Uses in Transportation

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The use of high-definition surveying/laser scanning for transportation-related projects is one of the “sweet spots” for this technology. This article takes a closer look at the latest trends and the specific applications and benefits that this technology brings to transportation projects today.

Trends

Laser scanning technology is being used at a rapidly increasing rate for transportation-related surveys. This is evident based on discussions with numerous surveying organizations that have scanning capabilities and provide services to transportation clients. It’s also evident based on the growing number of transportation agencies that have acquired laser scanning systems or have started to require subcontractors to have suitable scanning capabilities in order to bid on certain contracts.

There are two primary drivers behind this trend. First, transportation project “clients” or end-users are becoming increasingly educated about the benefits of the technology. As a result, end users are increasingly open to its use and, in fact, many are requiring its use for certain types of projects.

The second driver is simply economics. Experienced service providers, armed with the latest round of full field-of-view high-definition surveying systems and surveyor-friendly office processing solutions, have sharply driven down the cost of scanning-based transportation surveys. Field costs have been driven down sharply by full field-of-view scanners that minimize the number of scanner setups and target placements. Office costs have been driven down by new surveyor-friendly software and workflows, along with more features that automate processing point clouds into final deliverables.

For many transportation surveys, scanning-based surveys today cost less than or the same as traditional surveys. Even at an equal cost, scanning provides many added-value benefits that have often made it the method of choice: improved safety, faster turnaround, and more complete and accurate survey data.

In the early days of laser scanning technology, its “ancillary cost savings” were a key economic driver. For example, end-users could deploy scanning to eliminate the cost of lane closure services, which can be as costly as field surveys. In these early days, the cost of a laser scan survey was often only competitive with traditional methods for surveying objects/sites that were hard to reach (e.g., bridges or rock faces) or that contained lots of detail. Today, however, the pure productivity advantage of the technology for everyday transportation surveys has led to the sharply increased use of scanning. For example, a proper scanning system and its crew can survey many roadways 20-30% faster than a conventional crew. Moreover, for the same task, the size of a scanning crew is typically smaller than the size of a corresponding conventional crew.
High-definition surveying is used for many types of road-related surveys. A major advantage of the technology is the ability to perform many road surveys without lane closures and/or to conduct them at night. Safety is another key benefit.

- **Road topo for design**—common for multi-lane roads, such as highway widening projects, when engineering-grade accuracy is required.
- **Intersections**—many intersection surveys involve collecting detail, a task for which scanning is well-suited.
- **Pavement QA**—surfaces and profiles can be collected very cost-effectively with a greater level of detail. This is a common use for scanning.
- **Road topo for problem analysis**—many high-definition surveys have been done on pavement where water gathers and can cause vehicles to hydro-plane. Scanning has also been used to monitor roads suspected of subsidence.
- **Paving volumes**—the technology is regularly used for calculating actual volumes of materials applied.
- **Input to road milling**—the detailed data from a high-definition survey provides accurate guidance for where and how much to mill surfaces that have been paved too thick.
- **Accident investigation and analysis**—the completeness of high-definition survey data, the accuracy of the data, and the ability to capture data without disturbing the scene are all advantages.
- **Slope stability and retaining wall surveys**—some roadways are cut into the sides of steep hillsides. Many are subject to falling rocks or landslide risk. High-definition surveys are highly cost effective for monitoring and assessing slopes and retaining walls adjacent to roadways. Slope terrain is difficult to access; aerial surveys are problematic for highly sloping surfaces; and, geometry is complex. Scanning is an attractive solution,

Scanning is used to survey busy intersections without closing lanes. Image courtesy: Precision Measurements Inc. (PMI)

A high-definition survey was used to assess the sag of traffic light structure installed after a Florida hurricane. Image courtesy: Consul-Tech

Scanning is used extensively for toll plaza as-built surveys. Image courtesy: American Surveying Consultants
provided that a scanner can be located with a good line-of-sight to the slope and the surface is within the useful range of the scanning system.

- **Toll plazas**—many plazas are being upgraded to include automatic toll collection. Designing the toll plaza upgrades requires accurate, complete as-builts. For these surveys, scanning is often used in conjunction with conventional methods. The fully robotic capability of scanning allows field staff to also support conventional survey tasks while the scanner is automatically scanning. The combination typically provides overall productivity gains greater than 30% compared to conventional methods only; plus, there’s no need to close lanes.

**Bridges and Elevated Roads**

Bridge surveys represented some of the first successful transportation applications of high-definition surveying years ago. Today, the technology is used as an almost *de facto* standard in many areas. Inaccessibility to parts of the bridge, the ability to capture surfaces without lane closures, and the trustworthiness of the data for areas that are hard to reach are advantages. Overall, the cost of doing a bridge survey with suitable scanning solutions is often less than half of the cost of doing these surveys conventionally.

- **Design as-builts**—decks, undersides, piers, abutments, caps, railings, and structural elements are common content for scanning-based surveys.
- **Clearances**—a high-definition survey gives users the ability to locate the true minimum clearance both vertically and horizontally, again without having to occupy the roadway.
- **Topo for problem analysis**—scanning is often used to analyze structural damage or causal circumstances when a truck has hit a bridge (i.e., its height or width exceeded the actual clearance).
- **Heritage**—many old bridges are considered heritage landmarks. Scanning is used both for historical archive (e.g., HABS & HAERS) and for retrofit/modification projects. On rehab projects it is important to preserve many façade and ornamental features. The detail of a high-definition survey is well-suited to this task.

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Scanning was used to survey the approaches, bridge deck, and underside of James Creek bridge. Image courtesy: B.H. Mulkey Engineering Inc.

Stairway connecting an elevated highway was scanned for accurate design as-builts. Image courtesy: M.J. Engineering and Land Surveying, P.C.

High-definition survey of bridge damage caused by a truck. Image courtesy: ESP Associates.
Tunnels

Tunnel surveys (both road and rail) also represented some of the first successful uses of high-definition surveying for transportation projects. Here, the inaccessibility of tunnel ceilings and highwalls, the need for detailed profile geometry, and the need to perform data capture quickly are all major reasons for the success of laser scanning in this application. Over the last few years, access has been severely restricted to many tunnels in view of possible terrorist threats, making the challenge of surveying tunnels that much greater. Just as for bridge surveys, scanning has proven to be highly cost-effective when compared to traditional methods.

- Profiles—High-definition surveys capture profile details that traditional surveys may miss. The ability to slice the tunnel scan at any interval and create more closely spaced profiles is also a plus. Scan-based surveys are regularly performed on finished tunnels as well as tunnels that are being newly bored.
- Paving QA & Quantities—like road surveys, tunnel walls also go through a process of layered construction. Scanning is cost effective for QA and for quantity estimations.
- Clearances—just as with bridges, vertical and horizontal clearances are very important. High-definition surveys can readily provide true minimum clearances cost-effectively. When “time windows” for capturing data are severely restricted and the speed of data capture is critical, phase-based laser scanners are often the tools of choice. They can capture several hundred thousand points/sec and their otherwise limited range is not a constraint for profiling narrow tunnels.

Airports

High-definition surveying is commonly used for airport-related surveys. Key advantages of scanning are fast data capture (especially for runways that are only accessible for short periods at night); complete and accurate as-built of facilities and baggage handling areas; and the ability to easily and accurately capture hard-to-reach ceilings, terminal structures, towers, and antennas. International airports, regional airports and military air bases have all taken advantage of the technology.

- Runway pavement QA & Quantities—this is a common application for scanning, as high-speed data capture, the ability to survey remotely, and the ability to survey at night represent real advantages.
- Baggage handling areas—many areas are being updated with the latest baggage inspection equipment. These areas are often already densely populated with utilities, support structures, conveyors, and other physical elements that make inserting new baggage inspection equipment challenging. Scanning has been used for cost-effective as-built that are needed for design and construction planning.
- Terminal transport structures—scanning is used for surveying roadways, ramps, and inter-terminal infrastructure when changes are being planned to these parts of an airport. The information is used both for design and for construction planning, such as determining optimal crane locations. Remote data capture and the ability to easily capture complex geometry are pluses for scanning.
- Exterior envelope for landing patterns—3D models have been created using laser scanning for the purpose
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of updating key flight path information. Scanning can capture the geometry of large structures without having to use scaffolding or man-lifts.

- **Construction as-builts**—for hard-to-reach structures, scanning is often very cost effective.

One application that has been problematic for scanning at airports has been parking garages. Because scanning is line-of-sight to the surfaces being captured, parked cars can pose a significant problem for scanning pavement. Parking garages and parking lots, in general, are only suited to scanning if they are practically empty of cars during the survey.

**Rail**

Rail applications are similar to tunnel applications in that it can be difficult to gain permits and access for conducting surveys on a live track. Scanning can often be conducted from outside the rail right-of-way, which makes it a good option for open track surveys. This is particularly useful when lengths of track have to be surveyed at road/rail intersections.

- **Track**—scanning is used for limited lengths of track. Research is being conducted with high-speed phase scanners for use on moving platforms in which the complete, immediate environments of the track can be captured by scanning. This will be beneficial for identifying overhanging foliage.
- **Signaling**—the ability to remotely capture signaling in rail yards is an advantage of scanning.
- **Platforms**—many parts of a rail station or platform are often hard-to-reach and may contain complex geometry and structural details. High-definition surveys can effectively address these challenges.
- **Utilities**—like signaling, utilities at rail facilities can be difficult to capture.
- **Clearances**—for overhead and horizontal structures, rail clearances are critical. The high density of scanning can be an aid in identifying true minimum clearances.

**Ports and Harbors, Canals**

Although terrestrial laser scanning is not suitable to survey underwater terrain, it is successfully used on related structures, such as port and harbor facilities. In many cases these structures are difficult to physically access, therefore scanning’s remote measurement capabilities are beneficial. The U.S. Army Corps of Engineers, for example, has deployed laser scanning on a wide variety of as-built surveys. Many of these have been conducted for the purpose of assessing structural deformations or damage.

**Summary**

Many types of transportation-related as-built surveys are good candidates...
for taking advantage of the benefits and cost advantages of laser scanning. Recent trends in scanning have reduced the costs of scan-based surveys to be highly competitive with conventional surveys for a wide variety of such projects. Laser scanning’s capabilities for remote and overhead measurement, as-built detail, and fast data capture lend themselves well to transportation surveys where occupying the transportation structure itself is often problematic.

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Scanning has quickly become a standard for rail tunnel surveys. Image courtesy: American Surveying Consultants