THE POWER OF LIGHT

Terrestrial LiDAR technology offers distinct advantages when surveying live electrical substations.

By Vernen Lee, PLS

The voracious residential and industrial demand for power, along with the desire to add capacity from wind, solar and other renewable sources to the existing grid, is driving substations in the U.S. and around the world to extensively expand and upgrade their physical plants, perhaps for the first time in decades. This trend is also requiring substation engineering teams to re-evaluate how they obtain their survey data.

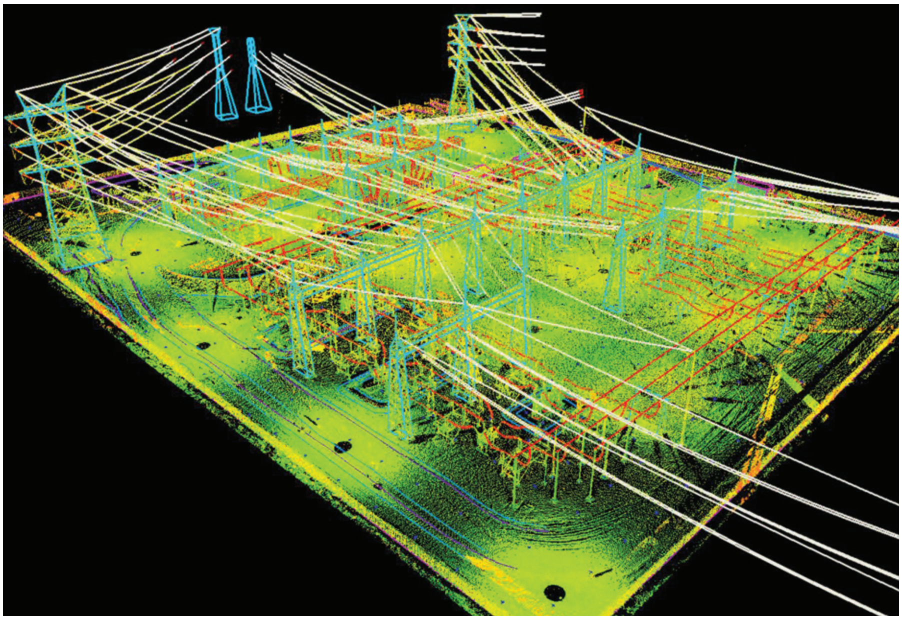
When a typical substation engineering team last ordered a prebuild site survey, they might have chosen between electronic total station and GPS methods, if they were aware of the options at all. But in the last 12 years or so, a third technology has been added to many surveyors' toolboxes–one that can make an enormous difference in the ability to design and build the most successful and high-performing additions to substation operations and do so efficiently, quickly and cost-effectively.

Terrestrial laser scanning, ground-based laser, terrestrial LiDAR–call it what you will, the technology, although not yet well known in substation applications, has revolutionized the role of surveying in many industries. However, there is perhaps no industry and no situation where the benefits of LiDAR can and will be felt as dramatically as in substation expansions. It is almost as if the technology were created with the specific challenges of this application in mind.

One of the primary benefits of using LiDAR in substation applications is safety. No longer do surveyors need to walk the grounds using a 5-foot metal prism pole or GPS rover to take measurements. With LiDAR, surveyors can set up on the perimeter and stay a safe distance away from anything live or hot.

This capability also means that a LiDAR survey will accurately map areas and items that could never be surveyed before simply because no one is allowed to get within several yards of them. That means that in the next substation survey, even live transformers, switches and everything adjacent to them can be mapped with precision–no small benefit considering their critical importance in most substation expansions.

Also vital to consider in the substation expansion process are the existing overhead transmission lines, of which there are likely hundreds at many different elevations. In the past, these elevations could never be mapped with any degree of precision, often leading to height clearance issues being discovered during construction as well as costly "mismatches" as crews linked up a new tower with an existing one. These problems created a need for field modifications and/or delays to construction while materials were reordered to overcome the difference. With LiDAR, all elevations can be pinpointed from the ground with a high degree of accuracy, and the true parabolic shapes of the transmission lines–their points captured



LiDAR data is post-processed to create a three-dimensional model of the facility that is unprecedented in its detail and accuracy. Opposite: Field survey technician, Chad Pringle, fires up the Leica C10 to collect a dense cloud of data points at a safe distance away from electrical components.

LiDAR Basics

Compared to total stations, which capture one point at a time and take several seconds to do so, a LiDAR unit in the hands of a skilled technician can capture as many as 50,000 measurements per second, or a few million points from a single occupation position. What LiDAR captures is not selected single points of an object but a "blanket" or "cloud" of the universe of data points that make up the object in its entirety. One analogy might be thinking of LiDAR as a shotgun, getting everything in its path, while other surveying technologies are more like a rifle shot, capable of hitting only one point at a time.

While this is an enormous paradigm shift in the way survey information is captured, the next part might be even more so. Unlike other survey methodologies, which pretty much begin and end in the field, LiDAR surveys have a second step. After the field survey is completed, the captured digital data cloud is fed into a PC, where, using readily available LiDAR post-processing software, it can be endlessly crunched, manipulated and mined, ultimately generating a 3D model of the facility that is unprecedented in its detail and accuracy.

And, speaking of a paradigm shift, here, perhaps, is the biggest one of all: Unlike electronic total station and GPS technologies, LiDAR doesn't require that any particular object be physically touched in order to map it. Objects can be mapped from up to hundreds of feet away, as long as there is a clear line of sight.

in a "data cloud" –can be readily visualized in the 3D survey model.

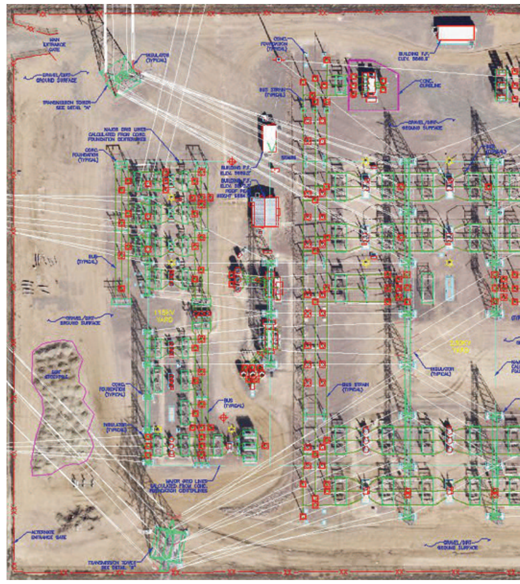
This improvement in the accuracy of capturing elevations can also be of great benefit when mapping many of the other common structures on substation sites, including high lattice towers, even those 80, 90 or more feet above the ground, and, of course, control buildings of all shapes and sizes, including those with peaked rooftops.

Another major benefit of LiDAR is that the often agonizing effort to ensure the comprehensiveness of the scope of survey service is no longer necessary. With total station and GPS surveys, the discovery of a need for an unanticipated measurement could necessitate a costly halt in the design or construction process and trigger the need to schedule another field survey. With LiDAR, however, it's just a matter of going back to the PC and quickly crunching some additional data points. With a GPS or total station survey, if you didn't purposely measure the object, it's as if it doesn't exist. A LiDAR survey, on the other hand, in essence brings the entire project site into the office PC, with every point within it captured, purposely or not, and waiting to be examined as needed.

There are a few potential challenges to using LiDAR for substation surveys. Cost, of course, is always a concern for substation engineers, and some might balk at the higher rate compared to traditional GPS or total station surveys. Because of higher equipment costs and additional desktop processing work, LiDAR surveys generally cost 10 to 15 percent more than conventional surveys. But these figures don't represent an apples-to-apples comparison. In fact, to get a survey using the other two technologies even remotely comparable to the one obtained with LiDAR, the GPS or total station bill would likely be in the neighborhood of five times the original amount since it would take several extra days in the field, and it would still fall short in detail.

In many, but not all, applications, a LiDAR survey can offer significantly better value. To those survey clients whose needs are for mapping, say, a parcel of undeveloped land or a parking lot, the order of magnitude increase in output detail would probably not be useful enough to justify any extra cost. But for electrical substations about to greenlight an infrastructure project costing hundreds of thousands of dollars among complex, unmapped as-built conditions, the additional detail would likely be worth an extra 10 percent in surveying fees.

Another limitation to consider is that LiDAR has a shorter range compared to other technologies and can only map about 500 horizontal feet at each setup. However, since most substations tend to be only several hundred feet in square footage or less, this limitation is usually of little consequence in these applications and wouldn't add appreciable field time to the data collection process.



LiDAR technology provides for an increase in upfront information, reduction of unknowns and the ability to produce a better, more informed mapping product.

The final drawback of terrestrial LiDAR compared to the other two technologies is its limitations in the face of some adverse weather conditions, such as rain, heat and heavy winds, although these impact the other technologies to a lesser extent, as well. LiDAR device manufacturers suggest that the equipment not be used in ambient temperatures above 104°F (40°C), give or take a few degrees. However, LiDAR surveys can be performed during nighttime hours when temperatures are moderate and can be scheduled on dates where calm winds and dry conditions are forecasted.

Unlike any other survey method, terrestrial LiDAR allows the surveyor to remain a safe distance from every piece of equipment, so the potential hazards of the process are greatly reduced for all concerned. For today's substation engineers, who are among the most safety-conscious and proactive professionals in industry, this benefit alone would be enough to generate significant interest. But the business case is perhaps at least as compelling. The promise of terrestrial LiDAR for the substation engineer about to design a project is an enormous increase in upfront information, an enormous reduction in unknowns, and the ability to produce a better and more informed solution with less threat of the need for rework due to a disconnect between the design and true field conditions. And, with few serious disadvantages weighing against these benefits, terrestrial LiDAR survey technology is worthy of serious consideration for any substation capital project. In fact, because it is safer, more efficient and more effective, it may not be long before terrestrial LiDAR is considered a "best practice" in global substation operations.

Vernen Lee is a project manager at Merrick & Company (www.merrick.com) in Aurora, Colo., and has more than 12 years of experience in performing terrestrial LiDAR data collections and office post processing. He is also experienced in performing topographic surveys using total station and GPS technology.