ELECTRIC POWER RESEARCH INSTITUTE

Incubatenergy Labs 2021
Oct. 19, 2021

WHENEVER. WHEREVER.
We'll be there.

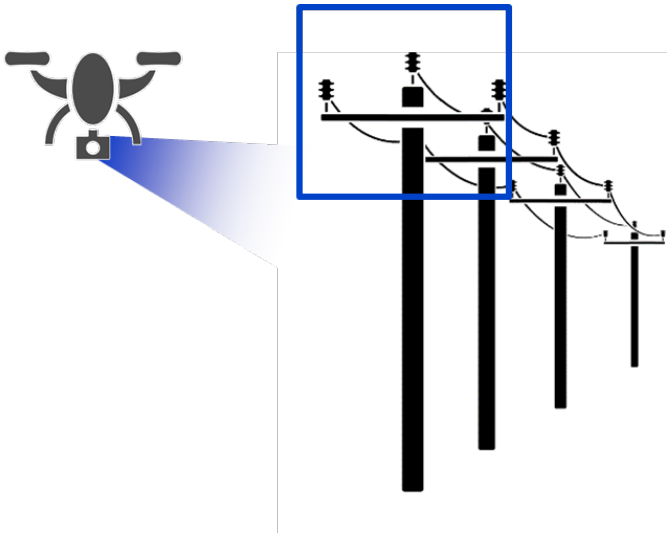
NEWFOUNDLAND POWER
A FORTIS COMPANY

Buzz Solutions

incubatenergy labs

About the Need/Opportunity

Today, electric utility inspectors must review millions of images spending thousands of hours to turn raw data into actionable information.



Example:
In 2020, SCE targeted inspections*

- 105,000 Distribution Structures
- 22,500 Transmission Structures
  - Estimated images?
    - 105k x 5 = 525k
    - 22.5k x 50 = 1.125M
    - 1.65M (visual only)
  - Estimated time?
    - 17s / image**
    - 17s x 1.65M = **7,791 hours**
  - Estimated cost?
    - $100 fully loaded rate
    - **~$780k for image review**

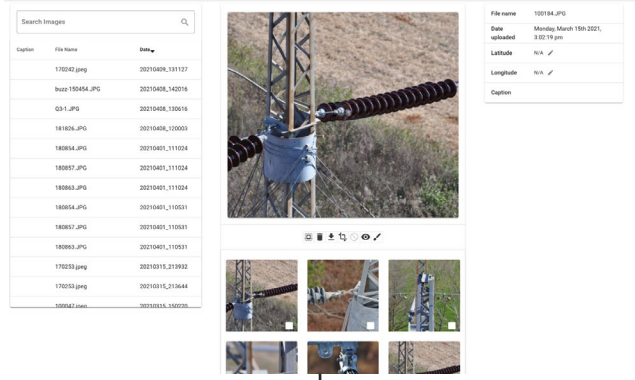
*Reference: SCE 2020-2022 WMP Rev 1. Inspection Program IN-1.1 & IN-1.2

** Human baseline, *Unmanned Aircraft Systems (UAS) Automation Technologies for Transmission Inspection: Image Prediction Testing.* EPRI, Palo Alto, CA: 2018. 3002016958.

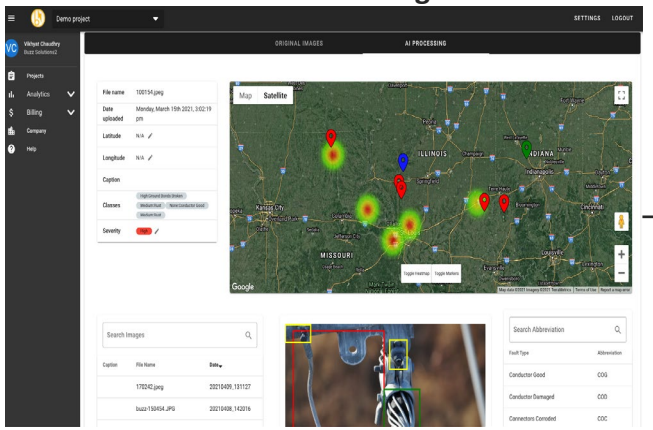
About the Potential Solution

PowerAI: End-to-End Digital and AI solution for cost and time efficient visual data management, processing and analytics around power line and grid infrastructure inspections

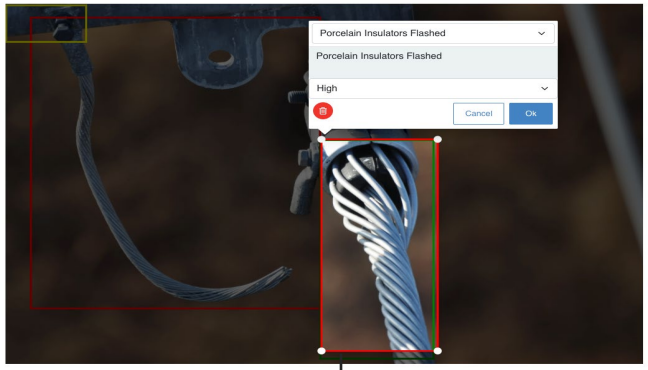
Data Ingestion and Management



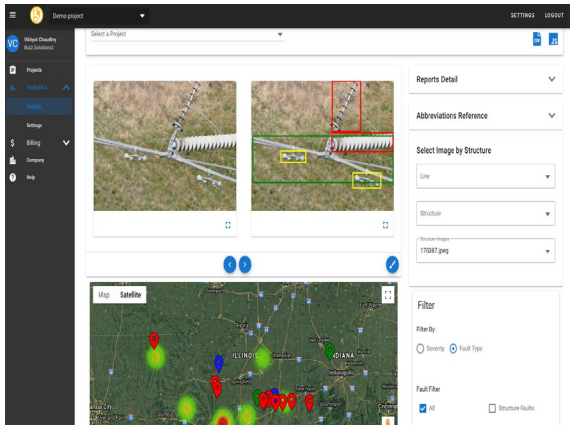
Data Processing

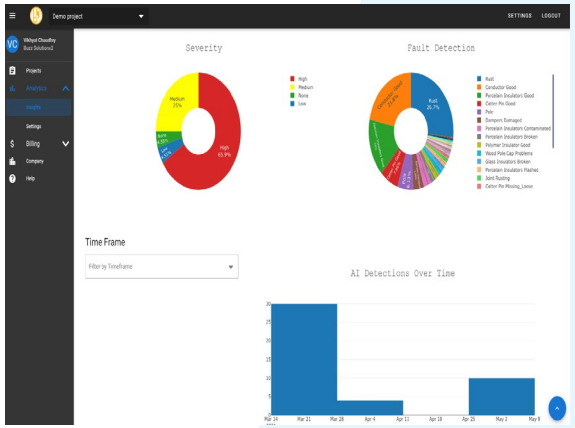


Human-in-the-loop and Active Learning



Analytics, Actionable Insights and Reporting





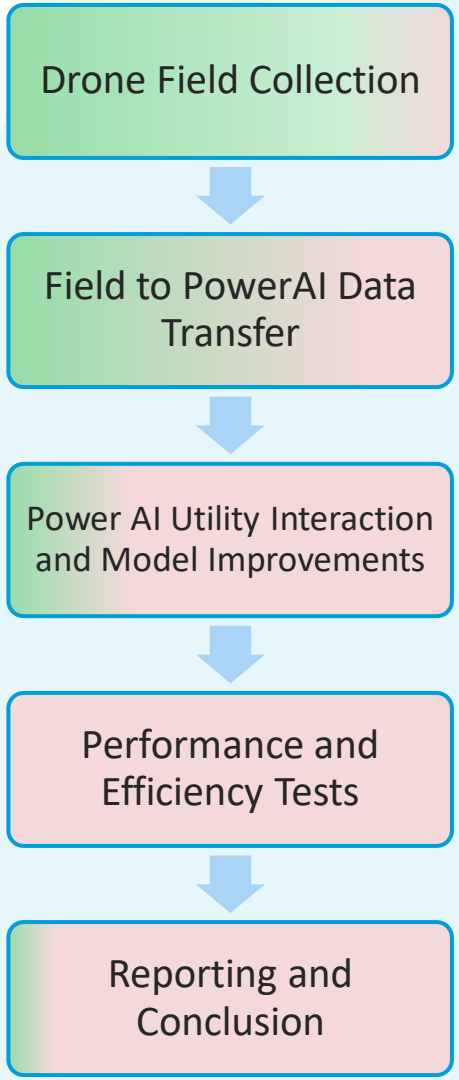
- Data Ingestion
- Data Management and Project Collaboration
- AI-Based Data Processing
- Asset mapping, AI predictions and severity metrics
- Human-in-the-loop and Active Learning
- Analytics and Visualizations
- API Connectors
- Actionable Insights exporting to Work Order Management systems, GIS systems, data Management systems, etc.

Project Scope at-a-Glance

Key Objective: Demonstration of PowerAI to support automated review of drone-based, distribution inspection imagery

Key Tasks:

- Integration of the PowerAI software with drone-collected inspection imagery and utility interaction by **mid-July**
- Model retraining and deployment within PowerAI to be complete by end of **August**
- PowerAI inspector efficiency evaluation to be complete by **October**
- Prediction performance test against prelabeled inspection imagery to be complete by **October**



Drone Data Collection

Summary of Planned Work							
Region	*Feeders [#]*	*Poles [#]*	*Average Windspan [m]*	*Length [km]*	*Drone Flight Time [h] **	*Image Requirements [#] ***	*Storage Requirements [GB] ****
Eastern	2	1650	46	76	59	6600	92
Western	8	2237	38	82	81	8948	125
St. John's	6	2718	37	103	98	10872	152
Total	**16**	**6605**	**40**	**261**	**238**	**26420**	**370**

Additional Scope (Complete):

- 1 km of high-resolution imagery
- 2 km of LiDAR

** Estimated from the first drone operation section - based on 2.16 minutes/pole*

*** Estimated based on an average of 4 images/pole – Likely larger due to wide-angle and zoomed images*

**** Estimated based on 14 MB / image*

Drone Data Collection

Status of Completed Work					
Region	*Feeders [#]*	*Poles [#]*	*Length [km]*	*Skipped Segments [km]*	*Status [%]*
Eastern	2	1650	76	0	100
Western	8	2237	82	7	92
St. John's	6	2718	103	10	90
Total	**16**	**6605**	**261**	**17**	**94**

Reasons for Skipping Segments

- Safety (kids playing in the area, crane operation)
- Environmental (Osprey nests)
- Aggressive customer behaviour
- Customer Complaints
- Media Attention

Modify Operation Locations

Drone Data Collection

Drone: DJI Matrice 300 RTK

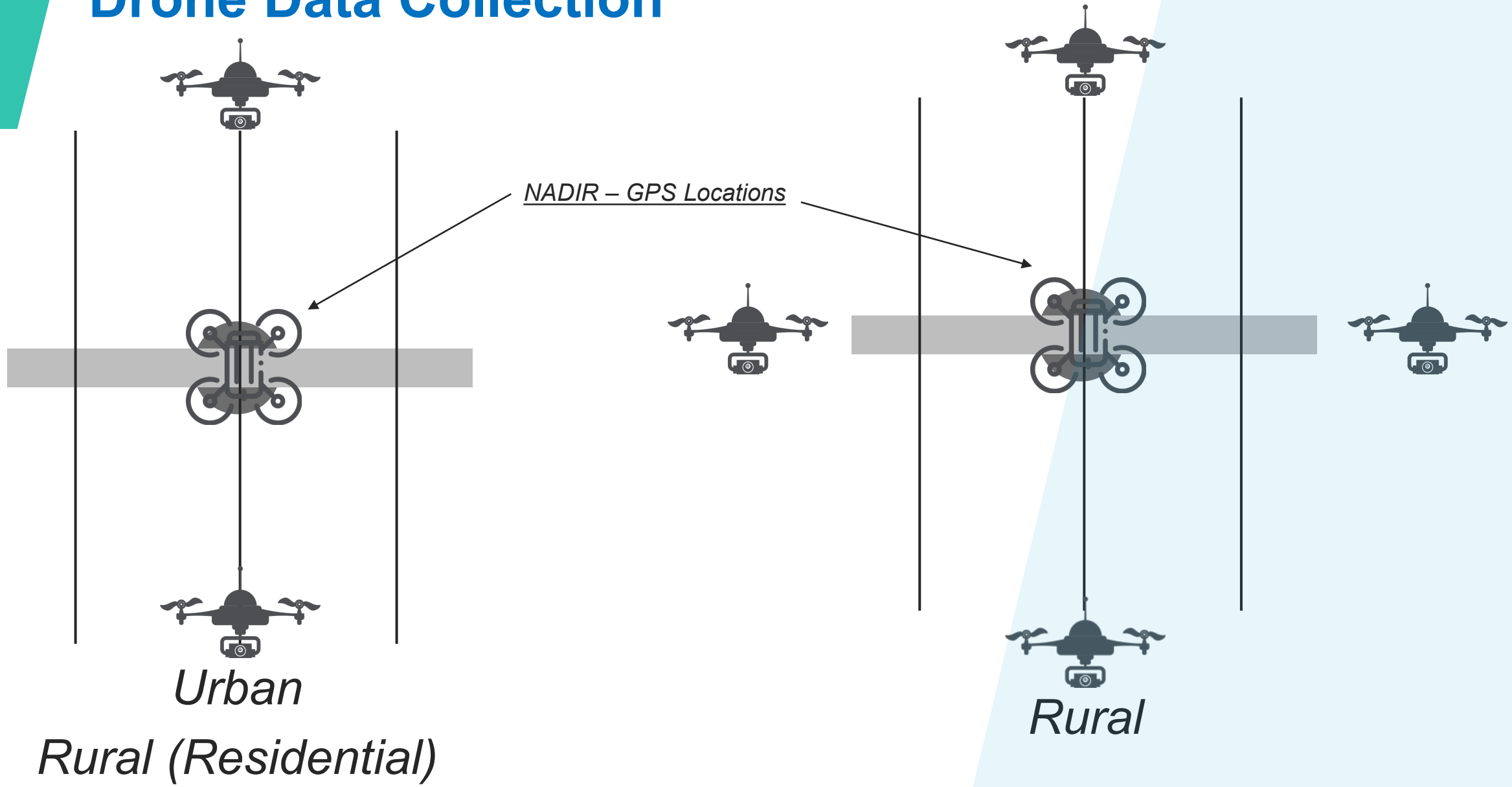
Camera: DJI Zenmuse H20T

LiDAR: DJI Zenmuse L1

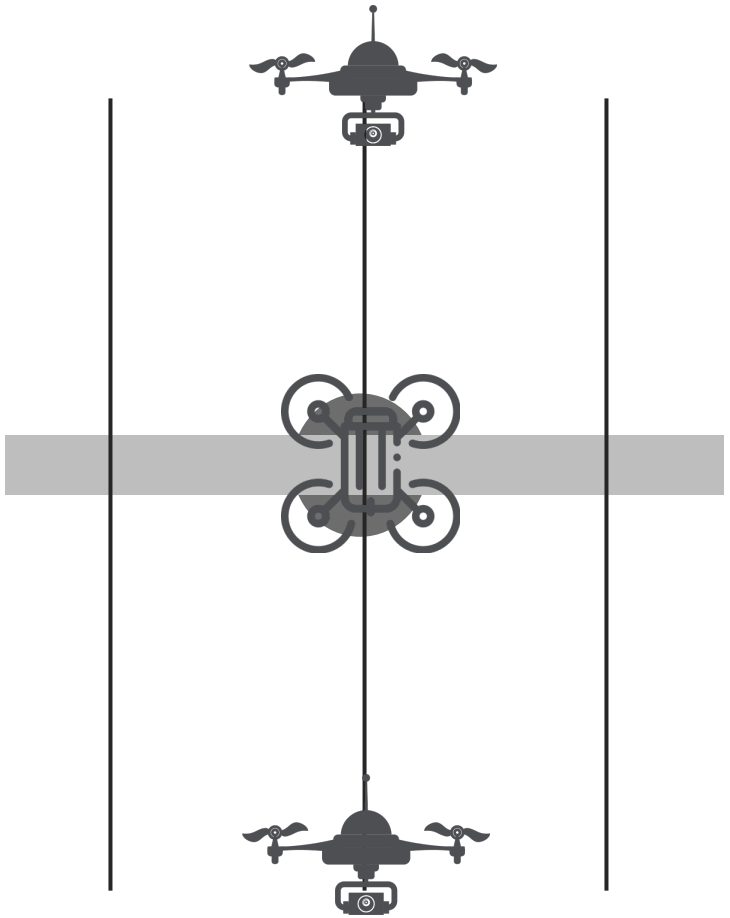
Obstacle Avoidance: DJI CSM Radar

Safety System: AVSS PRS-M300

Drone Data Collection



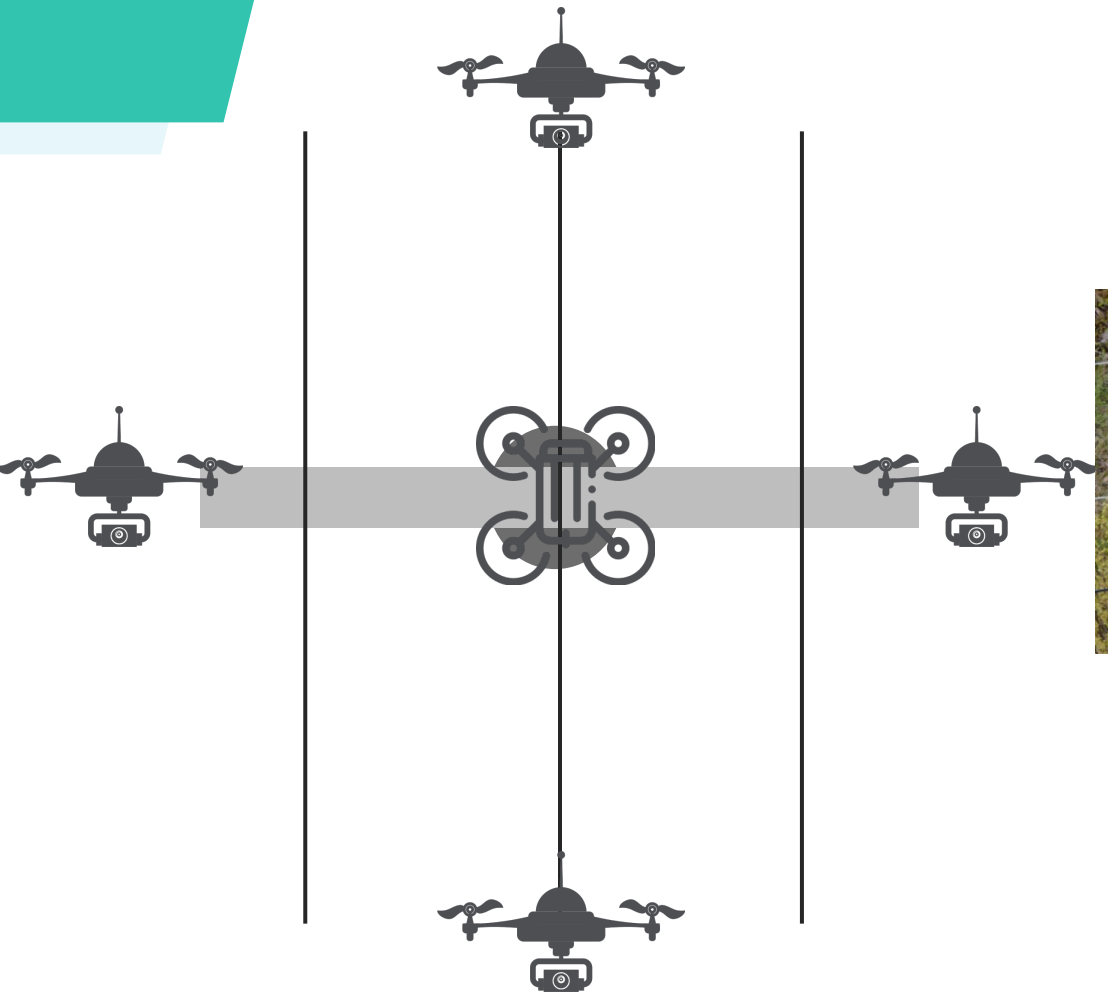
Drone Data Collection



Urban

Rural (Residential)

Drone Data Collection



Rural

Drone Data Collection

Eastern Region – 3 Phase Structure with Transformer

Western Region – Base of a Pole

First Thoughts:

- *Excellent Detail*
- *Great Perspective*
- *Good Coverage*
  - *Images from all angles of the structure*

Cons

- *Missing zoomed image for the base of the pole in Eastern region*

Solution

- *Acquire zoomed images for pole bases in Western/St. John's regions*
  - *No additional cost*

Free dataset!

Unlabeled Distribution Drone Dataset(DDD)

30,000 Images

For access, download the data sharing forms, sign, and return to AI@EPRI.com
https://epri.app.box.com/folder/146770642610?s=ikx0xubpiihu698zqlooxgl9jwbd3cc2

Post Data Cleaning and Sharing

Example image removed from the shared dataset

Images with vehicles, people, and homes with windows have been removed.

Image names have been changed.

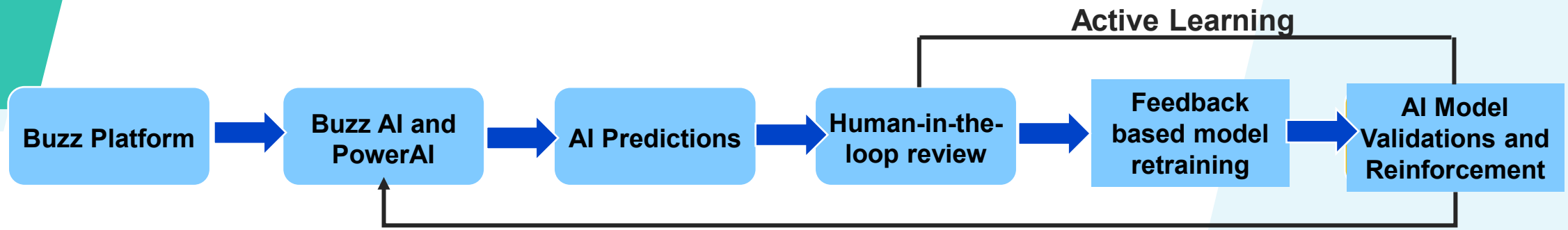
Image exif metadata including time/dates and GPS info has been removed.

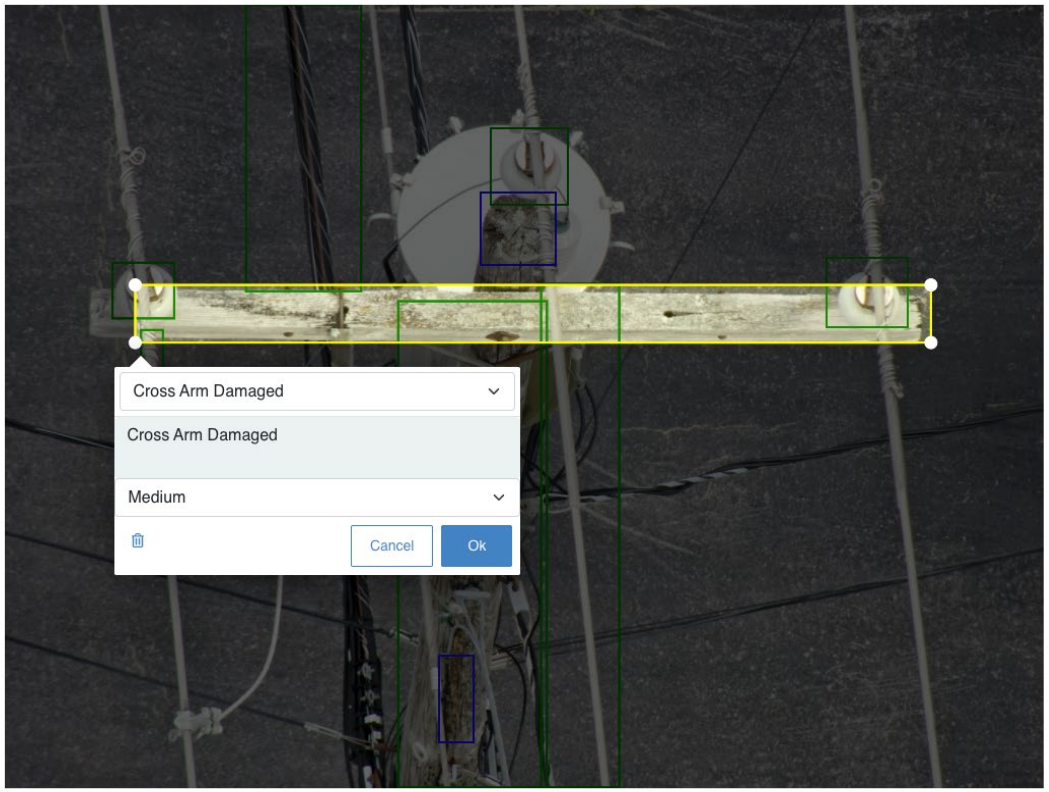
“Cleaned” images have been shared under Creative Commons licensing to support more industry collaboration.

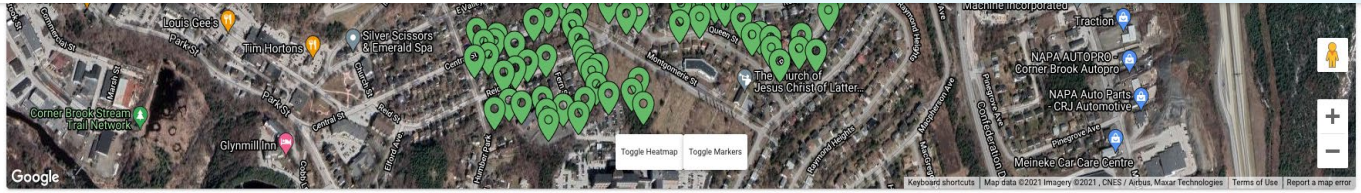
If you have imagery you’d like to share with EPRI, contact dlewis@epri.com

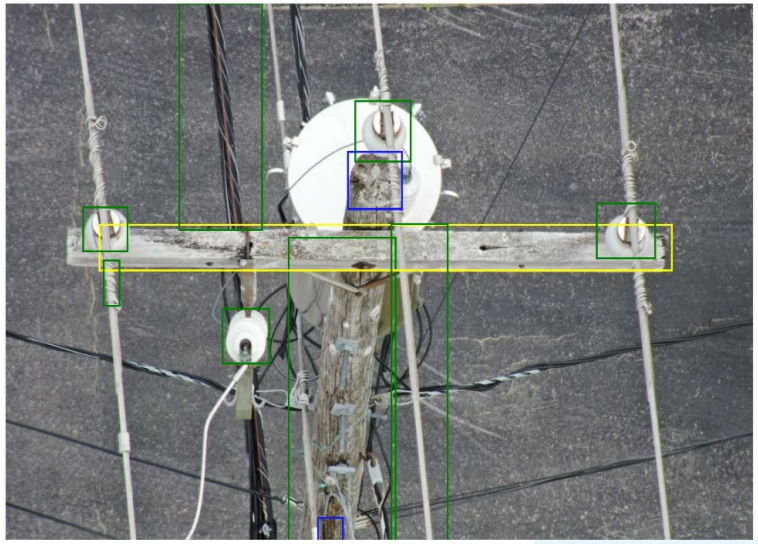
- If not shared with EPRI, consider contributing to publicly available datasets to support AI/ML development.

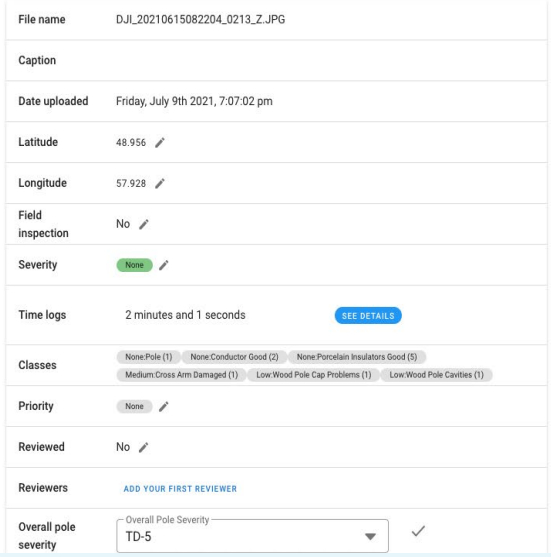
PowerAI Utility Interaction and Model Improvements







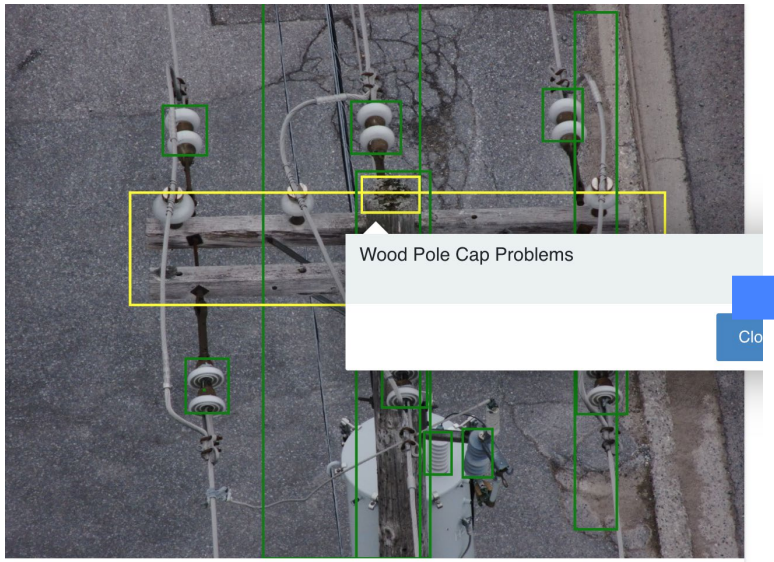




PowerAI Model Retraining

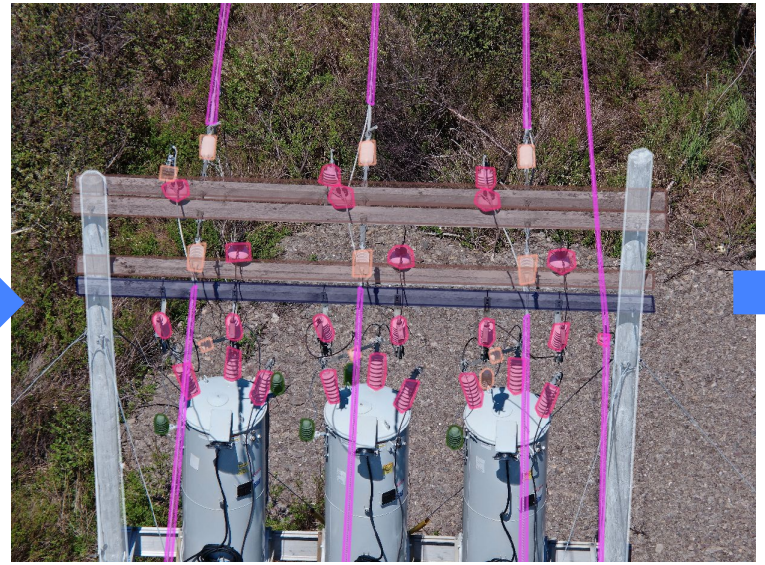
Active Learning

Human-In-The-Loop Feedback



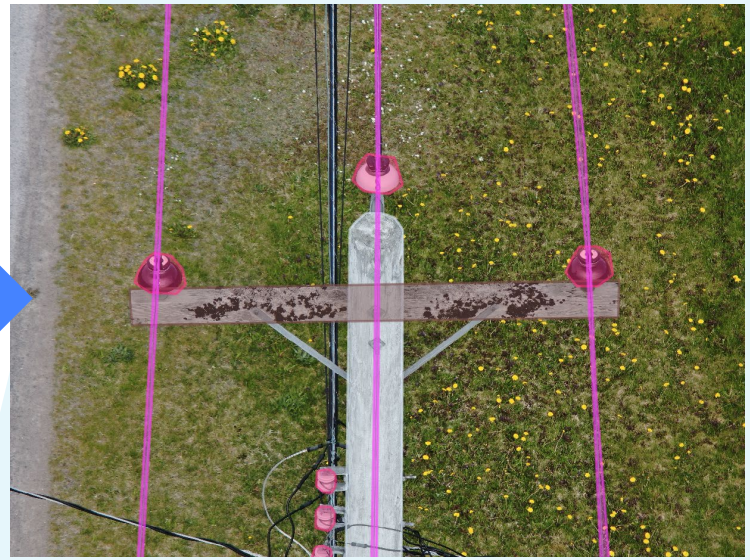
Training Dataset

- Label Tightening
- AI picks images with faults for training



Validation/Test Dataset

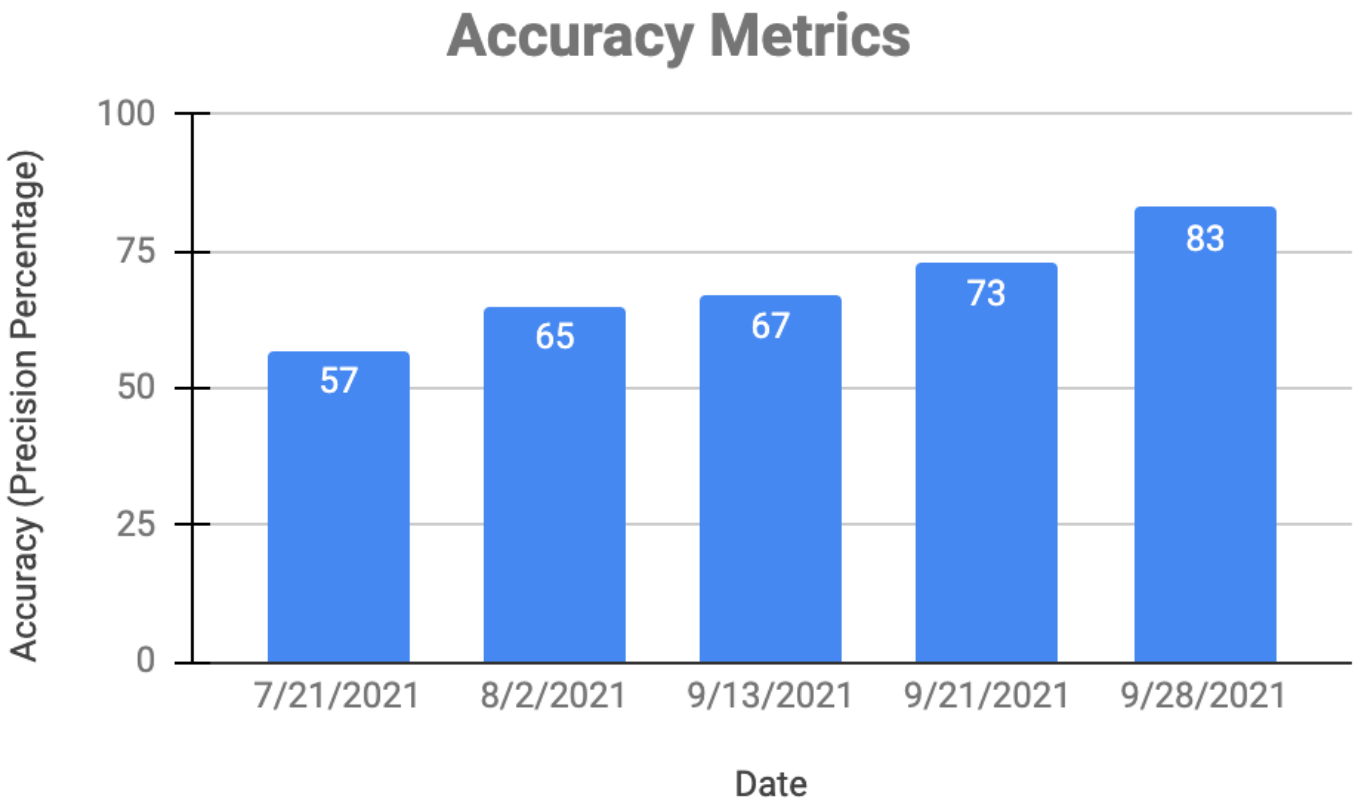
- Test dataset constant during retraining
- Used to measure Precision, Recall, False Positive and Negative rates



PowerAI Model Accuracy Improvements

What is Precision?

- **Precision is the ratio between True Positives and all the Positives. In our case, Precision is the measure of the asset fault labels or asset labels correctly identified out of all the labels identified. We measure the Mean Average Precision across all the labels in our AI system to describe the accuracy of our systems.**



Accuracy or Mean Average Precision increase for AI detected labels at the end of project versus at the start: 45%

Assets and Asset Faults detected by our AI systems

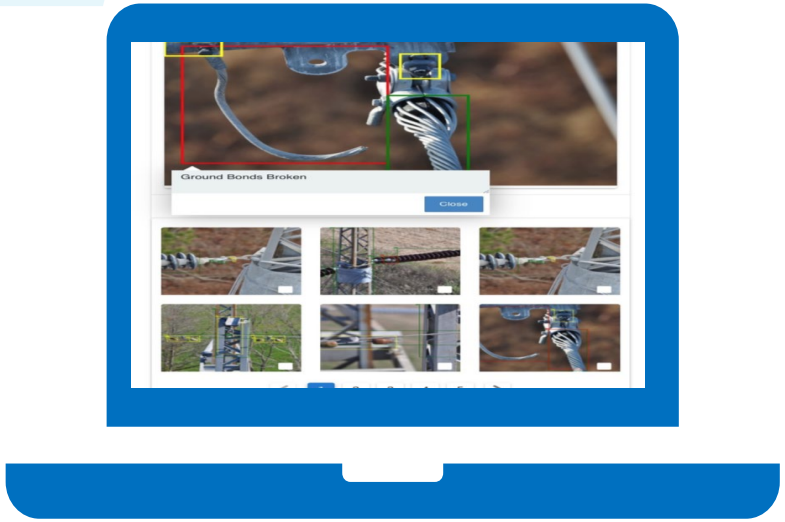
Conductor Good, Conductor Damaged, Connectors Corroded, Cotter Pin Missing/Loose, Dampers Damaged, Glass Insulators Broken, Glass Insulators Contaminated, Glass Insulators Good, Ground Bonds Broken, Misaligned Amor Grips, Misaligned Hardware, Polymer Insulators Contaminated, Polymer Insulator Good, Polymer Insulators Flashed, Polymer Insulators Broken, Porcelain Insulators Broken, Porcelain Insulators Contaminated, Porcelain Insulators Flashed, Porcelain Insulators Good, Wood Pole Cap Problems, Wood Pole Cavities, Rust, Cotter Pin Good, Vegetation Encroachment, Pole, Cross Arm Good, Cross Arm Damaged, Joint Rusting

PowerAI Utility Interaction and Model Improvements

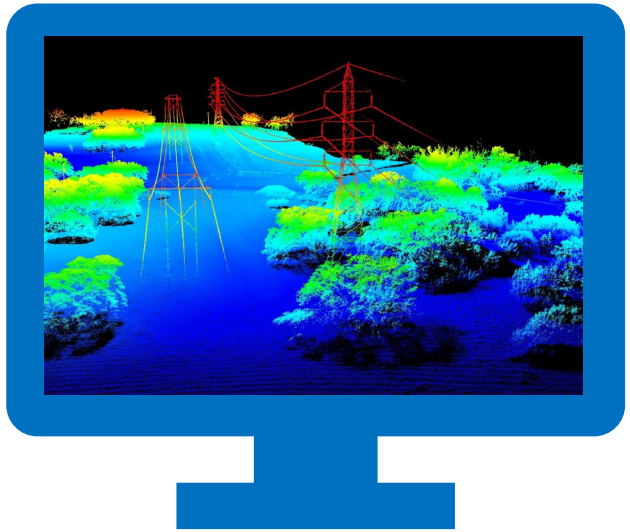
Utility Interaction

- Clustering the images to their respective poles and Geo Locations
- AI-based data processing
- Review by planners for AI detected labels and faults
- Assigning priority levels to pole structures based on the severity of the problems
- Storing and tracking this feedback from planners by PowerAI backend
- Using reviewed images to retrain PowerAI models for enhancements
- Tracking the planner review time using human-in-the-loop tool
- Generating result reports and exporting to Avantis work order management systems

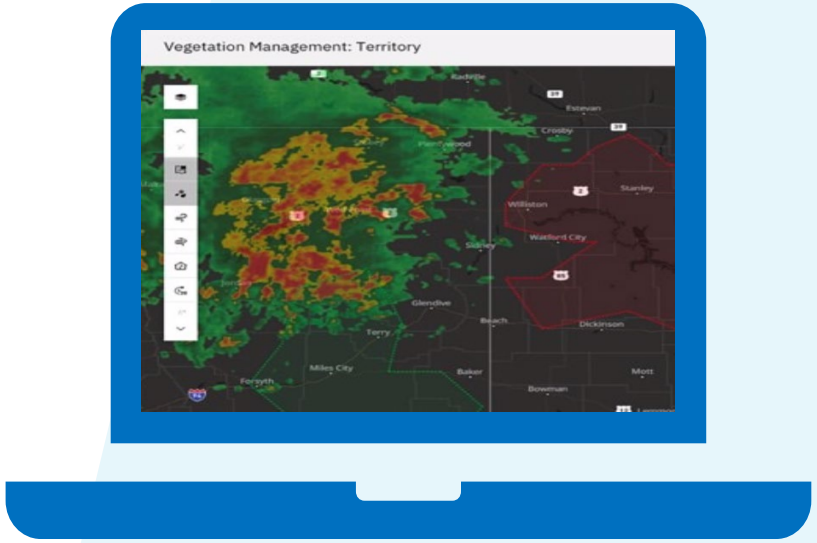
PowerAI Future Feature Releases



- Improvements in accuracy, robustness and personalization of AI systems
- Additional labels incorporated



- LiDAR sensor data to map lines in 3D space for improved vegetation management business use cases using AI systems on LiDAR data



- Predictive insights engine for vegetation hotspot areas and health of vegetation forecasting

Advanced Distribution Inspection:
Using Automation for Inspection

Overview

- EPRI and collaborating utilities are researching autonomous inspections. In summary, the intent is to use drone automation to collect inspection imagery/video and AI/ML to improve the data review process.

Value

- Experience with a new, automated inspection approach that may reduce the cost of distribution inspection
- Provide objective data to inform deployment decisions

Tasks

- Task 1: Determine aerial inspection image capture specifications
- Task 2: Validate specifications through field testing
- Task 3: Build image labeling guidance and taxonomy of terms
- Task 4: Explore synthetic image creation
- Task 5: Host data science competitions for AI model testing

Status

- **Ongoing EPRI project** underway and set to conclude Q2 2022
- For more information, contact Dexter Lewis (dlewis@epri.com)

Our Team

Utility Representative:

Brett Belbin, Electrical Engineer T&D Engineering, Utility Project Lead

Startup Representative:

Kaitlyn Albertoli, CEO, Buzz Representative

Vikhyat Chaudhry, CTO, COO, Buzz Representative

EPRI Representative:

Dexter Lewis, Pr. Technical Leader, EPRI SME

Our Team Meetings

Weekly, Fridays, 3:00 – 4:00 PM ET

To get added to meeting: contact Joyce Hawkes (JHawkes@epri.com) person who is listed as “host” on WebEx meeting on the books now.