A New Way to Control **Mobile LiDAR Data**

Survey control has always been a critically important issue when conducting mobile LiDAR surveys. While the accuracies currently being achieved with the most capable mobile LiDAR systems are unprecedented, the use of a control network established through conventional survey practices is imperative to achieving the tolerances demanded for engineering design surveys.

Historically, the control network for mobile LiDAR is placed throughout a project area utilizing two different types of control points. This control network is usually a combination of the targeted control points placed as photo identifiable points and the untargeted validation or check shots that are collected to ensure the overall integrity of the data from a quality control point of view. While these traditional control networks are sufficient for most mobile LiDAR mapping projects, there are situations where the highest levels of accuracy are required, but the traditional targeting and control methods just aren't feasible.

Surveying Solutions, Inc. (SSI) has invested a lot of time and resources in a new and innovative method for establishing control on these difficult projects and applications. The use of EMATs—Elevated Mobile Acquisition Targets are a new and exciting approach that is now being used by SSI as an option for establishing survey control on mobile LiDAR projects. Although vertical targeting has long been a standard operating procedure for static laser scanning, the use of vertical targets in mobile LiDAR has been virtually nonexistent.

After months of research, testing, refinement and deployment of EMATs, SSI has been able to successfully build the proper workflows to take full advantage of vertical targeting for mobile LIDAR. With standardized practices for field collection and the development of proprietary and specialized software, SSI now is able to offer a solution for projects

BY BRIAN **BAILEY**

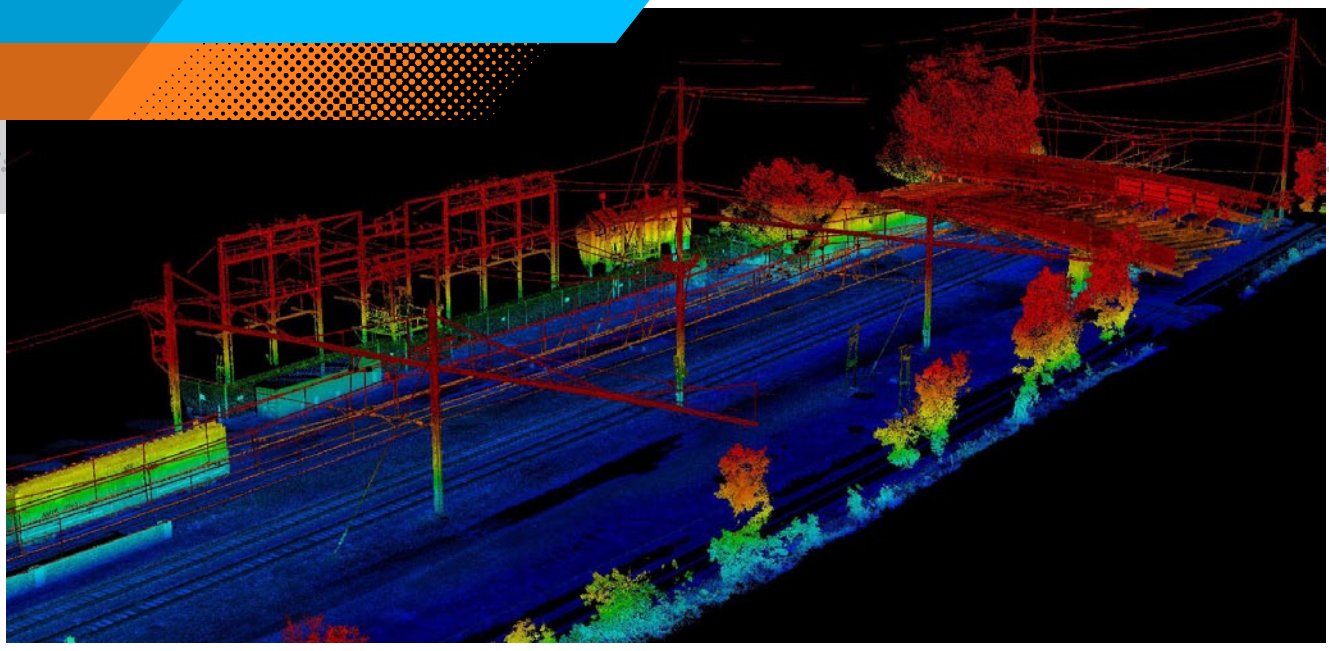
SSI's RaLi™ (Rail LiDAR, pronounced "rolly") system on track for the project. The SSI Riegl VMX-250 is integrated to a Ford F-350 HI-Rail vehicle for railroad applications.

that were previously categorized as "not the right opportunity" for mobile LIDAR technology. This development offers a significant opportunity for SSI clients and partners, as well as the entire industry.

Railroad corridors are very unique and intense environments in which to conduct mobile survey projects. SCATs (Scan Acquisition Targets) are the targeted control points established throughout an entire project that are used for controlling the mobile LiDAR dataset. These photo-identifiable, highly reflective targets are often placed as chevrons with reflective taping or reflective paint striping. For most mobile LiDAR control projects, SCATs are placed on highly visible, flat, hard surfaces. This is generally easy to do with traditional transportation projects that are conducted on paved or concrete highways.

Railroads often have very limited hard surface areas. In urban areas, horizontal targets can be placed at street crossings and intersections, but in rural settings a railroad track can often run for miles before it crosses or comes in contact with a road or hard surface. This makes the placement of identifiable control targets a real challenge.

Additionally, railroads are constructed on compacted mounds of rock or ballast. The cross ties are attached to the steel rails, with the ties being spaced to ensure the overall track alignment remains



Mobile LiDAR point cloud colorized by elevation and collected by SSI's RaLi system.

constant for the trains traveling through the corridor. The ties often flex during train traffic causing them to settle and change location, potentially on a train by train basis. The ballast eventually breaks down causing the railroads to spend a large amount of time and resources annually on replacing and replenishing the ballast. This makes targeting ties embedded in the ballast difficult as their location cannot be relied on.

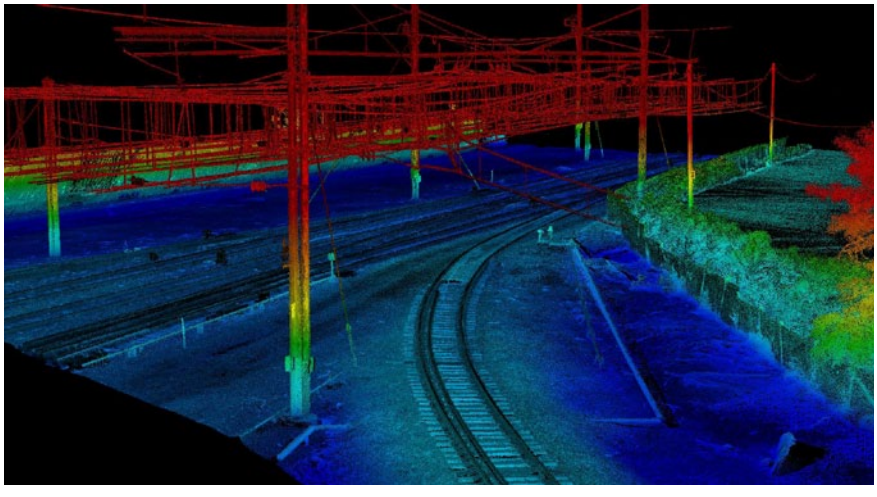
In a multiple track scenario, the rail infrastructure also makes it difficult to utilize a traditional targeting approach. By utilizing vertical targets, SSI is able to use a single target for multiple passes on different tracks without fear of any shadowing, interference, or blind spots. This is vitally important when matching the different drive paths or passes together, as well as tying them to the control coordinates. This helps ensure that the highest levels of data accuracies are achieved throughout the entire dataset.

A very experienced and detail oriented mobile LiDAR project team must be aware of the project conditions in order to properly utilize EMATs. The variables that must be accounted for by the project team are numerous.

It is well known that mobile LiDAR sensor point densities are far less on vertical objects at range compared to the point densities on the horizontal surface behind the vehicle drive path. Therefore proper planning and placement of EMATs is critical. LiDAR sensor laser pulse repetition rates, scanner (mirror) speed, the distance from the drive path, the speed of the vehicle, and the size of the targets are just some of the variables that have to be considered.

In August 2012 SSI was tasked to conduct a mobile LiDAR survey utilizing their RaLi™ (Rail LiDAR) system on a four mile, multi-track project in the northeast United States. Railroad corridor projects are an application where SSI sees substantial benefits of using EMATs, in addition to the conventional methods of establishing control.

The project site had previously been scanned by another mobile mapping firm. However, the accuracy and quality of the data was not able to meet traditional engineering specifications. Because railroad projects are particularly difficult to control conventionally, EMATs offer



RaLi point cloud colorized by elevation. All railroad infrastructure and assets are clearly visible from the LiDAR dataset.

An SSI field surveyor occupying a control point in establishing the project control network. SSI set pairs of EMATs (Elevated Mobile Acquisition Targets) at 300 foot intervals over the entire project area.

significant advantages for obtaining the required engineering tolerances.

Since design engineering accuracies were demanded, SSI placed a pair of EMATs every three hundred feet throughout the project corridor. In addition, SSI established SCATs and VATs (Validation Acquisition Targets) on any hard surfaces that were available throughout the corridor. VATs are the untargeted check shots that are collected throughout the entire project to ensure that the required accuracies of a project are obtained for the complete dataset. Having a mixture of three of the different types of control points throughout the project ensured the highest level of accuracy was achieved. The traditional SCATs and VATs were located horizontally utilizing multiple observation rapid static sessions through RTK GPS. These same control points were located vertically through the use of digital levels.

Obtaining the coordinate values for the EMATs was very similar. EMATs are attached at pre-measured fixed heights that are repeatable and known values. The control point is located on the surface with a PK nail. The survey field crew is then able to survey through the control point utilizing the same survey practices. Since the EMAT is attached at predetermined heights, a simple offset

SSI survey field crew establishing the mobile mapping control network on the project area. The coordinate values were utilized to control the LiDAR dataset to maintain engineering design tolerances.

An image of an EMAT (Elevated Mobile Acquisition Target). The painted reflective checkerboard target ensures that SSI LiDAR technicians are able to rapidly find the center of the targets during data processing.

calculation is able to give the LiDAR technicians the correct values on the actual targets. To validate and ensure the offsets are measured precisely, the survey field crew is able to verify the measured height through robotic total stations. This allows the LiDAR project team an extra level of confidence when utilizing the targets throughout the entire project area.

After placing and surveying the targets, the RaLi™ data collection team was able to drive the project area and collect the mobile LiDAR data. Projects that are located on high volume railroad corridors are also susceptible to different challenges during the collection phase of the data. The collection team is allotted a limited amount of time to complete the mobile mapping. The team must complete the data collection the first time and within the allotted time slot by the rail company. Additional track time and repeating any data collection was not an option for the project.

SSI has developed a proprietary workflow to incorporate the use of EMATs. The LiDAR data processing team utilizes specialized and proprietary software that allows the data to be controlled and adjusted to the vertical targets. Once the data has successfully been adjusted and the initial data processing completed, it then is ready for the data extraction team to create the final deliverables that were required for the project.

The use of EMATS proved to be very beneficial to the overall success of the subject project. The final dataset reports and statistics showed that the residuals were well within the .06 feet specification. When compared to the previous mobile LiDAR dataset, which had errors up to three feet, the final SSI project data was able to produce deliverables that were used throughout the engineering design phases.

The data proved to be invaluable and a wise investment by the rail company. In addition, the data is still being mined by the engineers and the rail company for additional information without the need for having to send survey field crews back to the project site. Because of the benefits of mobile LiDAR and the use of EMATs on the first project, SSI has been able to complete additional railroad projects for this client demonstrating that the innovation and use of vertical targeting brings real value to the mobile LiDAR industry.

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