NERC Good Utility Practices – NM Group Commentary

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In December 2015, five years after the 2010 NERC Alert was issued, the North American Electric Reliability Corporation (NERC) published a '*Good Utility Practices*' whitepaper summarizing effective approaches for maintaining transmission line ratings consistent with as-built conditions. This document provides commentary on the NERC paper, by identifying themes that can be addressed through a **cohesive spatial data strategy**. Through coordination across departments and planning the way that data will be collected, analyzed, stored, integrated and used over time, utilities can exceed regulatory expectations while deriving maximum benefit for stakeholders. Application of a spatial data strategy addresses many of the separate activities identified by the NERC paper; including as-built verification, ROW encroachment identification, periodic line patrol practice, clearance buffer application, survey frequency and corporate management practice.

Keywords: NERC Alert, LiDAR, UAS, PLS-CADD™, Utility Vegetation Management.

INTRODUCTION

Following the NERC Alert, the majority of Bulk Electrical System (BES) circuits were analyzed using LiDAR and PLS-CADD™ to produce as-built transmission line models. The models were then used to assign accurate thermal ratings based on conductor clearances to ground and other objects. The implementation of mitigation actions as required (line modifications or de-rating) effectively established a new transmission system baseline, with all BES transmission facility ratings reflecting as-built conditions (NERC, 2015). NERC further stated that sustaining the clearance baseline will be vitally important to ensure facility ratings are maintained consistently into the future. Sustainable maintenance of the library of as-built models and transmission line ratings forms the first section of this paper. The second section addresses ROW change, vegetation management and line patrol practices. The third section of this paper describes approaches for building upon the solid foundation of asset information created by NERC Alert compliance efforts.

SECTION.1: AS-BUILT VERIFICATION PRACTICES – SUSTAINABLE MAINTENANCE

"Transmission line as-built verification practices include field verification measurements after all transmission line construction or maintenance projects are completed." (NERC, 2015).

Through experience working with a number of utilities across North America, NM Group has found that typically 5-8% of a utility's network will undergo capital changes or maintenance-related modifications in any one year. These are 'known' changes on the network and may result in a modification to the electrical load transfer capacity of a line. NERC observes that for larger programs (major facility changes), aerial LiDAR is typically used and that for smaller programs (minor facility changes), ground based LiDAR or other ground based measurement techniques are used. While this assessment is historically correct, we would recommend the following additions to best practice.

MAJOR FACILITY CHANGE

Major facility change is summarized in Table.1. The quality of as-built models and ratings reports from this process will largely be determined by the positional accuracy of the final modeled conductor position. Two key developments that increase PLS-CADD™ model accuracy are:

(1) The use of ultrasonic weather stations to measure even very low wind speeds (<5 ft per second) that can have a significant effect on conductor temperatures, and;

(2) The use of the IEEE-738 transient ratings calculation. Current industry convention is to use the steady-state ratings calculation. However, this does not take into account the thermal lag of the conductor and has been shown to be less accurate (Richardson, 2015).

Consideration of these important factors will ultimately lead to more functionally accurate line models.

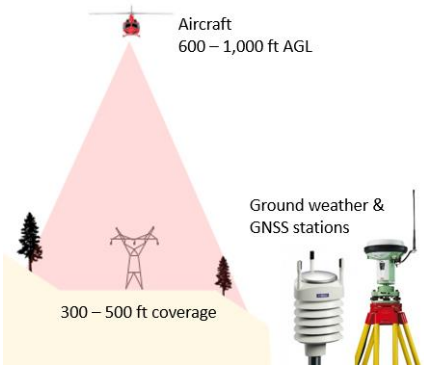
<table>
<tr><th colspan="3">MAJOR FACILITY CHANGE – BEST PRACTICE</th></tr>
<tr><td>Name</td><td>Aerial LiDAR + PLS-CADD™</td><td rowspan="4"> 
</td></tr>
<tr><td>Description (brief)</td><td>Rotary or fixed-wing airborne LIDAR with PLS-CADD™ as-builts and ratings analysis. Requires MET data collection and IEEE 738 transient ratings equation to maximize positional accuracy of the final modeled conductor position.</td></tr>
<tr><td>Timescales</td><td>Typically 4-8 weeks following data acquisition.</td></tr>
<tr><td>Price</td><td>Varies based on scope from $500 - $1,000 per mile.</td></tr>
<tr><td>Key use</td><td colspan="2">Post-construction/ modification as-builts and ratings reports for major line segments (>10-15 miles) that have undergone change ensure on-going sustainable compliance to FAC-008. A key spinoff benefit is the update of asset management and GIS systems to reflect as-built conditions.</td></tr>
</table>

Table.1: Major facility change best practice

MINOR FACILITY CHANGE

The NERC paper points to ground-based measurement techniques such as conventional surveys as the most appropriate means to capture minor changes on the network (<10-15 miles). NM Group believes that in most instances these techniques may no longer represent best practice, and that a LiDAR enabled Unmanned Aerial System can deliver a superior product at an equivalent cost. This comparison is summarized in Table.2. UAVs are not currently cost effective for major facility change (as-builts of >15 miles) when compared to manned flights. This threshold is likely to change when regulation enables Beyond Visual Line of Sight (BVLOS) flight and higher take-off weight UAVs.

MINOR FACILITY CHANGE – BEST PRACTICE COMPARISON TABLE		
Name	Conventional survey	LiDAR enabled UAV
Description (brief)	Ground surveyors walking the ROW shooting in survey points using ground based equipment.	Lightweight LiDAR scanner and nadir RGB camera capturing 100-200 ft swath of data suitable for transmission as-builts.
Timescales	7-10 days	7-14 days following data acquisition
Price	Approx. $2,000 per mile	Approx. $1,500 to $2,000 per mile
Quality	Typically a few hits on conductors, attachment points, ground and ROW hard features.	Comprehensive survey of ROW at >20 points per meter – comparable to manned LiDAR.
Image		

Table.2: Minor facility change best practice

SECTION.2: ROW ENCROACHMENT, PERIODIC LINE PATROL, AND SURVEY FREQUENCY PRACTICES

New LiDAR-based survey techniques employed on a regular interval are providing transmission operators with an opportunity to address ROW encroachments, periodic line patrols and (re)survey frequency with one tool. NM Group has developed Patrol+® to capture updated LiDAR data during currently scheduled visual aerial patrols [Tab.3]. This has fundamentally lowered the cost when compared to conventional LiDAR flights by eliminating the cost of the helicopter from the equation and automating components of the collection and analysis process. Application of the updated LiDAR data and ROW oblique photography captured at the same time offers auditable NERC compliance support as follows:

- ROW encroachment – Use of the updated LiDAR data allows existing PLS-CADD line models to be refreshed and new conductor clearance infringements to objects on or crossing the ROW to

be quickly identified. Correction of identified infringements assures continuing and auditable NERC FAC-008 compliance. This works through use of a proprietary change detection algorithm to determine both ROW feature changes and unauthorized ROW uses.

- Periodic Line Patrol and Survey Frequency– NERC FAC-003 recommends annual line patrols for identification of vegetation encroachments. This can establish the frequency baseline for conducting coincident line condition and Patrol+ inspections.
- An audit trail provides robust NERC FAC-003 and FAC-008 compliance.

Further organization benefits include;

- The update of high resolution structure RGB, UV and TIR imagery for the detection and reporting of maintenance issues, asset health and maintenance forecasting.
- Operational spend efficiencies for Utility Vegetation Management programs through effective program management, business process improvement, accurate contractor procurement and visual patrol cost displacement.
- Reduction of OPEX spend on aviation through reducing the number of helicopter flights.

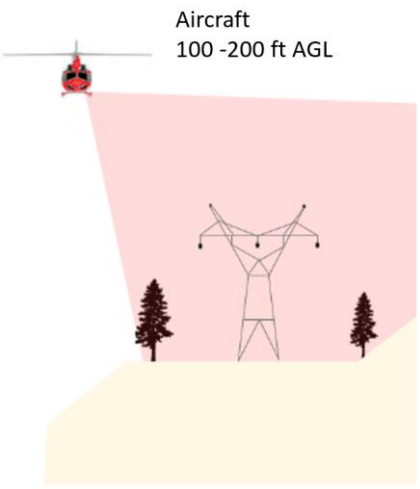
<table>
<tr><th colspan="3">PATROL+® ADDRESSES ROW ENCROACHMENT, PERIODIC LINE PATROL, AND SURVEY PRACTICES</th></tr>
<tr><td>Name</td><td>Patrol+® LiDAR augmented visual patrol flights</td><td rowspan="4"> 
</td></tr>
<tr><td>Description (brief)</td><td>Lightweight sensor system with small form factor and largely autonomous operation installed on existing visual patrol flight. Gyrostabilized camera ball can be added for line maintenance works.</td></tr>
<tr><td>Timescales</td><td>Typically 2-3 weeks following data acquisition.</td></tr>
<tr><td>Price</td><td>Varies based on scope but typically an order of magnitude lower in cost when compared with conventional LiDAR.</td></tr>
<tr><td>Key use</td><td colspan="2">(1) Vegetation clearance and analytics.
(2) Updating PLS-CADD™ models for ROW changes.
(3) Line defect reporting.</td></tr>
</table>

Table.3: Patrol+® system

The use of routine helicopter patrols as a platform for Patrol® will likely be replaced by UAVs when the appropriate regulatory framework for BVLOS flight is introduced. The miniaturized Patrol+® sensors work on UAV aircraft. NM Group will therefore switch to use of these platforms for network-wide patrols when it makes economic sense to do so.

SECTION.3: DATA MANAGEMENT, INTEGRATION and EMPOWERMENT

DATA MANAGEMENT and OWNERSHIP

Digital information for transmission lines assets and Right-of-Ways will grow in size over time due to a shorter information refresh cycle and the advent of ever-increasing sensor resolution. It is important that this information is tracked over the years with the data managed such that value can be extracted from it. Many utilities use off-line hard disk or file based servers to store data, with consequent loss or corruption of information. A robust data management framework and storage system should therefore be deployed that version tracks and controls information throughout the asset lifecycle. NM Group's system, EPIC, provides server side tracking, version control and storage. The ownership of this data is a key issue which is often overlooked by industry in terms of who owns both the raw data and any derivative information produced from the raw data. It is NM Group's default position that a utility should own the Intellectual Property for all raw data and derived information as a result of deploying sensors on the network.

DATA INTEGRATION and EMPOWERMENT

In order for organizational users to consume the information collected, it needs to be easy to access and simple to use. NM Group's approach is to integrate the information produced to enhance and update functional software already used by the organization. This includes Asset Management Systems (AMS), Outage Management Systems (OMS), Geographic Information Systems (GIS), Computer Aided Design (CAD) and Building Information Modeling (BIM). NM Group can assist in providing a data architecture and integration options for these existing systems. Furthermore, NM Group has developed Caydence® 3D, an immersive platform that allows the user to navigate transmission and distribution networks in a virtual environment, calling up information at the touch of a button. This includes asset IDs, maintenance information, clearances, ROW objects and more. The Caydence® 3D system is shown in Figure.1.

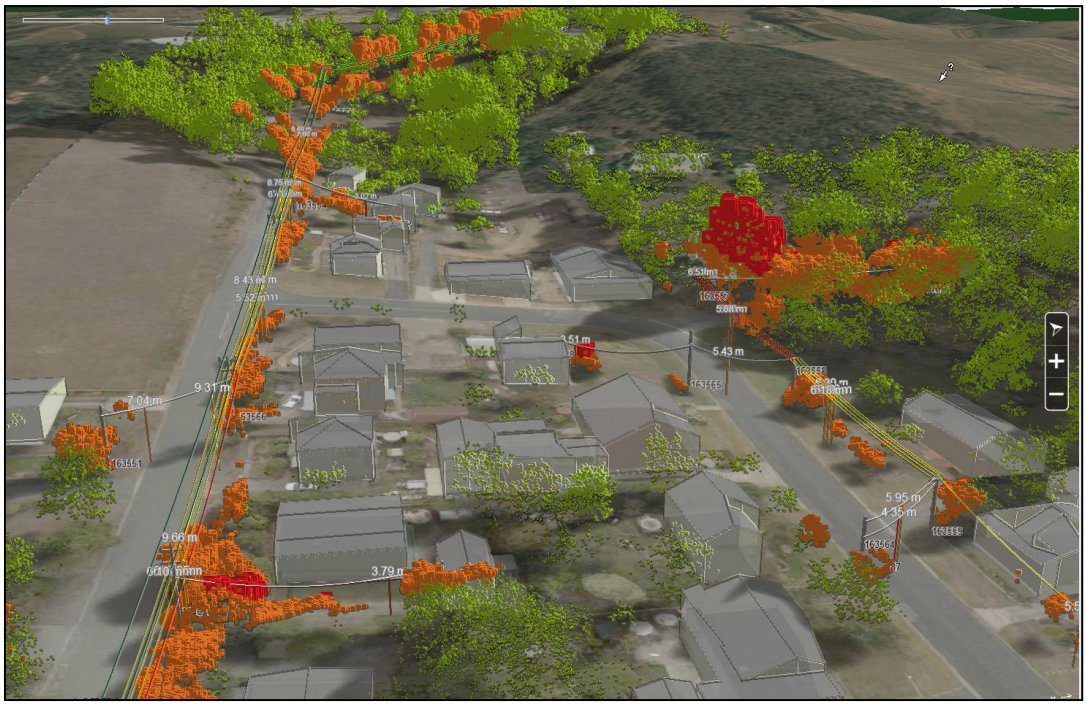


Figure.1: NM Group's immersive world, Caydence® 3D.

SUMMARY

LiDAR and PLS-CADD™ modeling of transmission systems in response to the NERC Alert has created a base map of the BES and this method is considered best practice for major facility change. Minor facility changes, previously addressed by ground based conventional survey, is becoming the preserve of LiDAR-enabled UAVs, which are similar in cost of application but deliver a superior output. ROW encroachment, periodic line patrol and survey were observed by NERC to be separate practices within industry. NM Group's Patrol+® is changing this paradigm through augmenting existing patrol flights and producing both survey and maintenance information that address ROW and facility change. The availability of regularly updated transmission system asset information made available across an organization can benefit multiple departments, if there is a mechanism is place to facilitate data sharing. Those groups within a transmission operator's organization who would benefit from this highly accurate asset data include engineering, real estate, vegetation management, line maintenance, environmental and other functions. We often observe that without strong corporate management guidance, the data can fall into silos, or worse, duplicated as a result of failure to communicate across departments.

Implementation of a cohesive and coordinated spatial data strategy as described above can unlock value in many ways and among numerous groups while providing a clear roadmap for regulatory compliance. Several large utilities are now moving towards a cohesive spatial data strategy at the corporate level and this trend will inevitably accelerate.

To discuss this paper within the context of your own organization please feel free to contact one of NM Group's specialists using the information below;

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BIOGRAPHY

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Nick is Senior Vice President Business Development at NM Group (Network Mapping, Inc). Nick has an academic background and interest in the application of spatial technologies to generate value for businesses (BSc and MBA). He has worked for 8 years alongside electrical transmission and distribution utilities with global exposure to best practice in the US, Canada, Australia, UK, Middle East, Africa and India. Email: nick.ferguson@nmgroup.com.

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Paul is a renowned industry expert in the field of transmission line engineering and long-time proponent of the use of PLS-CADD™ for improving reliability and utilization while minimizing cost. Paul is a Chartered Civil Engineer (BEng. Hons, CENG, MICE) with previous experience that includes more than 20 years of powerline engineering for National Grid Plc. At National Grid Plc., Paul was involved in the formation and development of the original Network Mapping (NM Group) from its inception as an R&D project in 1997. Email: paul.richardson@nmgroup.com.

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