System Hardening and Vegetation Management

Key Trends in the U.S. Electric Distribution Systems

Objectives of the presentation

01

Setting the Context:
Rising risks in U.S. electric distribution systems

02

Strategies in Focus:
Approaches to address these emerging challenges

03

Need for Granular Data:
Why detailed insights are becoming critical

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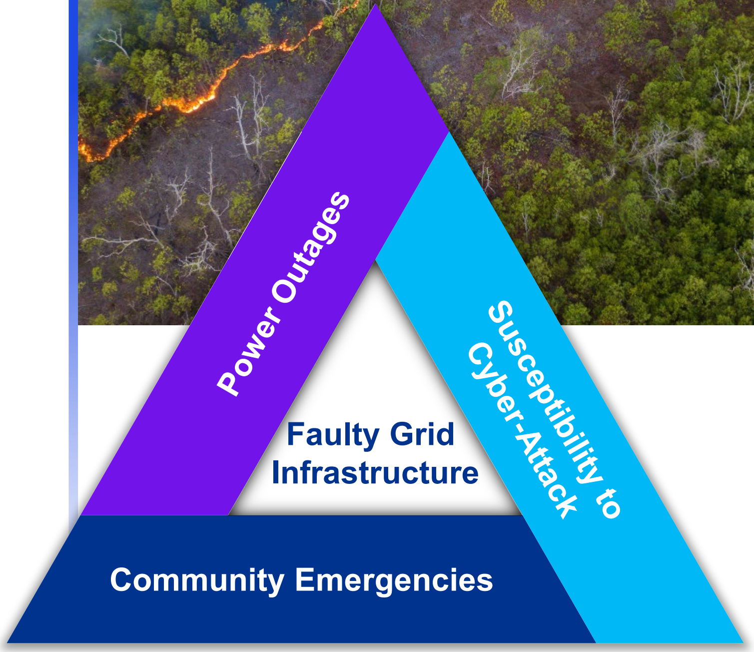
Extreme weather, wildfires risks and aging infrastructure are driving unprecedented investment in grid resilience

- In the past five years, U.S. electric utilities have faced mounting threats from wildfires, hurricanes, and aging equipment.
- These challenges have made **grid resilience a top priority**, prompting utilities to accelerate investments in system hardening and vegetation management.

Grid infrastructure investment has increased over the past decade and is expected to continue growing over the next 5 – 10 years[1]

~$60B	*U.S utility distribution CapEx spend in 2024*
~$203B	*Projected U.S. utility distribution CapEx spend between 2025 – 2027 [2]*
~23%	*Investments directed to underground distribution infrastructure in 2023, growing more than double in the last 20 years*
$8B+	*Spent annually on vegetation management*



Over 70% of U.S. T&D lines are 25+ years old, leading to more frequent equipment failures as infrastructure nears the end of its lifespan

Source: [1]U.S. Energy Information Administration (EIA), Department of Energy (DOE), [2]EEI, KPMG analysis, select utility rate cases, EIA, [3]What does it take to modernize the U.S. electric grid? | Department of Energy

To address the growing risks utilities are deploying a range of complementary strategies

1

Undergrounding

2

Pole Hardening

3

Covered Conductors & Spacers

4

ADMS / FLISR

(Advanced Distribution Management System & Fault Location, Isolation, and Service Restoration)

5

Sensors

6

Vegetation Management

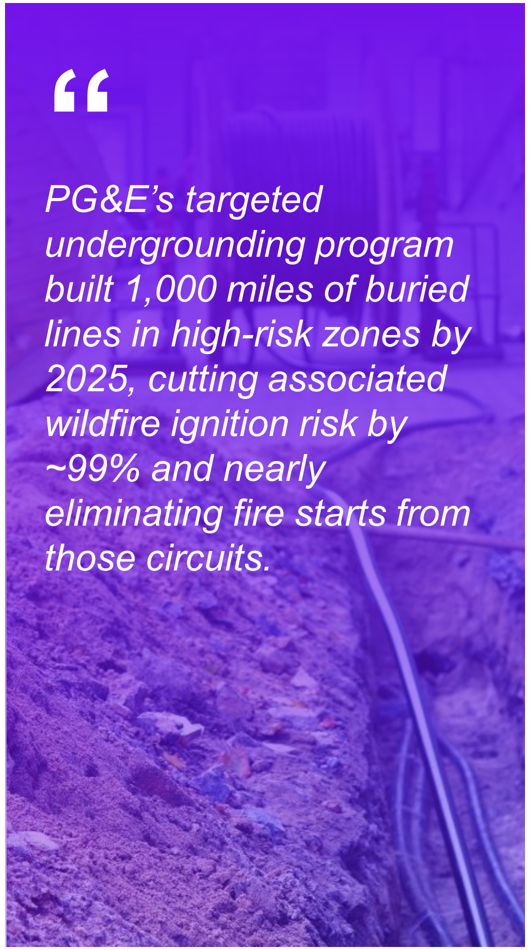
Utilities across the country – from hurricane-prone Florida to wildfire-threatened California – have invested heavily in these approaches, supported by new technologies for inspection and maintenance.

Undergrounding delivers the highest reliability and wildfire protection, but requires targeted investment due to high costs and complexity

Key Innovations & Trends

Utilities are advancing undergrounding by leveraging **targeted, technology-driven** strategies to maximize resilience and cost-effectiveness:

- **Targeted undergrounding** of high-risk circuits
- **Efficient trenching** to cut costs and speed up construction
- **Smart fault detection** for faster restoration
- **Hybrid hardening:** Underground + overhead upgrades for optimal resilience



Advantages

- **Reliability:** Cuts storm-related outages by up to 95%
- **Wildfire risk:** Reduces ignition risk by up to 99%
- **Storm resilience:** Outage rates as low as 4% vs. 24% overhead; restoration drops from days to hours

Key Considerations

- **High cost & long timelines:** Planning + construction often 3–4 years
- **Repair complexity:** Faults are rare but harder to locate; require excavation & specialized crews
- **Geographic limits:** Unsuitable for flood-prone or dense urban areas

Typical Costs

- **Cost range:** \$0.2M–\$6M per mile (recent CA projects avg. \$3.1M/mile after innovations)
- **Relative cost:** Undergrounding is 3–10x overhead hardening and ~3x covered overhead wire

Source: U.S. Energy Information Administration (EIA), Thousands of PG&E Customers Now Protected from Wildfires as 1,000 Miles of Powerlines are Energized and Underground, LBL-ETA: Grid Resilience

Pole hardening boosts grid resilience to storms and wildfires, however, requires smart prioritization and investment in advanced materials and inspection

Key Innovations & Trends

Utilities are modernizing pole infrastructure by adopting advanced materials and data-driven maintenance:

- **Condition-based inspections** to assess pole health using AI and advanced tools
- **Reinforcement technologies** with steel rods, fiberglass wraps, and preservative bandages
- **Material upgrades** replacing wood poles with steel, concrete, or composites
- **Digital inspection tools** like drones, LiDAR, and infrared for high-accuracy checks

Advantages

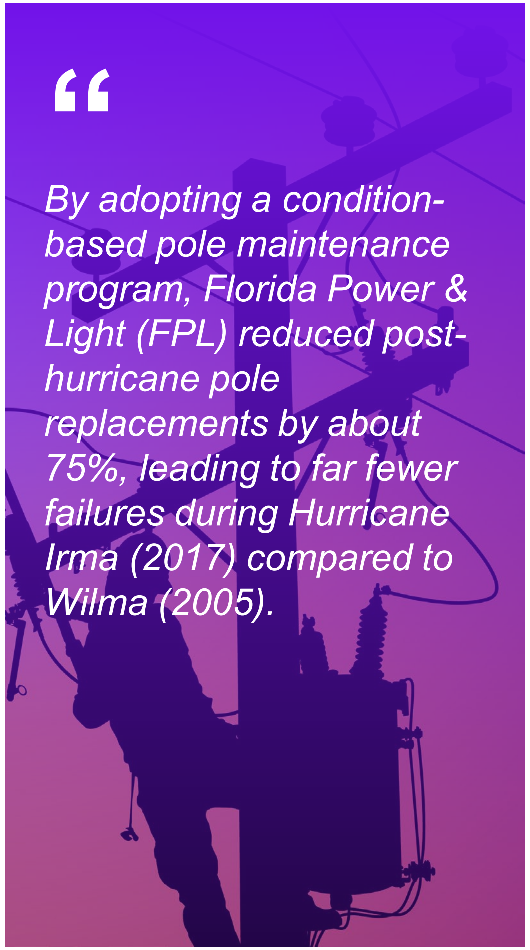
- **Enhanced reliability:** Cuts post-storm replacements up to 18x, outages by 5x
- **Longer asset life:** Reinforced poles need fewer replacements
- **Storm/fire resilience:** Steel & composites withstand extreme conditions

Key Considerations

- **High cost:** Advanced poles are expensive; prioritize critical areas
- **Logistics:** Heavier poles harder to transport & install
- **Inspection accuracy:** Data-driven checks essential
- **Integration:** Combine with other grid upgrades for best results

Typical Costs

- **Distribution poles:** \$500–\$10K per pole
- **Transmission poles:** ~\$37K per mile
- Non-wood poles **2–10x costlier; composites 5–10x** more than wood



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By adopting a condition-based pole maintenance program, Florida Power & Light (FPL) reduced post-hurricane pole replacements by about 75%, leading to far fewer failures during Hurricane Irma (2017) compared to Wilma (2005).

Source: U.S. Energy Information Administration (EIA), US DOE- Utility Pole Maintenance and Upgrades, LBL-ETA: Grid Resilience

Covered conductors and spacer cables sharply reduce wildfire and outage risks, providing a faster, lower-cost alternative to undergrounding in high-risk areas

Key Innovations & Trends

Utilities are rapidly deploying covered conductors and spacer cables to harden overhead lines, especially in wildfire-prone and heavily vegetated regions:

- **Multi-layer insulation** to prevent short circuits and arcing
- **Spacer cable systems** for bundled, weather-resistant conductors
- **Targeted deployment** using analytics for high-risk circuits
- **Advanced inspection** with drones, LiDAR, and infrared imaging

Advantages

- **Wildfire risk reduction:** Cuts ignition risk by 60–98%
- **Outage prevention:** Up to 67–90% fewer storm/tree-related outages
- **Rapid deployment:** Faster and cheaper than undergrounding

Key Considerations

- **Upfront cost:** Higher than bare wire; may need hardware upgrades
- **Not a full substitute:** Extreme events still need mitigation
- **Operational learning:** Crews need training and monitoring
- **Best for targeted use:** Ideal where undergrounding isn't feasible

Typical Costs

- **Covered conductor:** $630K–$1.43M per mile
- **Spacer cable:** $200K–$777K per mile
- About **one-third the cost of undergrounding**

> "
> *In California, Southern California Edison's rapid deployment of covered conductors achieved a 98% reduction in associated wildfire ignition risk on upgraded lines between 2019 and 2022, demonstrating the technology's effectiveness in high-risk areas.*

Source: U.S. Energy Information Administration (EIA), Utility Wires Investments Resilience Investment Guide, LBL-ETA: Grid Resilience

While ADMS and FLISR enable faster, smarter outage response and grid optimization, these requires significant investment in digital infrastructure and integration

Key Innovations & Trends

Utilities are modernizing grid operations with advanced digital management and automation:

- **Real-time grid visibility** with integrated sensor and smart meter data
- **Automated fault response** for rapid isolation and restoration
- **Integration with DERs** to manage distributed energy resources
- **Predictive analytics** using AI for fault anticipation and optimized switching

Advantages

- **Faster outage restoration:** Cuts duration from hours to minutes
- **Improved reliability:** Reduces outage frequency and impact
- **Operational efficiency:** Enables remote control and supports renewables

Key Considerations

- **High upfront investment:** Sensors, IT, and communications
- **Data complexity:** Managing real-time data at scale
- **Cybersecurity & change management:** Requires robust security and workforce training

Typical Costs

- **ADMS/DERMS:** $10.7–$20.9 per customer
- **Comprehensive modernization:** ~$200 per customer

"

By deploying ADMS and FLISR, Consumers Energy in Michigan enabled automated fault response and remote restoration for thousands of customers, significantly improving reliability and reducing outage durations.

Source: LBL-ETA: Grid Resilience

Sensors and advanced monitoring enable predictive maintenance and rapid grid response, but require careful integration and data management

Key Innovations & Trends

Utilities are deploying a range of advanced sensors and analytics to modernize grid monitoring:

- **Line & pole sensors** to detect faults and monitor structural health
- **Remote sensing** with drones, LiDAR, and infrared for vegetation and line checks
- **AI & predictive analytics** for failure forecasting and maintenance optimization
- **Grid integration** linking sensor data to ADMS/FLISR for automated decisions

Advantages

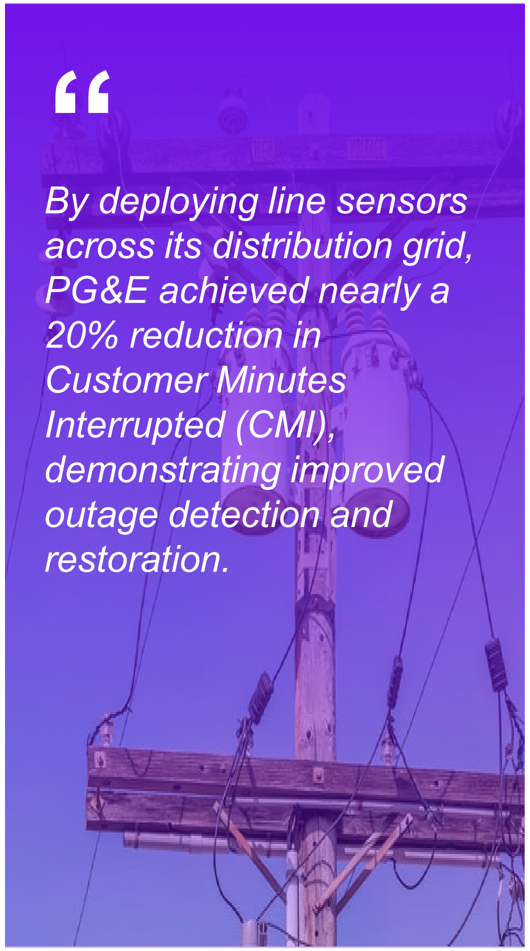
- **Early fault detection:** Identifies issues before outages occur
- **Predictive maintenance:** Targets high-risk assets, reduces manual checks
- **Improved safety & efficiency:** Minimizes crew exposure and speeds post-storm assessments

Key Considerations

- **Integration & data management:** Requires robust systems for large data volumes
- **Upfront investment:** Hardware, communications, and analytics costs
- **Ongoing calibration:** Sensors need regular validation for accuracy

Typical Costs

- **Vegetation monitoring:** LiDAR/drone inspections cost **$1–$2 per mile**
- Costs vary widely by sensor type and application



"By deploying line sensors across its distribution grid, PG&E achieved nearly a 20% reduction in Customer Minutes Interrupted (CMI), demonstrating improved outage detection and restoration.

Source: Utility Wires Investments Resilience Investment Guide, LBL-ETA: Grid Resilience, PG&E Quantifying SAIDI Reduction | Sentient Energy

Vegetation management is evolving with upcoming technologies, delivering major reliability and wildfire risk benefits, and demands ongoing investment

Key Innovations & Trends

Utilities are modernizing vegetation management with advanced technology and analytics:

- **AI-driven risk assessment** using satellite imagery, LiDAR, drones, and machine learning
- **Enhanced clearance programs** for expanded tree trimming and hazard removal
- **Integrated digital tools** combining remote sensing with arborist expertise for proactive management

Advantages

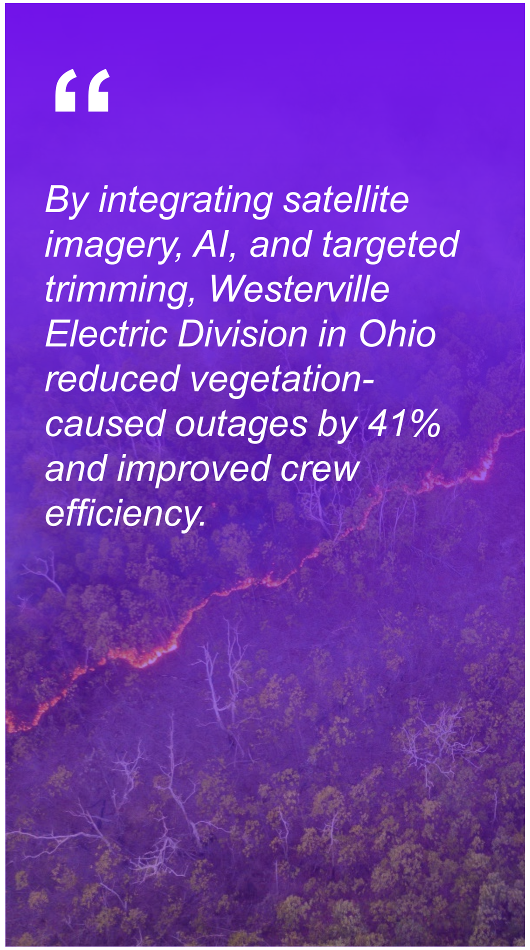
- **Outage reduction:** Cuts vegetation-related outages by 40%+
- **Wildfire mitigation:** Significantly lowers ignition risk
- **Cost-effectiveness:** Targeted trimming maximizes reliability per dollar

Key Considerations

- **Ongoing investment:** Sustained funding for tech and crews
- **Regulatory pressures:** Compliance with standards and public concerns
- **Integration with grid hardening:** Most effective when combined with other resilience strategies

Typical Costs

- **Vegetation management:** $3K–$12K per mile
- **LiDAR inspection:** ~$1.21 per mile
- **Industry spend:** $8B+ annually on vegetation management



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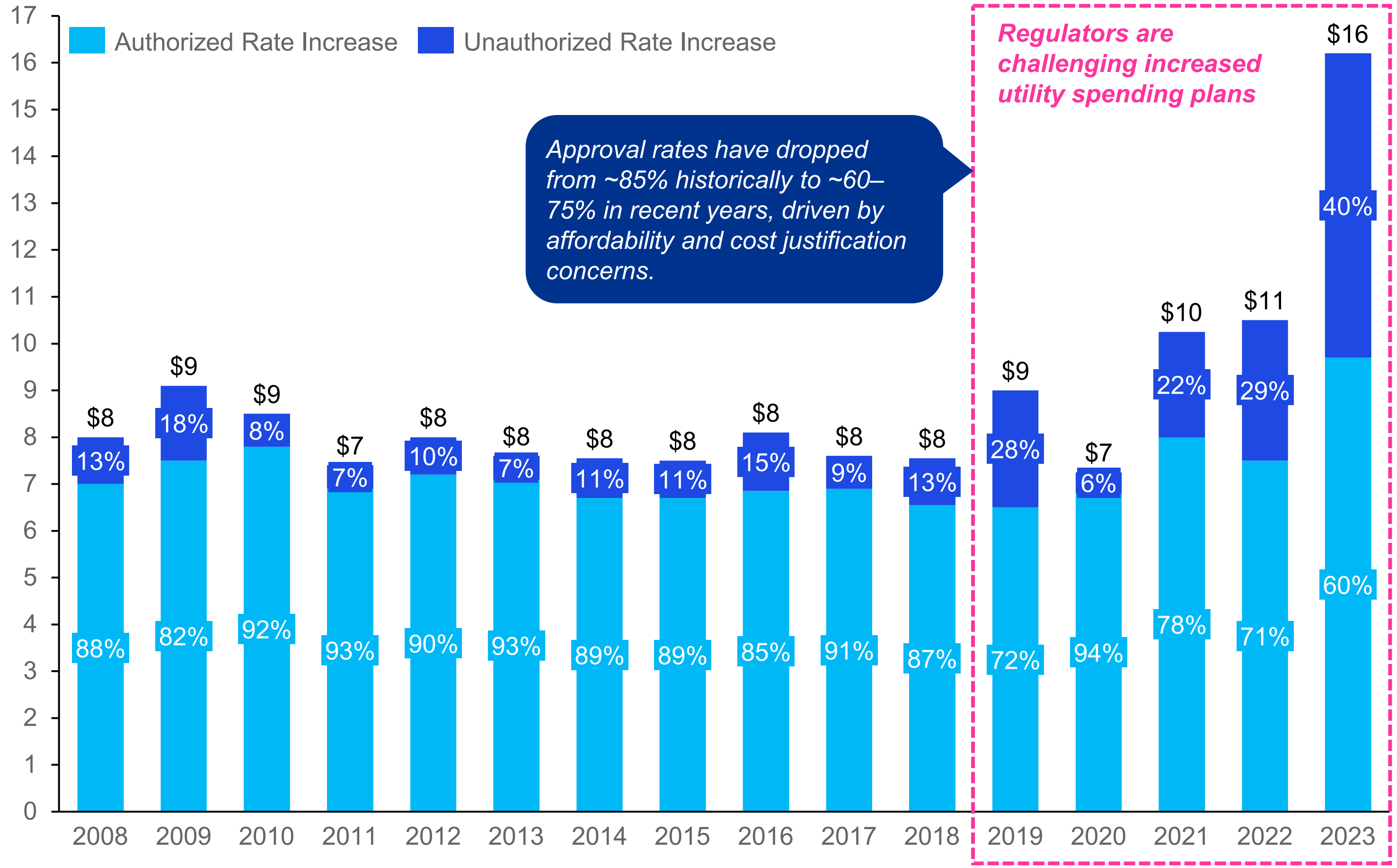
> *By integrating satellite imagery, AI, and targeted trimming, Westerville Electric Division in Ohio reduced vegetation-caused outages by 41% and improved crew efficiency.*

Source: LBL-ETA: Grid Resilience, Modernizing Vegetation Management: How Westerville Electric Divided Embraced Data-Driven Solutions | TD World

While rising demand for grid resilience requires major investment, regulators and customers are pushing back on higher potential rates

Authorized Versus Unauthorized Utility Rate Requests Per Year
$USD Billions



Source: S&P Capital IQ

Top Reasons for Disallowance:

- Insufficient justification (e.g., cost-benefit analysis)
- Lack of evaluation for alternative solutions
- Affordability concerns
- Cost efficiency issues

Granular asset and circuit intelligence enables utilities to justify investments with precision, prioritize high-risk areas, and explore cost-effective alternatives.

Granular asset and circuit intelligence ensures every action delivers maximum impact while improving regulatory justification

System hardening and vegetation management are critical, but without detailed, location-specific intelligence, utilities risk overlooking hidden vulnerabilities, over-investing in low-risk areas, and facing regulatory pushback due to insufficient justification.

Pinpoints high-risk assets and circuits for targeted upgrades

Optimizes investment by focusing resources where they matter most

Enables risk-based decision-making for hardening and vegetation management

Improves reliability and resilience by addressing the true weak spots

Supports regulatory & customer expectations for data-driven, transparent planning

Helps in adapting to changing threats (weather, vegetation, load) in near real-time

AiDASH Company Overview

#1 Most Used
Satellite-powered vegetation mgmt. provider

1M+ Miles
of T&D lines

50 States
& 5 continents

185+
Clients

SOME UTILITIES WE WORK WITH

Avista Corp.	entergy	nationalgrid
Southern Company	Xcel Energy	Your Energy Partner OPPD Omaha Public Power District
The Electric Company El Paso Electric	United Power Your Touchstone Energy Cooperative	**100+ More** Utility Clients

UTILITY INVESTORS

nationalgrid partners	Duke Energy
Edison International	Schneider Electric
Sabanci Ventures	Marubeni

The AiDASH Platform

Helping utilities to keep the "lights on" affordably while mitigating multiple escalating threats

Vegetation Encroachments & Hazard Trees

Increased Failures from Aging Assets

Heightened Storm Frequency & Severity

Growing Risk of Utility-Related Wildfires

AiDASH

Asset Inspection & Monitoring System (AIMS) for grids

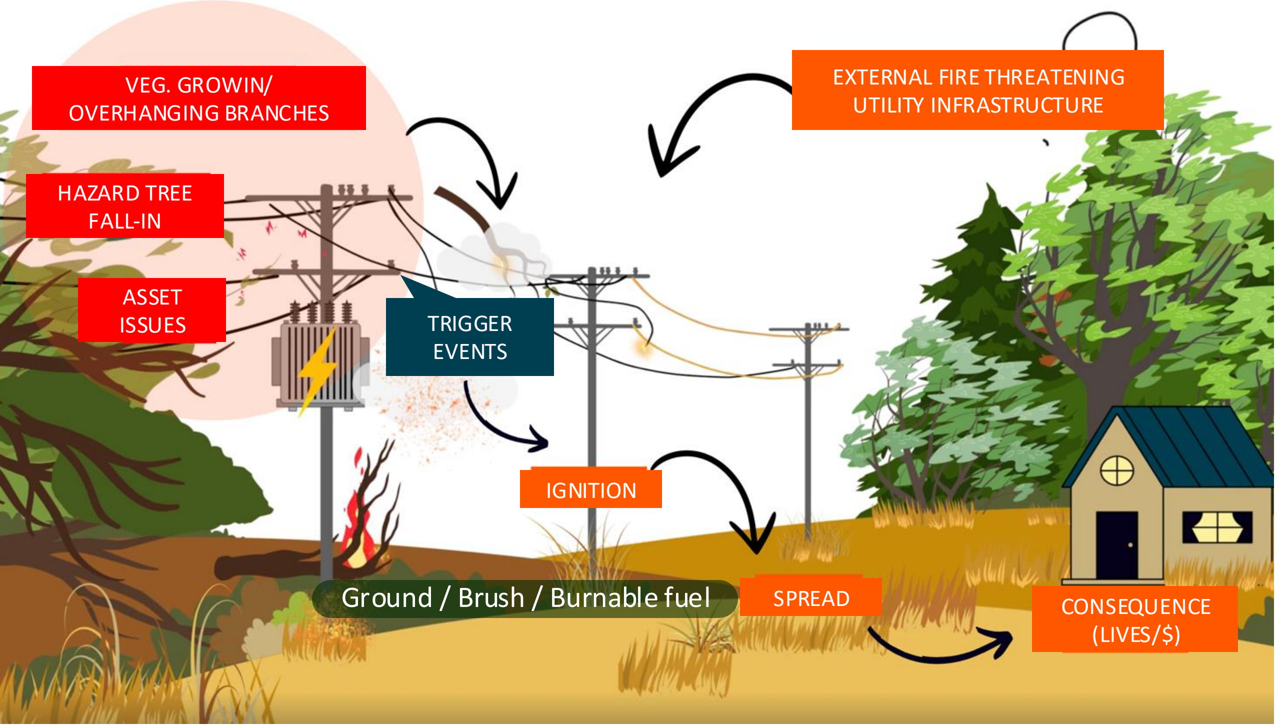
Building on the AiDASH DNA of solving big problems for utilities

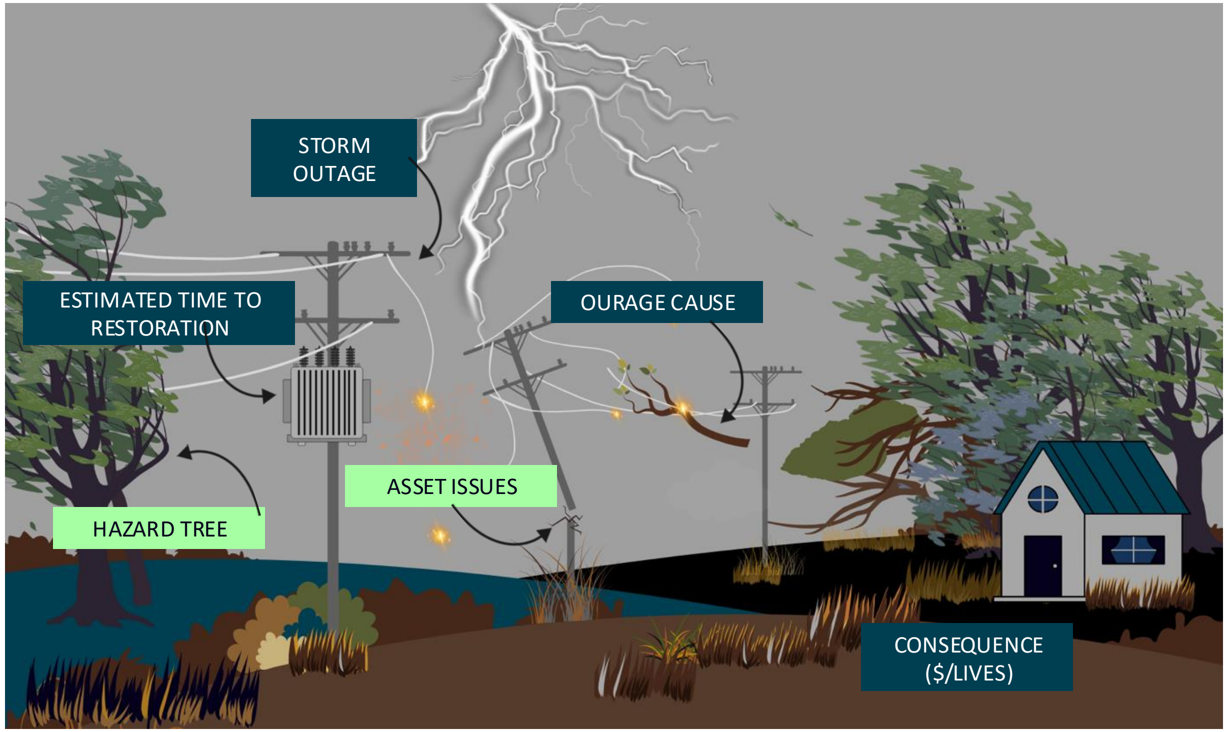
Customer Need	*"Vegetation management is my biggest O&M expense, yet still my biggest cause for outages"*	*"80% of our outages during storms are caused by trees"*	*"Wildfire mitigation is a critical imperative for us and our customers"*	*"While you're looking, what can you tell me about the location and health of my assets?"*
Product	IVMS™ Intelligent Vegetation Management System	CRIS STORM™ Climate Risk Intelligence System	CRIS WILDFIRE™ Climate Risk Intelligence System	AIMS™ Asset Management & Inspection System
Technology	#VegetationAI™	#StormImpactAI™	#IgnitionIntelligence™	#AssetAI™

Vegetation is the threat multiplier: Enabling a prevention-first approach to wildfire and storm mitigation

Key insight: Where vegetation is absent (desert/barren land), these risks virtually disappear

- #1 cause of outages during storms
- Primary source of ignition & fuel for wildfires
- Traditional inspection methods can't keep pace
- Constantly changes (growth, storm, disease)





AiDASH monitors the entire grid using a Satellite-First approach, eliminating blind spots & empowering AiDASH's full stack applications

AiDASH

1 REMOTE SURVEY & DATA GATHERING

Satellite First Scan
– Full Network Scan

High Resolution Multispectral Satellite scans
(1-2 times a year)

- Historic, current & future weather data & predictions
- Utility Data

Need Based additional scan
– Partial network Scan

Satellite	Vehicle	Aerial	Drones	Manual Patrol
(daily/high frequency/ additional scans)	Mounted (Visual and/or LiDAR)	(Visual and /or LiDAR and/or Hyperspectral)	(Visual and / or LiDAR and / or Partial Discharge etc.)	

2 INSIGHTS GENERATION

Ai Models

- VegetationAI™
- AssetAI™
- IgnitionIntelligence™

3 APPLICATIONS

IVMS
Intelligent Vegetation Management System
For smarter, scalable vegetation management

CRIS - STORM
Climate Risk Intelligence System
For proactive storm preparedness and faster response

CRIS - WILDFIRE
Climate Risk Intelligence System
For dynamic ignition and spread modeling and proactive risk mitigation

AIMS
Asset Inspection & Monitoring System
For targeted, risk-based, accurate asset inspections and maintenance

… while optimizing remote grid surveys using the right sensor modality, at the right time and cadence, at the lowest cost — all while accounting for business constraints.

Satellite-first Approach (Full Network Scan)

Comprehensive High-Resolution Scan

(1-2 times annually at highest resolution)

- Terrain Data
- Access/ Accessibility
- Vegetation/ Fuel Load
- Asset Locations

Business Considerations (for additional remote survey planning)

Goals & Use Cases

- Vegetation Management
- Wildfire
- Storm
- Asset health
- Digital twin, conflation, etc.

Criticality for Impact

Budget & Operational Constraints

Optimal Remote Survey Plans (Need-based Additional Scans)

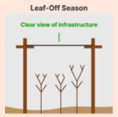
Right data collection & processing at lowest cost

- Additional Satellite Scan multi-spectral / thermal
- Vehicle-mounted Imagery / LiDAR
- Aerial Imagery / LiDAR / Thermal / Hyperspectral
- Drone-based Imagery / LiDAR / Partial Discharge / Thermal
- Manual Patrol

Right Frequency

- Daily for Wildfire mitigation
- Quarterly - Annual for vegetation
- 1-5 years for assets

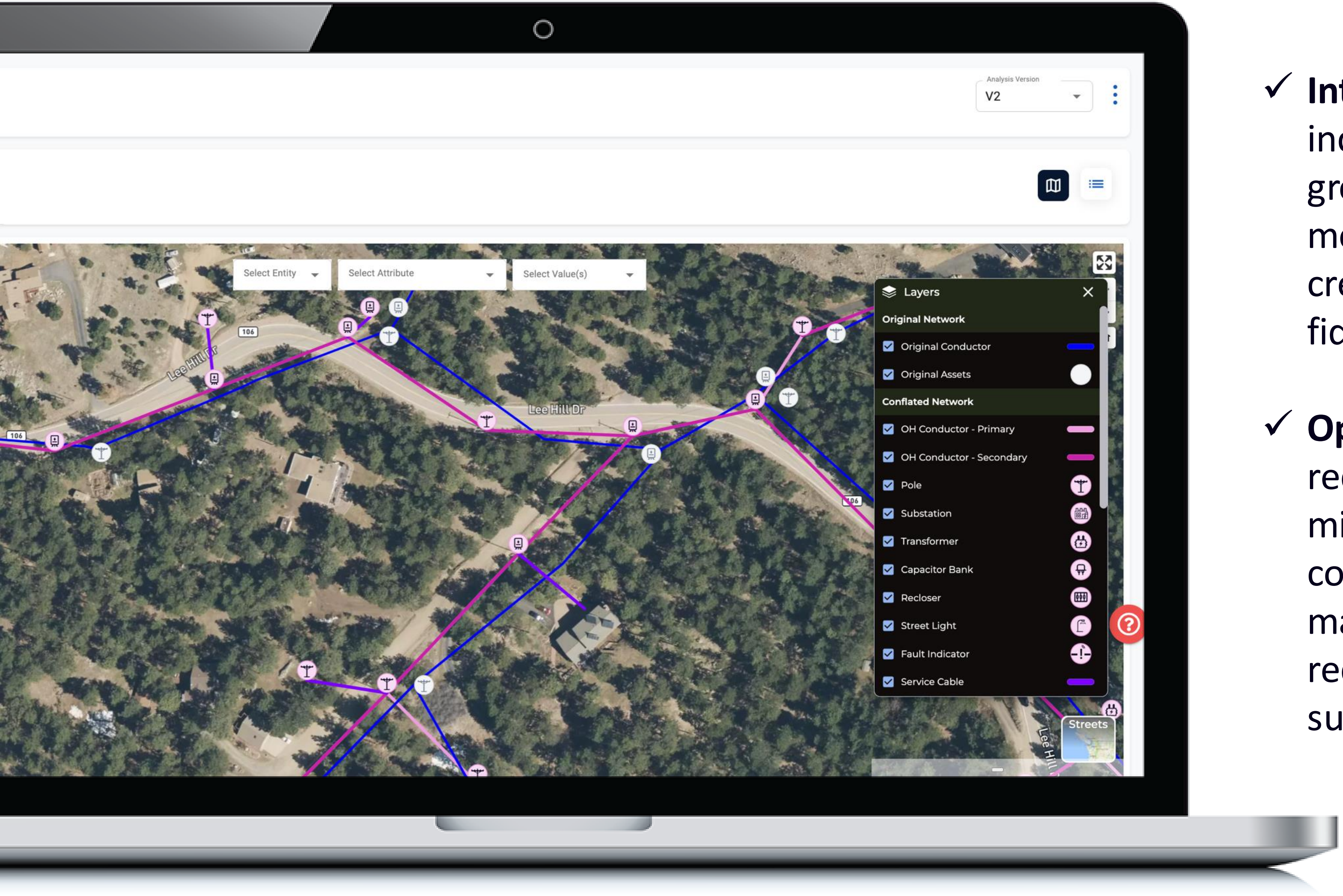
Right Timing for Right Visibility



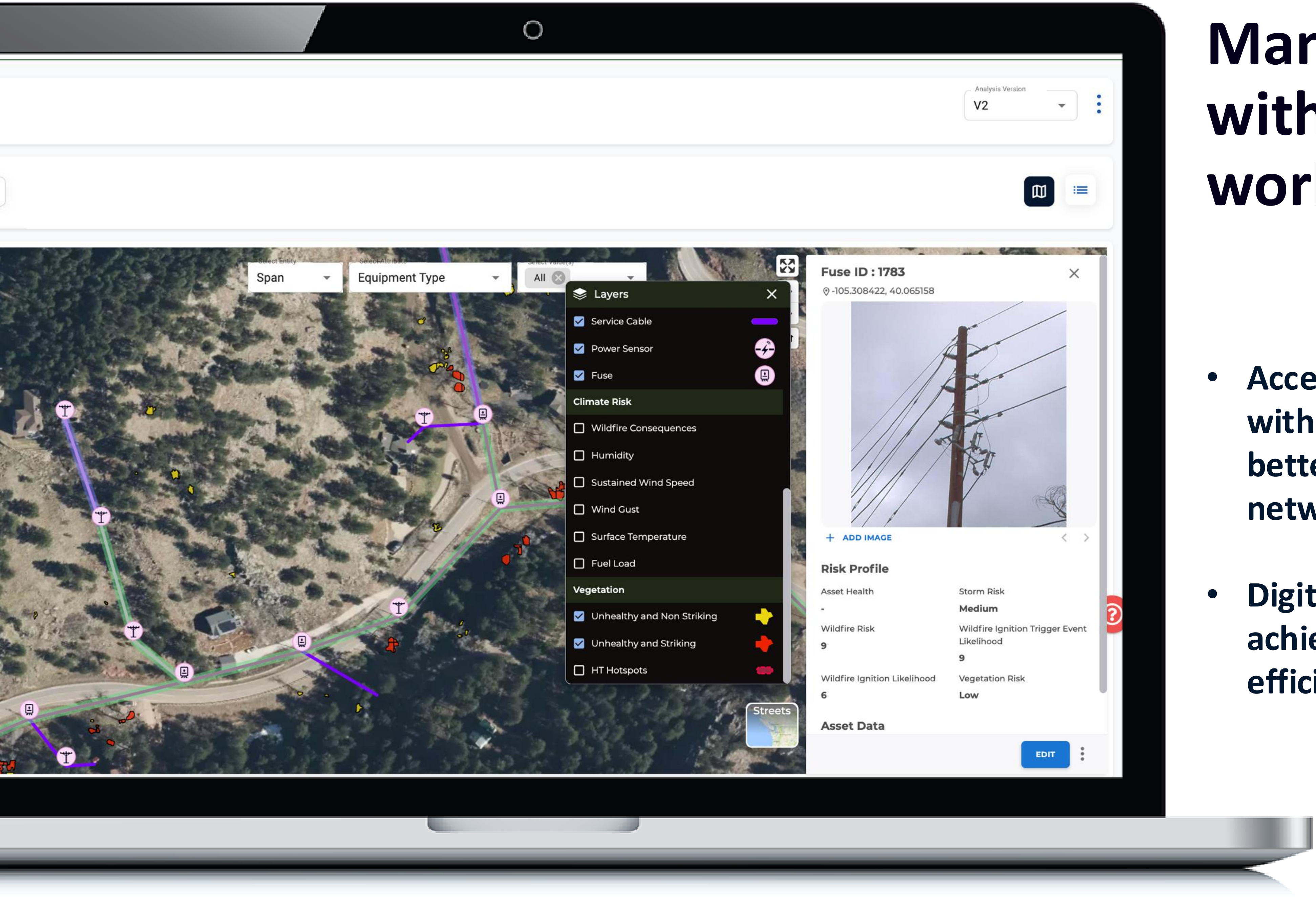
Leaf off for assets

Leaf on for vegetation

Multi-Modal Conflation Process for GIS accuracy of assets



- ✓ **Integrate multiple data sources** including satellite imagery, ground surveys, vehicle-mounted sensors, and LiDAR to create comprehensive, high-fidelity asset maps
- ✓ **Optimize operations** by reducing field survey costs, minimizing data collection complexity, and decreasing manual verification requirements while achieving superior positional accuracy

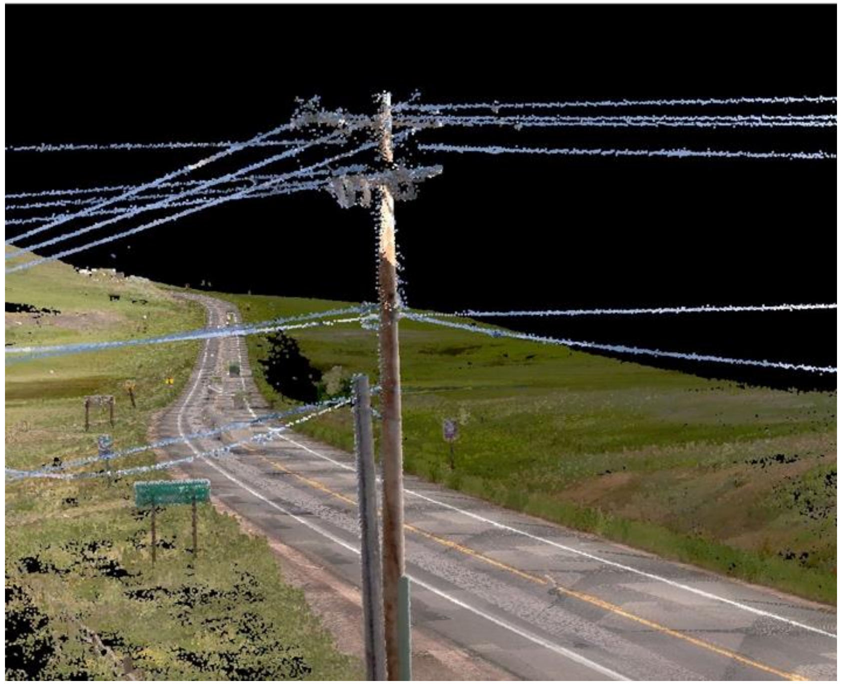


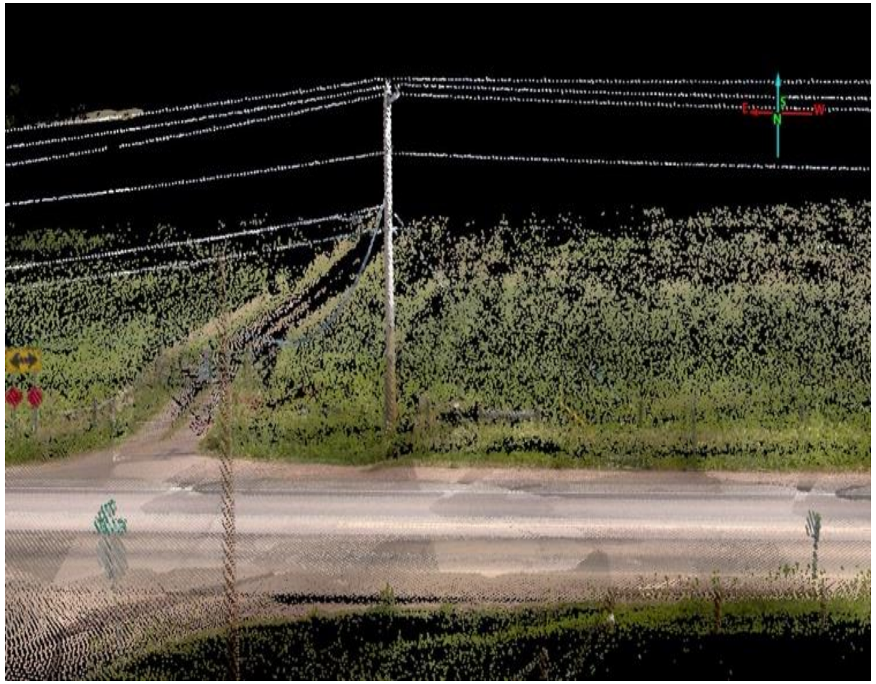
Manage assets with digital workflows

- Access asset level data with latest images to better understand the network
- Digital workflows to achieve operational efficiencies

Visualization of Digital Twin & Assets

- Near perfect digital twin for all the assets
- Accurate snapshot of the entire network with individual asset level visualizations

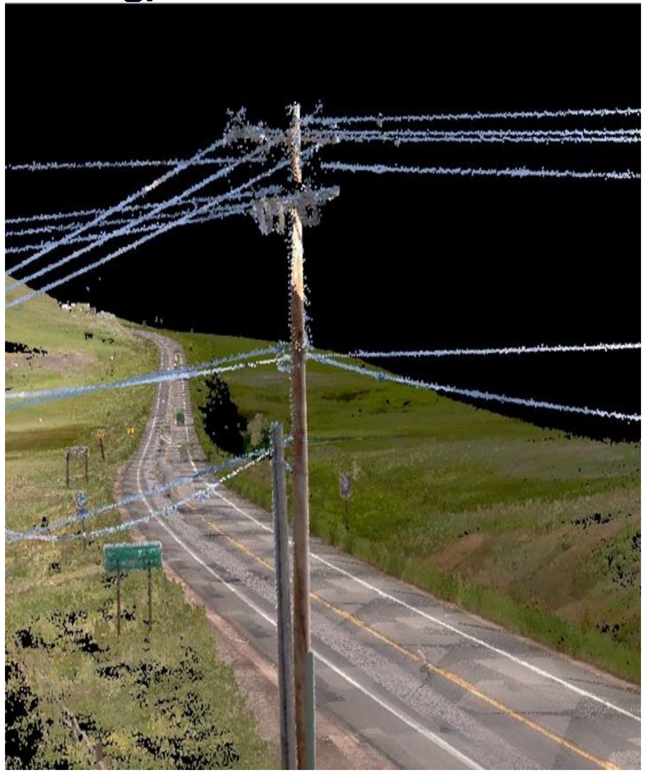




Capture Critical Asset Data for Understanding Asset Health and Modeling Risk

Create a Splice Inventory

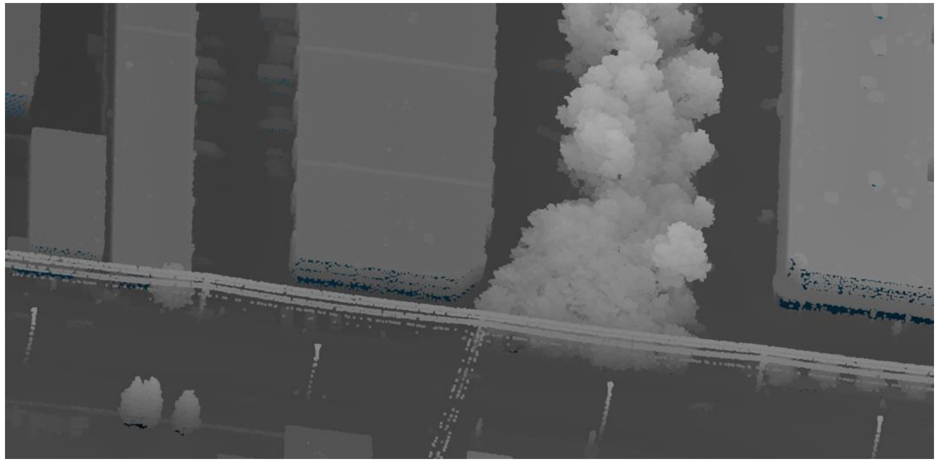
Pole Height/cross-arm config/Pole Attachments



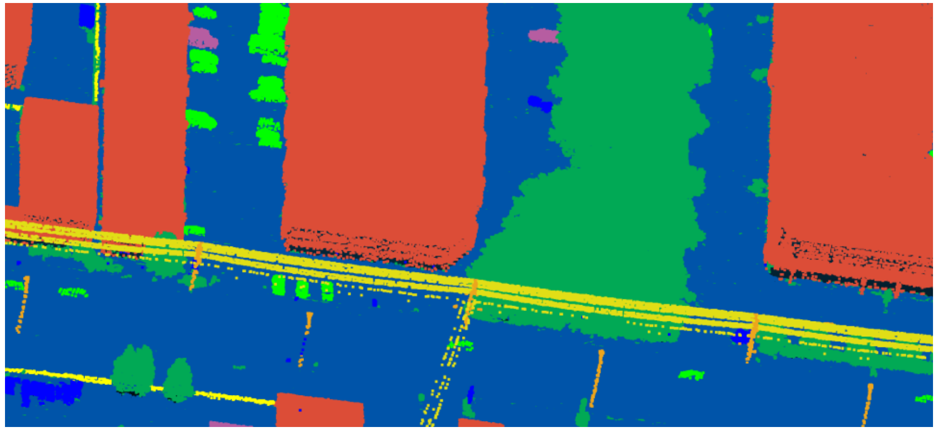
Leaning poles

LiDAR Point Cloud Classification

- **Objective:** To Classify lidar point cloud into multiple classes such as ground, vegetation, buildings, vehicles, utility assets such as poles and wires.
- **Inputs:** unclassified Lidar point cloud
- **Model:** Transformer based model to classify poles and conductors in Lidar point cloud trained over thousands of Lidar tiles.
- **Output:** Point wise classification of point cloud.



Lidar Point Cloud

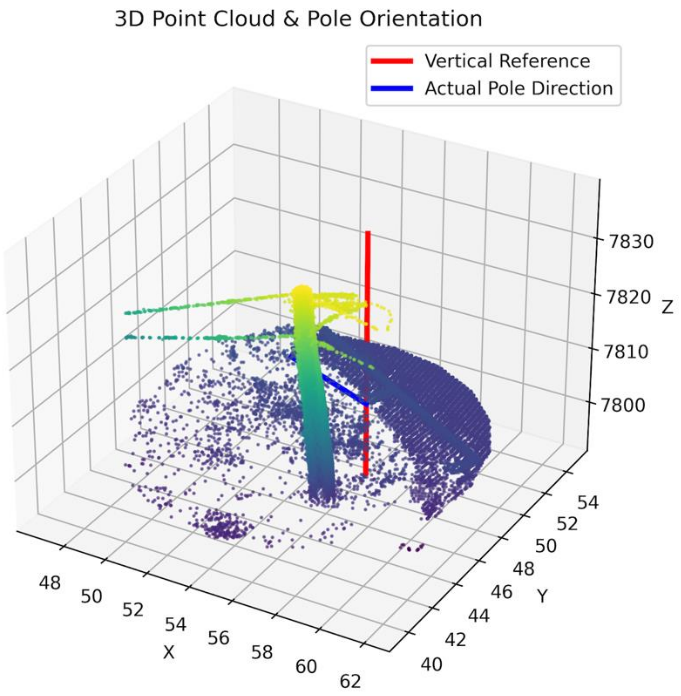


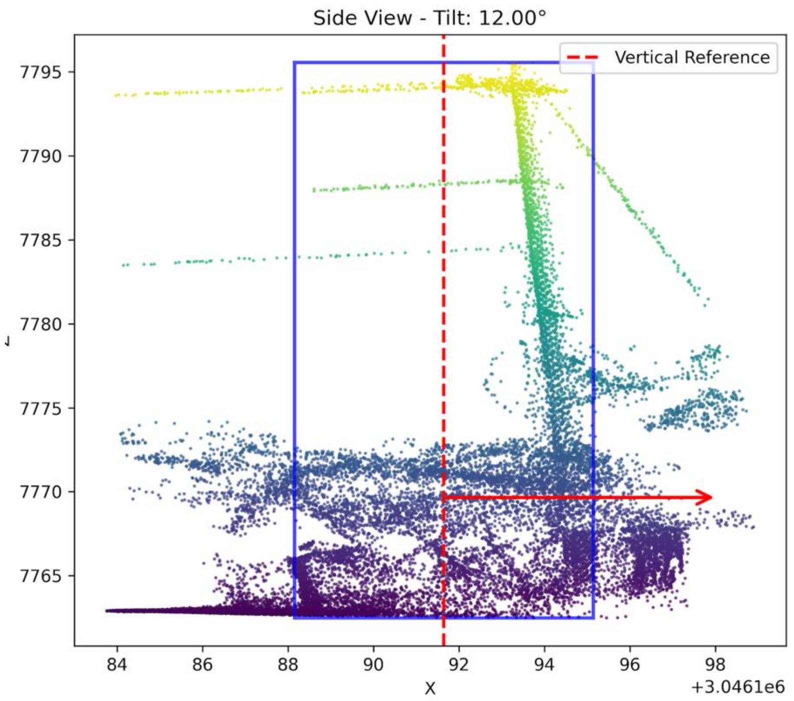
Point Cloud Classification: Wires (yellow), poles (orange), trees(dark green), ground (blue), buildings (red)

AiDASH

Pole Lean Determination

- **Objective:** Segment pole masts in captured imagery, estimate 3D tilt angle and direction.
- **Input:** Vehicle mounted RGB panorama image & Vehicle mounted LiDAR
- **Model:** The model detects the pole and its principal axis which is triangulated from multiple views to estimate the tilt angle of the pole.
- **Output**: Tilt angle per pole is provided

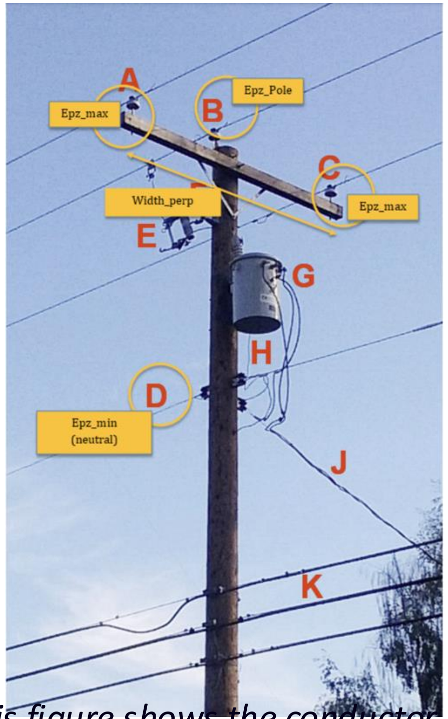




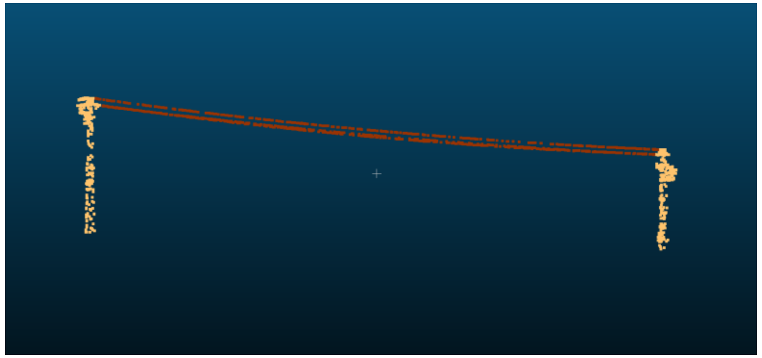
Lean angle is the tilt w.r.t vertical from the ground.

Extraction of Conductor Attributes

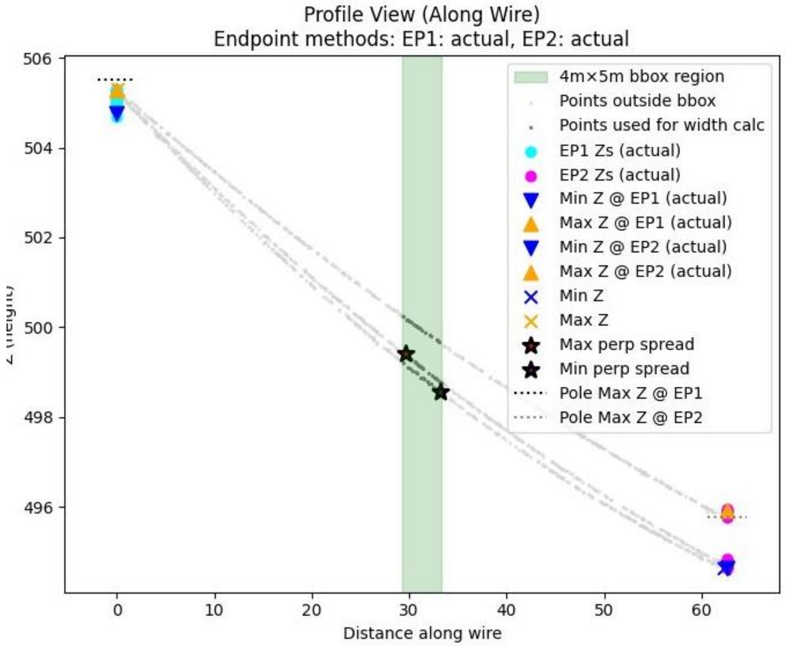
- **Objective:** Automatically derive conductor mechanical properties from LiDAR data.
- **Inputs:** Classified Lidar point cloud
- **Model:** Conductor-span detection and profiling algorithm (endpoint finding, 3-D curve fitting, sag estimation)
- **Output:** Conductor heights, span lengths, and sag measurements.



This figure shows the conductor attributes extracted.



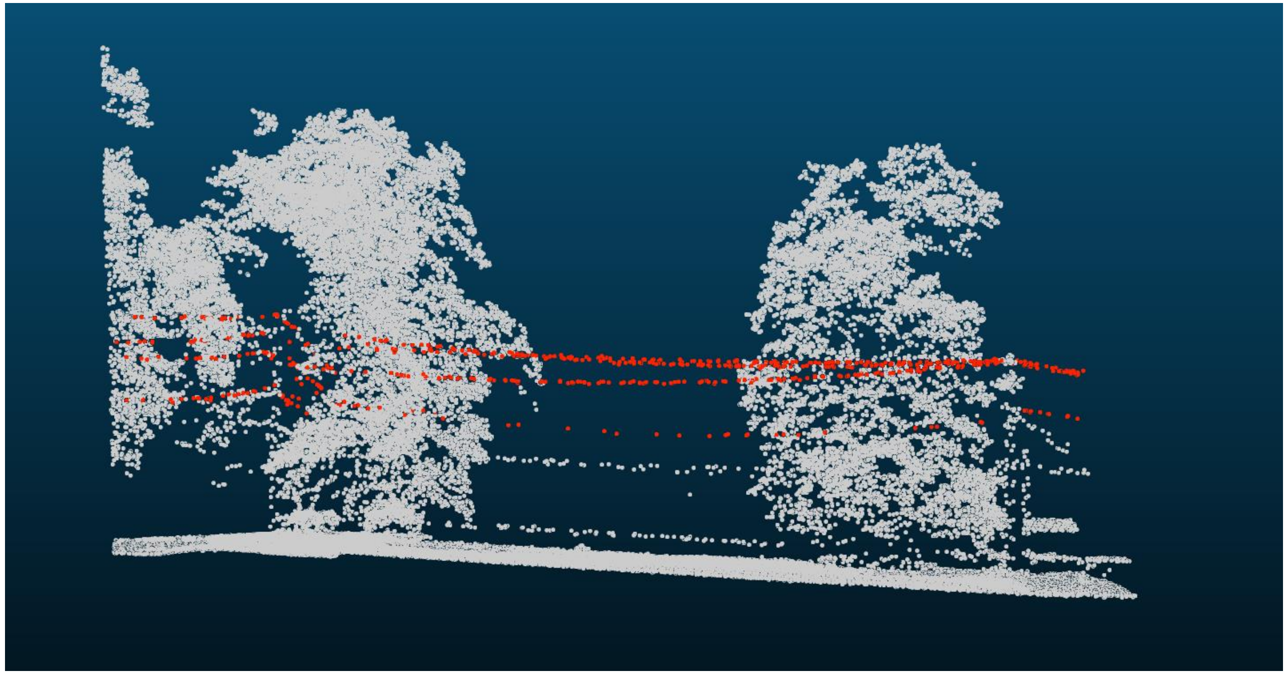
Span extracted in Point Cloud



Estimate configuration, heights, and sag of the conductors.

Extraction of Conductor Configuration

- **Objective:** Automatically derive conductor layout: vertical or horizontal.
- **Inputs:** Classified Lidar point cloud
- **Model:** Conductor-span configuration is detected by using the conductor endpoints and estimating the arrangement.
- **Output:** Wire configuration (cross-arm or vertical)



Vertical Configuration of the wires is detected


THANK YOU
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SECURING TOMORROW