Updating the Lady in Black

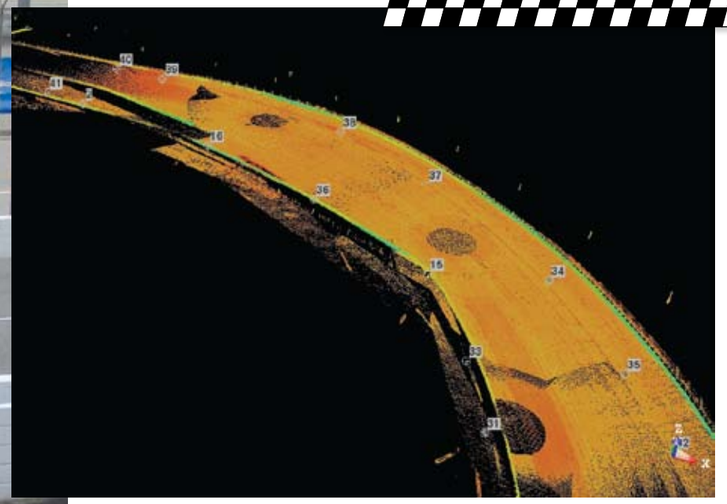
BY CRAIG R. DYLAN

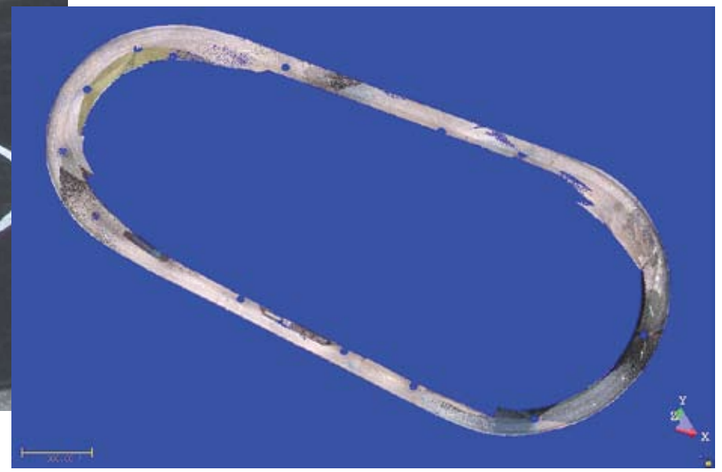
3D scanning infuses new life into NASCAR's first superspeedway.

NASCAR is rich in tradition and no NASCAR track is home to more legends than South Carolina's Darlington Raceway. Known as the track that's "too tough to tame," Harold Brasington began its construction in 1949, making Darlington the first superspeedway built specifically for stock-car racing.

Brasington, a retired racer, knew that wide sweeping turns were a necessity for the high speeds of a NASCAR event. But the 70 acres of cotton and peanut fields he bought had one limitation: The seller, Sherman Ramsey, insisted that his minnow pond remain undisturbed. So, Darlington Raceway ended up egg-shaped with a long and broad turn at the east end of the track and a considerably tighter and steeper turn at the west. This unusual configuration turned out to be Darlington's most important feature.

Drivers say it's hard to get in a groove at Darlington and that the track rewards skill. Some drivers have said there's no better victory than a Darlington victory.





caption for opening pic (opposite) IMG1298-B.jpg. This page screen 05 and screen 07.

25 degrees–were shedding asphalt. There was rutting, exposed aggregate, failing subgrade and in some places, pavement was actually slipping down the track. But at the same time, Darlington's most bankable asset is its "racer's racetrack" character, and if the track turned into just another modern superspeedway, a lot of priceless tradition would be lost.

An extremely accurate survey of the track was needed to ensure a faithful reconstruction, and an accurate 3D model would be needed for use in the specialized software used to analyze track characteristics. Raceway officials mandated survey shots at 3-inch spacing with accuracies of at least a hundredth of a foot vertically and three hundredths of a foot horizontally. Since the track is a lot like a 1.4-mile section of highway, complete with barrier walls and other features, this would amount to millions of shots. The lead contractor decided that 3D scanning was the best available technology.

This would be only the second time scanning was tried at a NASCAR track and crew members of Sanborn Map Company Inc., the subcontractor hired to do the scanning, knew they had their work cut out for them. "We did our due diligence on this one," says James P. Peterson II, PE, PLS, Sanborn's vice president.

A Challenging Job

Sanborn used a Trimble (www.trimble.com) GX 3D scanner for this project and, after consultation with the manufacturer, decided to set a maximum scanning distance of 250 feet each way for a maximum of 500 feet from each scan setup. The GX will scan much farther, up to 1,100 feet, but the low angle of incidence of most track shots and the relatively tight accuracy requirements suggested a lower limit. This meant that a large number of control points would need to be set and a larger number of discrete scans would need to be registered.

Consequently, a good performance at Darlington is a badge of honor. And when rookie drivers hit the wall there–as they often do–they're said to have earned their "Darlington stripes."

Almost 60 years later, the track is still breaking ground by taking advantage of innovative 3D scanning technology to record and preserve the unique track characteristics that make Darlington popular with drivers and fans.

Several years ago Darlington was facing an uncertain future. But major capital investments in recent years have infused new life into the *Lady in Black* (so called because the track was the first paved superspeedway in NASCAR's history). In 2004, Darlington added lights to support nighttime racing and increased seating capacity in 2006. The biggest investment to date began in early 2007 when the current owners decided to put $10 million into repaving the track, the first complete repaving since 1995. Highly accurate surveying that captured subtle track characteristics is integral to the repaving project. The upgrades already seem to have added to the magic of the historic raceway. For the past three years, Darlington has sold out its NASCAR Sprint Cup Series events, further protecting its place on the Sprint Cup Series schedule.

Preserving Character

Repaving was definitely needed. NASCAR tracks see a lot of abuse, and Darlington's steeply banked turns–23 and

Surprisingly, weather turned out to be an important factor. June temperatures in South Carolina combined with black asphalt pavement on the multi-acre site pushed the daytime heat index to well above 80 degrees. Temperatures inside the scanner were even higher. Peterson found that the scanner handled temperature differentials quite well; that is, data was as accurate at 40 degrees as at 99 degrees, but at internal temperatures greater than 104 degrees (outside of the GX specifications) data was unreliable. An umbrella was used effectively, but when sun angles were low, he occasionally had to shut down for an hour. Peterson says that the galvanometer indexing, dual-axis compensation and other atmospheric-correction features on the scanner were so essential that without them he "couldn't have done the job–there would have been significant scanner drift."

Barrier walls were also actual barriers to scanning, mainly because the obstructed sight lines would create shadows that could have doubled the number of scan setups. To get around this, setups straddled the wall–or alternated from one side to another–and were on tall tripods with the scanner up to 10 feet high. Ladders were used to set up and level the scanner and were also needed to determine the height of the setup. Needless to say, the ladder work turned out to be one of the project's more tedious–but necessary–aspects. High setups also led to large unscanned areas directly beneath the scanner. Typically, these were "backscanned" from adjacent setups, but in a few cases a Trimble 5600 robotic total station was used to fill in scan shadows.

caption for screen 01 (above), screen 08 and Darlington logo.

Deliverables for the project called for stripes to be located accurately. Since Darlington's stripes were nonreflective and difficult to scan, this could have meant a lot of extra total station shots. But the GX, controlled by Trimble PointScape software, took georeferenced photos that could be aligned with known points in the scanned data. "One of the cool things about the GX," Peterson says, "was that we were able to take images from the scanner and apply them (in Trimble RealWorks Survey software) to the mesh created from the point cloud. We were actually able to survey the paint striping from the image and didn't have to take separate shots except as a check."

Edge detection–especially important in corridor surveys like this one–is traditionally a problem with scanning because the scanner doesn't necessarily take shots exactly at toes and other breaklines. Some conventional shots were taken for quality control, but Peterson relied mainly on Trimble RealWorks Survey's edge detection tools, and found they worked well.

Tight Control

With Trimble GPS equipment, Sanborn used rapid-static GPS techniques to set 21 primary control points around the track. Because aerial photography was part of the project and georeferencing would help tie the scanned data to orthophotos, South Carolina State Plane Coordinates were applied. The Trimble 5600 robotic total station was used to densify the control network and create ample options for backsights and setup

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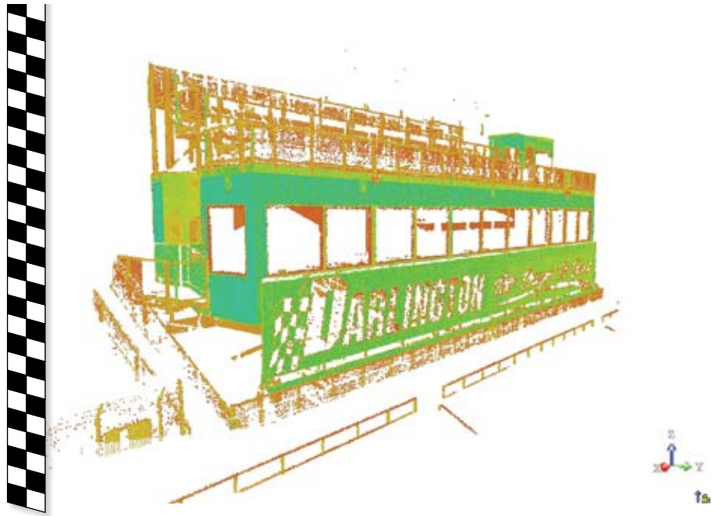


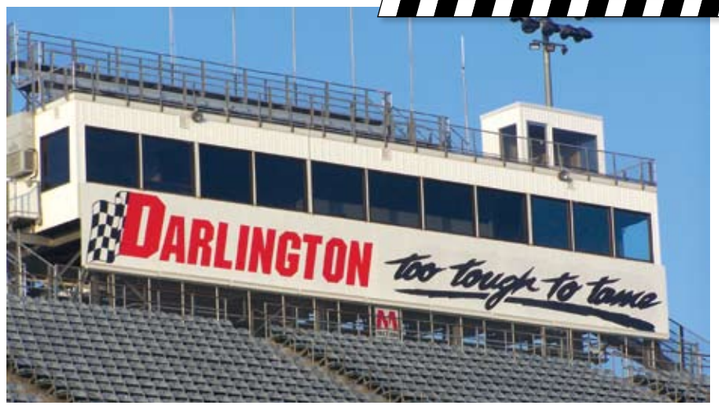
points–plenty of control meant there would be little temptation to stretch scan limits beyond the 500-foot maximum, and a primary control point could be observed from every setup.

Survey Workflow, a feature of the Trimble GX, proved invaluable for this large scanning project. With Survey Workflow, the GX could be used to traverse around a site much like a conventional total station; the GX could be leveled and backsights and foresights taken as part of the setup process.

"The ability to zero-index the galvanometer, thermo indexing, atmospheric corrections, real-time level compensation, and a dual-axis compensator has allowed for a more traditional survey workflow," Peterson says. "The user can calculate the position of the scanner by normal traversing or resection. It creates flexibility, and I wouldn't want to do a job like this without this ability. Without Survey Workflow, each scan setup would have started at arbitrary 0, 0, 0 coordinates, and in the office, all the scans would have been stacked on top of each other. This way, we were able to check scan data as it was gathered and use PointScape to check setups and registration and avoid drift. It made a big difference."

For each scan, the GX was set up on a known point, and four more known points were shot: "three points for the plane, one for a break in plane, and one to throw out," Peterson explains.

This was a sensitive job, and accuracy and reliability were extraordinarily important. So the lead contractor hired a second survey firm to traverse the primary control network and to shoot 11 track profiles from barrier wall to barrier wall. After scanning data was registered and processed, these profiles were used to verify that scanning data was within tolerance. Overall, after checking, Peterson was pleased with the accuracy of scanning data and found that residual error after quality control checks and a few revisions was within tolerance for the entire project.



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RealWorks Survey software was then used extensively to apply breaklines and further refine the track model.

Although it would be possible to perform a scan where control coordinates are not known and rely on office technique for registration, Peterson believes that this would be a mistake. The advantages of field registration and checking against known coordinates are just too great.

Tools of the Future Preserve the Past

There is no escaping the futuristic appeal of scanning technology. The largely automated, extremely rapid collection of huge amounts of data and the easy conversion of that data to accurate 3D models, complete with photographically accurate appearance, would have seemed like magic just a decade ago. It still has the capacity to astonish today. And thanks to the accuracy of this evolving technology, it's possible for South Carolina's *Lady in Black* to get a facelift while preserving the qualities that made her beautiful in the first place.

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Getting it Right in the Office

Trimble PointScape software and the GX's Survey Workflow created scans with a "phase one" registration, meaning that data was where it should be geospatially but might benefit from re-evaluation. Field operators were instructed not to worry too much about which configuration of the four backsights yielded the most accurate resection. Office staff went through various iterations of control data and made a few adjustments to fine-tune results. Occasionally, holding fewer backsights gave better data.

After an acceptable point cloud was created, profiles from the quality control surveys were imported. These profiles were checked against the scanned surface visually to catch large errors, and then a digital terrain model (DTM) was created so the vertical coordinates of the quality control profile shots could be compared to points at the same horizontal coordinates on the DTM. Results indicated that the scan data matched the control data well and within the project tolerances of a hundredth of a foot vertically and three-hundredths horizontally. Trimble