DIGITAL FOUNDATION; PROVIDING THE NECESSARY VISION AND TOOLS TO ENABLE A CONNECTED ENERGY LANDSCAPE

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ABSTRACT

This paper explores the 4D digital foundation applied specifically to asset management challenges faced in the distribution of electricity through overhead assets. Sophisticated, deep-learning, computer algorithms 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. An almost infinite number of scenarios can be modelled to determine outcomes by quickly running complex simulations on extremely large datasets to detect the change environment around a utility network.

INTRODUCTION

For four consecutive years the digital twin has been in the top 10 of strategic technology trends published by Gartner and is a fast-growing concept in the power utilities industry. According to Gartner, by 2021, half of large industrial companies will use digital twins, resulting in those organisations gaining a 10% improvement in effectiveness [1]. If we look at an average distribution company in Europe, we find around 12 to 15 poles per kilometre. Corporate Geographic Information Systems (GIS) register the locations of poles, all assets in a substation, and other assets in 2D. This is a good start for the digital twin, but our real world happens to be a 3D environment, with associated 3D challenges. Numerous factors impacting risk, asset health and reliability of large-spread electricity grids cannot be efficiently coped with using 2D information and technology only. Understanding the context, or 3D environment, of grid assets is one of the key elements not yet covered – but crucial to the industry.

Innovation and digitalisation are the basis of this major change in current processes at many utilities. By implementing the latest remote sensing technologies, combined with cloud computing, automation, artificial intelligence, immersive visualisations, and advanced data analytics provides a direct shift towards a more advanced and reliable digital approach to asset management and operations. Based on the collected data, the data analytics and the visualisation over time provide the tools to build a 4D digital foundation. This foundation is fundamental for the grid of today and the future.

This 4D, digital approach to asset management and operations will result in reducing operating expenditure, streamlining works delivery and response times, and optimising capital investment programs. It has been proven to improve risk management, safety, network performance, resilience and disaster response, customer service and strategy execution. Moreover, it supports for example the integration of distributed renewable energy resources and economic dispatch of energy, while fostering collaboration and seeding innovation across the enterprise.

The main question is how many of the Energy Utilities are ready - at this very moment - to apply this digital foundation for a connected energy landscape, revealing vital, and sometimes unforgiving Asset Context data?

DIGITAL TWIN AND DIGITAL FOUNDATION

In a recent report by Juniper Research the following statement is made: "Digital Twins help to improve operational reliability and availability, minimise costs, reduce unscheduled downtime, and reduce operational risk."[2] In this article the researchers claim that "by 2021, digital grid technology is expected to deliver almost US$19b in cost savings worldwide". The main drivers for this cost reduction are through reduced energy use and avoided emission costs, but improving operational reliability and availability are also important drivers. What is this digital twin, and how can this concept be applied to the Energy Utilities?

In 2002 researchers of the University of Michigan presented a concept for Product Lifecycle Management (PLM) that included the linkage of two systems throughout the full lifecycle of a system. Such a system would contain a virtual representation of the physical system at the moments of creation, production, operation, and demolition. This concept of the digital twin is nowadays widely adopted in asset management in different industries. For energy utilities the priority is to create the digital twin, and to keep it up-to-date.

The main issue with keeping the digital twin synchronized with the physical asset is that differences appear at the moment the asset changes between phases.

Creation Phase

In the design (creation phase) the physical asset does not yet exist as a whole. Known components might be available and used as separate parts on the drawing board.

The asset, so to say, only exists in the design application. Many of these applications offer possibilities to store additional data on the components, this metadata is in a later stage used in the asset management suites that become increasingly important within the industry. What is stored is highly dependent on the company standards and integrated systems. There are many examples of this such as ERP and GIS systems. If this additional data is not stored at the moment of design, then it must be done at a later stage, often introducing extra costs.

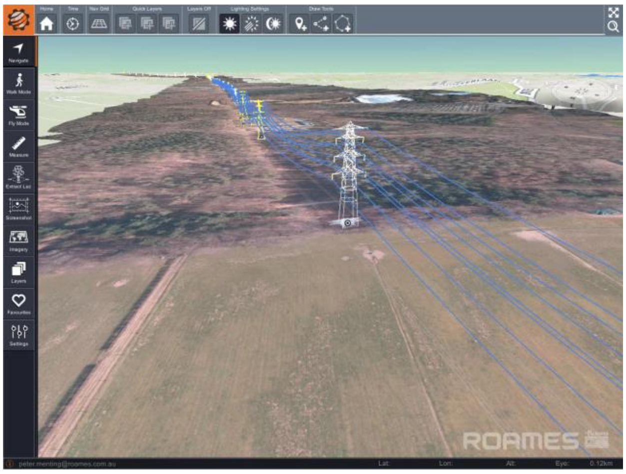

Figure 1. Example of PLS-CADD model in Roames World

Construction Phase

When the final designed asset moves to the actual construction of the system i.e. becomes a physical asset, we can find the first design changes. Is this unexpected? No, not if all changes aren't registered in the design files. In the case of a distribution network operator (DNO) we often see the network as designed is created differently in the real world, for example, the proposed siting of a pole might be impossible due to locational circumstances which can be as simple as an existing hedge or a soil condition.

Figure 2. Roames World visualisation of a shift vector of 7.9m on SPEN's network

Operation Phase

This is the phase where most of the digital twins grow apart with a widening gap between the asset that once was designed and the physical asset. Firstly, during the operation phase changes are commonly made based on work orders that come from the ERP or works management systems. We frequently see these changes registered in the systems but often the design files are not updated.

Secondly, we should take account of the wearing of assets. The majority of power utility assets are outdoors and exposed to (sometimes extreme) weather conditions. Wooden poles and cross arms are of course the best example, but also the conductors deteriorate over time, sometimes causing dangerous situations when broken or loose. For example, these are the cases where repair is needed on the actual network, in many of these cases the digital twin connection remains the same.

Decommissioning Phase

In the final phase, the asset enters the decommissioning phase and gets (partly) replaced or discontinued.

In the ideal situation, one would use information from the virtual asset to optimise performance and predict failures of the physical asset. Generally, this information is derived from a variety of systems and is used to correlate changes and the probability of future failures. To be able to do so, information stored in the virtual system that are part of the digital twin must be up-to-date.

ROAMES

One of the elements that is often missing in many of the digital twin environments (DTE) is the context in which the asset is placed or interacts. In this respect the assets of energy utilities differ from many other industries and hence the digital foundation comes into play. The digital foundation is a crucial part of the digital twin taking account of the asset, its direct context and detecting the changing environment around a power grid. This is exactly what Roames Virtual World Asset Management technology provides; a model that links to the real world using (big) data analytics and machine learning providing the information needed for a more advanced asset management. Through understanding the dynamic asset context, asset managers can tune their capital and maintenance programs and operational incident response to achieve an optimised risk and service quality outcome.

Figure 3. Roames in relation to other business systems.

The innovative Remote Observation Automated Modelling Economic Simulation (Roames) technology creates a representation of the real world of such fidelity that it can be used for asset inspection, identification, and condition assessment without the need to deploy workers to the field. Within Roames, assets are modelled with their relevant structural, mechanical, electrical, and thermal characteristics, enabling a deeper understanding of asset behaviour and supporting many asset management activities.

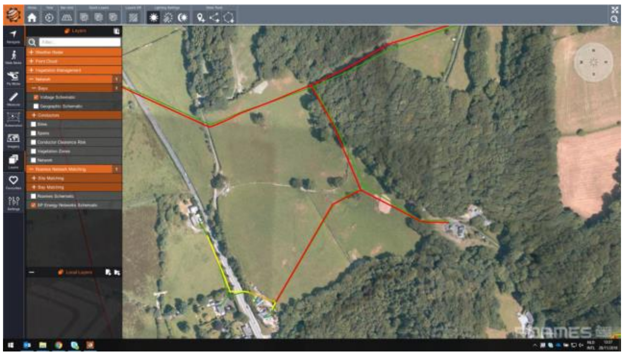

Figure 4. Example of Roames schematic loaded into Roames World

The main goals for the development of Roames included among others to: maintain an accurate inventory of distribution assets; improve visibility of network risk; identify a cost-effective means to promote safety; and ensure regulatory compliance. Currently this service has been made available in Australia, the United States, and Europe with many distribution and transmission operators. Our client's asset managers use Roames for informing their vegetation management strategies, risk assessment, and pole-top inspections.

THE DIGITAL FOUNDATION

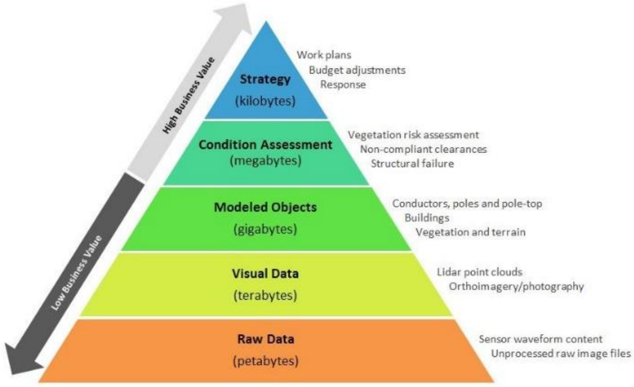

Figure 5. DIKW (Data, Information, Knowledge, Wisdom) pyramid derived from information science.

For many electricity utilities the first step in creating a digital twin is to model their assets in the as-built situation. Aerial surveys are generally the best way to acquire this data flying the network with a combination of specialised remote sensing technology.

From the petabytes of raw data collected we can ascend in the business value pyramid to the kilobytes of the final strategy document. This model is a variation on the DIKW pyramid derived from information science that starts with Data and grows by Information to Knowledge and finally Wisdom. The data in this case is both the raw waveform and imagery data, as well as the derived visual data.
No interpretation is done on the data in this phase, only the primary processing of factuals acquired by the sensors: data as a signal. This data is meaningless without further interpretation - a lidar point cloud or image is just a collection of data gathered by the sensor.

Lidar data measures the return from the sensor to a reflecting object, often called the target. The data is 3-dimensional and can be used to create a 3D model of the as-built situation. This is where we enter the next step of the pyramid and begin to convert data into information. In the definition, as stated by Wallace, "information is defined as data that are endowed with meaning and purpose"[3]. In the case of an electric utility's network we see the information on the general form of the assets (conductors, poles, towers and cables) and different types of equipment that represent the full picture of the network. Moreover, and this is where the digital foundation comes into play, we see the context of the network i.e. vegetation, buildings, and other structural objects in the acquired corridor. This information can be used for multiple purposes and that is where knowledge ensues.

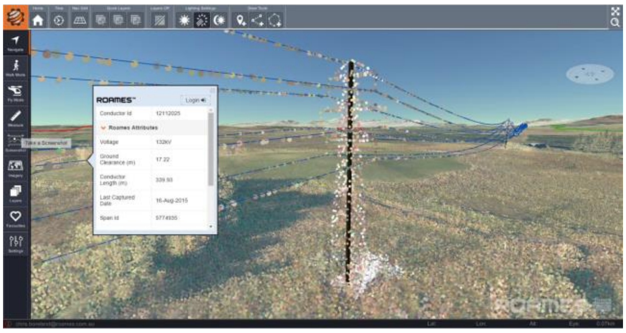

Figure 6. Roames World point cloud of 132kV tower on a European operators network

The LiDAR data provides very precise (cm accuracy) location information that can be used in, for example, the company's GIS system to update the location of assets, which in many cases are not in line with their real-world position. Roames uses data analytics to automatically update this information, or at least give an indication of the real-world location. These corrections are part of the digital twin strategy.

Analysing clearances and the distance between vegetation and the network is crucial for network utilities. Not only is this a legal requirement, it also has a huge influence on the actual condition of the network. Furthermore, vegetation that is too close to the network can cause bushfires, subsequently resulting in severe damage or even lethal outcomes. Analytics are important in business and risk management processes, and providing those analytics can positively mitigate serious risks.

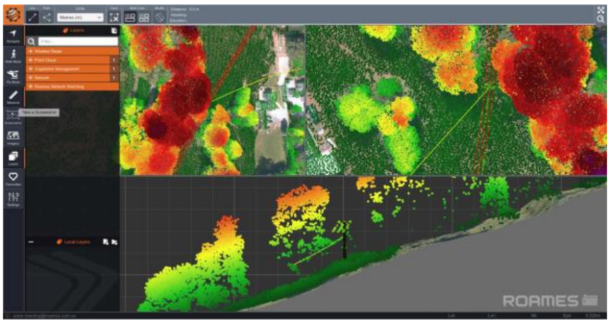

Figure 7. Roames World Profile view of an 11kV line with surrounding trees

For example, many electricity utilities have a rather arbitrary vegetation management program, often done – and often well done – by experienced field teams. Still almost every DNO has experiences where the vegetation management was not undertaken as efficiently as it could be.

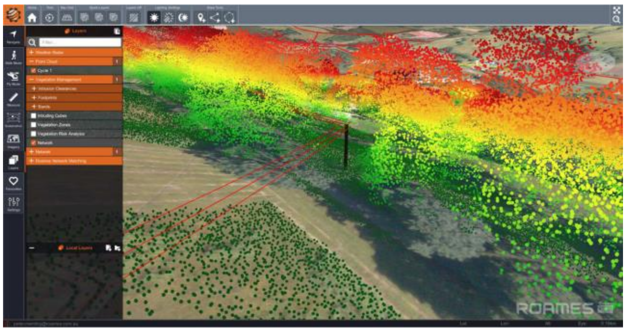

Figure 8. Roames World Visualisation of vegetation shape around power lines using the point cloud data

By using objective analytics, a utility can not only reduce the costs of their vegetation management, but also focus on those locations in their network with actual issues, avoiding expenditure in areas where it isn't needed. An example of this are the locations where fall-in from second- or third-line trees may cause a risk to the network. Why call this an objective method? The answer is simple, it is based on factual data without any human interpretation.

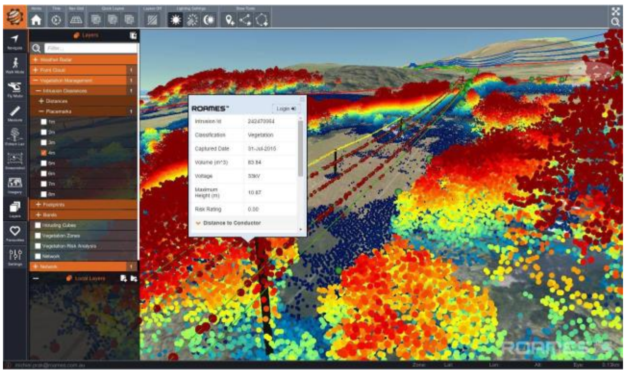

Figure 9. Example of Intrusion point locations within 4 metres from the conductor on 33kV circuit with point cloud coloured by height in Roames World. The defect in the foreground is 3.55m from the conductor. The Intrusion Clearances Layer menu is open on the left.

The next step in the value pyramid – the wisdom phase – is when you relate the knowledge about the asset and its surrounding environment to prevent or mitigate risks and create a stronger, fact-based strategy for the future. Dashboards provide the asset and vegetation managers with insights on the state of the network. Visuals support these insights, and since that visual data is presented in 3D the viewer can base decisions not only on the network itself, but also on the context, so again the digital foundation. The analytics dashboards provide a quick overview generally by maps that link to tabular data. This description – maps and tabular data – might sound like GIS, but it is not.

That is where Roames differentiates itself from GIS, ERP or other business systems. Roames creates a true virtual world that supports both the digital twin as well as the digital foundation concepts.

IN SUMMARY

To summarise, when going through the DIKW pyramid we see that the digital foundation for the energy utilities has three main levels. At the front end, the energy utilities need to digitalise via data acquisition and processing workflows. On the information level they need to add a strong data management capability, create digital representations of their sites and assets, and develop analytical tools that extract and deliver the required information. Finally, in order to benefit fully from the knowledge derived in level two, the company needs to include it in their internal processes.

Fugro's Roames solution offers all the above and can be used to create both the digital twin and the digital foundation. The result, high business value from strategic decision-making with Fugro as the asset optimisation partner.

We started off with the question 'how many of the Energy Utilities are ready - at this very moment - to apply this digital foundation for a connected energy landscape, revealing vital Asset Context data?'. We see that more and more of the energy utilities are moving towards a digital foundation, but there is still a long way to go.

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