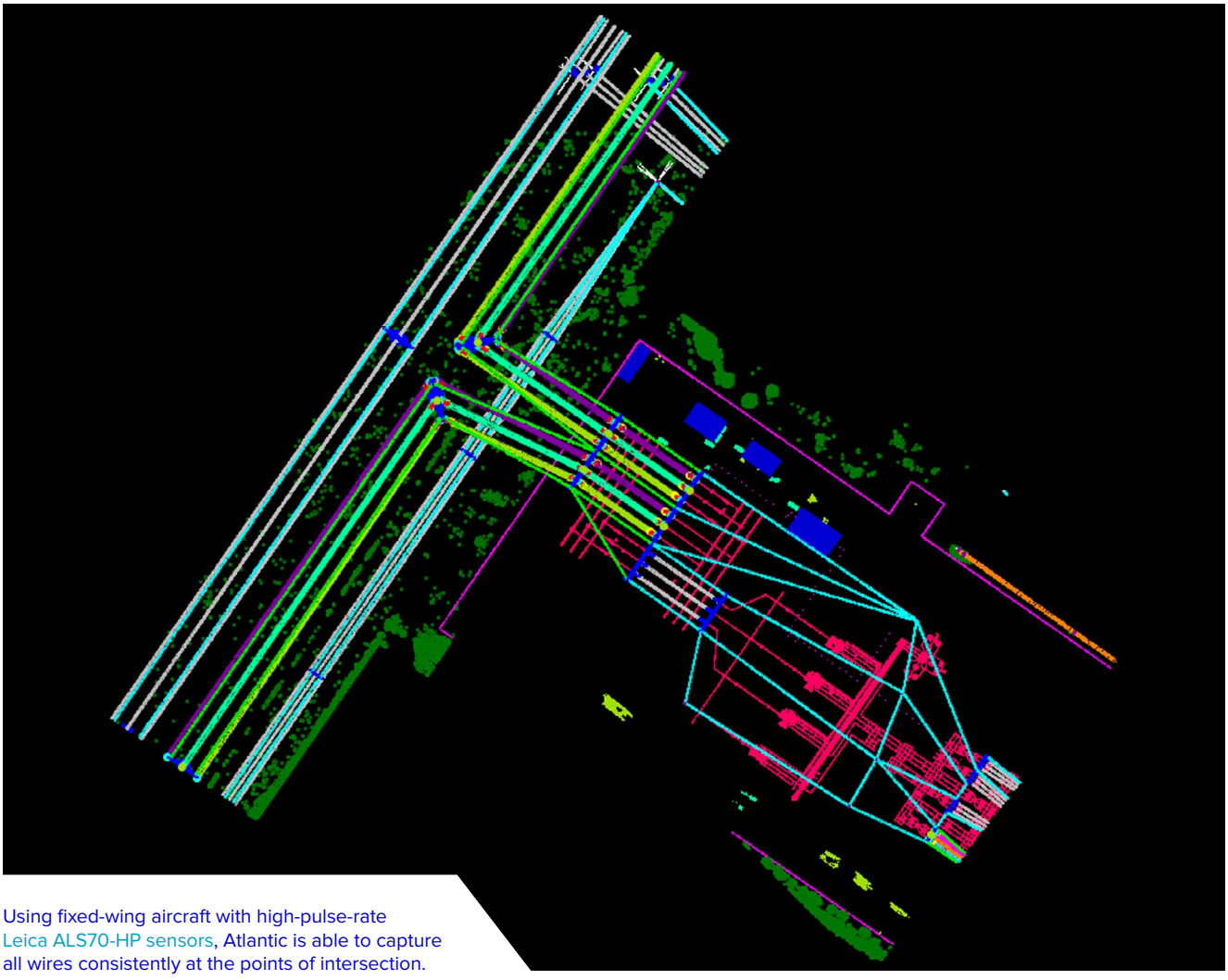
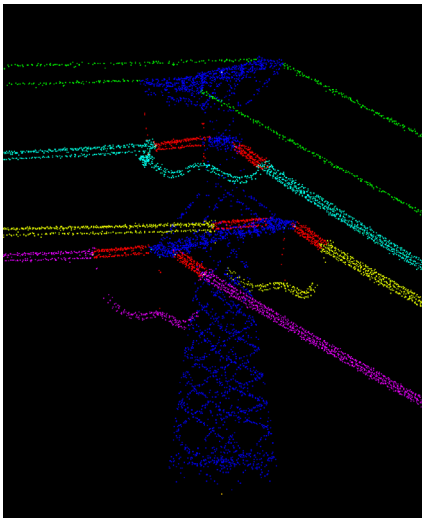
Cost-Effective Electric Transmission Corridor Mapping with LiDAR and Fixed-Wing Aircraft



Using fixed-wing aircraft with high-pulse-rate Leica ALS70-HP sensors, Atlantic is able to capture all wires consistently at the points of intersection.

BY LINDA DUFFY



Insulators and jumpers are clearly defined for hot and cold attachment points.

Industry perceptions can damage a business, resulting in lost sales and missed opportunities. When Atlantic, a remote sensing, surveying and consulting firm based in Huntsville, Alabama, realized they were not being considered for electric transmission line data collection projects, they starting asking questions.

"After being an approved prime contractor with electric utilities for several years without receiving any work for transmission corridors, we wanted to discover the reason and fix whatever was wrong," said Brian Mayfield, president and chief operating officer at Atlantic. "It turned out that most electric utilities are used to companies flying helicopters equipped with low-pulse-rate LiDAR sensors, and they believed this is the only way to get the required data."

For its part, Atlantic flies fixed wing aircraft with high-pulse-rate Leica ALS70-HP sensors. The company set out to prove the advantages that an alternate solution would provide.

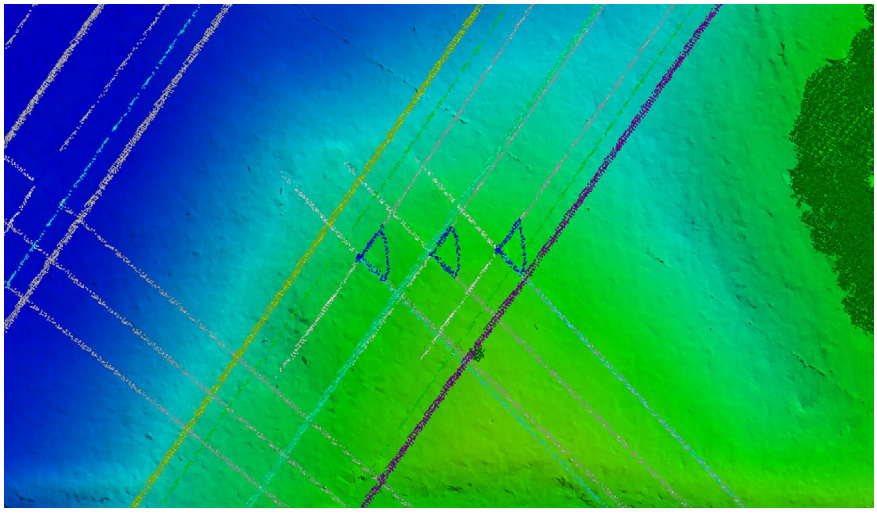
Unique Requirements for Electric Corridors

The North American Electric Reliability Corporation (NERC) develops and enforces reliability standards to ensure uninterrupted operation of the bulk power system in North America. NERC is subject to oversight by the U.S. Federal Energy Regulatory Commission (FERC) and Canadian authorities. Due to the large number of people and businesses that rely on electricity, more stringent regulations were put into place after a notable power outage in 2003 shut down major portions of the Northeast. The first set of legally enforceable standards for the U.S. bulk power system became effective June 4, 2007.

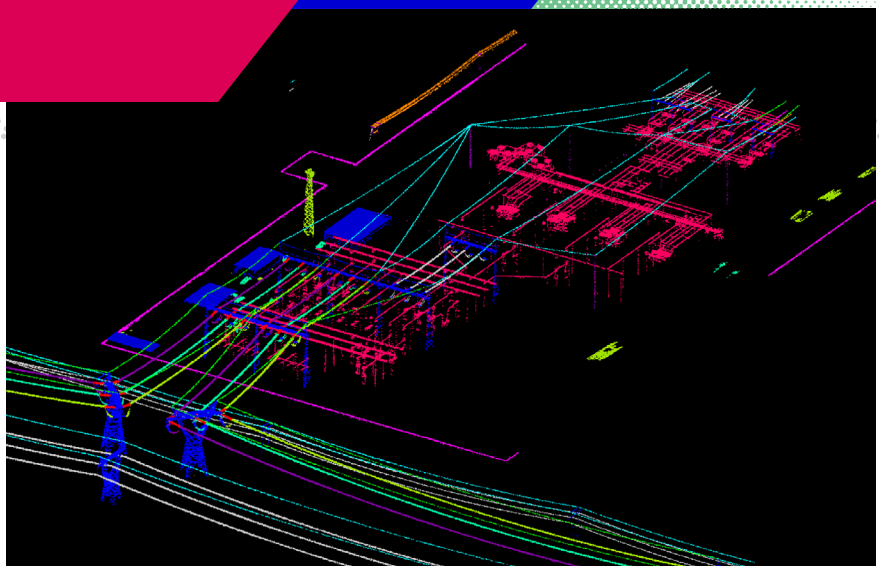
In general, the standards require electric utilities to closely monitor and maintain their transmission lines to decrease the potential for outages. To comply with the rules and avoid large fines, utilities acquire LiDAR, RGB imagery, oblique imagery and video on a regular basis. Due to the high level of image detail required for vegetation management, asset inventory and maintenance, and the current capabilities of the sensors most commonly being used for this type of work, helicopters are commonly thought to be the best platform.

Helicopters fly lower and slower than fixed wing aircraft, which results in a more dense LiDAR point cloud and more identifiable detail in the raw point cloud. To meet the NERC/FERC requirements, an approved classification schema is used that identifies many features, including guy wires, insulators, fences, conductors and poles. Although there is automated software that uses algorithms to classify some features, such as separating the ground from vegetation or finding all points on a wire, much of the work is performed manually by zooming in on a section of point cloud and assigning features to the appropriate class in LAS-formatted point cloud files according to the schema.

Also in a typical electric corridor project, meteorological data is vital for accurate modeling. Multiple terrestrial weather stations are used to capture



Guy wires can be clearly extracted even on low voltage and distribution lines.



Substation equipment and bus work is clear and distinguishable.

The RCD105 captured RGB imagery for the entire mission without any additional flights.

simultaneous weather information, and quite often oblique imagery and/or HD video requirements are included in a statement of work. Wind speed, ambient temperature, and how much current the conductors are carrying at the time of data collection all have an effect on how much the wire sags and whether wire is being blown to one side. "Blow-out" can be several feet in either direction on long spans. A hot, windy day with high current use accentuates the wire sag and deflection, which impacts vegetation clearances.

The ALS70/Fixed-Wing Solution

Atlantic owns two Leica ALS70-HP LiDAR sensors, which are known for being highly efficient for wide-area mapping but not as commonly used for corridor mapping. With the help of experts at Leica Geosystems, Atlantic set out to prove the feasibility of utilizing its ALS70-HP sensors for electric transmission LiDAR work, and documenting the cost savings of a fixed-wing solution compared with a rotary-wing solution.

"Atlantic has collected many linear miles of data for the oil and gas industry with fixed-wing aircraft, and we really wanted the opportunity to apply our experience to the electric corridor market," said Mayfield. "We worked with Leica Geosystems to determine the LiDAR system settings for electric transmission line data collection to optimize the capabilities of our equipment."

Atlantic's fleet of five aircraft includes a Cessna 210, which is a far less expensive alternative to helicopter-based data acquisition. The hourly usage rate (fully burdened but without fuel) is approximately $250 per hour, roughly 20% of the cost of operating a helicopter. A moderate flying speed combined with the ALS70-HP LiDAR technology produces data that meets high point density requirements (up to 50 pts/m^2) in a single swath.

To address concerns about the capabilities of the sensors to collect the necessary fine level of detail, Leica Geosystems had already made changes in its technology over the past several years. The latest configuration of the ALS70-HP sensor provides a much wider dynamic range (16-20 times wider) and greater sensitivity, and is not adversely affected by highly reflective features like paint on roadways.

Atlantic worked with Leica Geosystems to develop the optimal technical approach and system configuration specifically to detect small features in an electric transmission corridor with an ALS70/RCD105/fixed-wing aircraft configuration. The team came up with guidelines such as a maximum flying height of 800m AGL at 100 knots, a desired signal to noise ratio (SNR) of 25, and a scan rate of 63.8 Hz in a triangle scan pattern. By using these parameters, the expected point cloud would be approximately 53.4 points/m^2.

"When we became aware of issues with the sensitivity of earlier models of the ALS sensor, Leica Geosystems committed research and development resources to improve the design," explained Ron Roth, Product Manager—Airborne LiDAR, Hexagon Geosystems. "We were well aware that vegetation management is a primary objective for electric utilities, but also updating as-built models for tower locations is a common deliverable. Users need to see how a tower is constructed and exactly where it is placed. Details of substations are also very important."

In addition, utilities require data that shows the "under-build," where

Imagery captured simultaneous to the LiDAR flight resulted in a 0.1 meter (<4 inch) GSD.

smaller wires cross under other wires at different levels. Despite the number of different features and feature sizes, the ALS70-HP can collect everything in one pass by receiving multiple reflections from each outbound laser pulse.

"To assist Atlantic, the team also focused on precise calibration of the LiDAR sensor," Roth said. "The factory level calibration determines characteristics of the system not subject to change; however, the position and orientation data for a flight might be slightly different from day to day, so we recommend carefully evaluating the calibration every flight to maximize accuracy."

Electric Transmission Line Data Collection Test

The Tennessee Valley Authority (TVA) is the nation's largest public power provider, covering 80,000 square miles and serving more than 9 million people. "Our first step was proposing a test project to our existing clients at the Tennessee Valley Authority, in which we would fly a corridor with our ALS70-HP LiDAR and RCD105 medium-format digital camera on a fixed wing aircraft," said Mayfield. "TVA identified an 11.5 mile transmission corridor near Atlantic's offices in Huntsville that provided a suitable area of interest."

Atlantic employs a team of subject matter experts that are experienced in a variety of markets, including utility infrastructure modeling. Having mapped hundreds of miles of electric transmission lines, Atlantic's lead analyst is very familiar with the data schemas required under NERC and FERC. Fences, bridges, substation equipment and bus work, poles, insulators and many other features must be clear and distinguishable in the images and mapped to the schema.

"For an electric transmission line project, the goal is not mapping the ground accurately; the goal is mapping the features and the line sag—this is critical," explained Mayfield. "The data is structured to flow directly into the utility's PLS-CADD software so that the end user has the ability to identify problem areas in the power grid that need maintenance."

Successful Test Project

By combining the power and efficiency of the ALS70-HP/RCD105 system with the lower hourly usage rate of the fixed wing Cessna 210, the test project was a clear success. The ALS70-HP sensor returned a point cloud with approximately 53.4 points/m^2, while the RCD105 simultaneously collected RGB imagery for the entire mission in a 0.1 meter (<4 inch) GSD. The acquisition costs with the Cessna 210 were roughly 20% of the cost of operating a helicopter. The NERC/FERC schema requirements were met, with all features such as shield wires, guy wires, insulators, jumpers, tower heights, poles and fences, and substation equipment and bus work identified.

Atlantic's clients benefit from its 9+ years LiDAR-acquisition experience in other markets and the efficiency of the solution. "A LiDAR system is not a black box that will yield the same results regardless of the operator," said Mayfield. "Careful planning is necessary to optimize results that are directly suited for the business application of the remotely sensed data. Our subject matter experts are the ones that take a well-designed project plan and make it a high quality and highly accurate data product."

TVA's specifications were fulfilled for this test at a lower cost as compared to data acquisition with a rotary-wing aircraft. "The improvements that Leica has made in the ALS70-HP sensor make the collection of electric utility infrastructure totally feasible with a lower-cost fixed-wing aircraft," Roth said. "The sensitivity of the sensor makes it capable of returning data with the high degree of complexity required for vegetation management and asset inventory."

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