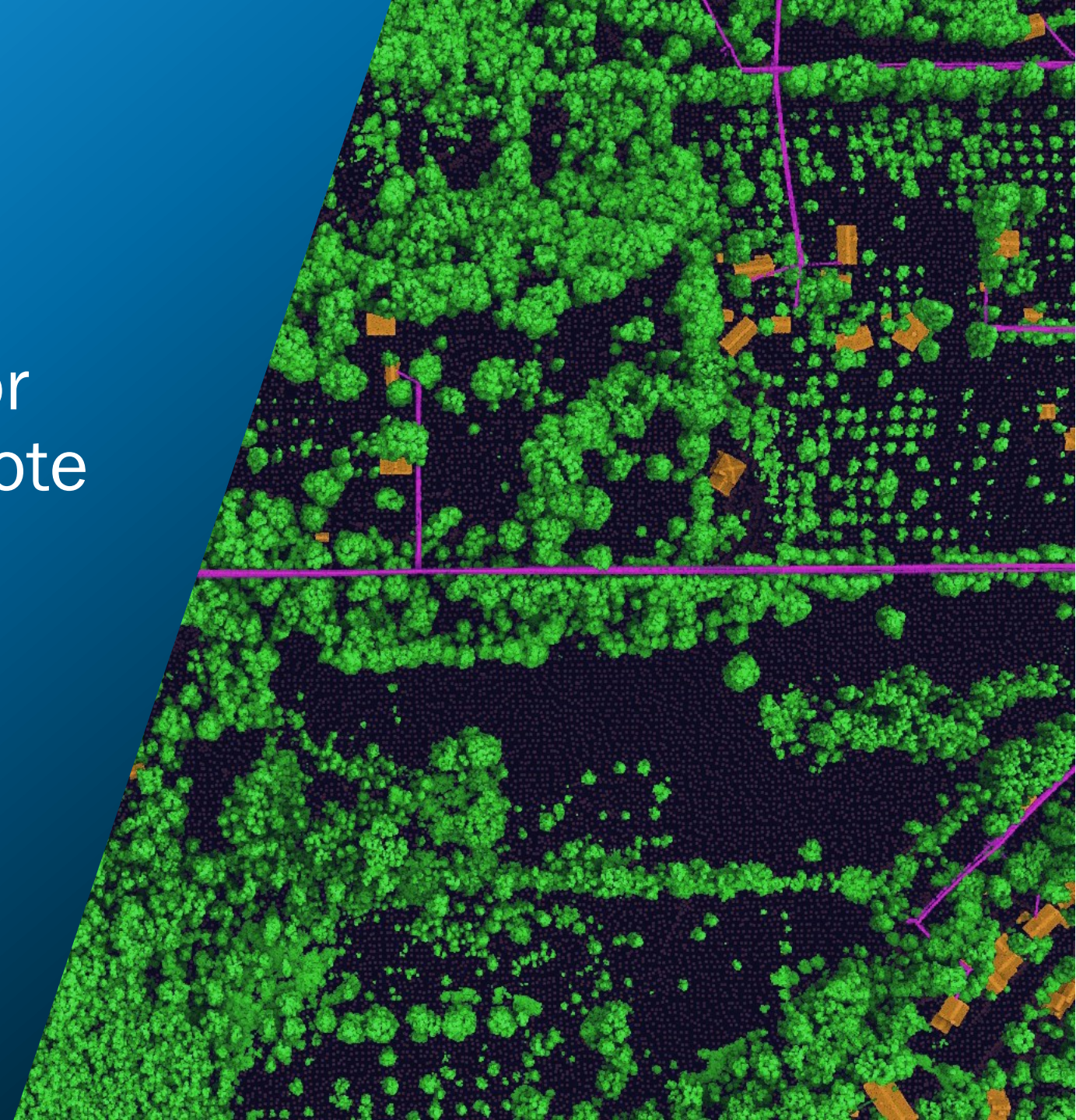


N|V|5 GEOSPATIAL

Vegetation Management for Electric Utilities using Remote Sensing



October 25th, 2023
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907-272-4495

- Vegetation poses risks to electric utility infrastructure to include power outages and wildfires.
- Vegetation management is expensive and time consuming. It takes good data input to plan and execute.
- Every utility is different. Each service area with different customers, ecology, and budgets (risk is different).

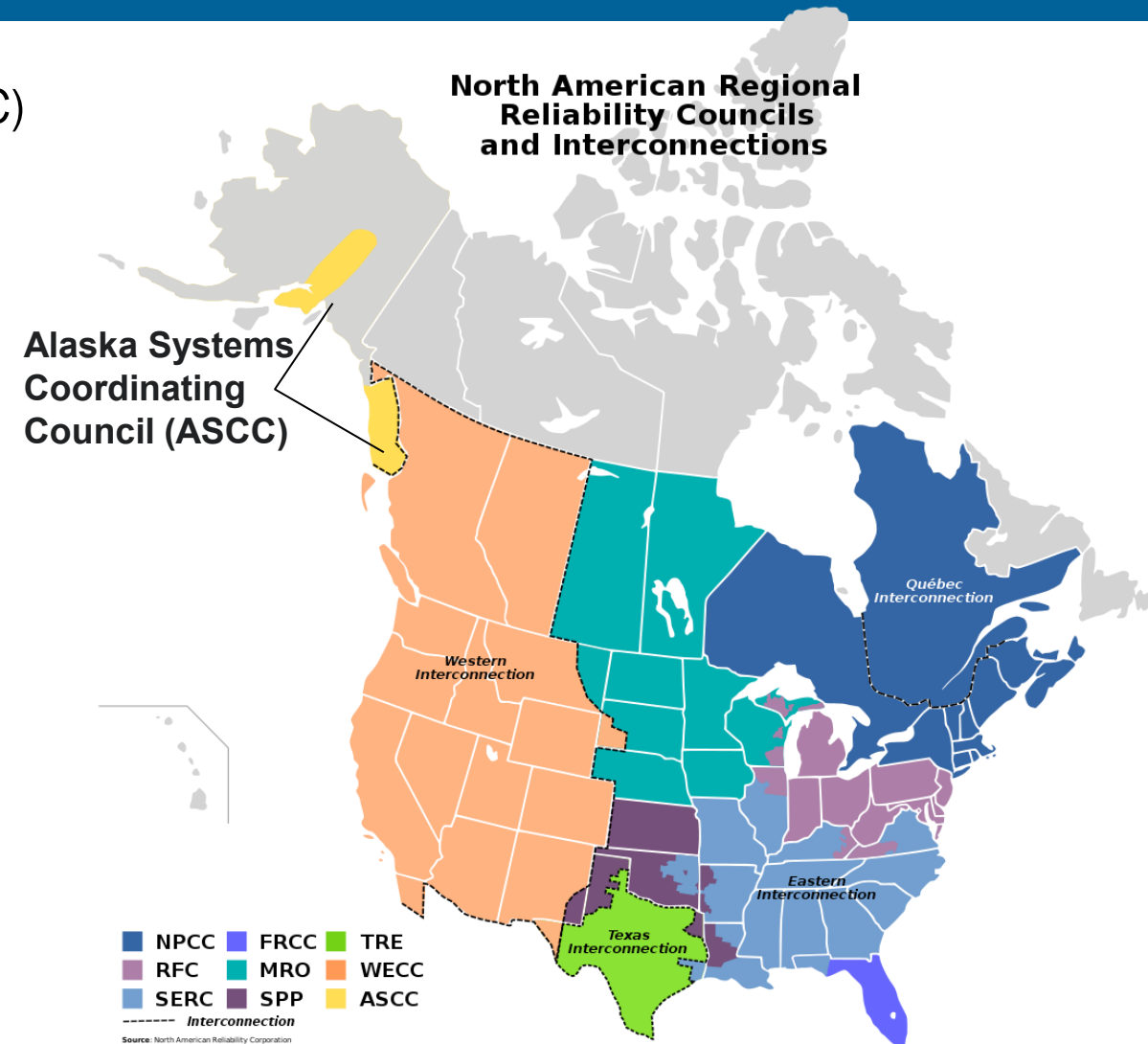


Smoke near power lines on the Kenai Peninsula during the Swan Lake Fire on Aug. 15, 2019. (Matt Tunseth / ADN)

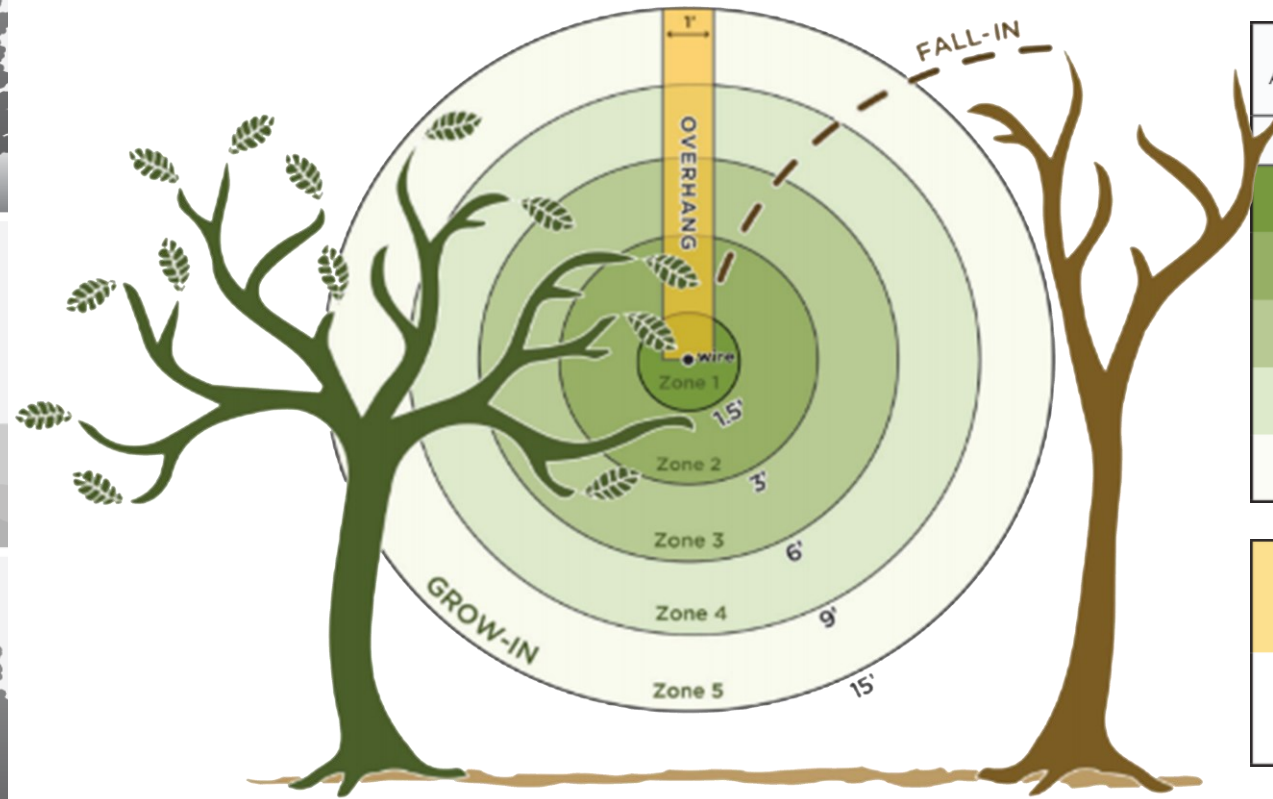
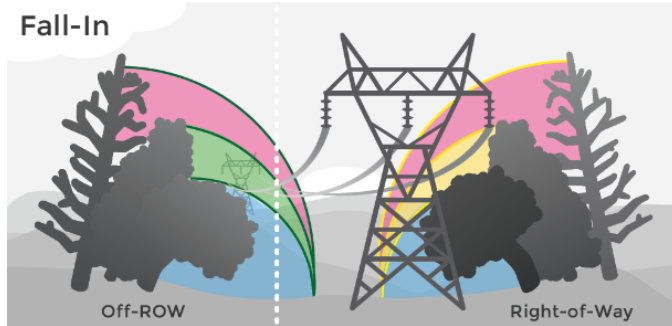
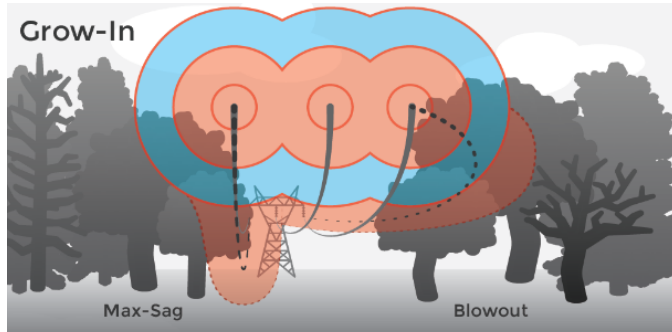
VEGETATION MANAGEMENT STANDARD

North American Electric Reliability Corporation (NERC)

- NERC Reliability Standards define the reliability requirements for planning and operating bulk power systems in North America.
- Outlines vegetation management standards for transmission lines (FAC-003-1).
- Fosters a regional approach through regional reliability councils.



VEGETATION RISK ANALYSIS



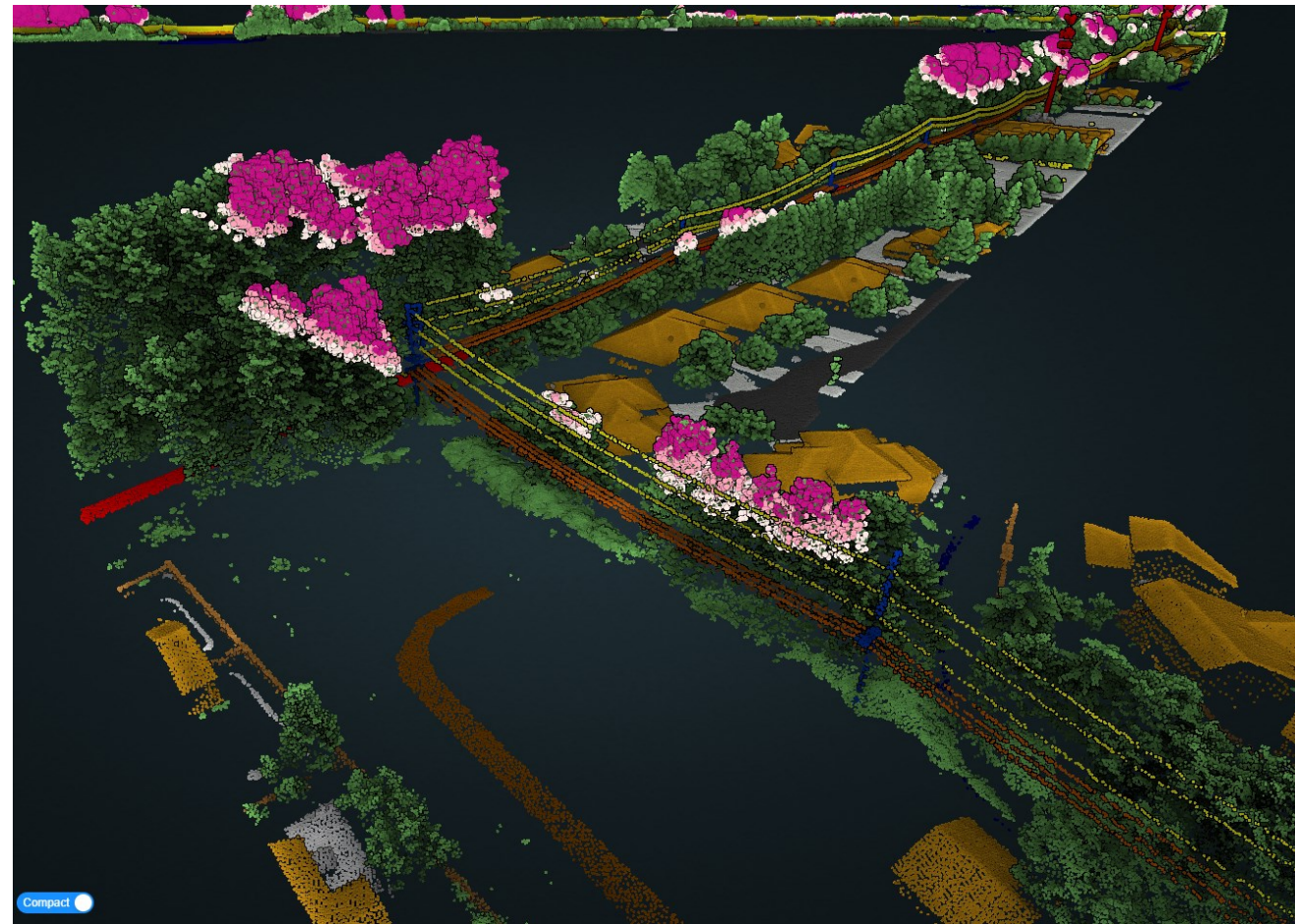
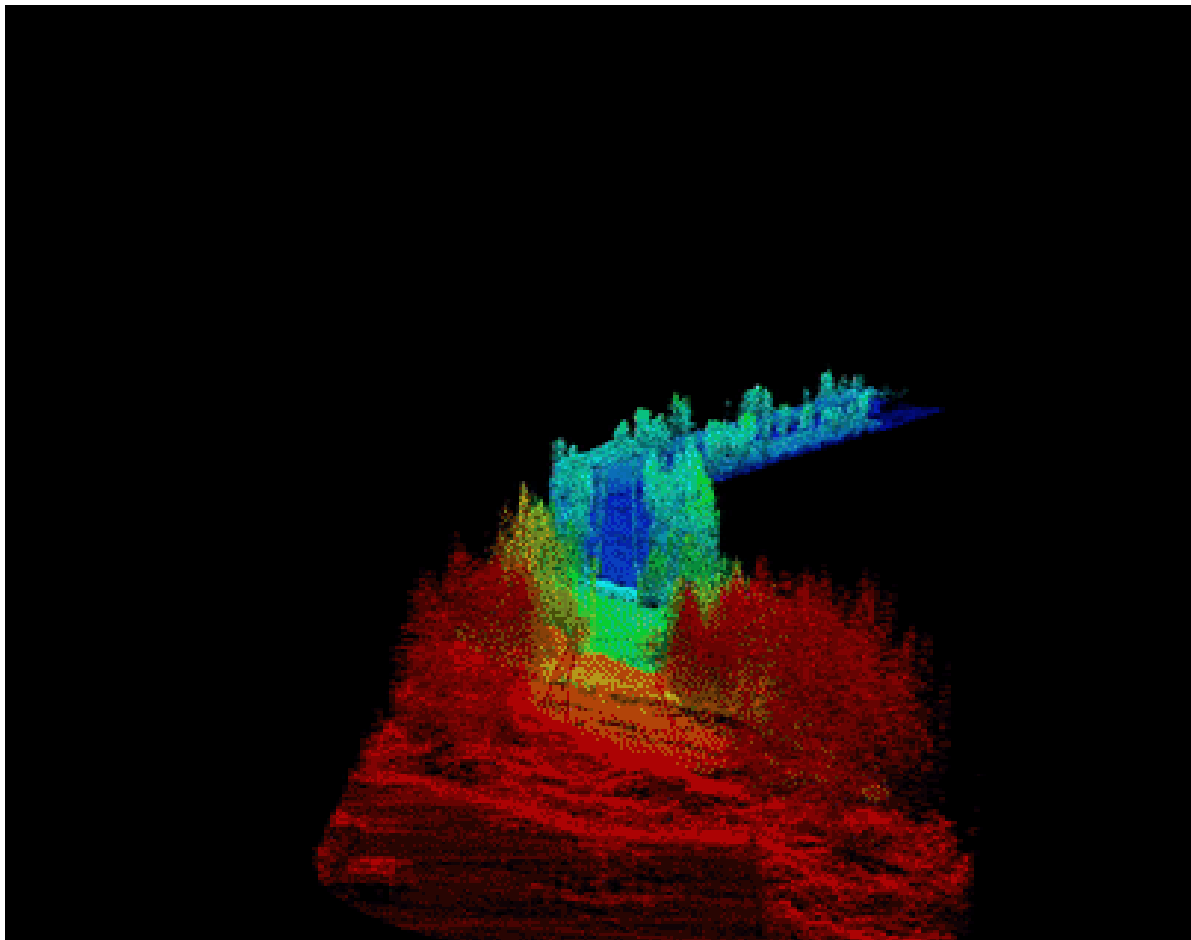
Vegetation Encroachment Categories:
At the time of flight, vegetation was encroaching on a primary wire:

ZONE	DESCRIPTION
1	Within 1.5 ft
2	1.5 - 3 ft
3	3 - 6 ft
4	6 - 9 ft
5	9 - 15 ft

Overhang*: A tree is found to have a branch overhanging up to 15 ft above a wire and within half a foot on either side of the wire

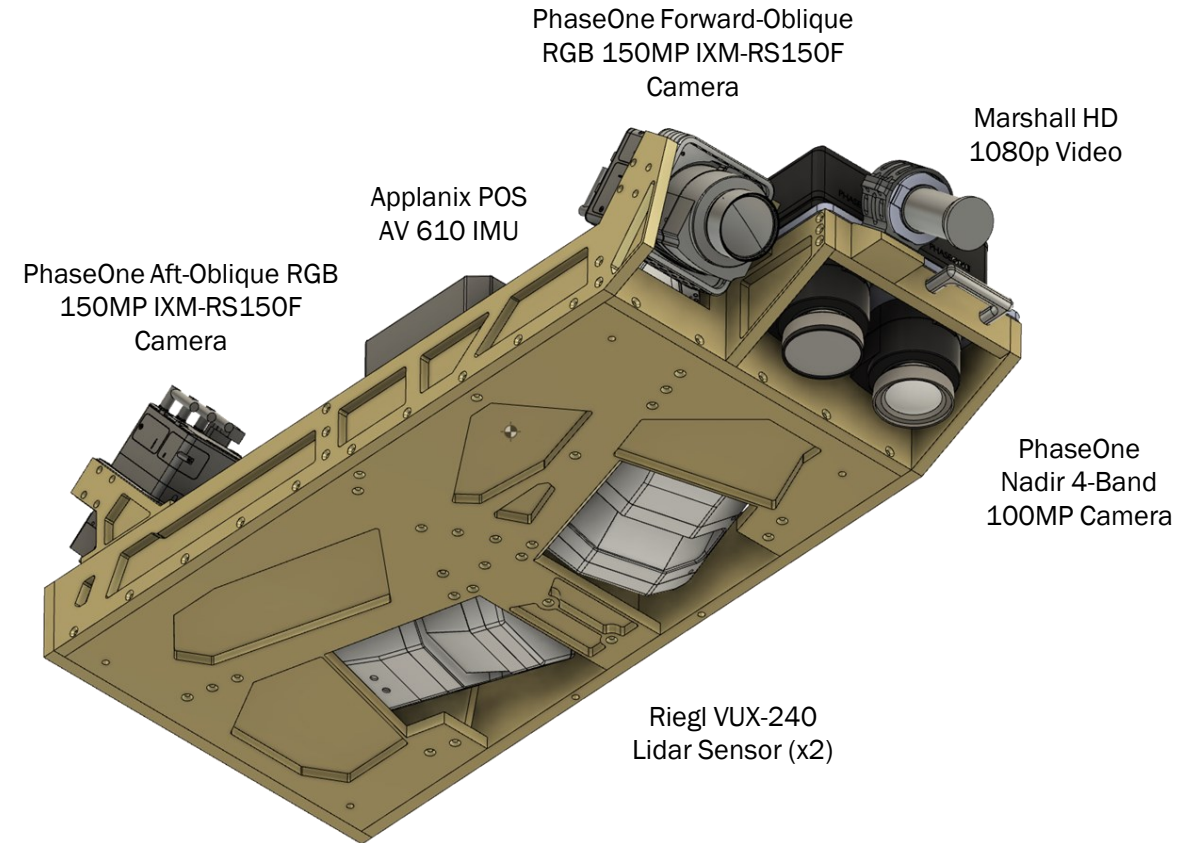
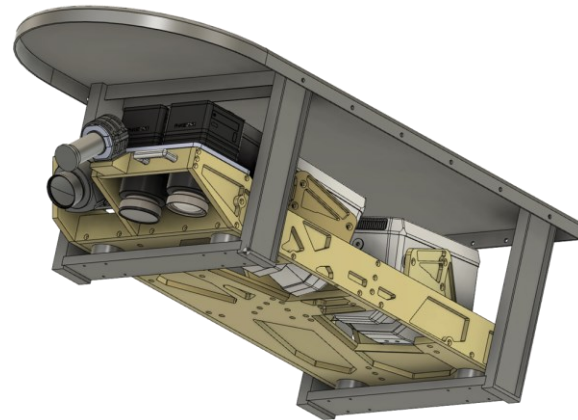
Fall in*: A tree is found to have the potential to fall across the line based on proximity to wire and tree height.

LIDAR FOR VEGETATION ANALYSIS



COMBINED LIDAR AND IMAGERY SENSOR

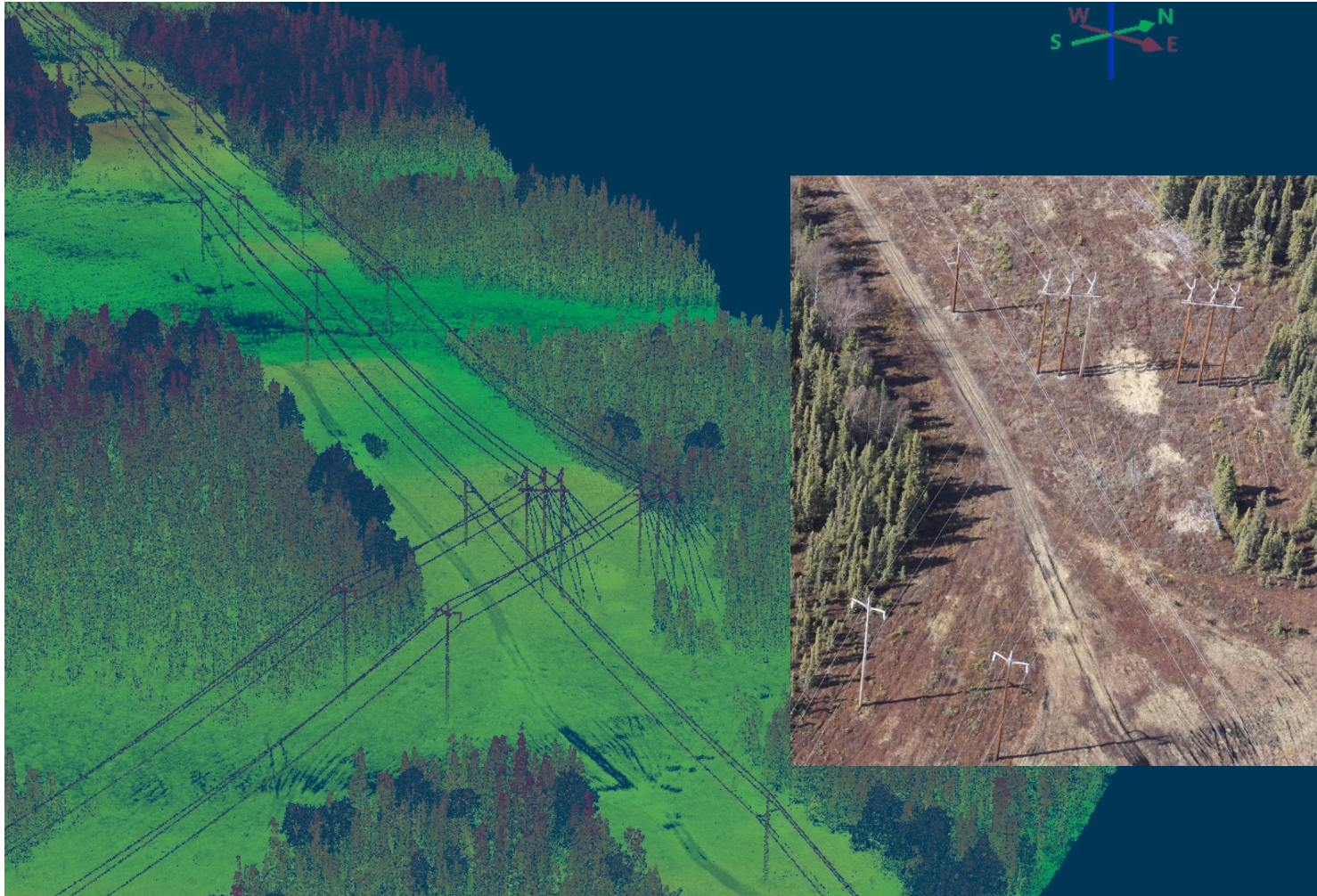
- System suited for transmission line engineering & vegetation management programs in a single platform.
- 1000' AGL @ 80 knots results in a 150 ppm LIDAR point cloud
- 1.4 cm GSD for ortho photos
- 2 cm resolution for obliques



COMBINED LIDAR AND IMAGERY SENSOR



COMBINED LIDAR AND IMAGERY SENSOR



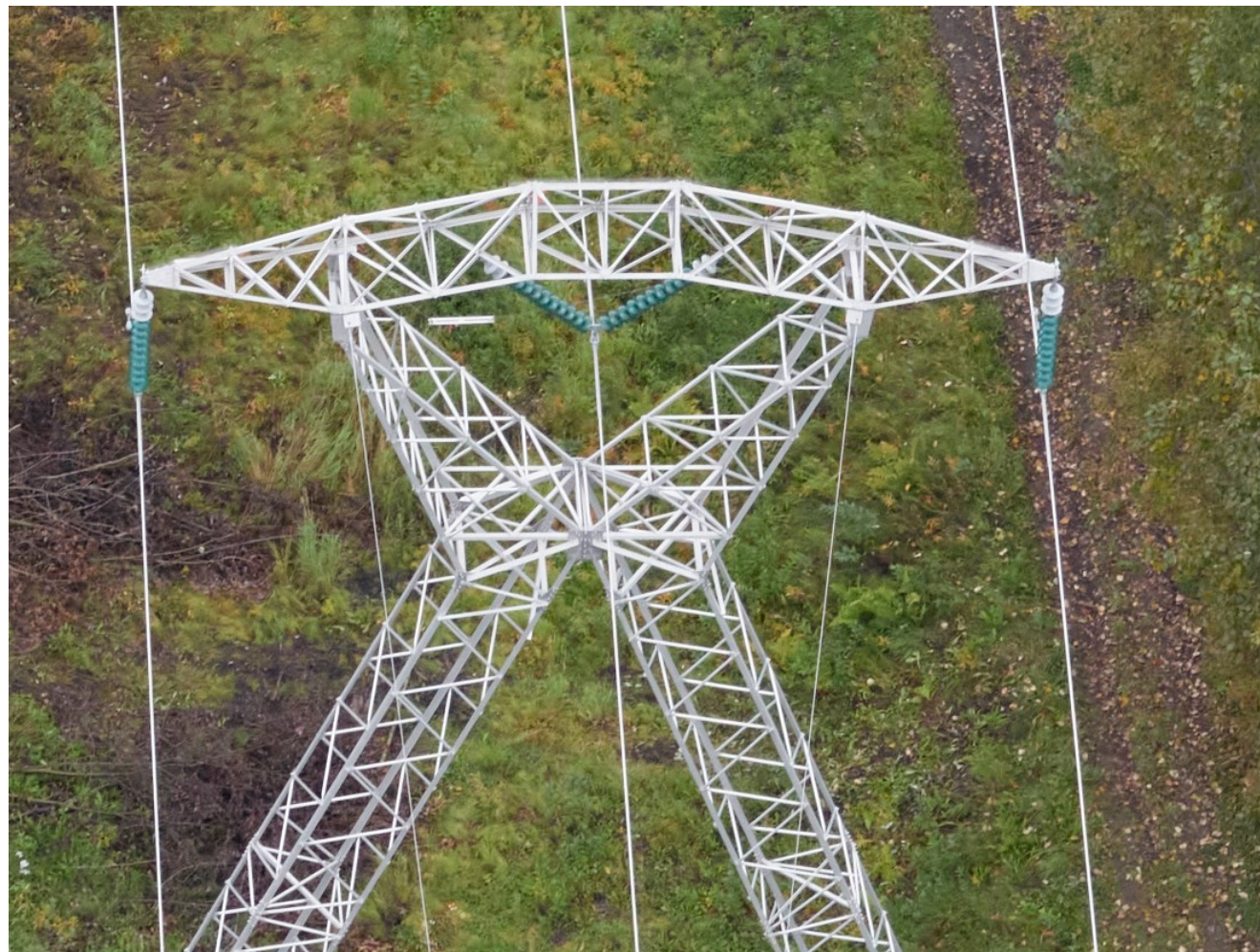
Lidar, Oblique, and Orthoimagery



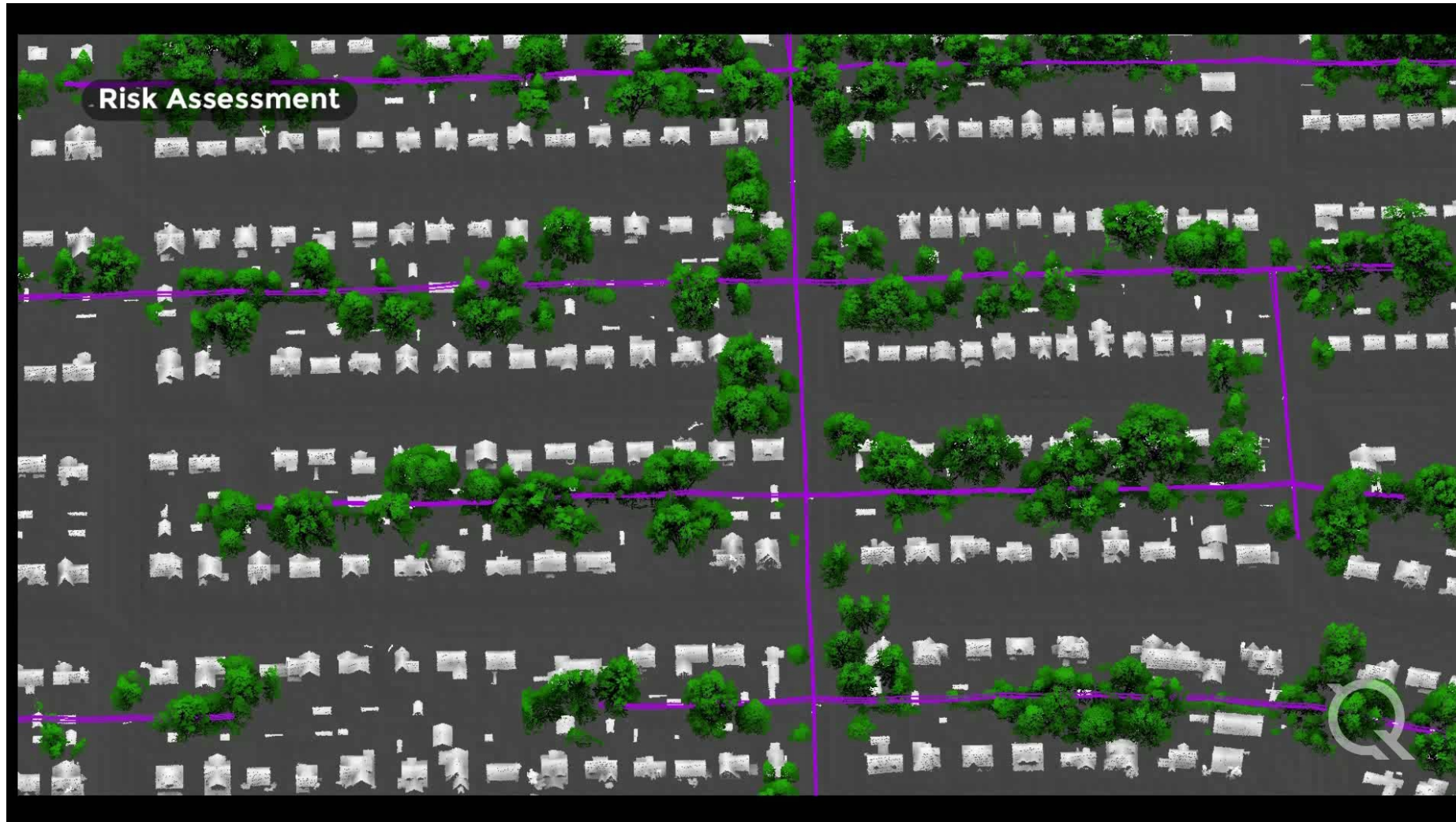
ORTHOIMAGERY



OBLIQUE IMAGERY



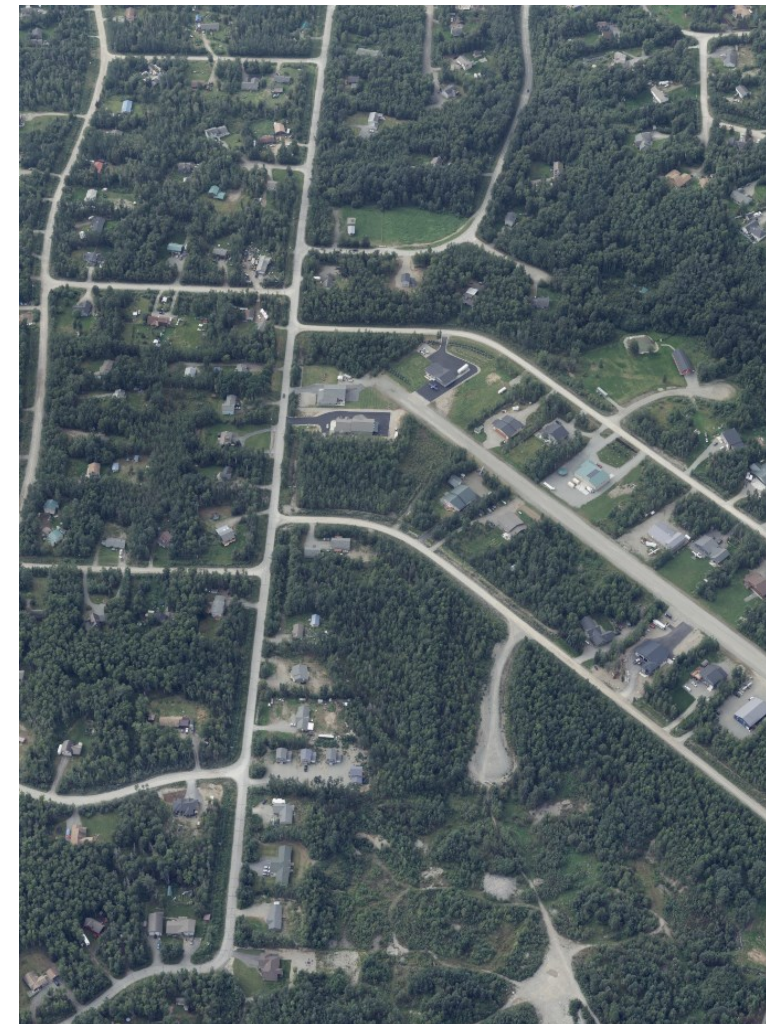
DISTRIBUTION SYSTEMS



DISTRIBUTION SYSTEMS LIDAR AND IMAGERY



DISTRIBUTION SYSTEMS ORTHO & OBLIQUE



VEGETATION RISK ANALYSIS

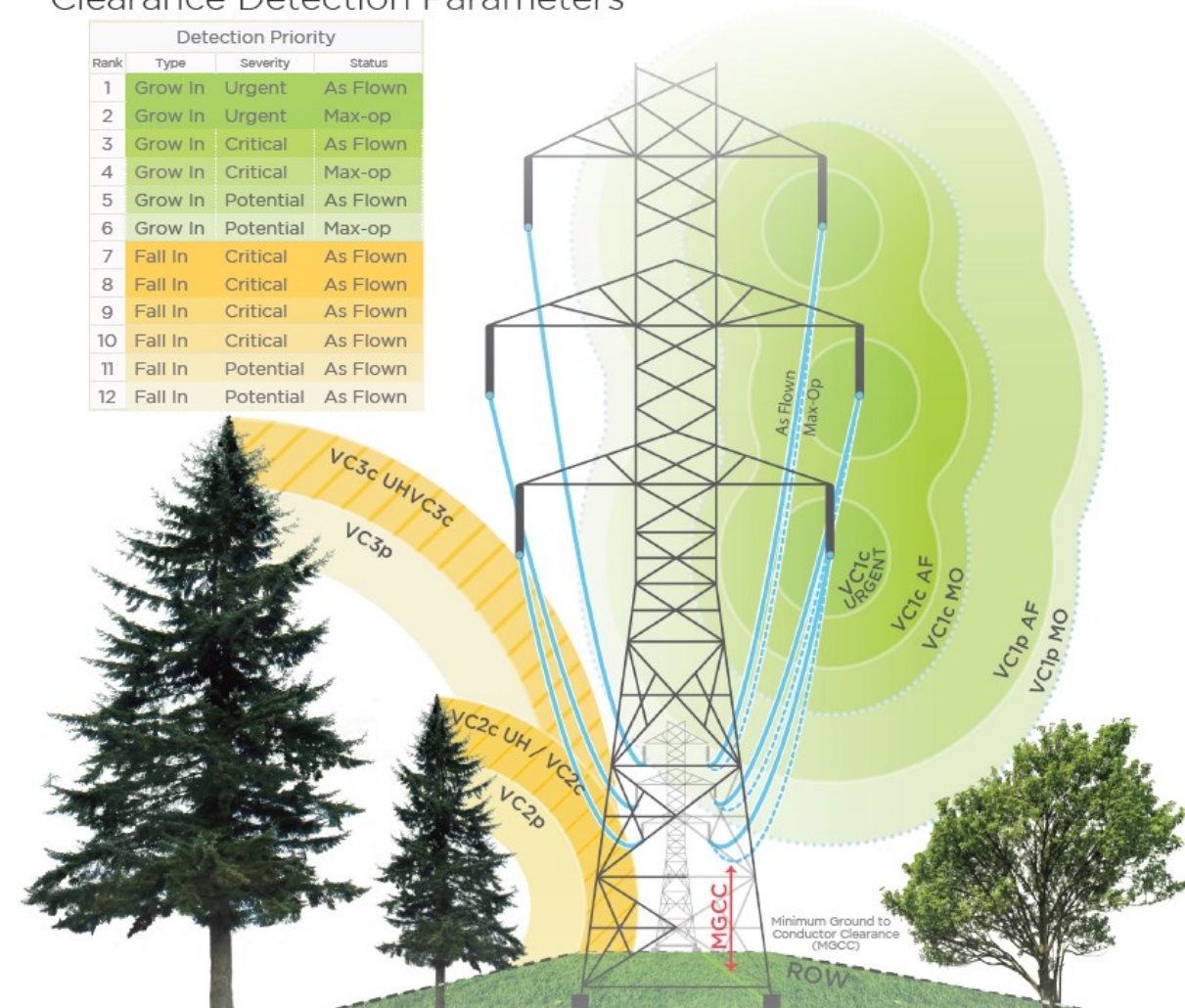
NERC (FAC-003 & 8 Analysis)

345kV										
CONDITION	RADIAL CLEARANCE ANALYSIS (GROW-IN)				FALL-IN ANALYSIS (OVERSTRIKE)			OVERHANG ANALYSIS		
	ZONE_1	ZONE_2	ZONE_3	ZONE_4	FI_ZONE_1	FI_ZONE_2	FI_ZONE_3	OV_ZONE_1	OV_ZONE_2	OV_ZONE_3
AVERAGE OPERATING CONDITION	0-12ft	12-21ft	21-31ft	31-41ft	Overstrike Greater than 10ft	Strike or Overstrike	Fall Within 5ft of Wire	Within Wire Zone - 1ft	Within 1 - 5ft of Wire Zone	Within 5 - 10ft of Wire Zone
MAXIMUM OPERATING CONDITION	0-12ft	12-21ft	21-31ft	31-41ft	Overstrike Greater than 10ft	Strike or Overstrike	Fall Within 5ft of Wire	NA	NA	NA
BLOWOUT CONDITION	0-12ft	12-21ft	21-31ft	31-41ft	Overstrike Greater than 10ft	Strike or Overstrike	Fall Within 5ft of Wire	NA	NA	NA

138kV										
CONDITION	RADIAL CLEARANCE ANALYSIS (GROW-IN)				FALL-IN ANALYSIS (OVERSTRIKE)			OVERHANG ANALYSIS		
	ZONE_1	ZONE_2	ZONE_3	ZONE_4	FI_ZONE_1	FI_ZONE_2	FI_ZONE_3	OV_ZONE_1	OV_ZONE_2	OV_ZONE_3
AVERAGE OPERATING CONDITION	0-5ft	5-13ft	13-23ft	23-33ft	Overstrike Greater than 10ft	Strike or Overstrike	Fall Within 3ft of Wire	Within Wire Zone - 1ft	Within 1 - 5ft of Wire Zone	Within 5 - 10ft of Wire Zone
MAXIMUM OPERATING CONDITION	0-5ft	5-13ft	13-23ft	23-33ft	Overstrike Greater than 10ft	Strike or Overstrike	Fall Within 3ft of Wire	NA	NA	NA
BLOWOUT CONDITION	0-5ft	5-13ft	13-23ft	23-33ft	Overstrike Greater than 10ft	Strike or Overstrike	Fall Within 3ft of Wire	NA	NA	NA

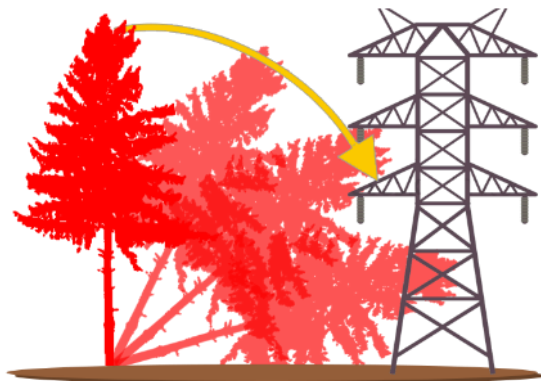
Clearance Detection Parameters

Detection Priority			
Rank	Type	Severity	Status
1	Grow In	Urgent	As Flown
2	Grow In	Urgent	Max-op
3	Grow In	Critical	As Flown
4	Grow In	Critical	Max-op
5	Grow In	Potential	As Flown
6	Grow In	Potential	Max-op
7	Fall In	Critical	As Flown
8	Fall In	Critical	As Flown
9	Fall In	Critical	As Flown
10	Fall In	Critical	As Flown
11	Fall In	Potential	As Flown
12	Fall In	Potential	As Flown

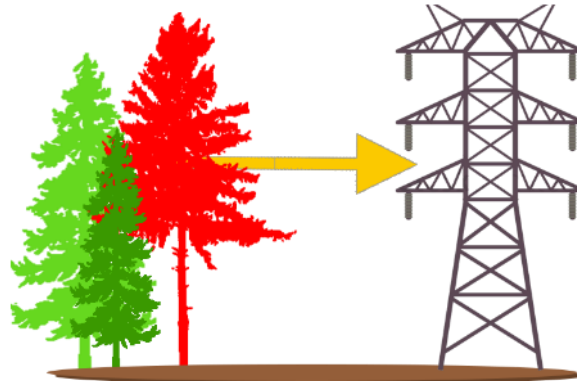


PREDICTIVE RISK SCORES

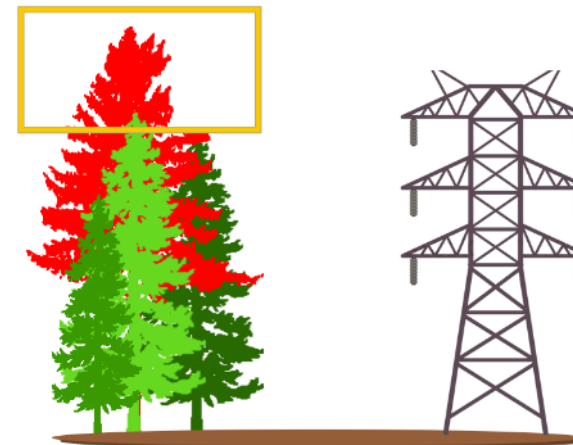
NV5 has identified 4 key attributes associated with tree caused outages based on a detailed historical analysis involving utility veg management professionals.



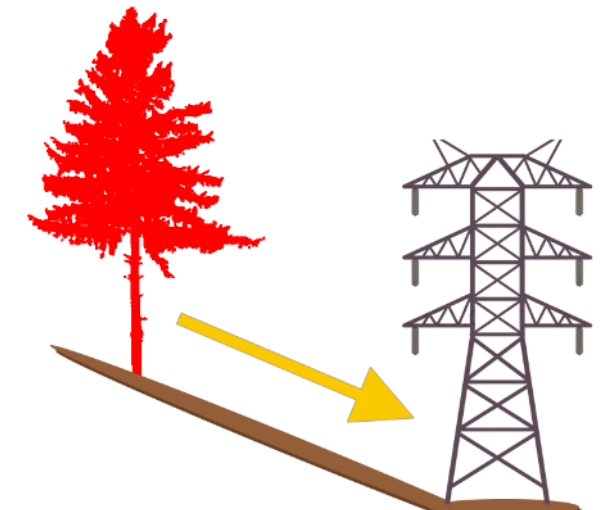
The percent of potential conductor overstrike distance relative to tree height. The greater the overstrike percent, the higher risk.



Calculates unobstructed paths at 1 deg. increments for tree to fall on conductor. Higher number of paths = increased risk.

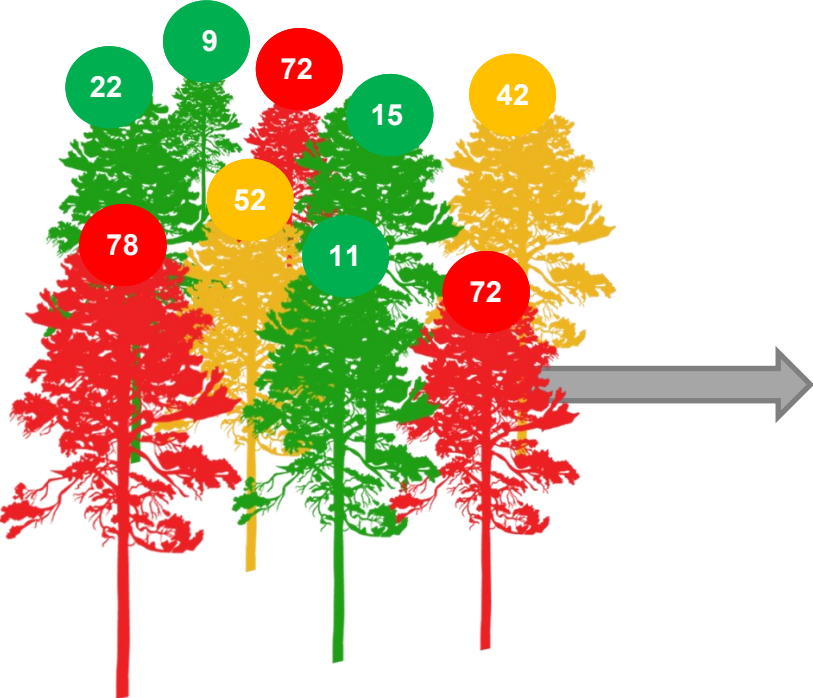


Exposure models calculate the relative vertical exposure for individual trees. The greater the exposure, the higher the risk.

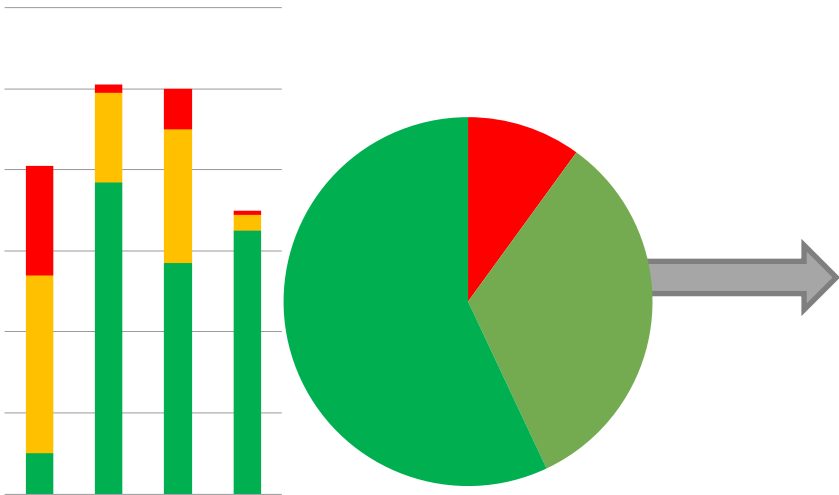


Calculates the degree of slope from tree to conductor (upslope or downslope) and aspect of tree to conductor. A tree on steep upslope has greater risk.

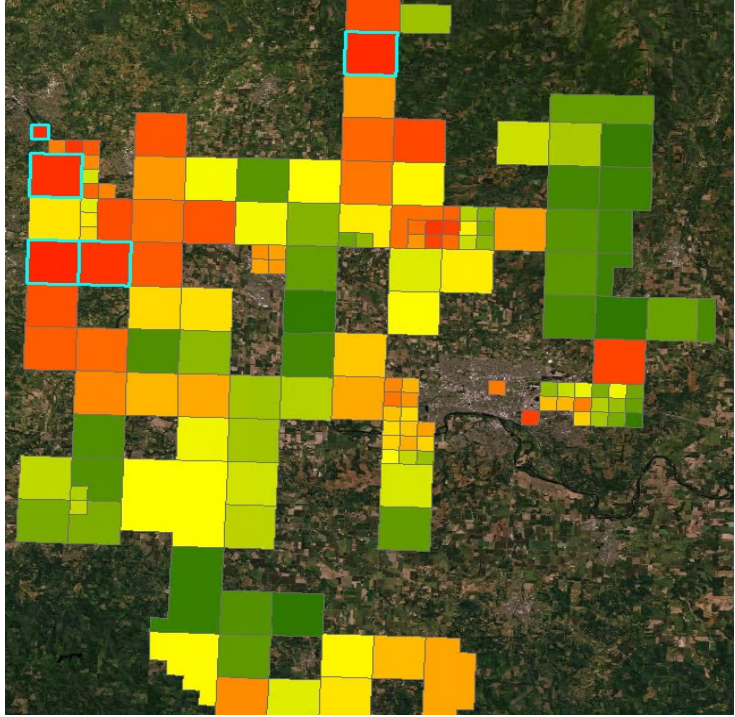
PREDICTIVE RISK SCORES



Lidar-derived Risk Scores



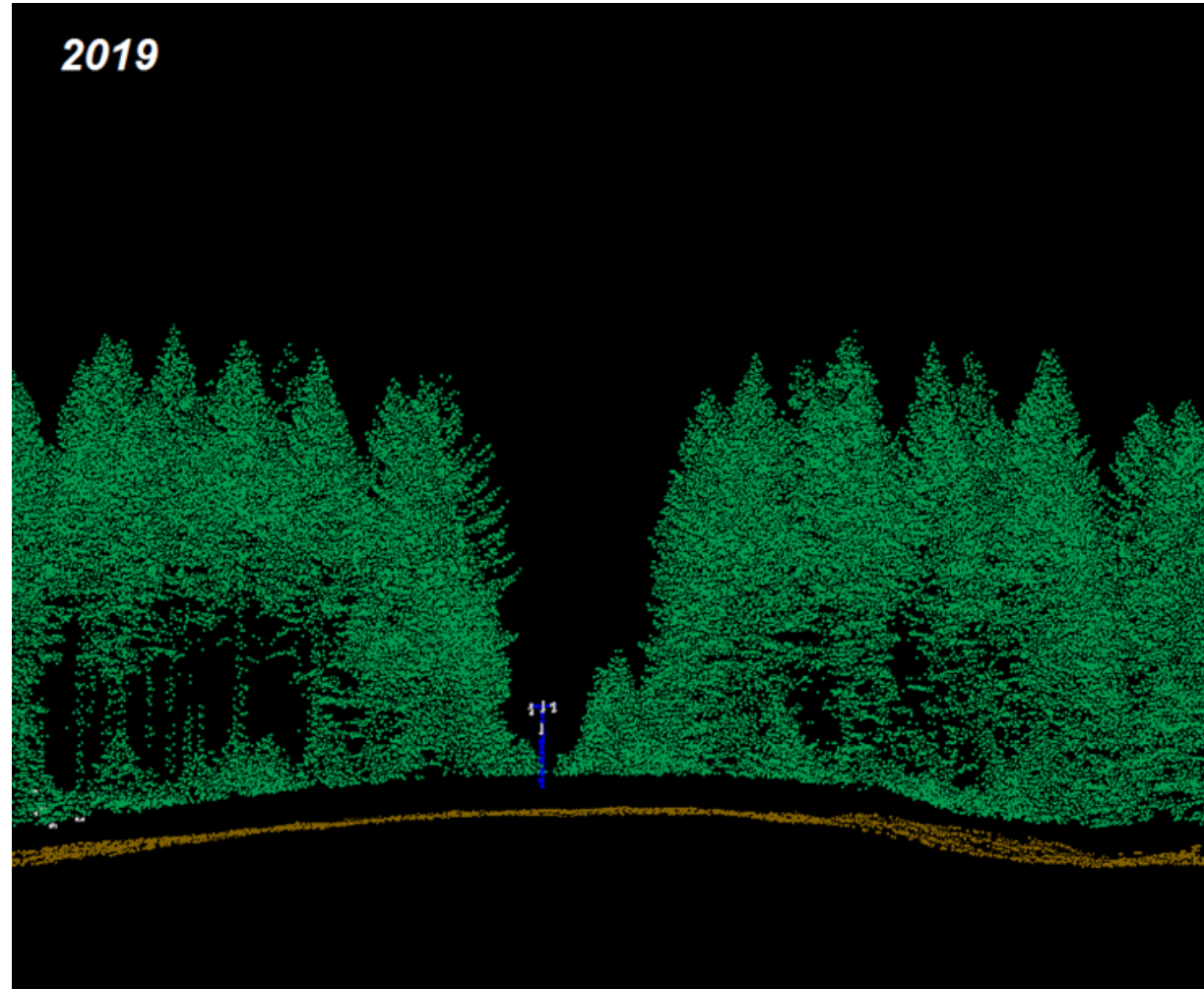
Utility Specific Variables



Data Aggregation & Delivery

CHANGE DETECTION & AUDITING

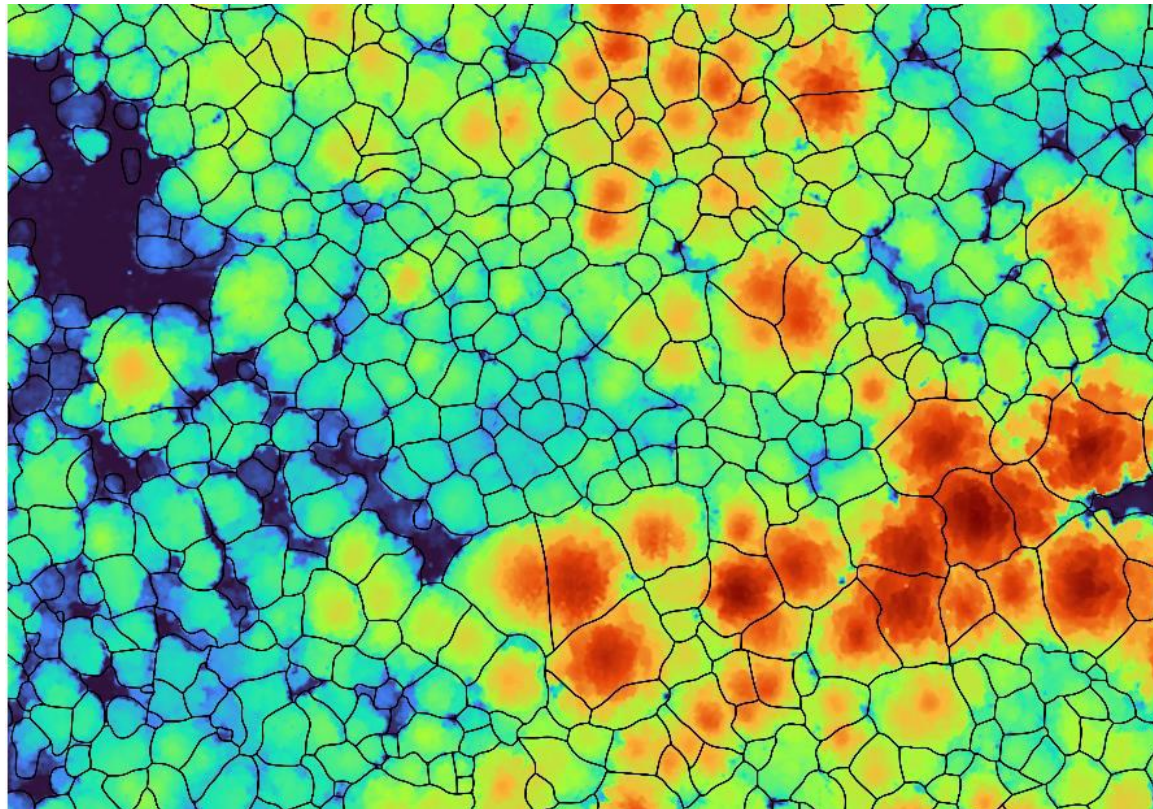
2019



2021

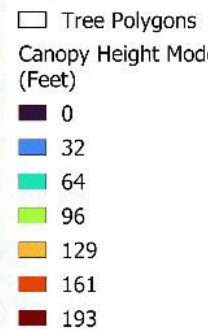


TREE SPECIES ANALYSIS



Vegetation polygons representing tree and shrub canopy clumps are created from the lidar point cloud.

Individual Tree Segmentation



Using the spectral and structural information made possible by “ray tracing” imagery to the point, we incorporate field data to train machine learning classifiers to classify the species and health of vegetation polygons

GROUND CONTROL AND FIELD VALIDATION



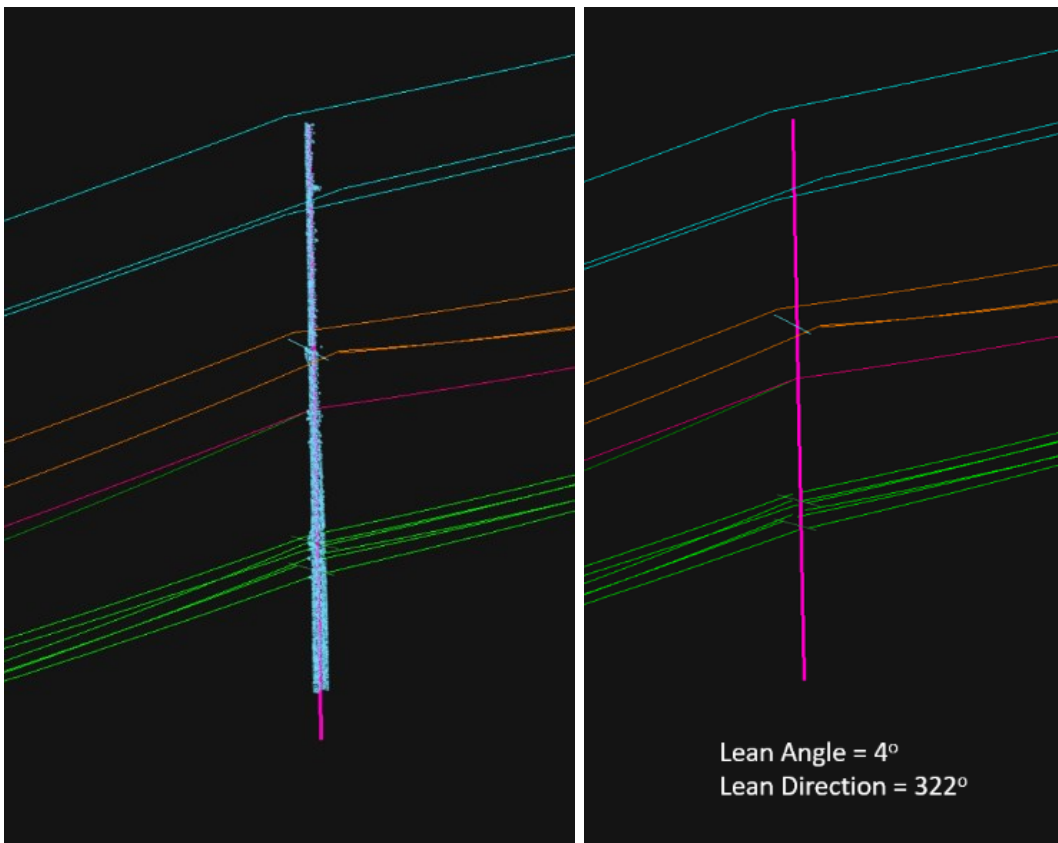
Lidar check point



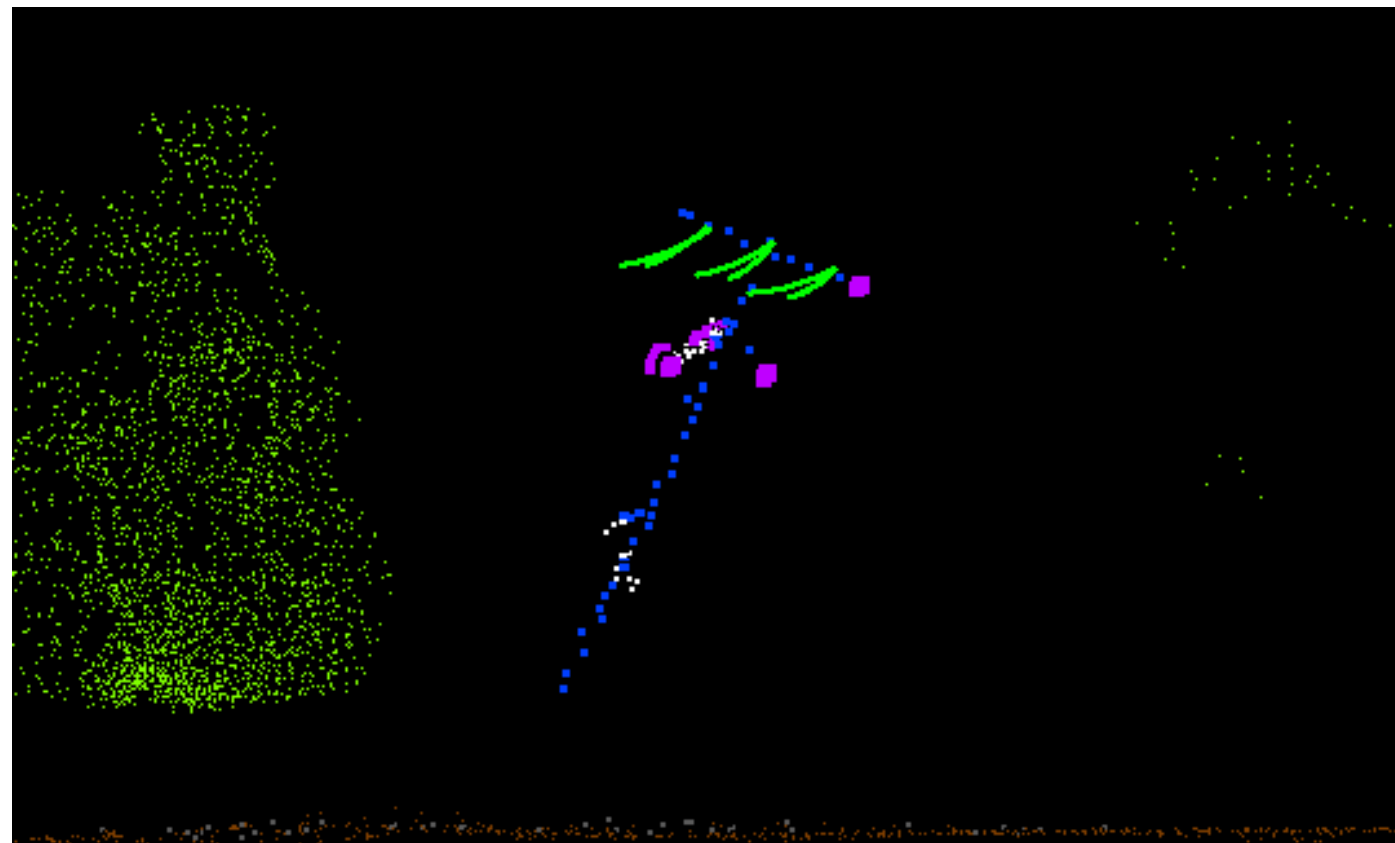
Photo IDs for imagery



Tree species and health field data collection

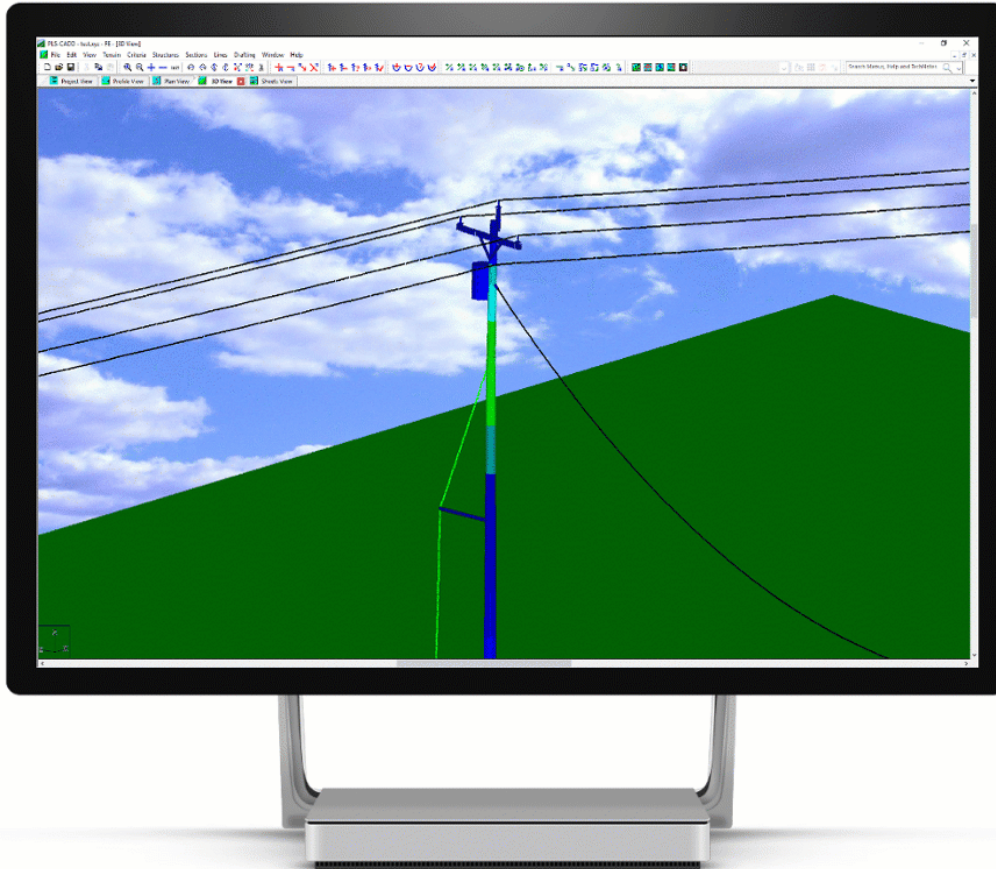


Pole lean measurements and monitoring



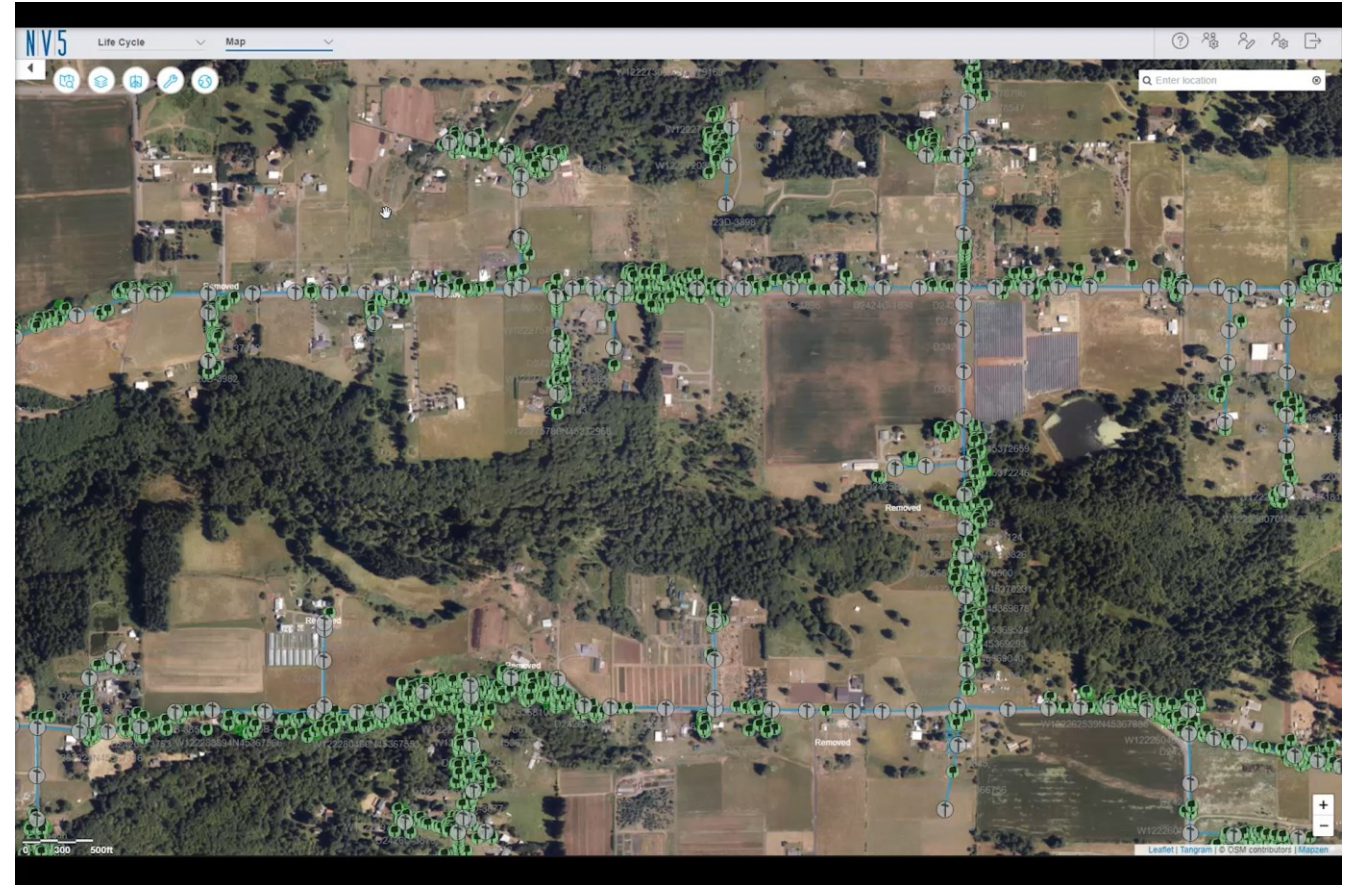
Subsidence and geotech hazard monitoring

PLS-CADD



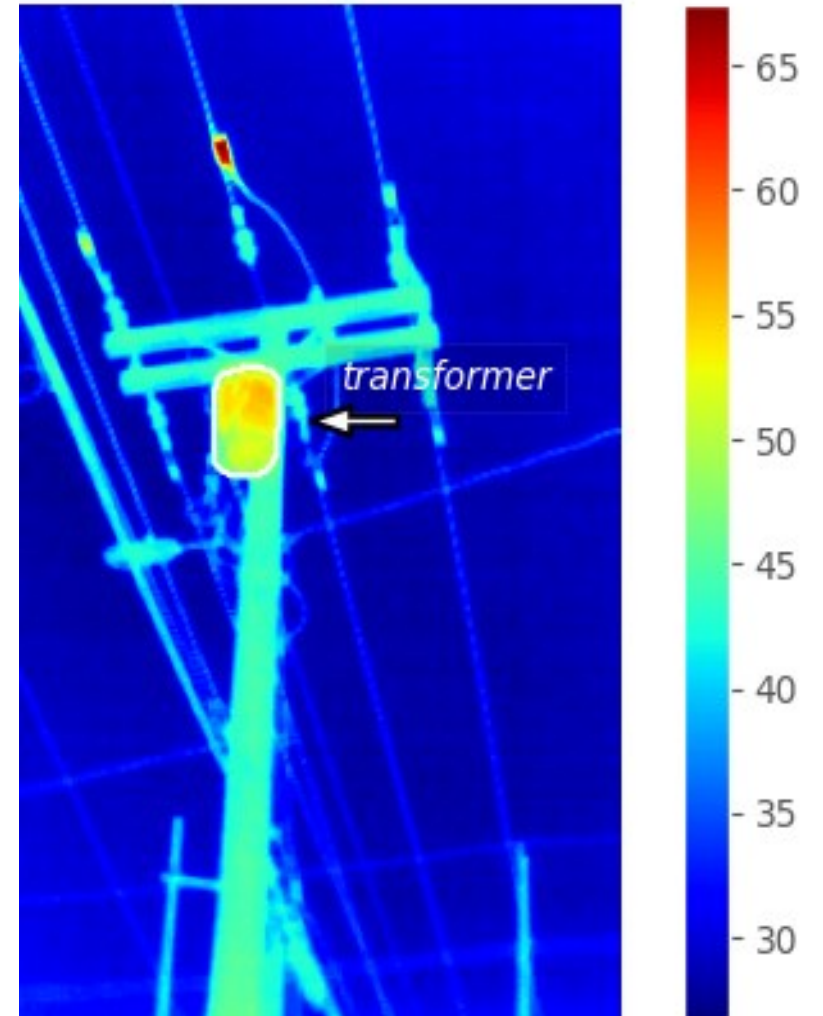
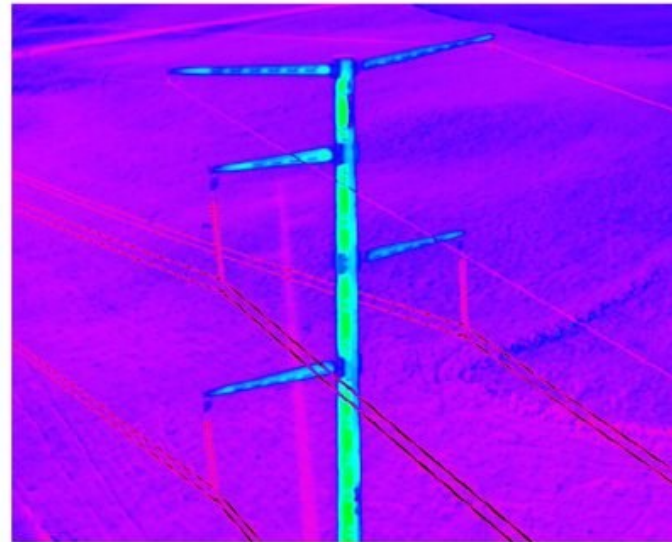
<https://www.powerlinesystems.com/products>

INSITE



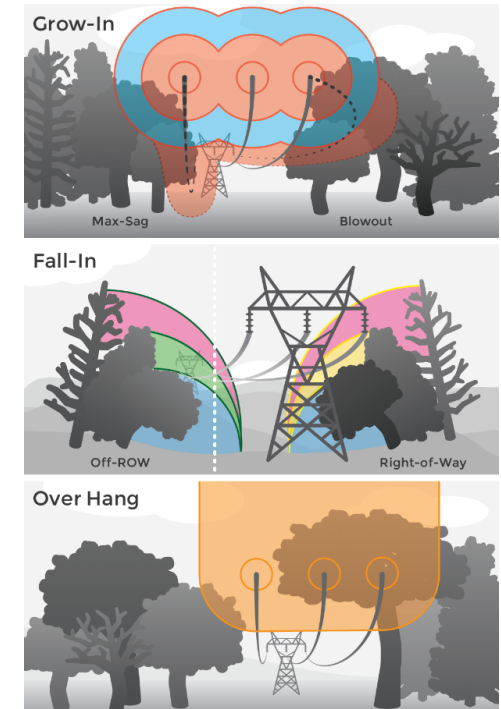
<https://www.nv5.com/geospatial/>

NEW TOOLS



SUMMARY

- Remote sensing data improves the timing, accuracy, and repeatability of data inputs for a more robust vegetation management plan.
- Can be combined with asset-risk analysis & impact analysis to drive planning decisions
- Lidar and imagery are data rich technologies that support multiple use functions beyond vegetation analysis.



THANK YOU!

