IDENTIFYING INFRASTRUCTURE CHANGE IN THE 4TH AND 5TH DIMENSIONS

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ABSTRACT

As humans we see the world in one-dimension (a 1D point), two-dimension (a 2D line), and three-dimension (a 3D object). Many will recognise the fourth dimension (4D) as time, which - while not measured in terms of Euclidean space - can be represented by the detectable change in state of a given object between two points in time. In that sense we cannot see in 4D but as asset managers and operators we experience asset performance and risk implications from it, and in a geospatial context it is more commonly understood through the application of change detection. While 3D addresses the questions 'what is the object and where is it?', 4D asks 'How did it change?'.

Identifying change detection is not new, however the ability to identify change at affordable scale - with detailed resolution and high accuracy across the entirety of a utility's network - has been made possible by the advent and adoption of cloud computing. Cloud processing data has enabled the use of increasingly sophisticated deep learning computer algorithms which can automatically identify and quantify change in timeframes that are a fraction of those achieved through traditional human-based methods and does not include the inevitability of human error or bias.

Given the limitless potential of analysing big data in the cloud, we are now able to move modelling into the fifth dimension (5D), which postulates all possible scenarios of change between two objects or locations. Now we are asking 'How could it change?'. This is extremely valuable because it allows us to quickly run complex simulations on extremely large datasets. For example, a utility operator can optimise their vegetation management strategy to meet certain cost or risk targets by virtually testing every possible combination of clearance standards relative to certain types of mapped objects for the entirety of their network.

UNLOCKING THE 4TH AND 5TH DIMENSIONS

Utility asset managers are not new to analysing changes to their assets and network over time or to modelling scenarios to plan for future network needs. What is new to asset managers is that they finally have the key to unlocking the full potential of the 4th and 5th dimensions. The key is cloud data storage and computing, which allows utilities to conduct annual full network LiDAR scans, providing high resolution and highly accurate snapshots of their network. The ability to analyse these data sets in the cloud enable utilities to fully understand the current risks to their network and see how those risks change over time. The cloud not only gives utilities the ability to trend what has happened, but it also enables utilities to run an unlimited number of different scenario simulations to determine what may be the right strategies to implement moving forward. By unlocking the full potential of change detection and network scenario modeling utilities are challenged to rethink the way that they approach delivering safe, reliable and cost effective electricity to their customers.

Observing the 4th Dimension

Any object on the surface of the earth has a 3 dimensional position. This is a 2 dimensional coordinate and an altitude that defines where an object is located. If you consider that the 4th dimension represents time, it is possible to observe the change that an object undergoes through time.

Utilising modern remote sensing technologies, changes in the condition or state of objects such as trees, poles and wires can be identified. Comparing newly collected data with multiple historical datasets allows for identification and observations of changes. The quantity and quality of the changes observed is dependent on the richness and extent of the historical datasets available.

Using two datasets allows change detection to be observed and assessed in its simplest form. Two data points provide two individual snapshots in time, but do not provide sufficient information to determine a trend (3 data points necessary) or give the option to remove outliers and detect error margins. The chosen frequency for capturing data is dependent on economics (return on investment), resolution (what is the size of the change you want to detect) and natural cycles (yearly vegetation growth, asset lifecycles).

Determining the 5th Dimension

Analysing multiple historical datasets provides information on trends and patterns to a greater and more reliable extent. Extrapolating these provides asset managers with valuable information on the future state of their network and its surroundings. Due to the virtually unlimited processing power available through cloud computing an almost infinite number of scenarios can be modelled to determine outcomes. This is extremely valuable because it allows us to quickly run complex simulations on extremely large datasets. For example, a utility operator can optimise their vegetation management strategy to meet certain cost or risk targets by virtually testing every possible combination of clearance standards relative to certain types of mapped objects for the entirety of their network. Adding the complexity of weather patterns, flooding risks and other physics based circumstances, strengths and weaknesses in the network can be determined and acted upon.

The remainder of this paper looks at these principles when applied specifically to asset management challenges faced in transmission and distribution of electricity through overhead assets.

Realising the Value in Asset Management

The goal of every utility asset manager is to achieve the highest level of safety and reliability from network assets while reducing operating expenses. Traditionally, these goals were achieved through the implementation of time-based maintenance programs. The interval at which maintenance activities were scheduled is driven by regulatory requirements, manufacture recommendations, or historical practices. The effectiveness of the maintenance programs is measured by the utility's ability to complete the required number of scheduled maintenance activities by the assigned deadlines and for the allocated budgets. The major assumption being made through this approach is that the utility has correctly identified the appropriate maintenance interval that correlates to how the risk to a network changes over time.

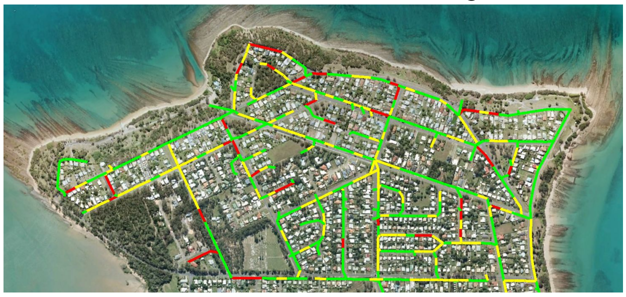

Figure 1 showing the ability to analyze, model and visualize network risk at a span level.

Data analysis capabilities that are enabled by the cloud means utilities can quantify the risk across their entire network, trend how that risk changes over time and even model how different asset management strategies will impact the risks to a utilities' network. These greater insights in the current network risks, challenge utilities' time-based maintenance strategies and will drive utilities to change the way they measure success within their maintenance programs. Success will no longer be measured by the number of tasks completed on time and at budget, but rather by the maintenance programs ability to reduce overall system risk at a reduced investment.

Vegetation Management

One of the largest utility maintenance programs that is ripe to be challenged is the vegetation management program. Historically, utilities have used inspections and cycle based trimming schedules based on average vegetation growth rates for their service territories to maintain the appropriate level of system risk. The challenge with this approach has been that there are always outliers, vegetation that grows faster than the average rate. To address this, utilities have accepted that their vegetation management programs would be required to have a certain amount of off-cycle maintenance.

As we move into a world where we have a greater understanding of our network, utilities can begin to use this data to improve the effectiveness of their vegetation management programs, while reducing the cost of the programs. The three main areas within a utility's vegetation management program to extract value are inspections, execution strategy, and compliance assurance.

Inspections

Conducting a highly accurate vegetation inspection in the field is a difficult task. The difficulty ultimately results in an increased cost to the utility's vegetation management program. An often occurring example during annual or scoping inspections is when an inspector, in an effort to ensure the reliability of the feeder, prescribes more work to be completed than is required. Another example could be when a work audit is performed and the auditor is unable to determine whether or not the specified clearance was achieved. By failing to achieve the specified clearance vegetation treatment is likely to be addressed again in off-cycle maintenance, resulting in additional cost.

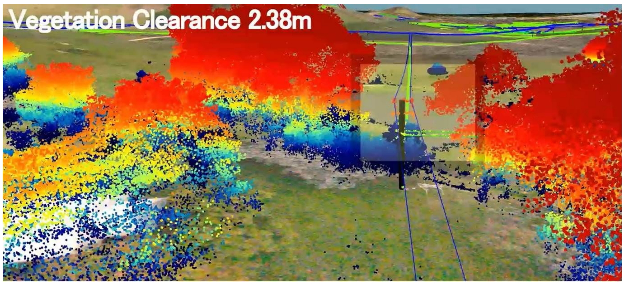

Figure 2: Human conducted foot patrol inspections can be replaced with highly accurate analytics

The three main inspection types which can be found in most utility vegetation management programs are annual inspections, scoping inspections and contractor audits.

Annual field inspections can be eliminated through the use of analytics that will identify and flag any vegetation that is within that given clearance profile for off-cycle maintenance. The use of analytics generates savings to the vegetation management program by ensuring that only the vegetation that has encroached within the prescribed clearance profile is identified for work. Any vegetation that is flagged can be either dispatched to your work order management system or packaged for your vegetation contractor to provide pricing.

Scoping inspections are vastly improved through the use of a Virtual World Asset Management (VWAM) data driven analytics platform. Inspectors can use quantifiable data to prepare their work packages from the office. There is the added security of knowing that the network will be assessed again next year limiting the desire to scope more than is required for the fear that something may be missed and result in a future network outage. Precise work scopes enables better pricing from vegetation contractors because the full extent of the programme is defined.

Contractor audits on the distribution network can be tough and utilities rarely audit a large portion of the work performed. This leaves utilities open to paying twice for the same work. Contractor's address prescribed work under various cost structures (e.g. unit rates, lump sum, outcomes-based, hourly rate) during cycle maintenance. In the current structure of outsourcing, limited audits can easily miss a tree or does not achieve the proper clearances. Flagging a consequential violation after two years will result in the contactor being paid by the utility to treat work they have not executed well in the first place. In contrast an annual assessment provides 100% contractor auditing capability through change detection algorithms. This removes the need for manual contractor audits.

Execution Strategy

The development of a successful programme execution strategy requires a deep understanding of how the vegetation around your utility network changes over time. The strategy must consist of ensuring that the correct vegetation management standards and specifications are in place to deal with the vegetation growth in the service territory. The schedule and program spend should be levelised to ensure that the program budget is aligned with the level of network risk that needs to be addressed within a given year to ensure successful execution.

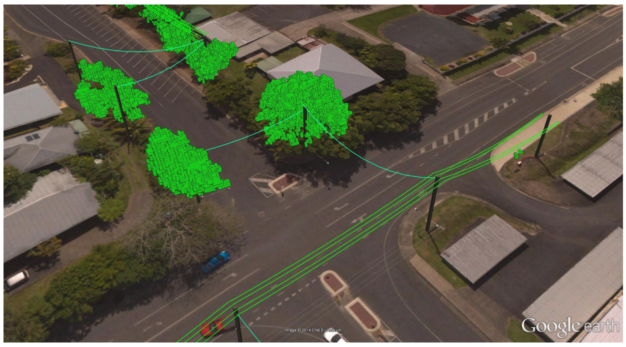

Figure 3: Identifying the impact of changing vegetation management standards and specifications across a utilities network using VWAM software.

Historically, utilities determined having the right trimming specification by looking at the reliability of the feeders and the quantity of off-cycle work performed.
Observing low reliability or high quantities of off-cycle maintenance, might be an indicator to change the approach. Through an annual assessment vegetation encroachments risks on a span by span basis become apparent, this gives the opportunity to identify risk changes over time and review the adequacy of the

trimming specification prior to paying for reactive tree work as a result of an outage.

After a minimum of three annual assessments, span by span growth trends can be identified. These growth rates assist utilities to match up the more aggressive trimming specification to the high growth spans and their relaxed trimming specifications with their low growth rate spans. The benefit of applying the right trimming standard is that it ensures operations and maintenance budgets are spent efficiently, increased customer satisfaction, and reduces environmental impact. By addressing high growth spans more frequently or more aggressively it is possible to lengthen your maintenance cycles.

The ability to model a variety of vegetation growth scenarios enables utilities to budget for the anticipated program spend in future years. The ability to conduct scenario planning for future years enables utilities to fully understand the impact of deferring or accelerating work within the current year. Utilities can began to develop cost effective vegetation management strategies that are designed to continually reduce the system risk.

Compliance Assurance

A larger responsibility for a utility's vegetation management program is to ensure that the company remains in compliance with all applicable regulations. An annual assessment allows a utility to have detailed documentation that they have been in compliance year after year. The ability to model different maintenance strategies allows Executives and Asset Managers to understand the compliance risk outcomes based on the implementation of a particular strategy. A larger barrier to making major changes to vegetation management programs is the inability to fully understand the risk that those changes represent. The result is that historical practices are continued because those practices have enabled utilities to remain compliant, even if those practices are not the most cost effective approach.

THE NEXT STEP IN NETWORK INSPECTIONS

The value of unlocking the 4th and 5th dimension of asset management is not limited to vegetation management. The same capabilities used to detect the change environment around a utility network can be applied to the network itself. Defects on the utility network such as broken tie wires, broken cross arm braces, bent insulator pins which are identified today through visual field inspections will soon be able to be identified through the use of change detection algorithms. By monitoring the position of conductors and quantifying the amount of change will allow Asset Managers to correlate that change to a particular type of defect.

VWAM PLATFORM

For industries that depend on reliable infrastructure, the key challenge is to maintain an ongoing understanding of the assets and the world around them. The VWAM platform maintains the data, analytics, and visualisations tools required to address this key challenge. Thanks to the open access philosophy, VWAM serves as an asset assessment and management environment for infrastructure owners, engineering and consulting firms, and data acquisition companies. The platform allows power utilities across Australia, the United Kingdom, and the United States to achieve 40% savings on traditional practices managing critical infrastructure through the use of such a platform.