Scanning Toward Better Condition-Based Risk Management for Electric Power Utilities

By Chris Bowman, P.Eng.
Principal Product Manager, GE Digital, Saanich

This article provides a broad overview of converged global trends in remote sensing and artificial intelligence (AI) that enable improved data feeds for electric power transmission and distribution (T&D) assets and vegetation risk management.

Asset managers maintain our livelihoods

Canada's 19th-century goal of achieving mass electrification has been attributed to creating our middle class and, by extension, locking us in as a top-10 country by gross domestic product. However, due to our enormous land mass, abundant trees, harsh weather, and the distant locations of hydro and thermal generation plants, Utility 1.0 has meant endless challenges for T&D asset and vegetation managers. Today, new remote sensing technology, surveying methods, and AI-enabled data management solutions are available. This offers electric power utilities a clear upgrade path from their legacy inspection and risk management programs. Needless to say, 2020 has already proven to be a unique year marked by the COVID-19 pandemic. Electric power still remains an essential service to our society. Sooner or later, we are predicting a big acceleration in the area of digital transformation. Utilities that adopt the new solutions will see improvements in reliability, traceability, costs, and better service to our society in general.

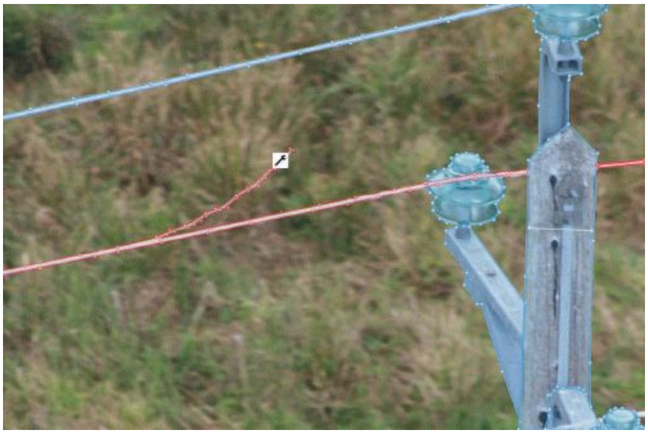

Figure 1: Conductor damage detection using image AI. (Photo courtesy of GE; used with permission.)

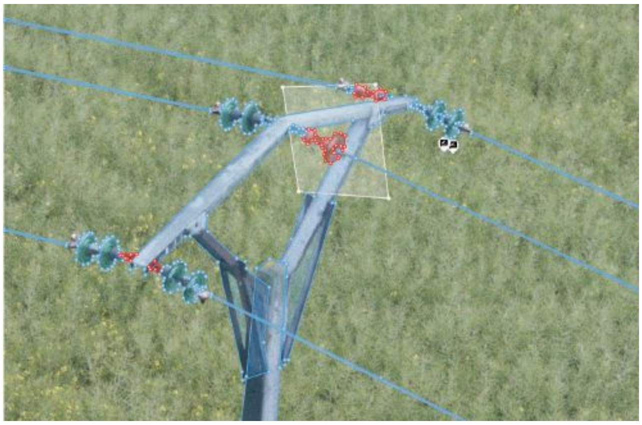

Figure 2: Insulator damage detection using image AI. (Photo courtesy of GE; used with permission.)

Why are these programs so important?

To understand the scale and criticality of these programs, consider that BC Hydro, Hydro One, and Hydro-Québec combined have more than 80,000 km of high-voltage transmission lines to manage. Canada is also electrically connected to the United States, something that both sides usually enjoy, except for the odd incident. We nearly claimed the world record in power outages when in August 2003, 10 million people in Ontario and 45 million in the United States suffered a sustained blackout. This outage is believed to have been initially triggered by part of a transmission line that sagged and contacted a tree that was allowed to grow too close to the line. It is for good reason that both countries are regulated by the North American Electric Reliability Corporation, which mandates periodic routine inspections of all transmission infrastructure and nearby vegetation. Slightly less frequently, utilities must also conduct a comprehensive visual inspection that goes right down to each individual line span, tower, nut, bolt, and even cotter pins that ensure that the insulator strings remain locked together.

The data that support current asset and vegetation risk calculation

Risk models are usually implemented according to the type of asset. This utilizes various attributes sourced from a utilities' enterprise asset management system and includes age, category, operating voltage, and installation configuration. These data are often supplemented by inspection data, which vary by a utility's practice and budget. However, most utilities maintain a reasonably rich database distributed across many types of assets. In countries and regions that have a wider financial reach and more regulatory requirements, a typical inspection data portfolio would include digital red-green-blue (RGB) photographs, forward-looking infrared (FLIR) images, or video (thermal imaging) and LiDAR (pulsed-laser imaging) (see Figure 1). In addition, utilities often record manual observations by tagging the database with indicators such as "Yes," "No," or "1-2-3-4" against issues like corrosion, structural defects, and danger trees. The size of the digital information can be measured in tens or hundreds of petabytes per year.

The challenges of legacy survey methods (fixed-wing aerial survey and land-based line patrol) are that they are very expensive, time-consuming, and can have unacceptable liability risk (especially with helicopter operation). Often, the images collected using this approach have a lot of variation and integrity issues due to inconsistent perspectives, focal accuracies, and distance from the target objects. Another major challenge with the legacy method is data management. This includes how to efficiently centralize and process the raw data, associate images (or point cloud blobs) with specific assets or trees, and extract the risk classifications so that asset managers can optimize their overall condition-based asset and vegetation risk management programs (see Figure 2).

Inspection data management 1.0

For any T&D asset or vegetation manager, the following inspection data management story should sound familiar.

We typically gather and process our inspection data manually, sometimes not even starting until the entire inspection program or at least a major phase completes.

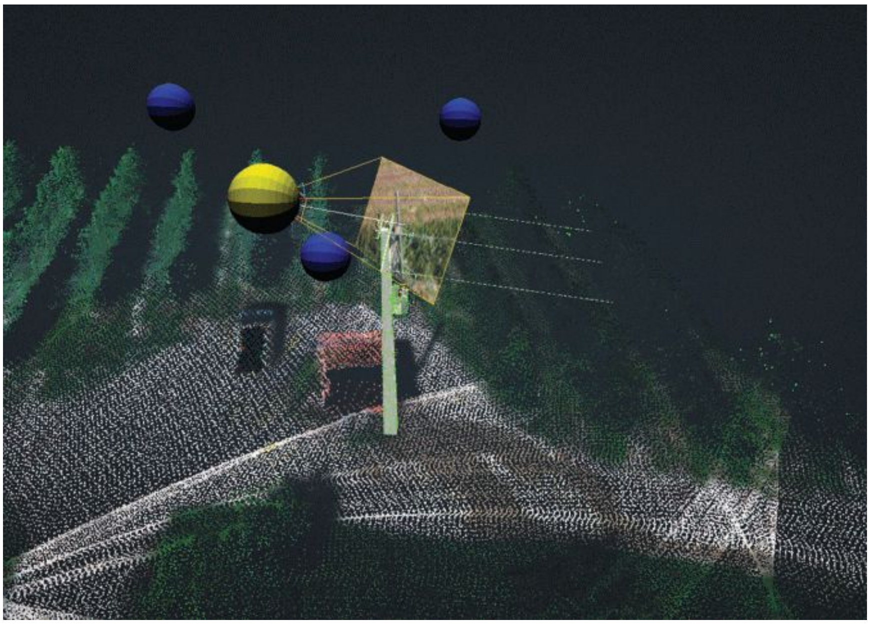

Figure 3: Pole and conductor classification using LiDAR. (Image courtesy of GE; used with permission.)

Figure 4: Vegetation encroachment calculation using LiDAR. (Image courtesy of GE; used with permission.)

We use teams of low-cost human resources, sometimes student employees. It takes them about five months to get through the analysis until we can get it all translated into our asset health and vegetation risk-calculation spreadsheets. From there, our asset and vegetation managers need to spend another few weeks or months trying to correct some data integrity issues caused either by poor or incomplete image collection, incorrect association to assets, and incorrect risk classifications. Finally, we can create next year's risk-based mitigation strategy using the cleansed and harmonized data.

Given the current situation, it's no surprise that asset inspection data management 1.0 has found itself staring down the barrel of digital disruption (students will enjoy their next summer job more anyway, so don't even start!).

What new approaches have emerged?

A recent global trend is that most electric power utilities are suddenly more open to changing their inspection processes and survey data portfolio so long as the new options are techno-economically superior, meaning that they can maintain or improve reliability for less money. For example, until recently, innovation had been too narrowly focused on incrementally better FLIR and LiDAR sensors (see Figures 3 and 4). However, so many other important aspects were not being examined. It is fair to say that we have now hit a critical convergence of innovation in multiple areas that can remove the pain points associated with surveying, managing inspection data, and efficiently analyzing data to generate business intelligence. This paradigm shift is being enabled by the following market trends: significant advancements in the commercial satellite industry, a new generation of drones that are purpose built for industrial infrastructure inspection, a leap in the maturity of AI-based image processing, unmanned aerial vehicle operation programs, and special applications of AI in utility data management.

At GE Digital, we have recently pulled all of these specific programs and innovations together to offer a complete managed solution. We brought in resources and technology from GE Aviation, GE Global Research's AI group, and GE Digital's Grid Analytic software and from strategic partnerships with commercial satellite companies, software companies, and cloud infrastructure providers. We are busy proving the value of our solutions as we speak with some of the largest and most progressive utilities in Europe, North America, and South America. The early adopters are all indicating the desire to prove to their regulators that the new methods are superior so that they can move toward full-scale production rollout. Prior to this, many utilities had been experimenting for years with different parts of the emerging approach. They are now signaling their intent to move from small pilots to full-scale enterprise programs to take full advantage without having to staff internally or integrate and manage disparate pieces.

A few specific improvements

A key aspect of our new program at GE Digital involves investments in multisensor data management. The starting point being a distribution of inspection data (RGB, LiDAR, satellites, and so on). We needed to streamline and generalize a data-ingestion pipeline so that asset and vegetation risk calculations can be made more automated. We are leveraging a federated image-classification AI engine that automatically identifies many of the important T&D asset types as well as critical defect types. The asset- and defect-classification framework is extensible, and we plan to continue implementing more inspection use cases by leveraging our GE Global Research team, customers, and partners. A final critical aspect to automated multisensor data management is our ability to associate assets identified from the 3D image maps correctly back into a utility's geographic information system of record. This "auto association" is critical to enable efficient data processing and risk calculation. This has been a problem for many of the companies that have pioneered this new technology.

Another innovative aspect we have been working on is the use of free and commercial satellite data as a means for generating relatively inexpensive wide area vegetation risk maps of entire T&D territories. A benefit of satellite data is that historic vegetation levels can be calculated, against which a utility's vegetation fault history can be used to generate insight on current and improved trim programs. The trend in the commercial satellite industry is clearly toward lower cost, improved spatial resolution (30 cm and decreasing), and more frequent and pervasive coverage. We have developed a flexible approach that combines orthoscopic 3D modeling, automated tree segmentation, and risk calculation. We are proving this in trials right now. We believe that satellite data will, for example, greatly improve overall inspection programs by displacing the need for complete LiDAR surveys. This is important because today, utilities spend roughly \$1 million for a 100 × 100-km^2 area using fixed-wing aerial LiDAR surveys. ■

About the Author

Chris Bowman is the principal digital product manager of grid analytics and asset performance management for GE Digital. He is a registered professional engineering physicist in British Columbia. He is a Member of the IEEE and the IEEE Power & Energy Society. He started his career in the power industry in 2008 at Powertech Labs—the R&D, testing, and consultancy subsidiary of BC Hydro. Over the past decade he has worked on a wide variety of transformative technology including electric vehicles, renewable generation, microgrids, AMI, IEC 61850-based protection and control, ADMS and FLISR, big data analytics, edge computing, artificial intelligence, and machine learning.