# 2023-2025 WMP
# Joint IOU Covered Conductor Working Group

## New Technologies Workstream

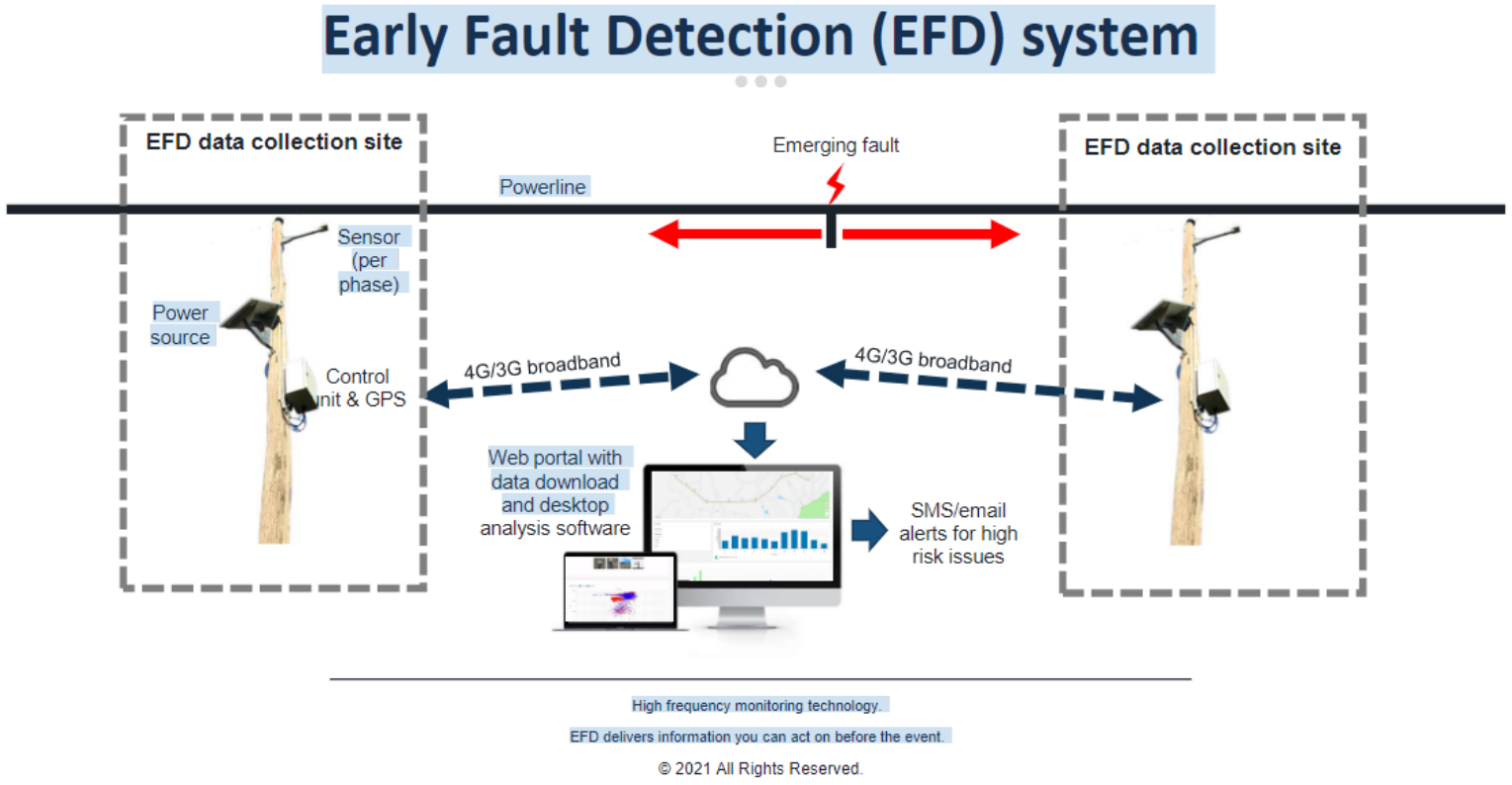
## Topic:
## EFD

# EFD – Early Fault Detection

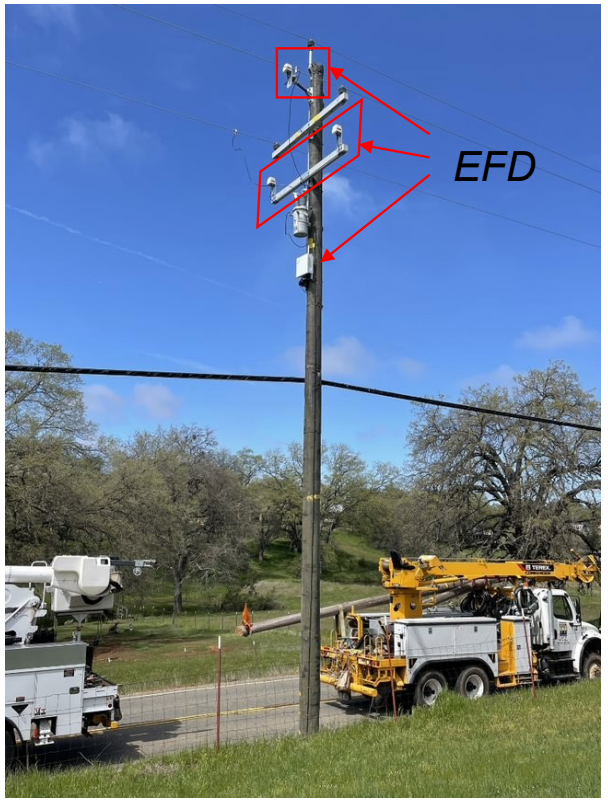
- Technology developed by IND.T in Australia to help prevent Bushfires
- The EFD system uses accumulated detections of partial discharge events to pinpoint equipment issues.
- Detection conditions types
  - Broken damaged conductor/splices
  - Broken damaged insulator
  - Failing service transformers
  - Vegetation encroachment
  - Fuse Cutout Malfunction

# Sensor Theory of Operation and Space

Sensors installed along circuit approximately every 3 miles



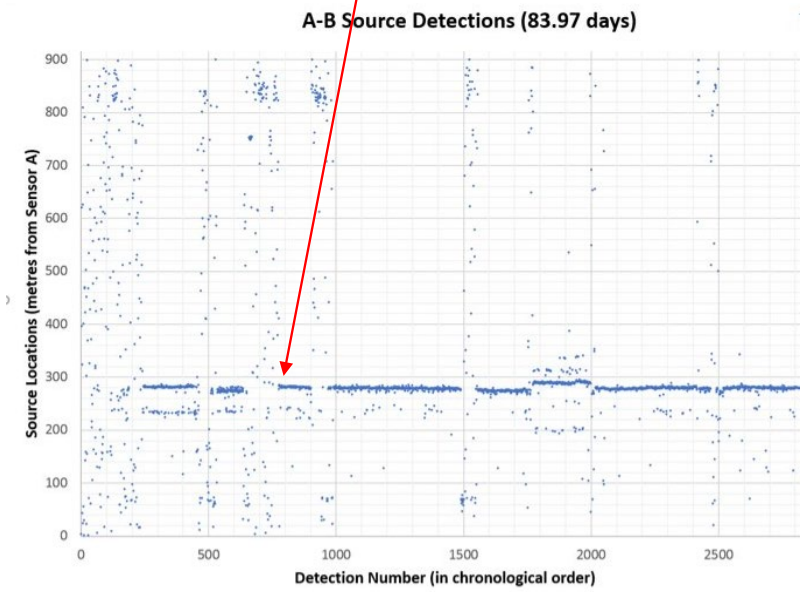
# Installation



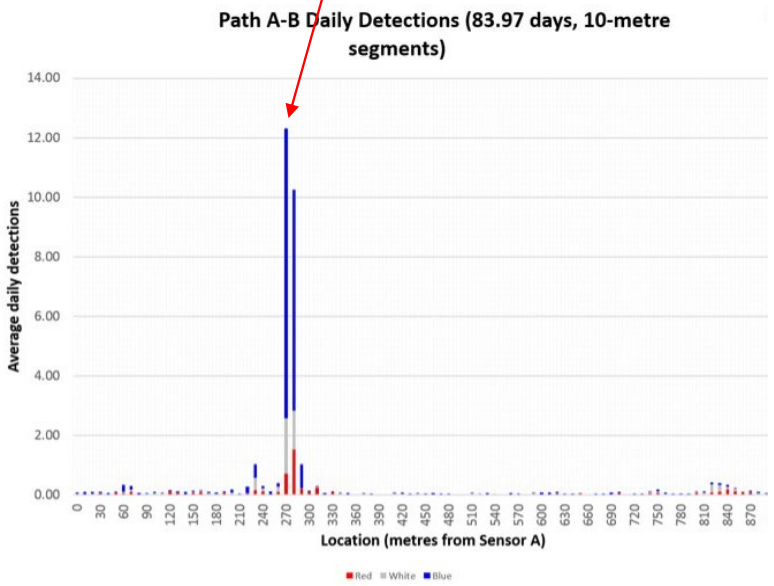
# Signal Analysis Example

## Signal Analysis Example

- Source Detections indicate where on a sensor path a problem is located

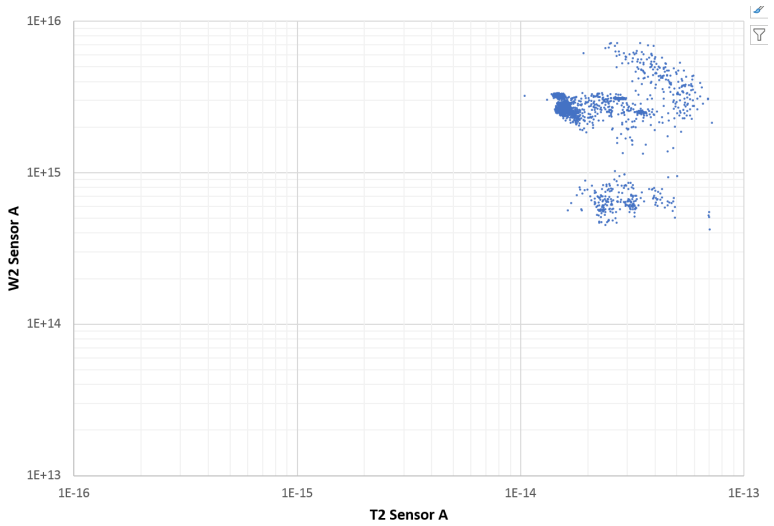


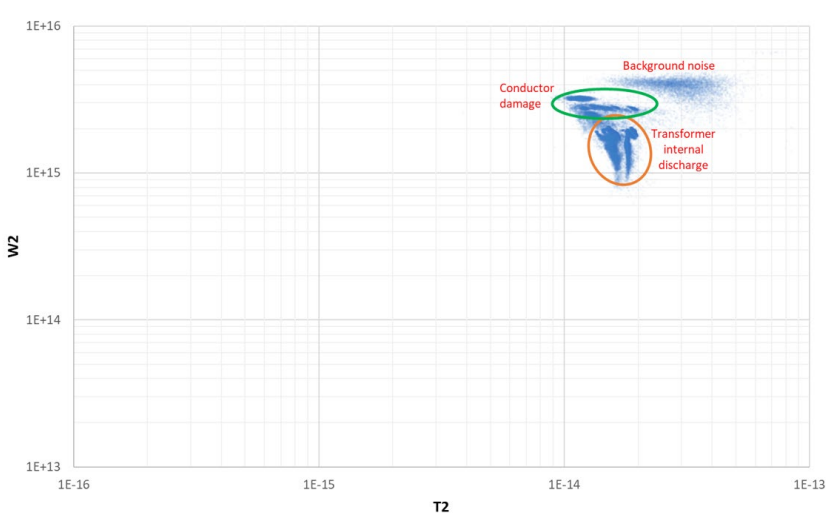

- Daily Detections indicate on which phase a problem is located



# Signal Analysis Example

- Below is SCE frequency-time (FT) Chart (left) with comparison FT Chart from another utility (right)
- Patterns on FT chart indicate potential cause of issue(s)
- Consistent across different voltage classes and utilities



# Examples of Findings - SCE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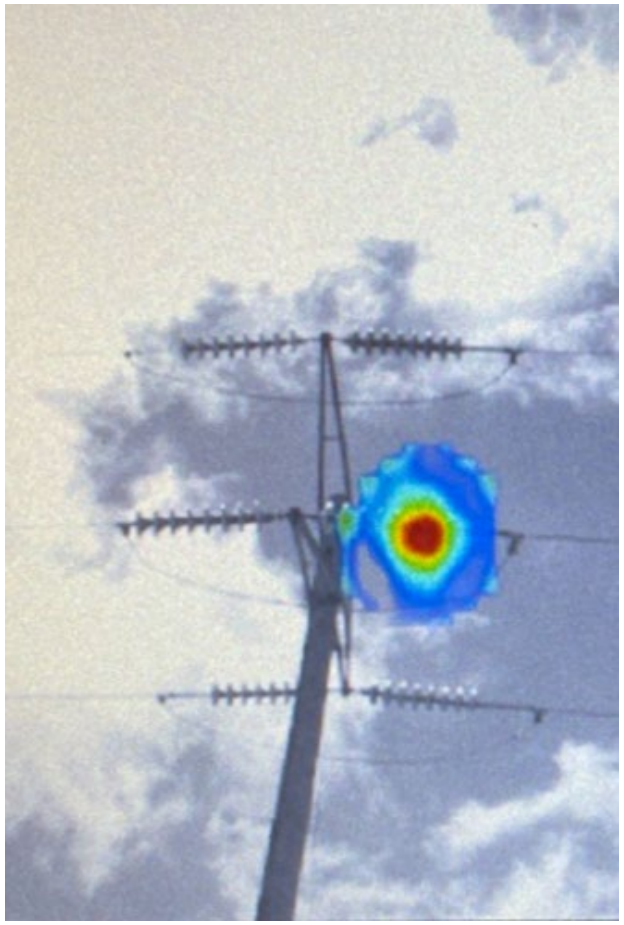
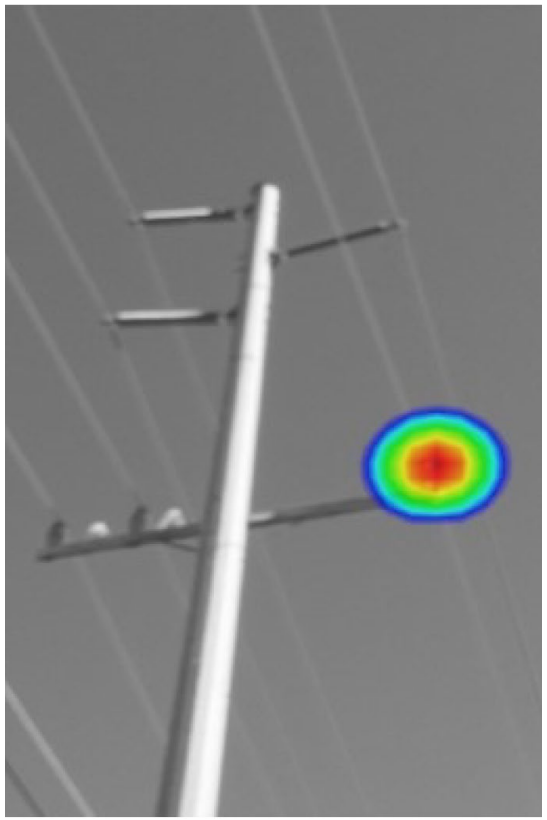
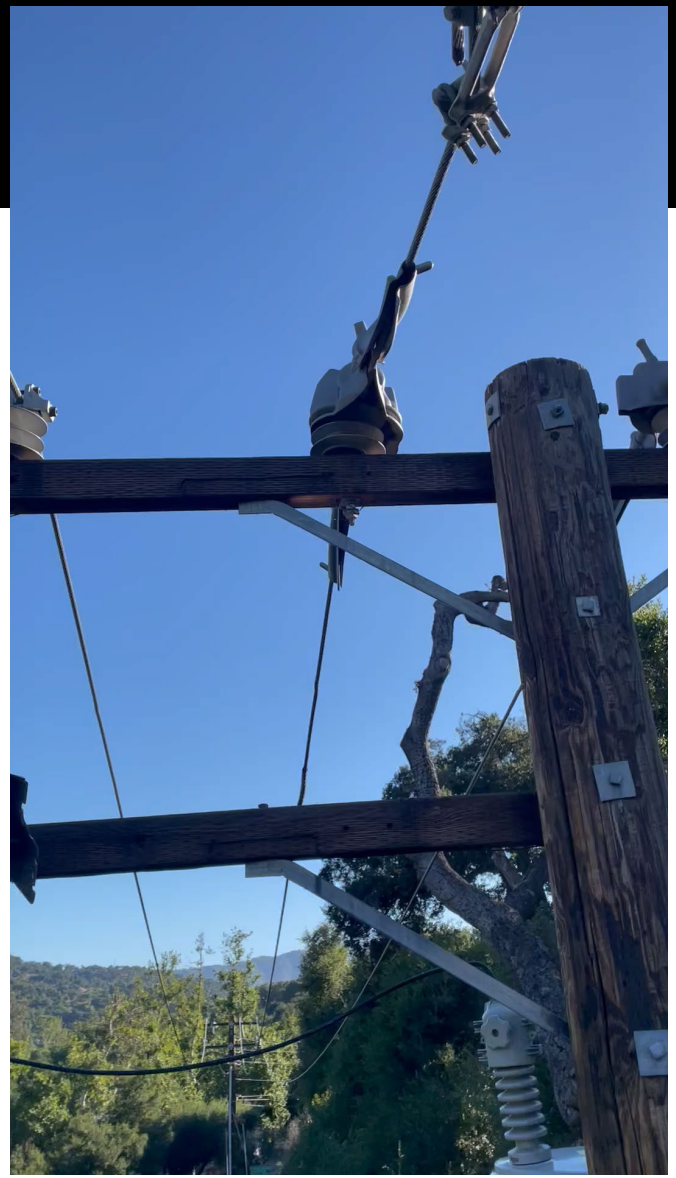


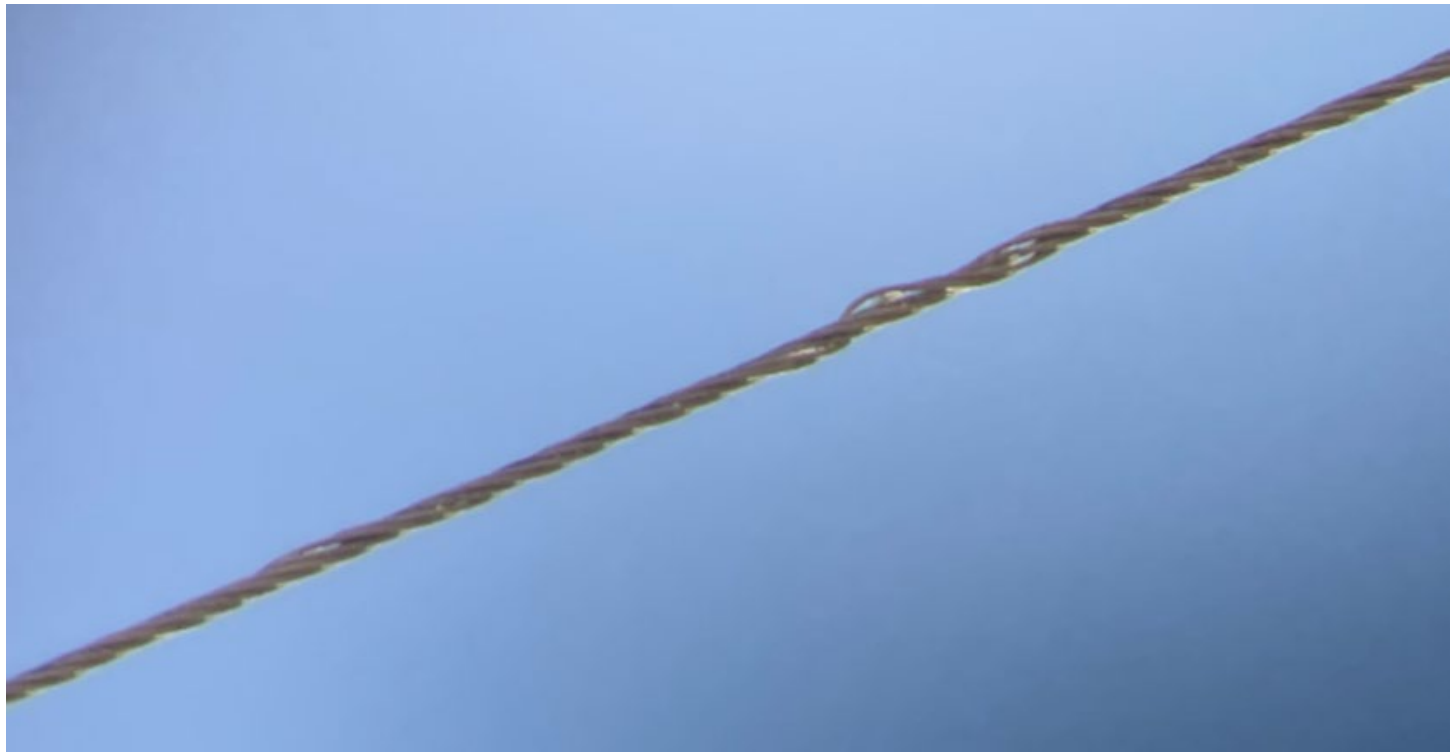
# Examples of Findings - SCE



# Examples of Findings - SCE



# Examples of Findings – SDG&E



# Examples of Findings – SDG&E

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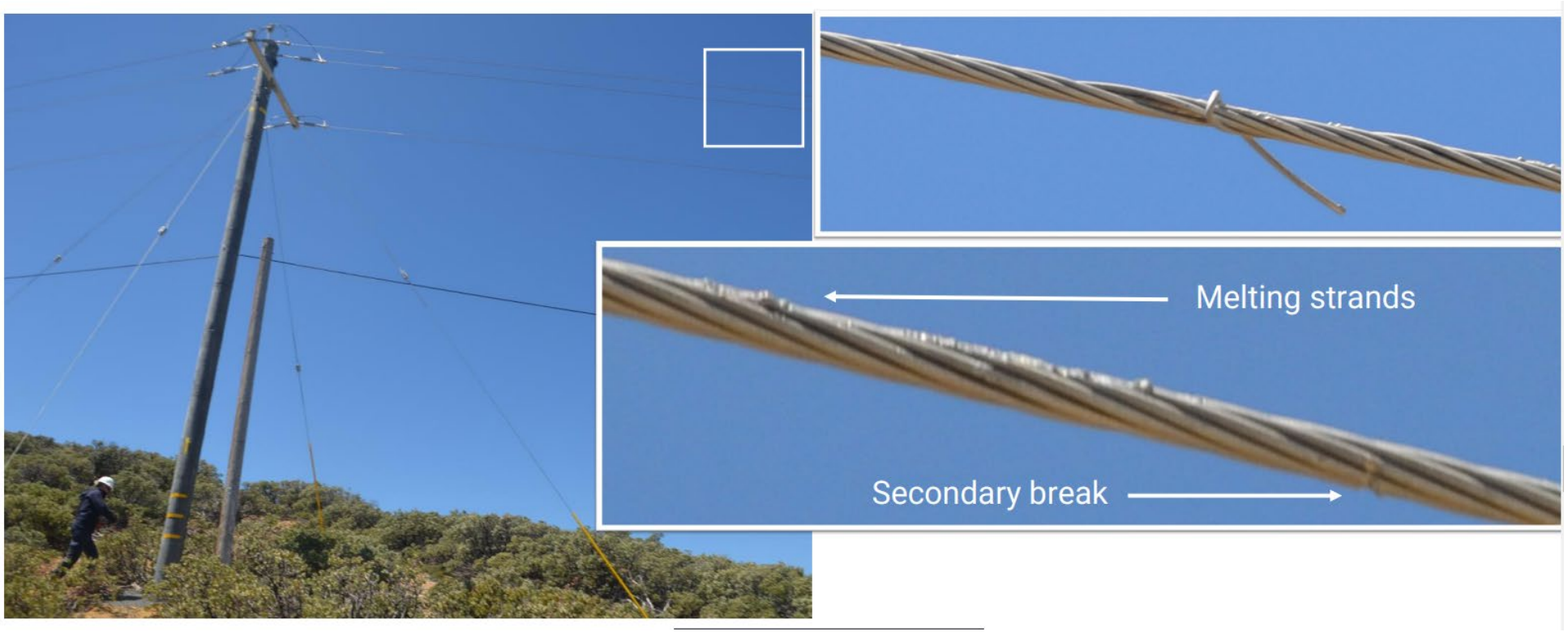
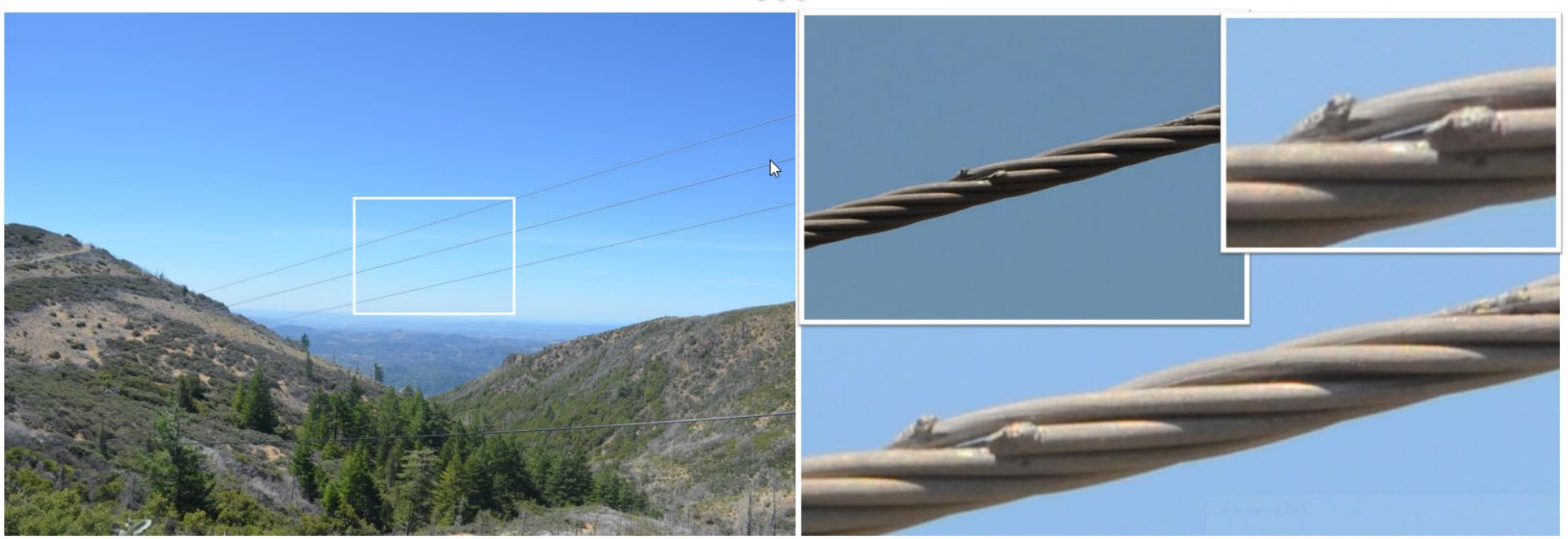
# Examples of Findings – PG&E

## Identified Condition – Broken Strands

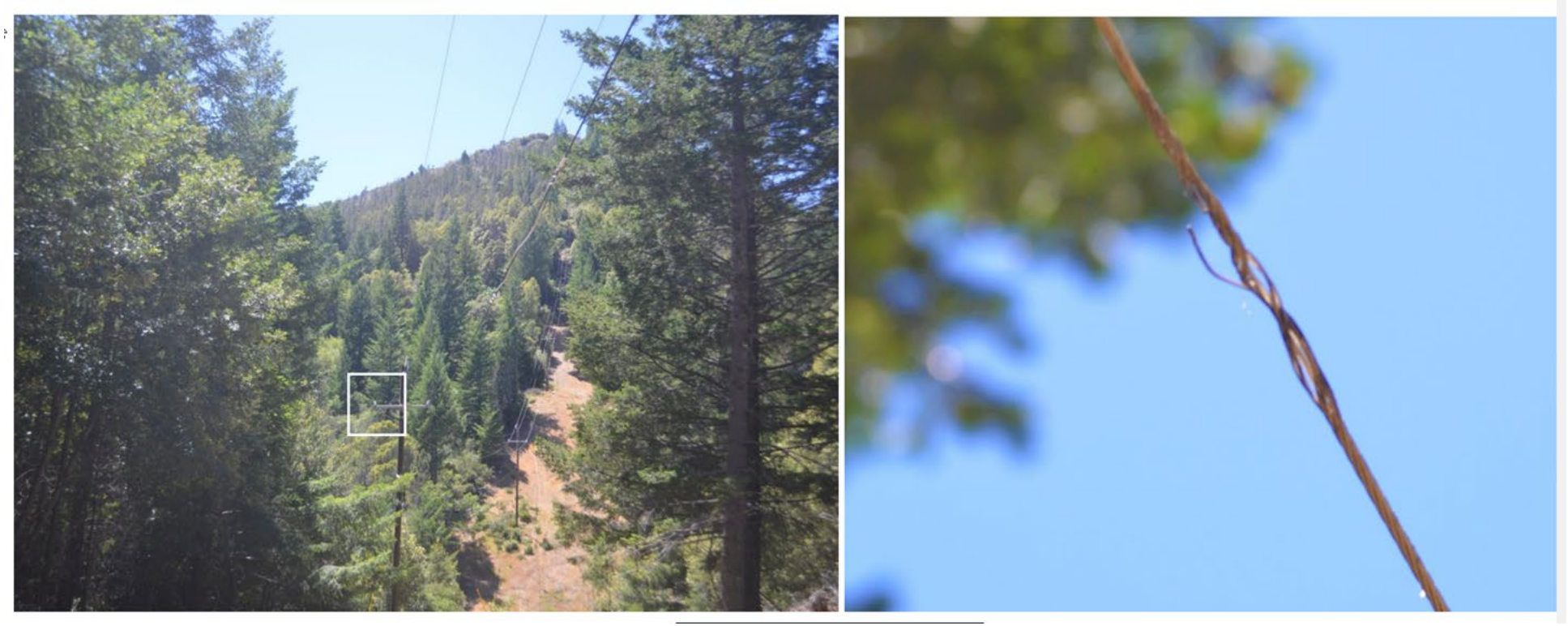


# Examples of Findings – PG&E

## Identified Condition – Broken Strands



# Examples of Findings – PG&E



# Examples of Findings – PG&E

## Identified Conditions- Broken Insulator/Pin, Melted Insulator

# Technology Overview – PG&E

## Situational Awareness Sensor Technology – Overview

**Line Sensors / cFCI's**

- Single phase, conductor mounted harvesting device; generally requiring 25 amps continuous power (line sensor) or battery-powered (cFCI)
- Continuously monitoring to capture overcurrent events
- Generates alerts and waveforms thru to PI and DMS; these alerts are usable in fault locator models like CYME to estimate disturbance location

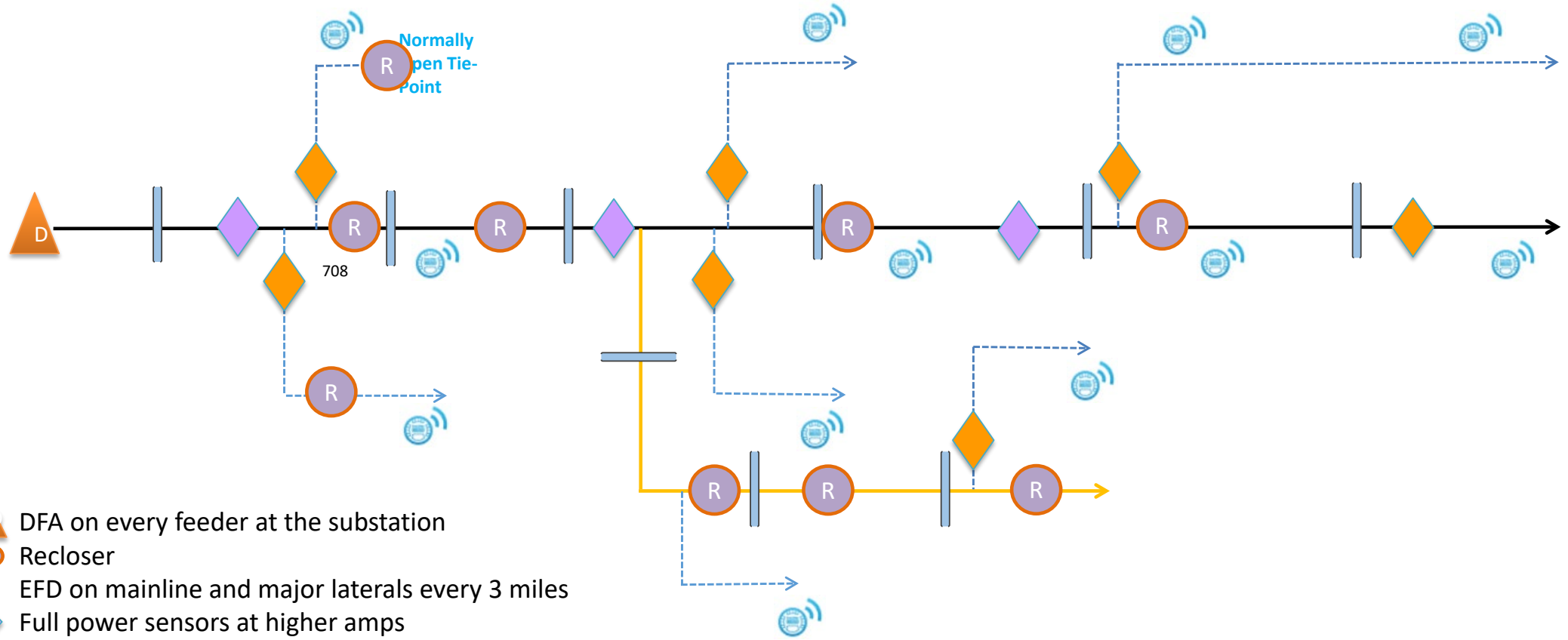
**EFD – Early Fault Detection**

- RF sensors mounted underneath conductor; 3 miles between sensor sets
- Sensors work in coordination from set-to-set; samples on a duty cycle basis
- Display matrix identifies concentrated patterns of discharge to a single span

**DFA – Distribution Fault Anticipation**

- Substation CT / PT-based device measuring volts, amps and arcing
- Monitors magnitude, phase, harmonics, real and reactive power, cycle-to-cycle deltas in these values
- Clusters and categorizes events and generates waveforms; these alerts are usable in fault locator models like CYME to estimate disturbance location

# Illustrative Circuit When Fully Implemented – PG&E




- DFA on every feeder at the substation
- Recloser
- EFD on mainline and major laterals every 3 miles
- Full power sensors at higher amps
- cFCI on tap laterals and at lower amps
- Smarter meters at every customer (higher sampling, smarter last gasp, waveforms, edge analytics)

# Rollout Process – PG&E

Revolutionary Technology

Automation, Integration & Analytics

Evolutionary Technology

**Short Term (2020 – 2023)**
Deploy existing devices; nurture emerging technology

- Accelerate line sensor and DFA deployment
- Deploy inexpensive cFCI's
- Select and begin integration of analytics platform with IT
- Move RF sensors to viability

**Mid Term (2024 – 2027)**
Deploy new technologies and integrate analytics

- Deploy RF sensors on 100 feeders
- Move Smarter Meters to viability
- Integrate SCADA data in ADMS into analytics platform
- Extend analytics to auto detection

**Long Term (2028 – 2032)**
Enable future analyses and foster innovation

- RF sensors on 500 feeders
- Deploy Smarter Meters
- Integrate advanced analytics in ADMS
- Auto detection + auto field dispatch

Years

# Rollout Process – PG&E

- EFD sensors detect incipient conditions
- DFA waveform collector in substations
- cFCI's segment distribution for restoration sectionalizing and fault detection
- Smarter Meters determine secondary voltage anomalies
- SCADA equipment provides additional data

- Continuous sampling and monitoring across all 3 phases

Monitoring

Sensors

Analytics (Foundry)

Grid Health Awareness & Response

- **Goal:** Detect conditions that warrant attention and auto-generate field tags with location details
- **Extent:** All Tier 2 / 3 feeders & select reliability needed feeders

**Awareness:**
- Knows as-switched model, DER contributions and loading
- Weather conditions
- Time series and geospatial
- Operational status of entire distribution network

- Identifies hazard conditions in automated format
- Analyzes data from multiple sources
- Generate investigate tag when incipient indications are triggered
- Automatically generate fault location
- ADMS integration