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Sharper intelligence for a safer world

Powerline inspection in a warmer world: What to expect and how to prepare

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Climate change: A clear, present and grave danger

In 2024, more than 8.9 million acres burned in US wildfires. That's an area the size of The National Arctic Wildlife Range aflame, with the fires ravaging communities, destroying property, and – in the most tragic cases – taking lives.

And fires weren't the only cause of devastation – on the other extreme, there were 5 hurricanes including Helene and Milton which were the costliest U.S. disasters of 2024. The economic impact of these hurricanes cost more than $225 billion in infrastructure damage and led to a loss of life estimated at 304 people, though the true number is likely to be much higher.

Though occupying opposite ends of the extreme weather spectrum, the two events share a key factor in common, besides the devastation they caused. Each is an example of extreme weather events that experts predict will increase in frequency and severity due to climate change.

And – to be clear – this is not a US-only phenomenon. From Portugal, to Turkey, to Russia, Argentina and Australia, almost every region of the world suffered. As we begin 2025, there can be no doubt: climate change is both real and inescapable; it is a clear, present, and grave danger to us all.

Climate change presents a profound and systemic threat that demands immediate and strategic action. While some impacts of climate change are now unavoidable, there are meaningful steps we can take to mitigate its worst effects and strengthen our ability to withstand and recover from extreme weather events. These efforts will extend across all aspects of society and the global economy. However, this discussion will focus on a critical area of expertise: power transmission and distribution infrastructure, particularly the role of electric utilities in the United States and beyond.

Electric utilities have a pivotal role in both combating climate change and responding to its consequences. Although electric utility infrastructure has historically accounted for less than 10% of reported wildfires, power lines have been linked to

nearly half of the most destructive wildfires in California's history. Poorly maintained infrastructure not only increases the likelihood of such disasters but also complicates recovery efforts following extreme weather events.

After these events, utilities are tasked with restoring safe, consistent, and affordable power—an especially difficult challenge during Public Safety Power Shutoffs (PSPS), which are designed to prevent further damage but can disrupt communities. Swift and effective return to service is essential.

From this perspective, climate change represents just one element of a complex web of challenges facing electric utilities. Power infrastructure is increasingly vulnerable to extreme weather, yet it remains a sprawling, underfunded, and aging network that spans over 7 million linear miles in the United States alone. At the same time, utilities must adapt to evolving energy demands driven by the rise of renewable power generation and the growing push for electrification across various sectors of the ecomony.

Addressing these challenges requires swift and sustained action. While efforts to mitigate climate change will need to unfold over several decades, planning for its near-term impacts is urgent. Electric utilities must innovate and adopt advanced technologies to safeguard the communities they serve and secure their own future viability.

A key element of this strategy is improving emergency preparedness and response through enhanced data management. This paper will explore how powerline data can provide valuable insights for risk mitigation and operational resilience. Central to these recommendations is the use of digital twin technology, a powerful tool that creates a virtual model of a utility's physical assets by integrating large streams of data. Digital twins offer a comprehensive view of infrastructure conditions, enabling utilities to anticipate risks, streamline decision-making, and enhance overall resilience. This approach represents a new standard for managing and mitigating the risks associated with climate change and an evolving energy landscape.

> **"there are steps we can take to head-off the worst effects of climate change, and to more successfully prepare for and endure what cannot be avoided."**

The time to act is now

The Grid Resilience Utility and Industry Grants program is designed to support the modernization of the electric grid, enhancing its ability to withstand and recover from extreme weather events and natural disasters. This program provides funding for comprehensive, transformative transmission and distribution technology solutions that address a wide range of hazards. These include wildfires, floods, hurricanes, extreme heat and cold, storms, and other events that could disrupt power supply. By investing in advanced infrastructure and technology, the program aims to improve grid reliability and resilience, ensuring that communities and regions are better protected from future disruptions. The program will provide up to $2.5 billion over five years ($500 million/year FY 22-26).

2025 brings growing challenges to grid resilience. The pressure is on for powerlines, as the US Department of Energy projects a 38% increase in demand for electricity by 2050, in part driven by the growth in electrification of transport.

Meanwhile, grid decarbonization and the associated fragmentation and decentralization of power sources means grid vulnerabilities will become widely dispersed. This comes at a time when climate change will pose an ever greater risk to utility networks: 90% of energy executives already report that extreme weather represents a financial threat to grid stability.

Extreme weather: The role of powerlines

Fast-growing vegetation and over-hanging branches close to powerlines pose significant risk in wildfire scenarios and high winds. Understanding the live network enables allocation of resources and maintenance to trim fast-growing vegetation in the right places at the right times. Faster and better decision-making equals lowered risk.

Prevention is the best cure

Emergency response

When disaster strikes, time is of the essence. An effective response plan with intelligent prioritization and smart use of scarce resources requires efficient real-time data collection from multiple sources. From the field crew and network monitoring systems that inform outages, to helicopters in the air and customer complaints, an integrated data approach can not only cut operational expenses but is vital to limit damages – to the environment, to assets and to people.

Reducing impact

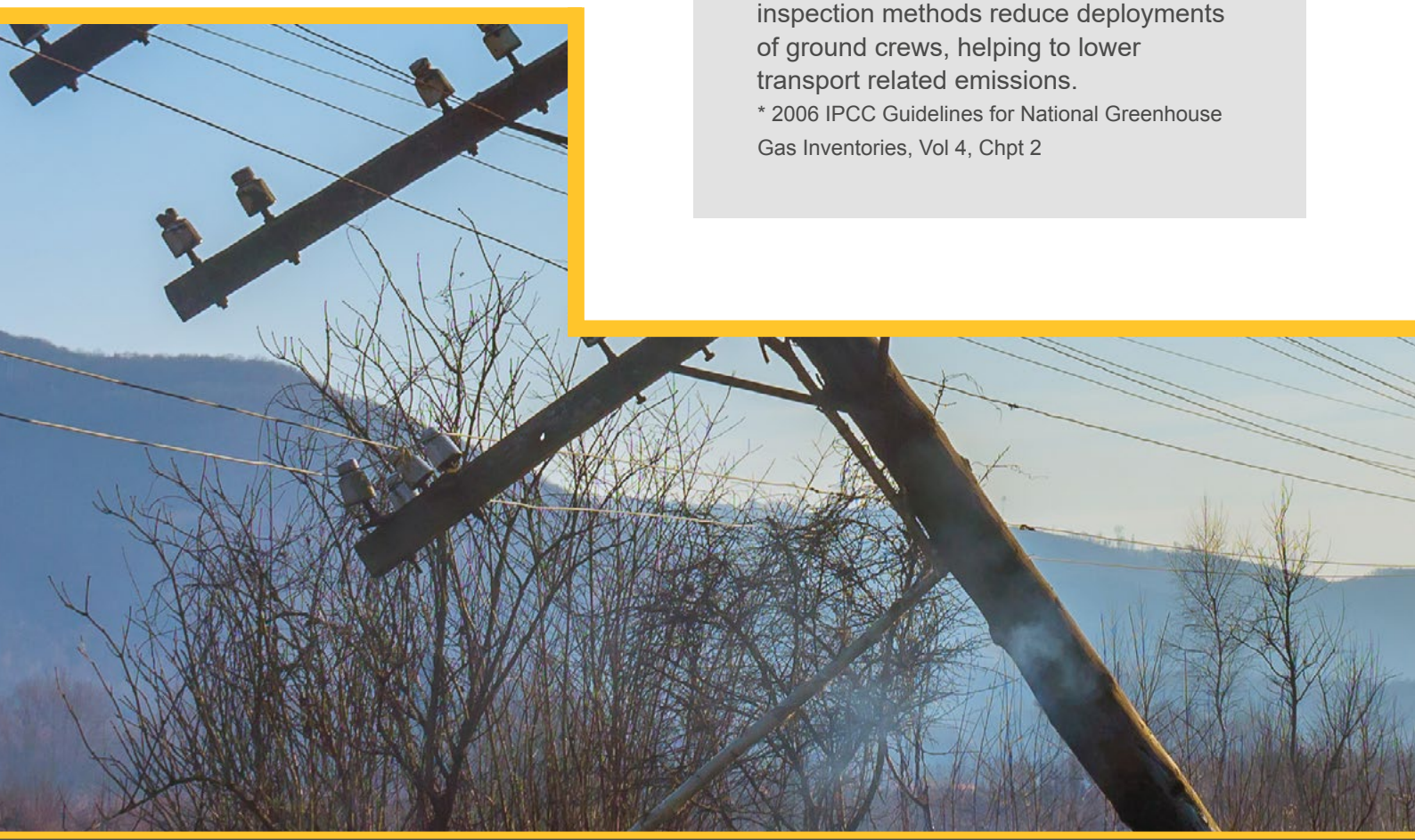
Without an extreme weather plan in place, powerlines can be an exacerbating hazard and lead to unacceptable power outages for communities. In the US, weather-related power outages are on the rise, with the number of outages in the last decade (2014-2023) doubling compared to the first decade of the century. From 2000 to 2023, 80% (1,755) of major power outages were due to weather.

Get it wrong, and the risks are exponentially high - from the safety of communities and employees, and the financial burden of asset repairs and fines, to the reputational impact on utilities.

Fortunately, in 2025 we have the tools available to reduce and mitigate these risks.

How proper powerline management reduces emissions

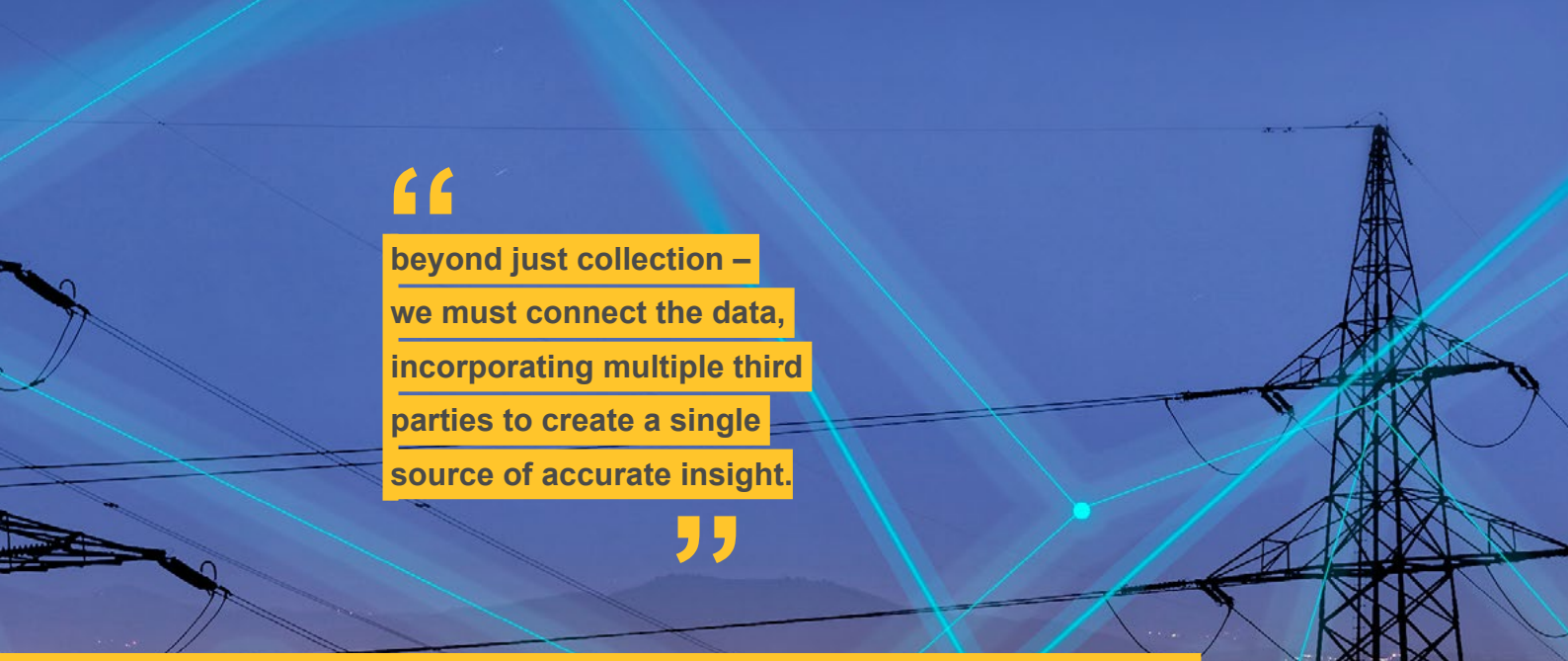
Transmission and distribution (T&D) utilities may often feel that their role in addressing climate change is more reactive than proactive. While power generation companies are tasked with reducing emissions, powerline operators are left to manage the consequences of global warming. However, effective powerline management can also play a direct role in reducing greenhouse gas emissions through various strategies. For example:



► For every wildland-acre that is prevented from burning, an approximate average of 31.6 metric tons of CO2-equivalent per acre reduction in greenhouse gas is realized* and an approximate average of 5.6 t CO2-equivalent per acre per year greenhouse gas forest-sequestration is preserved. Fortunately, in 2025 we have the tools available to reduce and mitigate these risks.

► Smarter, more efficient powerline inspection methods reduce deployments of ground crews, helping to lower transport related emissions.

* 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol 4, Chpt 2



> beyond just collection – we must connect the data, incorporating multiple third parties to create a single source of accurate insight.

Powerline management: Traditional tools vs modern best practice

Next generation data collection

To address the challenges posed by extreme weather, utilities need to centralize information for accurate analysis and prediction of inspection and maintenance needs before issues arise. Achieving this requires the collection and organization of large volumes of data, transforming it into actionable insights to develop a comprehensive understanding of assets and their surroundings.

Traditional methods of data collection, such as manually inspecting infrastructure for wear, damage, or potential risks, are becoming increasingly impractical as data demands grow. Best practices have shifted toward advanced digital solutions that enhance scalability and accuracy while eliminating data silos. Additionally, the right technology can consolidate multiple inspection processes into a single, more efficient session, streamlining maintenance efforts and improving overall operational efficiency.

All too often, multiple inspections are conducted to inform different types of maintenance; though with the right technology in place, this can be wrapped into one efficient session.

From collection to connection

Secondly, beyond just collection – we must connect the data, incorporating multiple third parties to create a single source of accurate insight.

For example, incorporating multiple sensor systems into a single payload – be it delivered by helicopter or drone flight – means technologies such as LiDAR, hyperspectral imaging, and AI component detection, can be utilized across vast distances. Mapped to digital twin technology, these can generate insights-based actionable reporting and best-practice disaster preparation plans.

Utility insights in Real Time: 4D Living Digital Twins

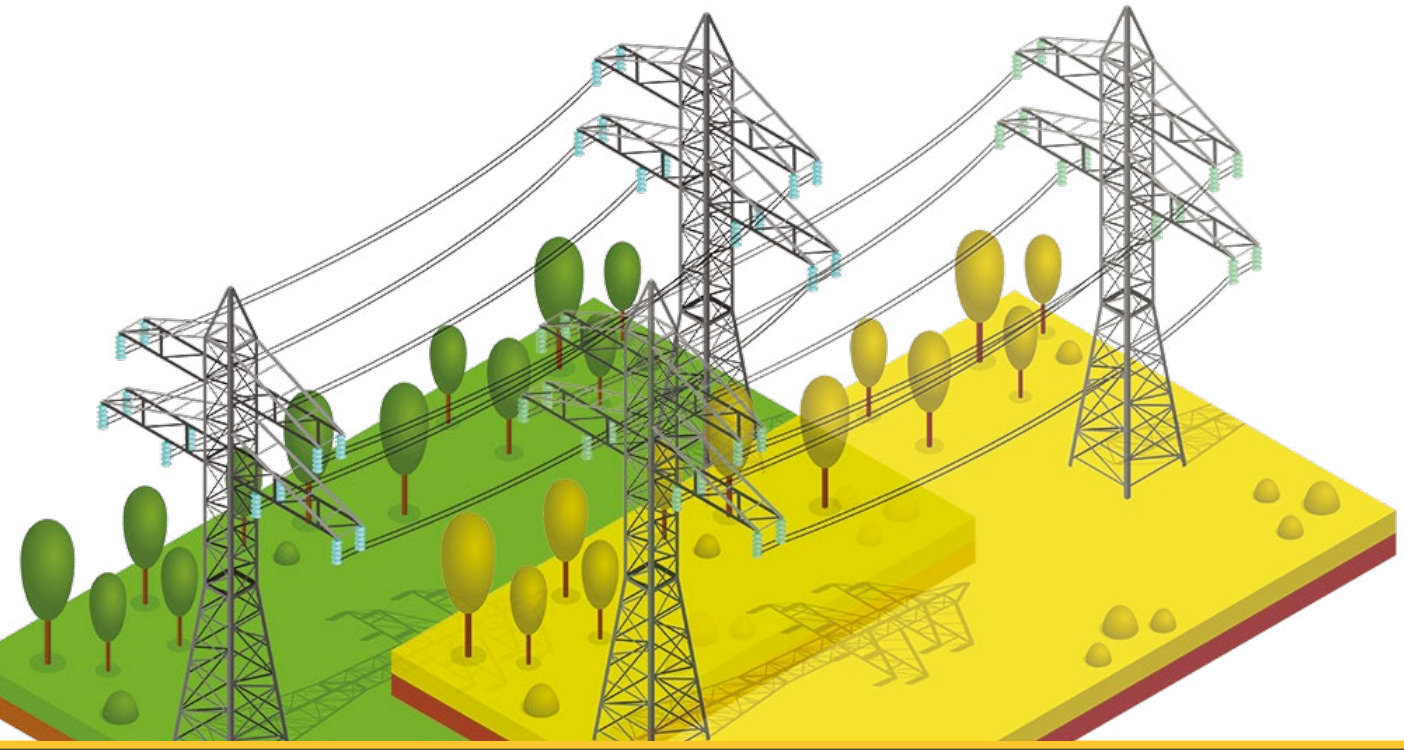
Smart technology is at the root of longevity for utility providers. No longer an exciting future prospect, cloud-operated AI technology maturity has meant digital twins are now taking center stage.

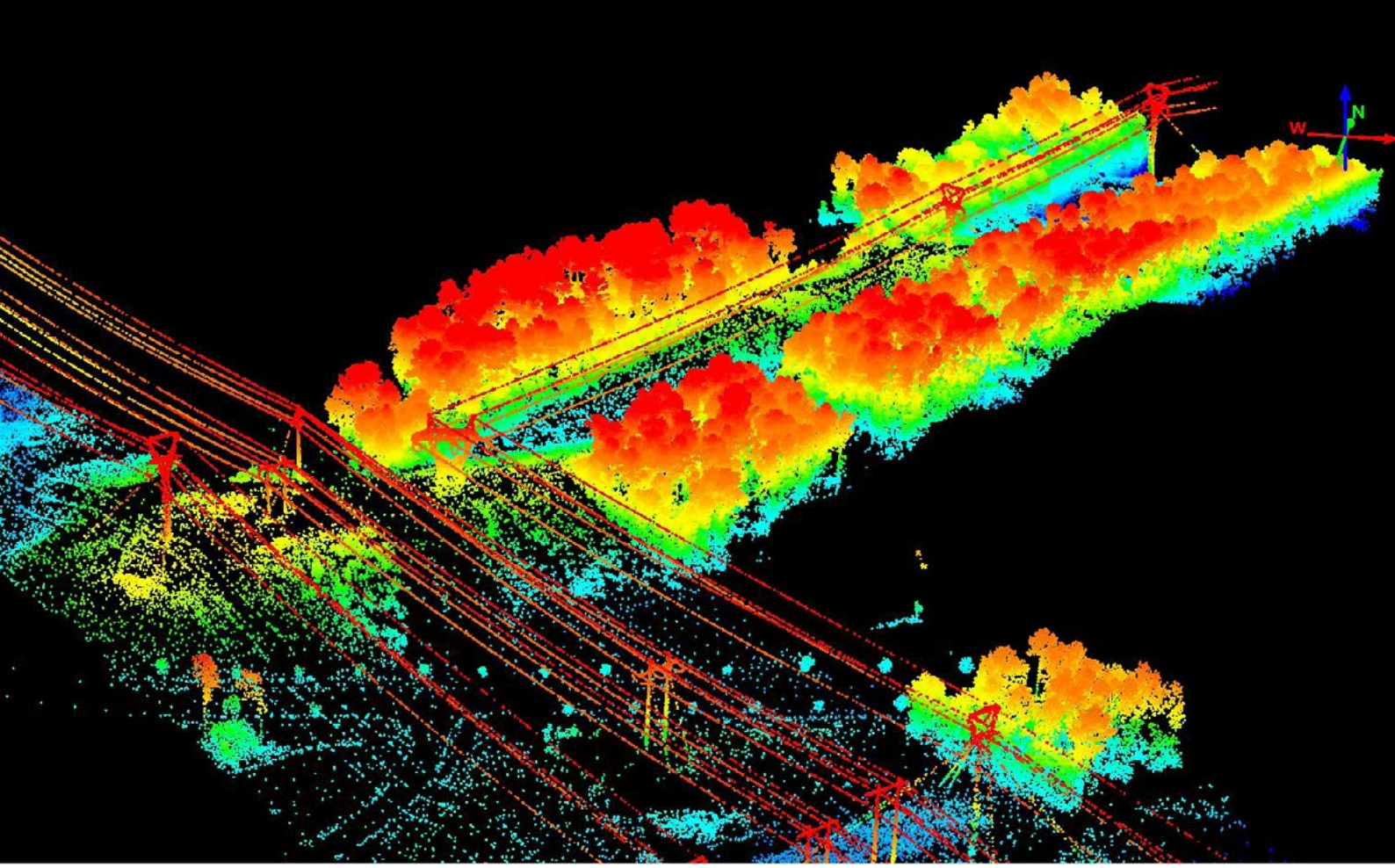
Reaching far beyond a spatial 3D model, ‘Living Digital Twins’ (LDTs) are cloud-based, highly detailed four-dimensional (4D) virtual replicas of a utility’s electric network, incorporating the fourth dimension of time with artificial intelligence-based algorithms.

Leveraging real-time aerial and ground data, as the surrounding environment and the asset itself changes, an LDT monitors and updates the model in real-time. This continuous change detection allows remote inspectors to monitor network risks, highlight qualitative differences and identify statistical patterns, while analyzing and prioritizing them in accordance with infrastructure-related needs and local regulatory requirements.

With an LDT providing a baseline, combining historical data with incoming live data creates network risk scenarios and allows for optimized resource and budget allocation, minimized risk and the highest safety standards. With this, a best practice future vegetation clearance and asset inspection plan can be made, resulting in smart, risk-based decision making.

Ultimately, this helps utilities identify problems faster and more cost-effectively by cutting down on ‘routine’ operational sweeps. For example, when it comes to vegetation risk assessment, utilizing historical risk statistics allows operators to target vegetation management in the most effective areas, whether that be due to close vegetal proximity to assets, density of fast-growth species or other factors.





How utilities can get optimal value from living digital twins

The nature of living digital twins means the longer they have data feeding in, the more mature and accurate the insights become.

Digital twin technology is transforming powerline inspection by enabling automated inspections using advanced drone technology, particularly for beyond visual line-of-sight (BVLOS) operations. Operators can train fleets of sensor-equipped drones to monitor powerlines almost continuously, with the drones returning automatically to recharge their batteries.

This approach is not only more cost-effective and safer than relying on human inspectors, but it also provides more detailed and frequent data.

This improved data collection enhances planning, inspection, maintenance, and vegetation management, leading to more effective and proactive system management.

A key advantage of digital twin technology is its ability to simulate real-world scenarios, which is especially valuable in the context of the climate emergency. For example, it can model the impact of a hurricane striking at a specific location and predict how assets in nearby areas will be affected. It can also simulate the consequences of a downed powerline sparking a fire, identifying nearby residences and informing evacuation plans.

In the aftermath of a disaster, digital twins serve as a comprehensive record of the network, enabling faster and more efficient rebuilding while reinforcing vulnerable areas. The predictive insights offered by digital twins are invaluable for both disaster prevention and response, helping utilities strengthen resilience and minimize disruption.

Staying ahead of the curve: Insights into action

Digital twin infrastructure resource management (DTIRM) can be used as a baseline to link all utility activities and data sources to create a holistic view across the network. But these insights are only valuable if they are actioned effectively.

By shifting from traditional, time-based inspection cycles to issue-based approaches driven by predictive analytics, utilities can operate more efficiently and strategically. This predictive approach enhances accuracy, reduces operational costs, and improves crew safety by enabling better scheduling for vegetation management and inspections. Measurable outcomes tied to key performance indicators (KPIs) allow for resource optimization, resulting in a more resilient and productive grid that is better prepared for weather-related disruptions.

As wildfire risk increases across the U.S., this proactive approach helps mitigate threats by addressing issues such as overgrown vegetation before they escalate. It also strengthens disaster response capabilities. The detailed, real-time understanding of the grid, assets, and surrounding environment provided by digital twins helps utilities and emergency services coordinate an informed, organized response during emergencies.

By integrating data from multiple sources and visualizing the status and most affected areas, utilities can triage effectively. In the case of a Public Safety Power Shut-off, this allows for faster restoration of power, minimizing disruption to communities and reducing financial losses from downtime.

> **“insights are only valuable if they are actioned effectively.”**

Laser-focus on vegetation management

Transmission utilities in areas of high wildfire risk are in a constant struggle with nature to keep the vegetation that surrounds powerlines and other assets in check. With August 2021 being the highest month on record for carbon dioxide released from burning forests, scientists are concerned that areas with dense vegetation are becoming a source rather than a sink of greenhouse gases, with nearly 2 million metric tons of greenhouse gas sequestration capability lost in the US' western states alone. On top of this, experts are warning the impact of smoke from longer-lasting more frequent wildfires could have serious health impacts.

Utility providers should seek out proactive, rather than reactive, asset maintenance and utility vegetation management (UVM) plans that model and forecast risks to eliminate hazards before they become a problem. These plans should be developed based on identified risks and subsequent growth modelling. This allows division of issues into segments of vegetation risk which allows for effective prioritization of issues and optimization of workload. For example, the most profitable approach is to trim vegetation as late as possible – before it becomes a hazard – to keep both costs and risk down. By informing line crews and arborists how to efficiently interpret and execute those plans, utilities can close the loop by providing the ability to audit the results, while also ensuring compliance with federal and state regulations and with internal operational guidelines.

A comprehensive digital twin will achieve this by incorporating the grid assets – a network of powerlines and pylons isolated on an otherwise blank screen – with the immediate surroundings, including local structures, roads, waterways and trees.

If the LDT is continuously enriched with vegetation data on factors such as the species, growth rate and health of a tree, then the utility can use it to assess and track the risk from any given twig or branch neighboring one of its assets and prioritize the dispatch of vegetation management crews accordingly.

Threat vs. solution: how to win the battle

As extreme weather continues to impact power supply consistency and poses potential damage to aging assets, threats to powerline management continue to evolve and – if global warming continues – will worsen.

Fortunately, by design, AI insights become better over time as the algorithms are refined and the datasets grow to become more representative, giving utilities the ability to set realistic KPIs and demonstrate improvement year on year, all the while keeping up with evolving risks.

In addition to the right tools, utility companies need the right mindset. Powerline inspection must be viewed as a strategic function at all levels – particularly by senior management – rather than a tactical maintenance task. Institutional silos must be broken down in order to maximize data value.

By taking this approach, spend shifts from operating expenses (OPEX) – in the sense of day-to-day trouble shooting – to capital expenditures (CAPEX) – an arguably more valuable, sustainable approach as an investment in powerline inspection capabilities that provide a framework of long-term success for utilities.

> **“Powerline inspection must be viewed as a strategic function at all levels – particularly by senior management – rather than a tactical maintenance task”**

Developed with utilities, for utilities

Utilities need a partner that can support them on the road ahead, from an efficiency and productivity point of view, but also importantly when it comes to operating in an increasingly volatile climate scenario.

Sharper Shape is already helping T&D electric utilites in the US and further afield globally navigate the impacts of climate change, accelerate their journey to net zero, improve grid resiliency and enhance overall operational performance. Our technology helps utilities to minimize risks both of and from extreme weather events, such as wildfires.

As a global provider of automated aerial inspection and asset intelligence software solutions, we focus on Infrastructure Resource Management, with an emphasis on the electric utility industry.

For utilities, we provide cutting edge answers for these crucial operational needs:

How to continuously secure the flow of power:

- To know everything that goes on in the network, plan ahead in an optimized way, while taking the highest levels of safety, efficiency and accuracy.
- Being fully compliant and keeping the network interruptions as short as possible to reduce penalty fees.

How to do it as cost effectively as possible:

- The need to optimize OPEX budget network planning, risk assessments and smart decision making.
- The need to get the maximum value from data.
- The need to be as profitable and compliant as possible, while maintaining a high public opinion and customer satisfaction.

Sharper Shape's unique technologies have been developed with utilities for utilities to answer their specific pain points and needs while upgrading their system maintenance programs to increase safety, enhance efficiency and reduce costs.

Our flagship solution Sharper CORE uniquely collates all automated collection, inspection and reporting capabilities in a single, powerful AI and ML- driven software platform, providing the utility with a 4D Living Digital Twin.

While other solutions use visualization and storage methodologies, we have architected Sharper CORE to be a true Living Digital Twin; a 4D, AI, and cloud-based model of utility and critical infrastructure assets, that enables capabilities far beyond traditional visualization. As infrastructure assets and the surrounding environment change, our LDT captures these changes and updates them in near real-time, able to ingest and incorporate all ongoing data collections by any third party, from the ground and the air. The real-time digital twin brings temporal insights to the operators on a scale previously unseen.

Combined with our innovative aerial sensor imaging payload, cutting-edge AI and ML algorithms provide wildfire risk assessment, specific asset preventative maintenance and UVM prescriptions. In fact, the LDT allows us to predict and simulate risks at network and circuit area levels, right down to spans and individual component issues. This enhances planning on where and when to allocate maintenance budgets for optimal risk mitigation. We then work closely with utility companies to ensure preventative maintenance and vegetation management plans can be followed, thereby ensuring that wildland fire risk is mitigated, greenhouse gas emissions are reduced, and our electric network is 'hardened'.

The future is in the power of data – and how effectively it is used. That's why we are committed to helping utilities evolve and positively impact their collection, inspection and reporting capabilities through the use of LDTs. In doing so, we ensure that down the road, utilities will be able to fully utilize the benefits offered by this innovative technology.

As our clients continue to evolve, so do our products, integrating more cloud-based computing, storage, and AI cognitive algorithms to enhance insights and reduce delivery times. We are adding new capabilities that were not possible even a few years ago, using

sharper intelligence, to create a safer world.