collect. Lighting may be poor or surface colors may be difficult to distinguish because the actual coloring may be drab, gray, or non-contrasting.



Geometry changes of this tank wall shown in 3D view are also color coded to reflect the extent of deformation. Image courtesy: North Surveys

Laser scan data sets represents an additional source of potential valuable imagery beyond actual photographic imagery, thanks to their ability to be "false colored." "False colored" scans can more clearly show a visual differentiation of surfaces with different surface reflectivities. Thus, using appropriate point cloud processing software, a matte gray and a glossy gray surface, which may be difficult to distinguish from a photograph, can be made to appear as sharply contrasting green and yellow hues based on laser scan data. In fact, many service providers provide such "false colored" laser scan images as part of their standard deliverables to clients because these images provide their clients with additional, valuable insights as to what's really there.



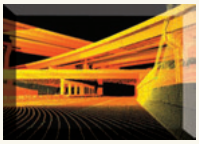
The damaged steel structure on top of a dam was surveyed remotely by laser scanning. Image courtesy: PMI

Unattended, Robotic Operation

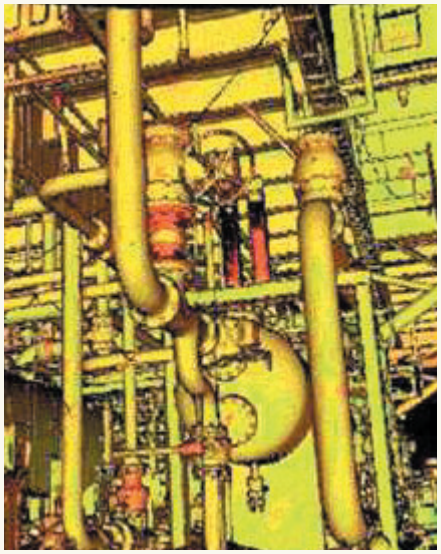
As noted above, many forensic and damage assessment surveys are done on structures that may be inherently unsafe to occupy. Just as the remote measurement capabilities of laser scanning are valuable for such surveys, the ability to use a scanner as a robotic measurement tool provides additional value for such surveys. Once the scanner is placed in a suitable spot, the scanner can literally be operated remotely via wireless operation or using a long length of lightweight computer wire. This avoids the need to have an operator "tethered" to the measurement instrument while measurements are being taken.

This aspect of laser scanners has made them popular tools of choice for capturing the geometry of nuclear power plant reactor areas, hazardous waste pits and containment facilities, etc. Not only are the measurements made remotely by the instrument, the instrument itself can be remotely operated - the ultimate in safety.

Researchers at Columbia University (NY) have even developed a "robot for the robotic scanner." This system allows an operator to remotely control



HIGHDEFINITIONSCANNING



False colored scans can often reveal objects and geometry more vividly than actual photographic images reveal. Image courtesy: ChevronTexaco

the travel of a wheeled platform that supports a laser scanner. The operator can guide the robotic platform, much like a remotely operated vehicle (ROV), and then make the platform stop in the right spots to perform laser scans. The operator can remotely instruct the scanner to take a digital image of the scene and wirelessly send it back to the remote operator. Based on viewing the digital image, the operator can then remotely instruct the scanner to scan specific parts of the scene, each part at an appropriate scan density. Although this work by Columbia is a research project, it's easy to imagine the possibilities of further developing this capability for such hazardous area applications.

Today's Status of High-Definition, Forensic Surveys

Today, high-definition surveying is often used for damage assessment and forensic surveys on "high-end" incidents. These are ones that involve potentially large lawsuit settlements, involve high-visibility incidents such as terrorist actions, or involve incidents with a large premium for quickly returning a damaged asset back into productive use. For example, high-definition surveys have been conducted for automobile accidents involving serious injury or even fatalities, including the investigation of the Lady Diana incident in a Paris underpass. The technology has also been used in the analysis of the USS *Cole* explosion, the Bali resort bombing, and the London Underground and bus bombings of 2005. High-definition surveying was very successfully used on Chevron's and Marathon Oil's Petronius oil and gas platform that was heavily damaged by Hurricane Ivan in 2004. This is a good example of using high-definition surveying to speed up the repair of a valuable asset and quickly put it back into production. There are plans to use the technology for quickly, accurately, and safely assessing Gulf of Mexico platforms damaged by Hurricanes Katrina and Rita this year. Likewise, it is expected that the technology will also be used to help assess infrastructure assets such as roads and bridges damaged by Katrina and Rita.

Cracks at the end of this concrete structure were scanned for assessment purposes. Image courtesy: David Evans and Associates

In addition to its extensive use on high-end forensic and damage assessment surveys, the technology is also being used by surveyors who create everyday 2D maps of intersections that have been the site of accident scenes. Such maps can typically cost in the range of $2,500 to $5,000. The overall cost of deploying high-definition surveying for mapping such intersections is often lower than costs based on traditional methods. Plus, surveyors enjoys the added benefits of better safety and more complete data capture, which provides higher confidence in the resulting maps and reduces the need for go-backs.

The Gulf of Mexico's Petronius platform, shown here new, was damaged by Hurricane Ivan and laser scanned for assessment. Image courtesy: Marathon Oil Corporation website

Summary

In many ways, high-definition surveying is a technology that is ideally suited for forensic and damage assessment surveys. It is, in fact, used for these applications daily around the world. Fast and rich data capture, safe and unobtrusive data capture, and the resulting 3D data sets and visual imagery all combine to provide significant benefits for professionals engaged in this critical activity. In the future, it is easy to see the technology becoming a standard tool for these types of surveys.

GEOFF JACOBS *has been employed by Leica Geosystems, HDS, Inc. since 1998. He currently acts as Senior Vice President, Strategic Marketing. He is also a contributing writer for the magazine.*