



SCANNING ON ALL LEVELS

BY SETH JONES

A surveying and environmental firm's inventory containing three 3D laser scanners creates a variety of project opportunities.

Tucson, Ariz.-based Darling Environmental and Surveying Ltd. (Darling) started out as many small businesses do: a venture of two professionals pursuing their careers, combining their skills and opening an office together. For Richard and Mary Darling, their company grew quickly; shortly after starting out in 1996, they added services and technology to their offerings. It was a good beginning.

Company President Richard Darling, a licensed land surveyor in Arizona and Nevada, and CEO Mary Darling, an environmental attorney, have been married for 12 years. They enjoy being leaders and strive to stay on the cutting edge with the best equipment available on the market—including 3D laser scanners. And while some companies struggle to fully utilize one scanner, Darling has found success with three.

In 2002, the Darlings purchased a Riegl (www.riegl.com) LMS Z360 rapid acquisition LiDAR scanner. Though it was a challenge, they managed to introduce the scanner to the local mining market as a practical means of topographical data collection. Since 2002, an Optech (www.optech.ca) ILRIS-3D Intelligent Laser Ranging and Imaging System and a Leica Geosystems HDS (www.leica-geosystems.com) ScanStation have been added to the company's inventory.

Darling's success can be attributed not only to the technology but also to its business foresight and savvy. Here's an overview of the Darling scanner lineup and some projects on which they've been used.

PRODUCT OVERVIEW: Riegl LMS-Z360

The Riegl LMS-Z360 is Darling's most frequently used scanning platform, mainly because many of the firm's projects are topographic projects. "The Riegl's ability to scan rapidly while mounted on a vehicle makes it our choice for scanning larger areas of ground," Richard Darling explains.

The unit is a line of sight, 360-degree horizontal field of view (FOV) rapid acquisition scanner that emits an eye safe Class 1 laser. It averages 6–8 million points per scan position, all of which have XYZ coordinates.

The Darling's LMS-Z360 was recently upgraded with a new 6.6 megapixel camera, which creates 3D pictures used for measurements. This is possible through software producer IntelliSum's (www.rapidmapper.net) LD3 Modeler software. LD3 Modeler ties a .jpg formatted picture into the LiDAR point cloud and assigns each of the picture pixels an XYZ coordinate. Accurate measurements can be taken directly off the 3D photorealistic model.

PRODUCT OVERVIEW: Optech ILRIS

The Optech ILRIS (Intelligent Laser Ranging and Imaging System) is a stop-and-stare scanner, meaning the scanner head rotates and stops to collect data rather than constantly rotating. The Darling unit is equipped with a motor-

Ryan Darling scans an eroded crevice at a copper mine with the Riegl LMS-Z360. Opposite: Scans from a Riegl LMS-Z360 were used to determine the safety of a subsiding mining maintenance facility located near an open pit mine.

PROJECT APPLICATIONS: Riegl LMS-Z360

Historical Missionary Church

Darling's Riegl LMS-Z360 aided the company on the restoration project of San Xavier del Bac, a historical missionary church built by Spanish priests beginning in 1783. The director of the project did not wish to damage the structure in any way; the thickness of the adobe domes was an important detail in the structural analysis of the roof, and needed to be determined non-invasively. To accomplish this, the exterior and interior of the building were scanned with the Riegl scanner and combined in a modelspace producing cross sections. The point cloud data provided accurate measurements of the structure's thicknesses, leaving the structure unharmed.

At the site, Darling was challenged with tourist and parishioner traffic during the day. To avoid infringing on the religious services held in the church daily, Darling collected interior scans at night. To prevent any harm to the structure, no permanent control was set, leading the scanning team to conduct point cloud registration using manual point-to-point/best-fit methods.



At a later date, the architect requested dimensions of the west bell tower. Due to the amount of data collected during the initial scans of the roof, no further scans were necessary. The architect received the data he needed, while Darling saved time by not needing to return to the site.

Open Pit Mine Maintenance Facility

Darling also used the Riegl LMS-Z360 to determine the safety of a subsiding mining maintenance facility located near an open pit mine. Mine engineers contracted Darling to scan the facility twice a month to monitor the movement of specific permanent targets placed on the structure. Targets were placed on the top and bottom

of steel beams within the building. To establish control, Darling set up a total station in an area more than 1,000 feet away that was not subsiding. Over a period of two years, Darling provided precise data to aid engineers in the necessary structural analysis.

Pre-construction of County Sewer Lines

Prior to the construction of new sewer lines in the Barrio District of Tucson, officials of Pima County's Department of Public Works raised concerns about possible damage from vibrations caused by heavy construction near the fragile, historic homes within the district. The general contractor called on Darling to scan the existing buildings prior to activities. The firm did so to verify the condition of each building prior to renovations should a claim for damages be filed against them during or after the renovations. Darling proved that it could detect minute changes with the use of InnovMetric's (www.innovmetric.com) Polyworks post-processing software, and no damage claims were ever filed.

Tunnel Entry to Prestigious Community

A tunnel entry to a prestigious community northwest of Tucson in the Tortolita Mountain foothills was in need of unique surveying techniques throughout its construction. Darling's scanning services checked alignment of the tunnel, ensured it was excavated according to design and ensured that utility lines would fit along one edge. Darling also scanned the tunnel's exposed bare rock.

Shotcrete was then applied to the tunnel walls and the tunnel was re-scanned, producing cross sections. This gave the client the exact thickness of the shotcrete throughout the entire span of the tunnel, which eliminated the need to drill test holes to determine thickness.

While the Rieggl LMS-Z360 provides Darling with an efficient tool for projects like these, the company owners recognized that the survey group needed to invest in a long-range scanner to meet the demand of some clients. To measure mountain ranges, tailings dams and massive meteor craters, long-range scanning was their only option, as aerial photography did not provide the accuracies required for digital terrain models. To meet this end, Darling purchased an Optech ILRIS-3D Intelligent Laser Ranging and Imaging System to increase range capabilities for these larger projects.

PROJECT APPLICATIONS: Optech ILRIS

Meteor Crater

The nationally popular meteor crater located outside of Winslow, Ariz., became the target of scientific research in June 2007. Darling subcontracted to a scientific research consulting firm who worked primarily for the National Aeronautics and Space Administration (NASA). NASA wanted spatially correct data of the meteor crater to aid in future mission planning. The research firm first researched aerial photography and aerial LiDAR methods to obtain the data its client needed. The firm came to the conclusion that the accuracies NASA required could not be obtained by those methods due to their inability to collect the vertical faces of the terrain. Terrestrial LiDAR, however, had this capability, and Darling deployed with the firm to collect the data. The crater was scanned with the Optech ILRIS, and a DTM was created.

The equipment's weight and extra supplies proved to be a challenge to Darling scan crews, who hiked the equipment down to the bottom of the crater and back out again. Scan data provided by Darling was hailed for exceeding the client's expectations. This data will be used to help research scientists plan some of the most technologically daunting missions in history.



Geological Feature

Apache Leap, a geological landmark near Superior, Ariz., is of historic and cultural significance to the nearby San Carlos Apache Indians. The landmark and its surrounding canyons and peaks spanning three miles were scanned to determine if mining operations were having a negative impact on its natural features—hoodoos (natural rock columns), boulders and steep cliff faces. The terrain was so steep and treacherous that scan crews had to arrive onsite and depart via helicopter. This project coincided with Darling's mission as an environmental and surveying consultation firm, as it was more environmentally and culturally oriented than most of its other projects.

Tailings Dam

Darling was contracted to scan a tailings dam near Tonopah, Nev., to determine if raising the height of the dam was an economically feasible option. The scans would also help to determine the volume capacity of the dam, should

ized rotating and tilting base, making the scanner's field of view 360 degrees. The ILRIS also features a digital camera, which provides point clouds in true color. The reach of the ILRIS is 3-1,500 meters (10-4,921 feet) and meets Darling's clients' long range needs.

Many of Darling's engineer clients desire the use of Polyworks post-processing software with ILRIS data for its reverse engineering and site study utilities, including change detection and Geometric Dimensioning and Tolerancing (GD&T). It has many other utilities, including tools for calculating rate of change/movement, dimensional analysis, CAD comparisons and creation of digital terrain models (DTMs) or digital elevation maps (DEMs).

PRODUCT OVERVIEW: Leica ScanStation

The Leica ScanStation's FOV scans directly overhead without tilting while scanning 360 degrees horizontally. This makes it easy to scan structures, tunnels or anything with overhead features. The unit boasts a unique traversing function that allows for quick setups, teardowns and precise control, decreasing the need for GPS or conventional survey control.

The unit's 3R class laser beam has a smaller divergence over distance, contributing to "clean" data. Its range varies depending on object reflectivity; at 90 percent albedo/reflectivity, it has a maximum range of 300 meters. The ScanStation also has a digital camera installed to produce true color point clouds.

Leica's post-processing software, Cyclone, has automated registration of ScanStation data, which cuts down on post-processing time. Cyclone also frequently takes on the task of "weeding," the removal of plants, vehicles, equipment and laborers from the scans to

An Optech ILRIS overhead image of Winslow, Arizona's meteor crater.



The author and Mark Chapman monitor the progress of the Optech ILRIS at Apache Leap, Darling's first job using the long-range scanner.

create neat DTMs for topographical mapping. "Without weeding," Darling says, "DTMs and DEMs would be jagged and difficult to interpret. Cyclone also has a useful library of catalogued steel that can be fitted to a point cloud based on specific industry standard sizes. Pipe runs are easily made through the Region Grow feature." Additionally, Leica's Cloudworks software allows Darling scan crews working with Cyclone the ability to open Cyclone in AutoCAD, easing the creation of architectural as-built drawings.

They Have Control

As with any survey, the most important step is to obtain tight control. Combinations of numerous point clouds cannot be tied together without it.

Incorrectly entering a target ID, or scan position, can bring a set of point clouds into a data set geographically upside-down. Darling prevents this by scanning five targets—two more than the necessary three—at alternating elevations and distance. This makes the pattern of targets unique at that specific scan position. Darling's team also scans five targets to ensure safety in numbers should a control shot turn out to be bad.

it be raised. The client required a fast turnaround on the deliverable in order to make a timely decision; scans of the two-mile long dam were collected over three working days using the Optech ILRIS scanner. A DTM was produced, which tied in to surrounding topographical data collected by aerial photography. Ultimately, the DTM provided Darling's client with a higher degree of accuracy in final topographies. The deliverable was in the client's hands within 10 days, providing ample time to come to a conclusive decision about the dam.

In all of these projects, the long-range capabilities of the Optech ILRIS allowed for much data to be captured in a short amount of time. Other clients, however, like engineering companies, desire highly defined detail and tight control. For this work, Darling purchased the Leica ScanStation for its medium range (3-100 meters), overhead field of view and post-processing software.

PROJECT APPLICATIONS: Leica ScanStation

Power Plant

Darling used the ScanStation to survey a power plant near New Orleans. Plans for the plant had been lost during Hurricane Katrina. The client needed as-built maps with the locations of existing steel and piping to aid in the retrofit design of an exhaust portal to improve the plant's emissions.



The Leica ScanStation collects data of a kiva at Casa Malpais in Springerville, Ariz.

The existing equipment was modeled from the collected point clouds and exported to AutoCAD. In Cloudworks, clash detection was performed and as-builts of the facility were produced for the client.

Native American Ruins

A 12th-century Native American ruin known as Casa Malpais, located in Springerville, Ariz., was scanned to create a model of what the ruin might have looked like at the height of the civilization that the Mogollon people occupied between 1200 and 1400 A.D. The site consisted of a main pueblo, a kiva and an astronomical observatory. The client, an archeological firm, will model the structure and have the Darling team create a fly-through model for the city of Springerville.

Coal Mine Tunnel

A declining tunnel in CONSOL Energy Inc.'s Robinson Run Mine in northern West Virginia was scanned to determine if mining equipment could fit into the new underground excavation. A 3D model of the structural design was inserted into the collected LiDAR data set to find areas in need of further excavation. Darling also provided clash detection to the client, which gave engineers the ability to avoid problems during construction caused by underexcavation, such as having to stop construction to further excavate an area. This aided in the timely completion of the project.

Control is obtained in two ways. One is via traditional total station, where targets are shot either reflectorlessly or with prisms. Darling uses a Trimble (www.trimble.com) S6 Series reflectorless robotic total station or a Leica Geosystems TCR-403 reflectorless total station when scanning indoors. The

other way is via GPS using a Trimble RTK 5800 receiver. Upon completing the survey for control, files are dumped into a computer and converted into a .csv (Comma Separated Value) text format. From there, the .csv is imported into the post-processing software and control is achieved.

Darling scan crews are also trained to utilize traditional survey equipment. When the company budget allows, they prefer to have a field survey crew accompany them to aid in the timely completion of projects. When scan crews are performing two different surveys at once, things get complicated quickly. Field crews are less likely to incorrectly enter a target ID into data collectors because of their daily familiarity with the more traditional equipment.

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Success with Scanning

Darling's team is frequently called upon to subcontract in joint ventures or strategic alliances. Large and small firms alike find it more cost effective to hire a scanning service provider rather than add the service to their own offerings. The cost of the equipment, the software and training of crews tend to inhibit the desire to take the plunge.

Because of its expertise, Darling has been deployed all over the United States to provide scanning services and produce the requested deliverables. Over the years, Darling has recognized that repeat business is the most stable of revenues in this survey and scanning field. The firm maintains communication with its clients for future business opportunities.

Marketing the scanning service, however, can be difficult. Darling carved out its niche by investing in the equipment and applying a revolutionary concept: capture everything in a scene quickly and safely, extract what you need and reduce rework by mining the data as needed. The company's success stems from its experience, adaptability and ingenuity. Darling will continue to adopt scanning technologies that expand its capabilities into as many applications as possible. ●

Seth Jones is an  specialist with Darling Environmental  Surveying Ltd. and a surveyor technician conducting mining claim boundary surveys across the southwest United States. He received technical training as a meteorologist in the United States Marine Corps where he was introduced to surveying instruments and techniques.