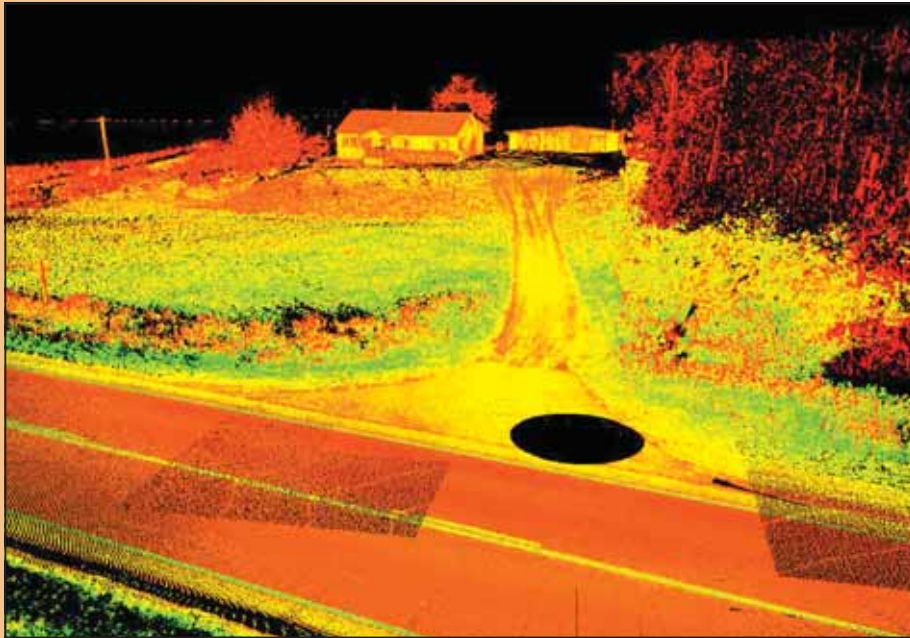


Field Productivity Factors in Laser Scanning Part 3



▲ As scanners become more productive, they are being used economically for rural route surveys—Image courtesy: Glahe & Associates

The potential for dramatic savings in field productivity by using laser scanning technology for as-built and topographic surveys—as much as 75 percent labor savings—is one of the primary drivers behind its rapid adoption. So, it's helpful for those doing their homework on this technology to be able to assess various field productivity factors of scanning systems.

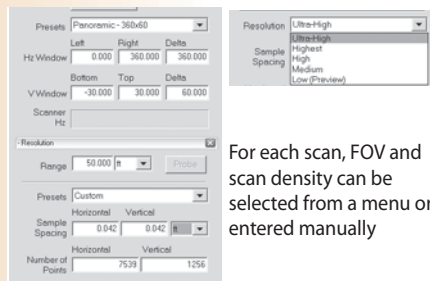
Parts 1 and 2 of this series (January and February 2007) describe field productivity aspects of **site reconnaissance, system portability, number of instrument setups, and the number of target setups**. Part 3 considers the final aspects of coordinated **image (picture) capture, scan time, autonomous operation, and other scanning tips and procedures**.

Scanning

The actual scanning process at the instrument itself can include the following elements:

- program the scanner for the desired scan densities and fields-of-view (FOV)
- capture images and/or “preview” scans (optional)
- scan the scene
- locate targets/fine features and scan them (optional)

Programming a scanner: Users can program a single scan or a sequence of consecutive scans from a single instrument set-up (the latter is often referred to as “scripting” a scanner). Programming consists of instructing the scanner via the scanner controller as to what FOV to scan and what density(ies) to scan them



For each scan, FOV and scan density can be selected from a menu or entered manually

at. Some users have developed standard scripts for repetitive high-definition survey applications, such as roadway surveys. By automatically re-using the same script at each scanner setup, scripting time is eliminated. For some scanners, the user can select from a pre-set menu of scan density options (e.g., five density options), while others allow users to program virtually any scan density.

In some cases, one scan density can be used for the entire scene. This is common practice when using ultra high-speed, “phase-based” scanners, as they can scan at very high density so fast that it may not be worth taking the extra time to script, other than to limit the amount of unnecessary data collected.

Capturing images or “preview” scans

Pictures of the scene (taken by a camera embedded within the scanner) and/or preview scans of the desired scene are often done prior to a detailed scan of a scene, especially when using scanners with longer range capabilities. Operators use pictures/previews to quickly select specific portions of the scene of interest and to speed up the scripting process. These pictures can also be useful for locating targets (or other features to be fine-scanned) and for marketing purposes, when overlaid on scan points. Accurate alignment of a scanner’s picture-taking mechanism with its scanning mechanism minimizes the required FOV for such scans and, thus,

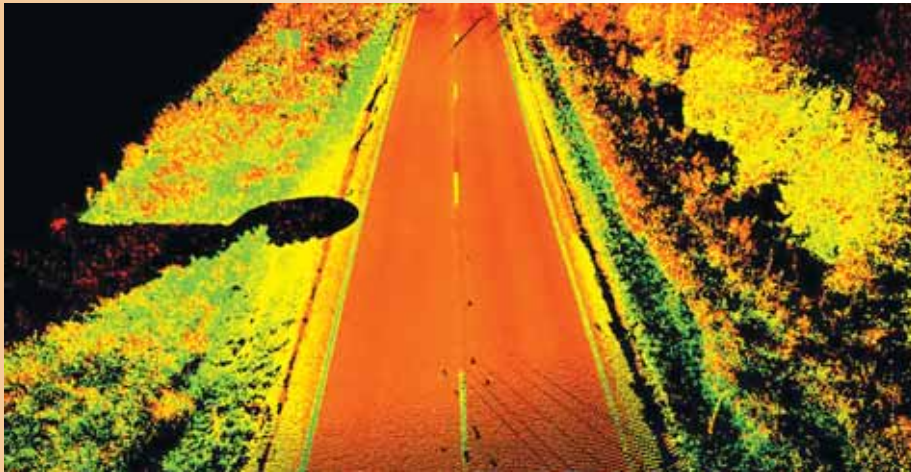


▲ FOV can also be selected by scribing a box around the desired area on top of a digital picture taken by the scanner’s camera

minimizes total scanning time.

If you need images for producing highly photorealistic 3D models, then a separate picture taking process is generally necessary with external cameras; this entails additional field time.

One last, handy option for quickly selecting the desired horizontal FOV for



▲ All other factors being equal, faster scan speeds can help reduce the time for surveying
—Image courtesy: Glabe & Associates

the scene is to quickly rotate the scan head through a horizontal “start-stop” FOV (just as one would rotate a total station) before the scan; however, not all scanners have this option.

Scan time: Press the “SCAN” button (on the instrument, laptop or handheld controller) and away you go. Scanning is automatic, and here’s where a scanner’s actual scan speed comes into play.

For those evaluating scanner speeds, there’s one fairly hefty challenge, however. For any given scanner, *actual scanning speeds* (the number of points collected in a specific period of time) can vary as a function of the FOV selected and the vertical and horizontal scan densities selected. Some scanners have high-speed modes and low-speed modes (for more accurate results), and the extent of these variations can affect *actual scan speeds* by a factor of four times or more!

There are so many potential FOV, scan density, and mode-of-operation scenarios that most vendors tend not to publish actual scanning speeds for all of the possibilities. Vendors’ published specs for scan speed (usually stated in points/sec or pixels/sec) can help, but they can also be grossly misleading compared to scan speeds actually achieved, and there are currently no industry standards. Scan speeds specified today range from a few hundred pts/sec to 500,000 pts/sec. Today, vendors tend to specify “maximum scanning speed,” or you’ll see specs that read “up to X pts/sec.” Maximum scanning speed figures can be further misleading, as they may

reflect the maximum instantaneous firing rate of the laser or maximum measurement extraction capabilities of the scanner’s algorithms, but not necessarily the number of points that are actually collected for multiple columns and rows over a certain period of time. This disconnect between maximum scan rate specs and actual scan rates is not unlike the disparity between a scanner’s maximum range specs and its practical, useful range.

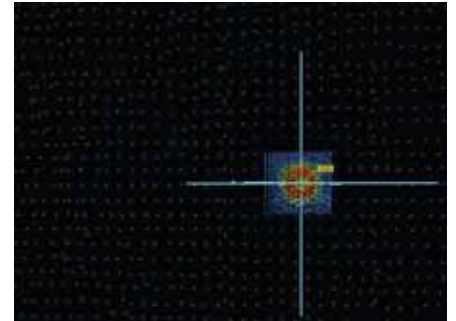
If you want to find out how fast scanners are in specific scenarios, your best bet is to ask users of various systems about “actual points/sec achieved” in these scenarios or run tests whereby you specify the FOVs and scan densities, then simply divide the number of points collected by the scan time for each test scenario.

Locating and scanning targets:

Depending on a project’s overall accuracy requirements, targets are usually scanned at very high density (e.g., 1.2 mm to 2 mm point-to-point spacing) in order to be able to very accurately extract the target’s center coordinates for accurate registration and geo-referencing.

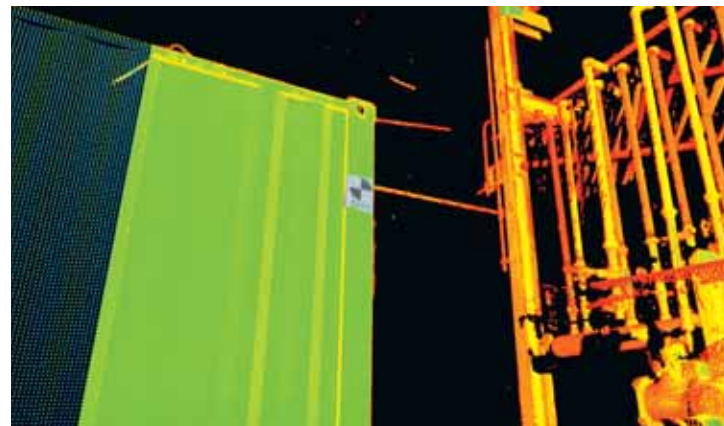
One option is to scan the entire scene at the same very high density that is needed to accurately extract each target. The second option is to separately scan targets (and other fine features) at a very

high density and other parts of the scene at lower (but still sufficient) densities; since very high density scans take longer, this can save field time and it also reduces the overall size of data sets for easier office processing.



▲ Targets can be fine-scanned separately from the main scene scan

Scanning the entire scene at very high density is most often done with phase-based scanners and is the main reason why phase-based scanner data sets are notoriously large. With today’s longer range (time-of-flight) scanners, selectively scanning targets at very high den-



▲ This target was captured as part of one high-density scene scan using a phase-based scanner

sity is best done via scripting. But how does a scanner operator single out these small targets in a complex scene? Some scanners have the ability to automatically identify certain types of targets. This approach is attractive, but not fool-proof, as other objects in the scan scene may have similar characteristics to targets and falsely indicate themselves as targets.

Users can also find targets in the scanner’s digital camera image or in “preview” scans displayed on the

laptop. Users select the density of a preview or full-scene scan such that at least one point will land on a target. For example, if the user has 3" square targets in the scene, then the minimum scan density to land at least one point on each target will be 3' point-to-point spacing. For software that displays scan points from targets as a unique, bold color, once a target is visually identified by the operator, then he/she can select "Acquire Target" and the automatic process for capturing it is usually very quick (less than a minute or so).

Autonomous Operation

Scanning is an automatic process. For some systems, operators can monitor the scan data being collected on a computer screen in real time. For other systems, operators must wait until the scan is done to view scan results for QA purposes. Scans can last just a couple of minutes or they can last more than an hour. For long scans, if a field crew can simultaneously perform other productive tasks such as locating subsurface utilities or establishing control while the scanner is scanning, then faster scan speeds will not necessarily reduce overall field costs for a given project. If, on

the other hand, a field crew is waiting for the scanner to finish scanning before other productive work can be done, then faster scan speeds can translate into significant, direct field-time savings.

Useful Field Procedures and Other Productivity Tips

If you talk with experienced users, you'll often hear them discuss a variety of tips and tricks that increase field productivity. Here are some of the more popular ones:

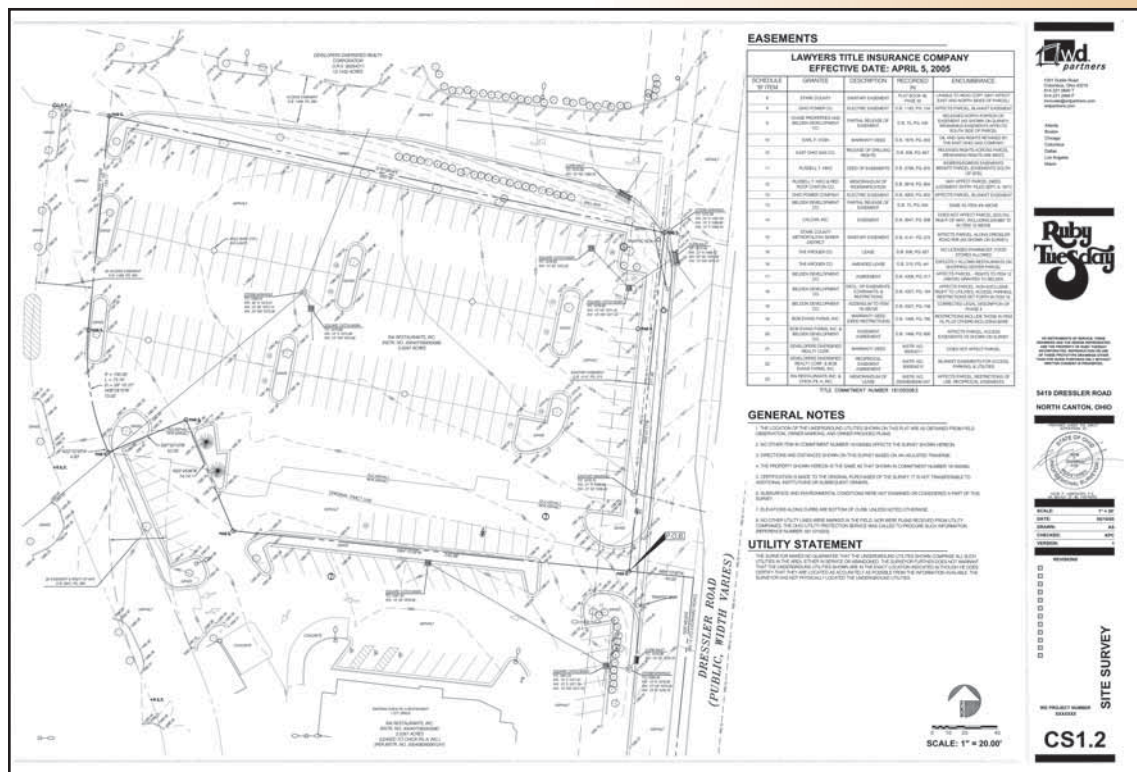
Elevate the scanner: For surveys of roads or other horizontal surfaces (not vertical surfaces or overhead structures), many users elevate the scanner, which can produce up to a 50 percent increase in field productivity. This increase results from fewer instrument setups needed to cover the same amount of roadway. Elevating a scanner is typically done using a tall tripod, but I've seen all sorts of devices used including lifts. One key for high accuracy work is to maintain the scanner in a fixed position. I've seen scanners mounted on stationary vehicles, but users sacrifice accuracy with this approach unless they go to great lengths to physically isolate the scanner from the vehicle's rubber wheel base

during scanning.

"Pausing" a scan: What if a scanner is set up to scan a roadway and midway through the scan a driver parks his/her vehicle near the scanner and in the active FOV? Rather than collect detail of the parked vehicle or have to restart the entire scan once the vehicle has left, it's beneficial to pause the scan and resume it once the vehicle is gone. This ability to pause a scan can be very helpful, but not all scanners have it.

Wireless operation: This option is becoming more popular for increasing field productivity on high-definition surveys. Wireless control of a scanner allows the scan operator to set up the scanner's laptop control in a convenient area (such as the cab of a survey truck/van) and then only have to worry about moving the scanner, not a cabled laptop for each instrument setup. It also avoids nuisance field problems associated with people tripping over laptop control cables and disturbing the scanner setup.

Automated field QA checks: There are many ways to independently check scan data in the field, including using an automatic "re-check targets" capability in the scanner control software. This efficient feature instructs the scanner to



▲ For some projects, the field crew can do other survey work on site while the scanner is scanning unattended
—Image courtesy: WD Partners

| Use | Pnt | Error | Method | FC | Comment |
|-----|-----|-----------|--------|-----------|---------|
| 2 | | -0.7 cm * | Auto | bc | |
| 13 | | 0.5 cm * | Auto | ep | |
| 8 | | -0.5 cm | Auto | flow line | |
| 4 | | 0.4 cm | Auto | fc | |
| 7 | | -0.4 cm | Auto | flow line | |
| 9 | | 0.3 cm | Auto | flow line | |
| 10 | | -0.3 cm | Auto | ep | |
| 6 | | -0.2 cm | Auto | fc | |
| 3 | | -0.2 cm | Auto | bc | |
| 11 | | 0.2 cm | Auto | ep | |
| 12 | | 0.1 cm | Auto | ep | |
| 5 | | -0.0 cm | Auto | fc | |

Search Distance (+/-) 100.0 cm
Max Elevation Error (+/-) 0.5 cm

MeanDev: 0.2 cm
RMSDev: 0.2 cm

Process Close

▲ Field software can automatically check scan elevation data with conventional data to produce valuable QA reports

automatically go back to target scans captured at the start of a scan and re-scan them at the end of the scan. Using the scan control software, operators can easily compare center coordinates of both the “original” and “re-check” target scans to determine if the scanner or targets were inadvertently moved during the scan.

Another highly efficient tool is to import survey points (collected via traditional survey means on the same site) into the scan data. Checking functions within appropriate scan software can automatically compare elevations from these imported, independent points with neighboring, geo-referenced scan data to produce valuable QA reports.

Other Field Productivity Aspects

As with any surveying instrument, other practical factors can also affect field productivity. A few key ones for high-definition surveying today are:

Power supply: Laser scanners and their laptop controllers consume much more power (typically at least ten times more) than total stations or GPS/GNSS systems in the course of a day. Thus, it's important to ensure sufficient DC supply or use AC when feasible.

Environmental factors: Laser scanners today do not have quite as wide a range of operating temperatures as total stations and GPS/GNSS systems have. Colder temperatures (below 32°F/0°C), for example, can shorten a scanner's effective scanning range, which can, in turn, lead to more instrument setups, etc. In many cases, there are ways around these limitations, but proper planning is needed.



▲ For indoor survey projects, AC power supplies for scanners can be beneficial

Access to customer support and back-up scanners: As fast as laser scanning is growing, there are still far fewer laser scanners in use today than there are traditional survey instruments. So, it's important to consider how extensive the support is from a vendor, their dealer(s), and other users of the same type of scanners/software. If you have problems in the field, how quickly can this support network get you back on task? Likewise, if you're looking at a remote site or a critical project that fully depends on a scanner, would you have access to a back-up scanner if necessary? When users examine these aspects today, they may find widely differing pictures among vendors, dealers, and the number of other users with similar scanners.

As laser scanning technology improves, the types of as-built and topographic survey projects for which it offers significant field productivity advantages (as much as 75%) continue to increase. For professionals investigating specific laser scanning systems, understanding their field productivity factors can be quite valuable. Some field productivity factors are generic to all types of surveying, but others are unique to scanning, such as considerations for targets. Today there is a wide range of capabilities among laser scanning systems and software on the market. For one of the more important aspects, scan speed, there are no industry standards that enable direct comparisons. So when comparing systems and vendor support networks it's helpful to be informed about the various factors and then ask experienced users about what can realistically be expected. ♪

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