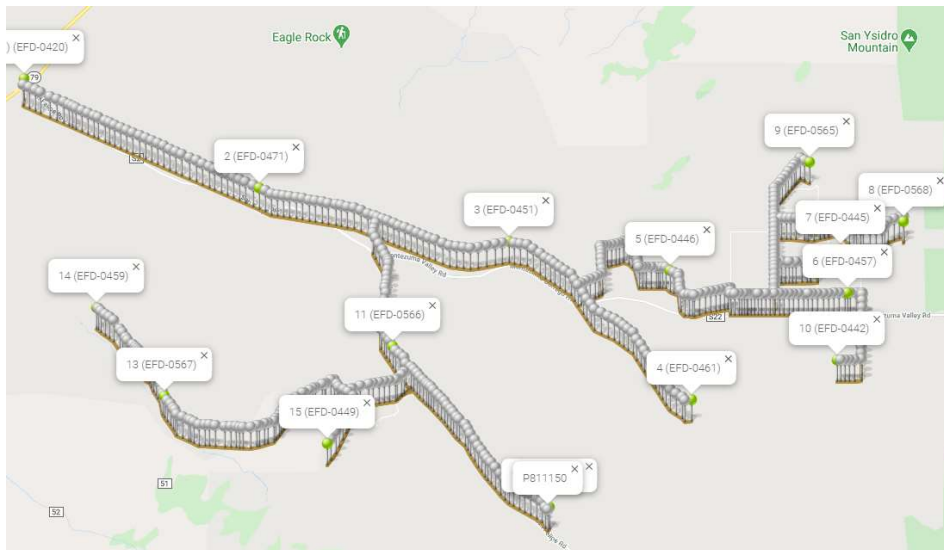




Early Fault Detection

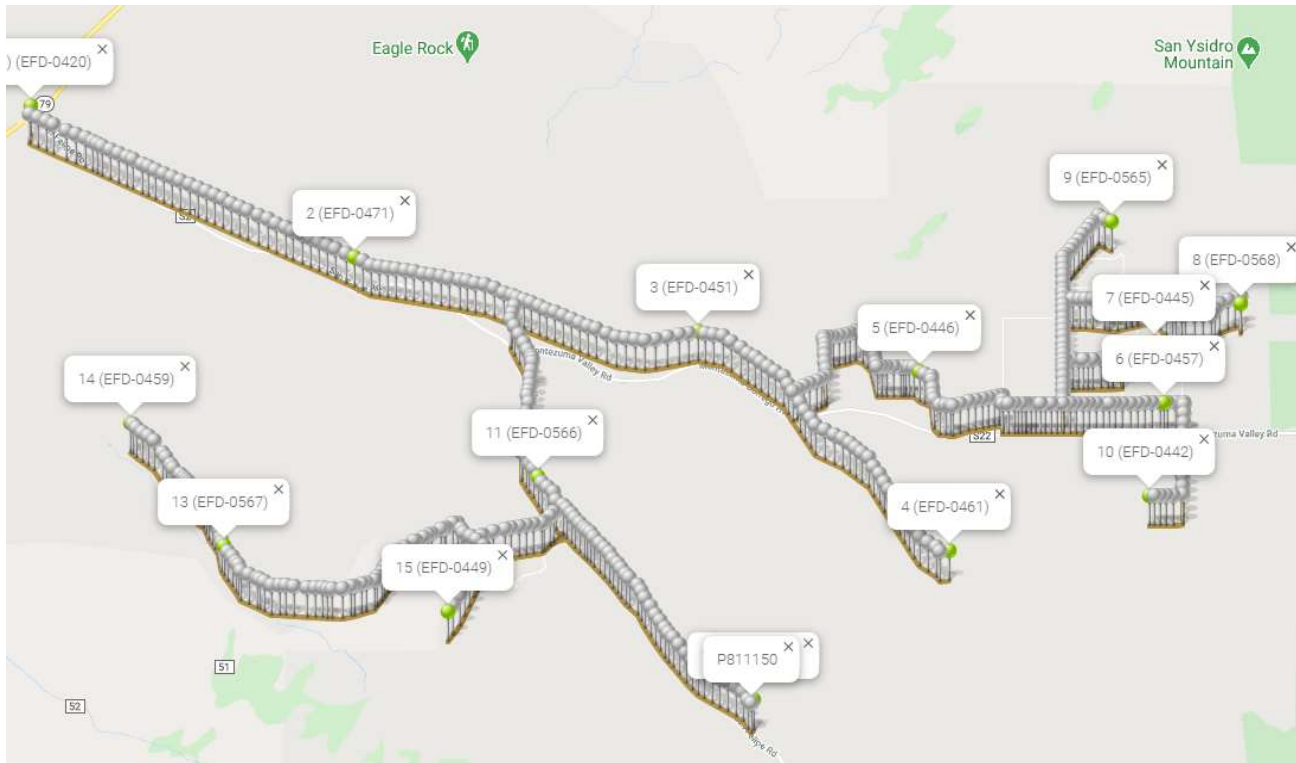


Agenda

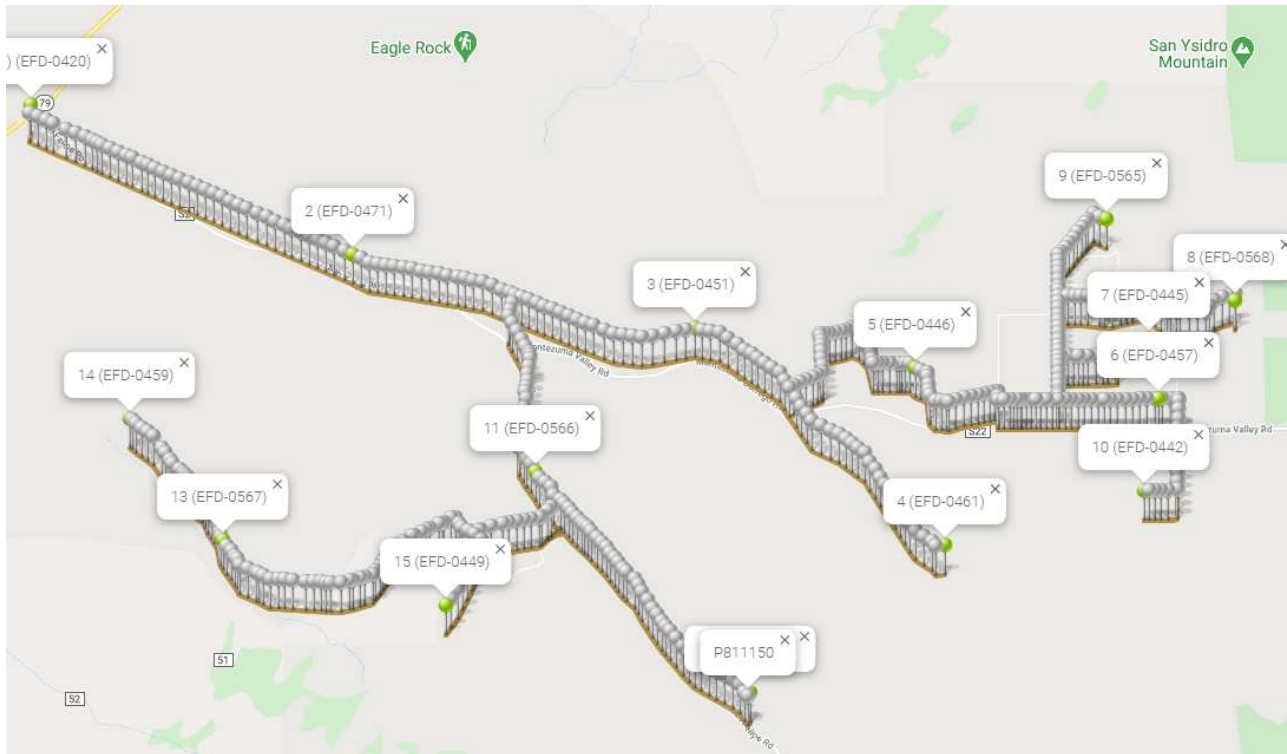


- Introductions
- Meeting Kickoff – Chris Bolton
- Program Overviews – Chris Brown
- Deployment Status – Shagufta Sayed
- IND.t reports and discoveries – Andrew Walsh
 - EFD system interface overview
 - Examples on how to use – two cases
 - Management of the EFD unit fleet
 - Operationalizing EFD
 - Preliminary final report
- Round Table

Project Overview



Project Overview

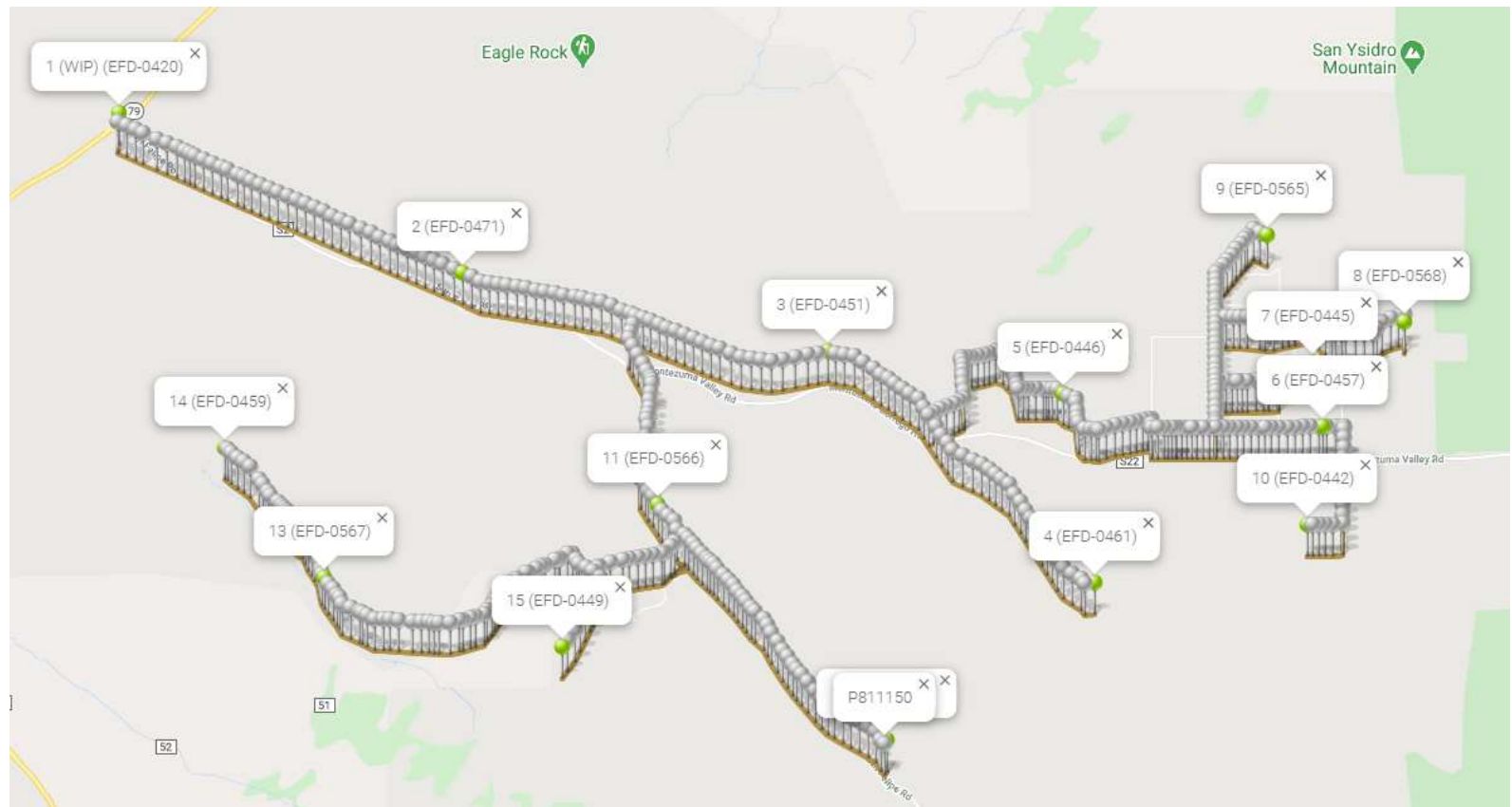


- Radio Frequency (RF) sensors set up at intervals on circuit
- Partial Discharges (PD) on conductor recorded
- Differential timing between installations used to locate partial discharges
- Magnitude and pattern of discharges indicate damage to components
- Linemen investigate particular location and repair prior to catastrophic failure
- 2 circuits completed, 3 more in construction, 5

Circuit 211 Overhead EFD System

EFD System works on paths between adjacent nodes

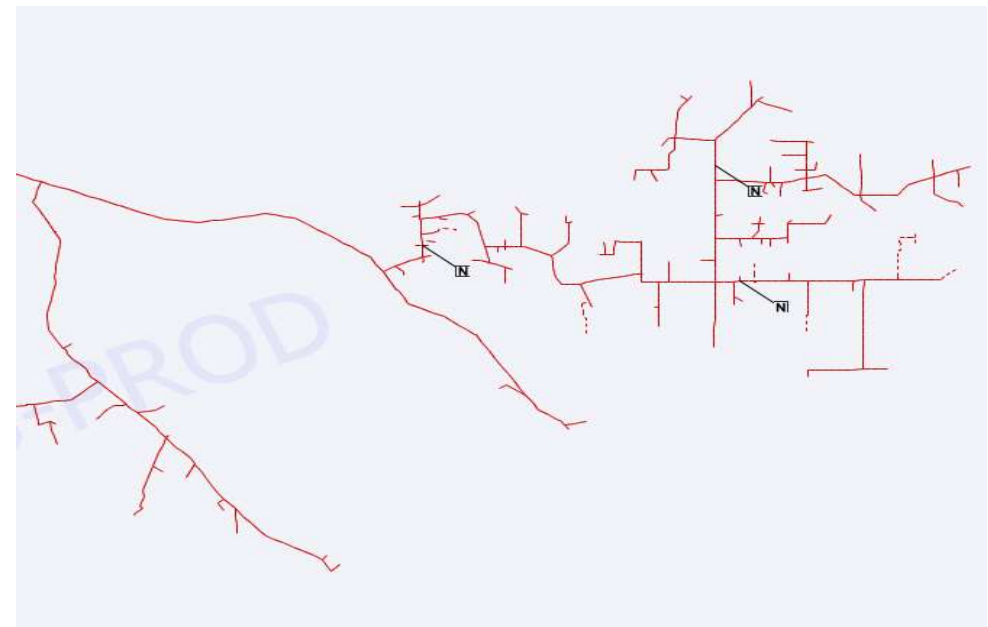
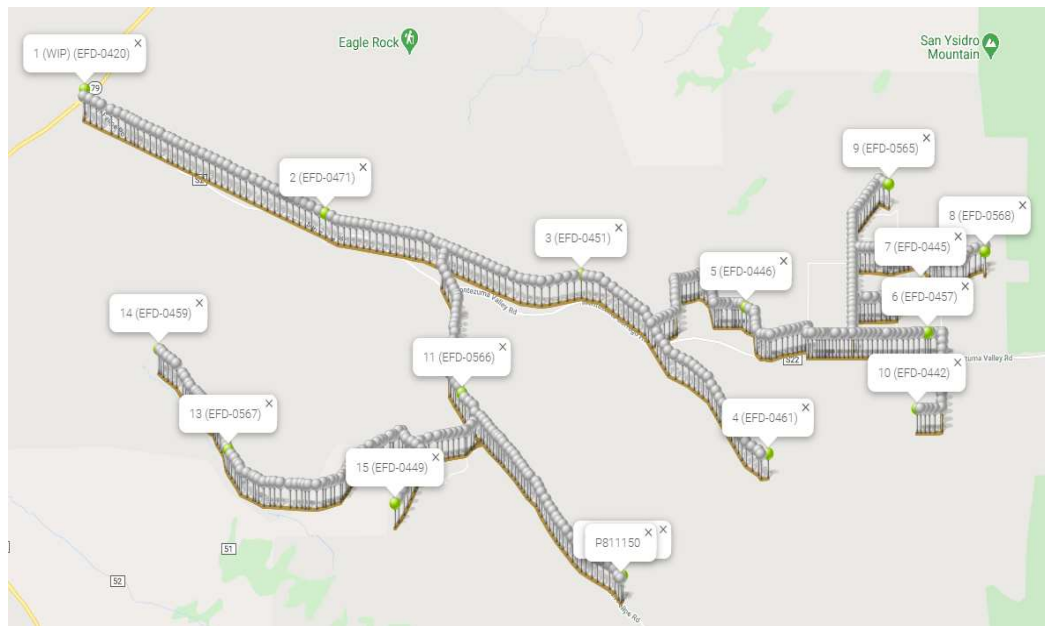
- 5km/3.2-mile max distance
- 4km design scope to allow for field limitations



Circuit 211 Overhead EFD System

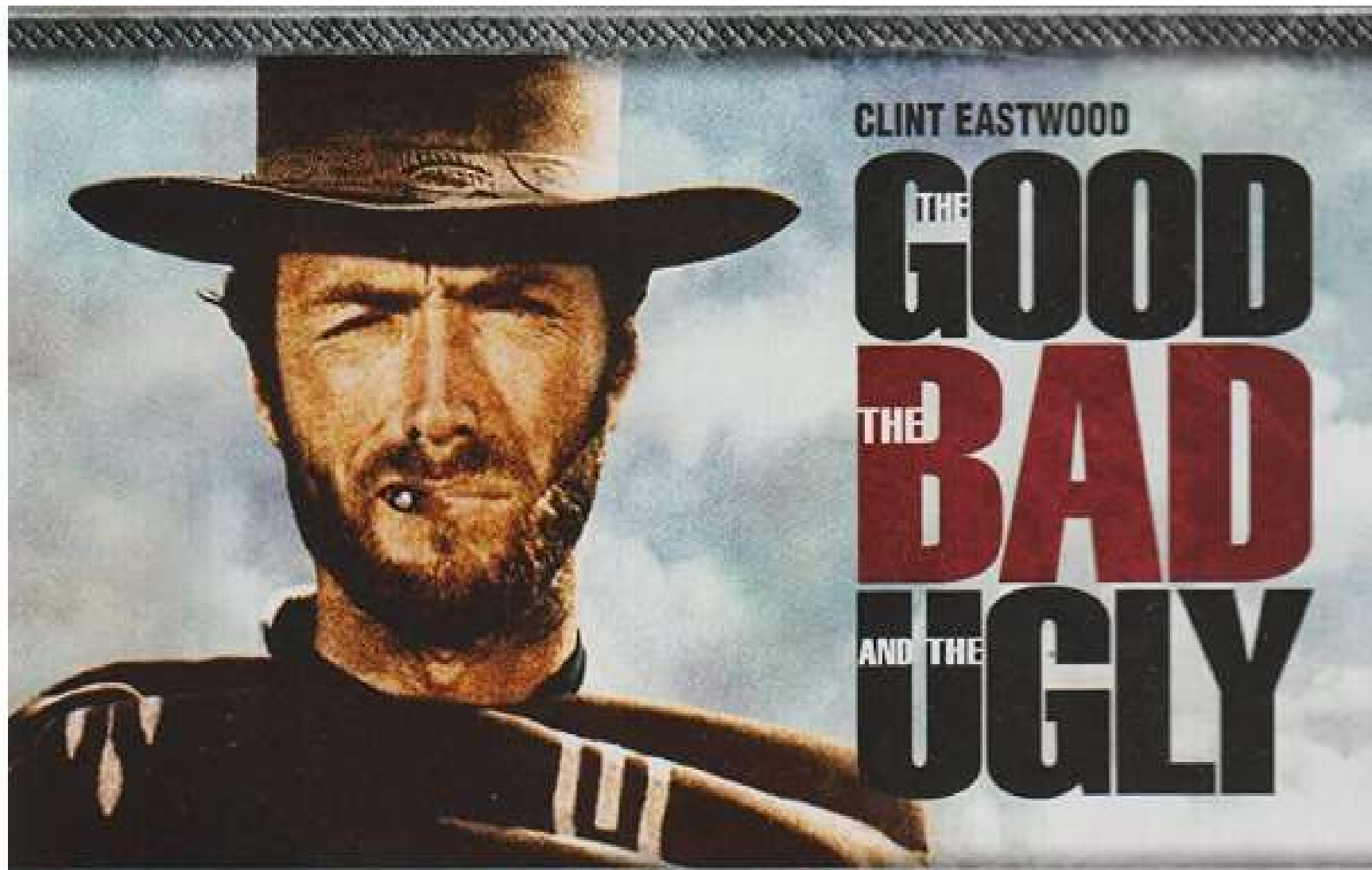
EFD System works on paths between adjacent nodes

PD data not on a path cannot be isolated to a specific location



System Limitations

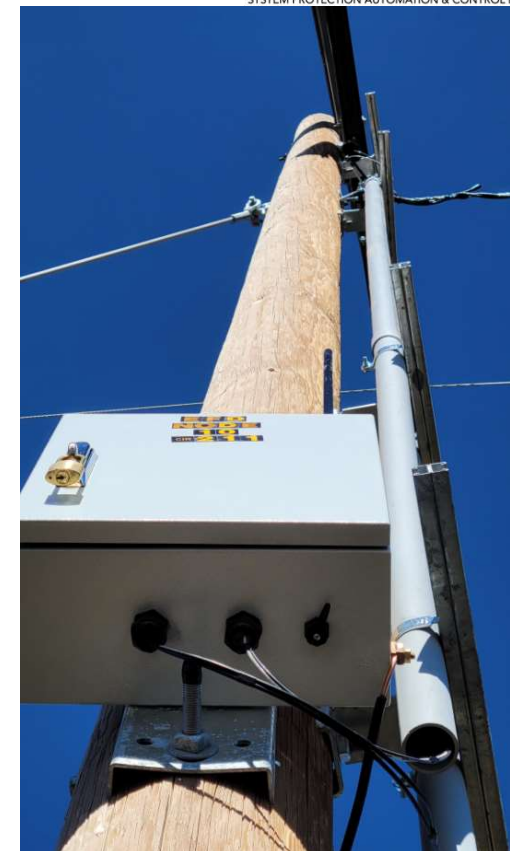
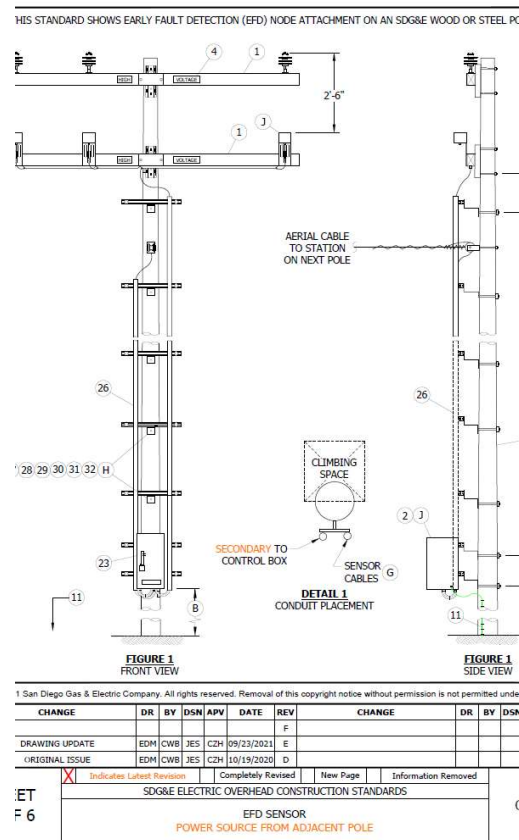
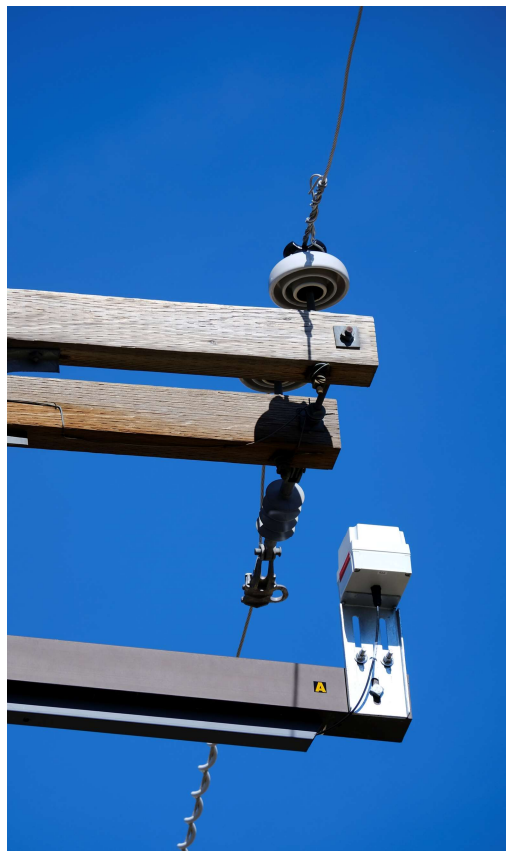
- Point-to-point
 - Branches appear at point of attachment
 - 2.5km off-path limitation
- Transformers cannot be co-located with a node
- Last span (or more) at branch ends not covered
- Underbuilt OK!
- Establishing baseline pattern takes some months

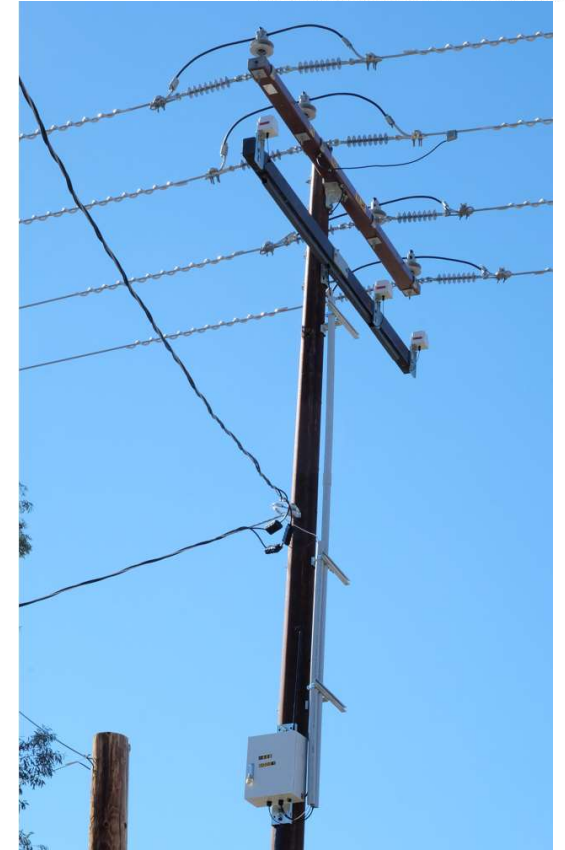


The Good

- Construction
- Fielding/Design
- Significant findings
- Generation 4 more capable units for 2022 Circuits
 - 96% “on”
 - Better hardware/software capability
 - IP68 to 1 meter
 - 4 channels – C445 Neutral Channel
 - Exception C216 use 4ea Gen 3B









SCOPE: THIS STANDARD SHOWS THE INSTALLATION OF AN EARLY FAULT DETECTION (EFD) NODE AT A PADMOUNT TRANSFORMER.

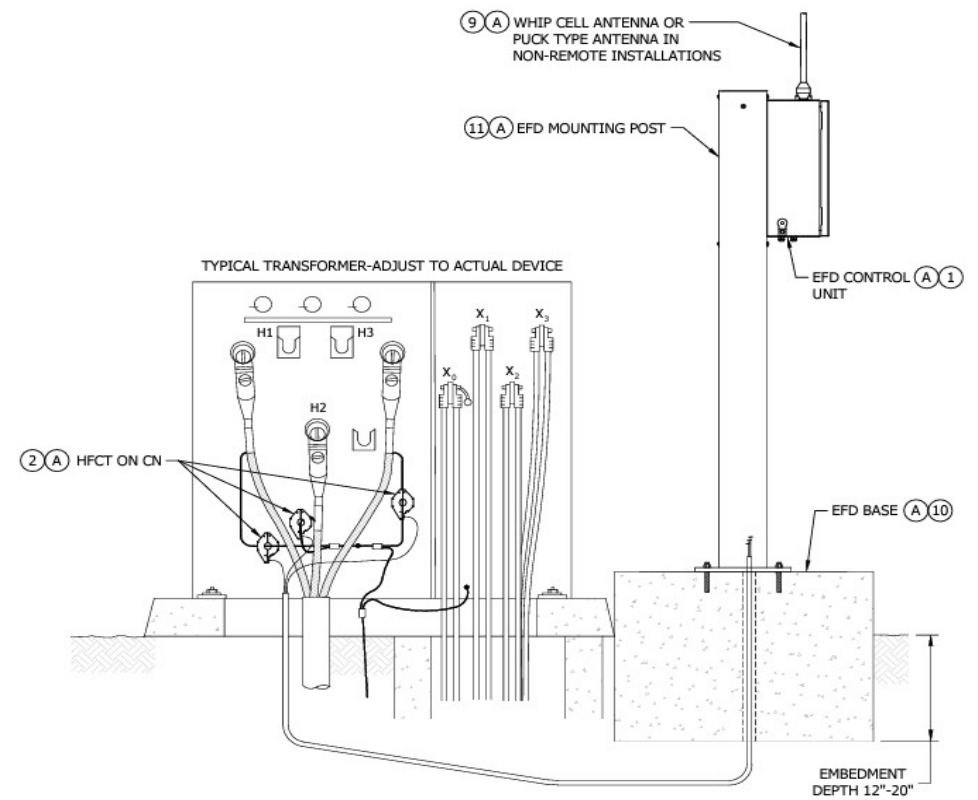
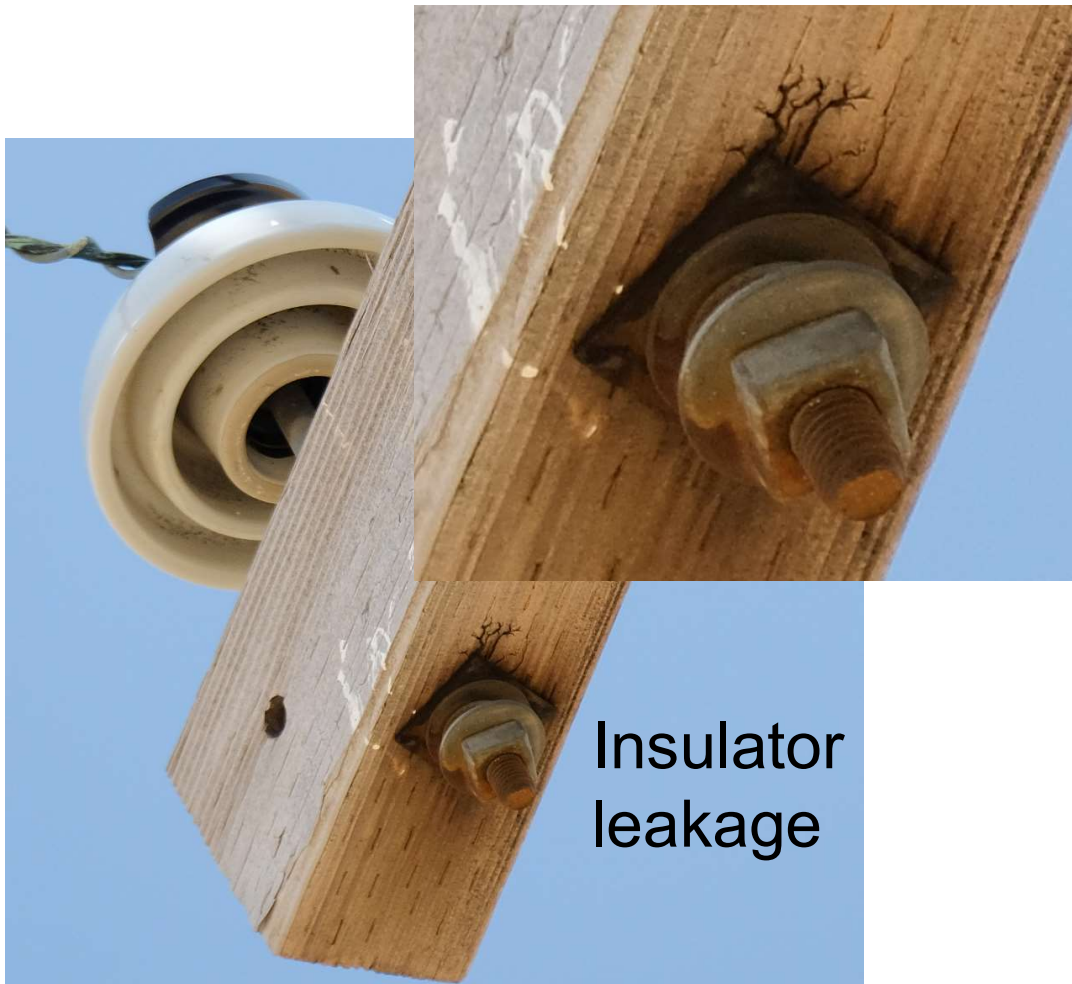
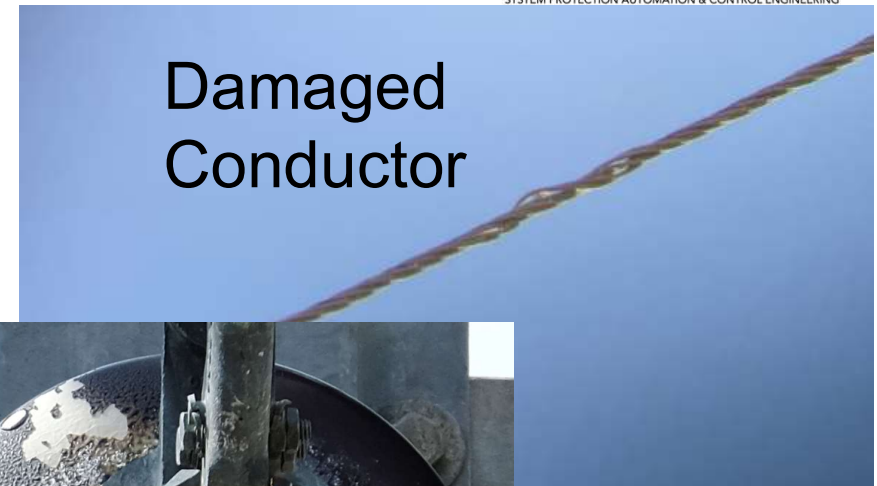


FIGURE 1
PADMOUNT EFD-POST MOUNT

Early Fault Detection Damage Detected



Insulator leakage



Damaged Conductor



Damaged Insulator

The Bad

- Most findings are not critical per districts
- No EFD System manual
- Sensitivity - QEW training needed
- Inventory/Shipping
- Single bushing PT on 3 wire system
- Installation Errors
- “Spare” Units
- ATT 3G system shutdown





△_CBF5119



△_CBF5120



△_CBF5121



△_CBF5122



△_CBF5123



△_CBF5124



△_CBF5125



△_CBF5126



△_CBF5127



△_CBF5128



△_CBF5129



△_CBF5130



△_CBF5131



△_CBF5132



△_CBF5133



△_CBF5134



△_CBF5135



△_CBF5136



△ CBF5137



△ CBF5138



△ CBF5139



△ CBF5140



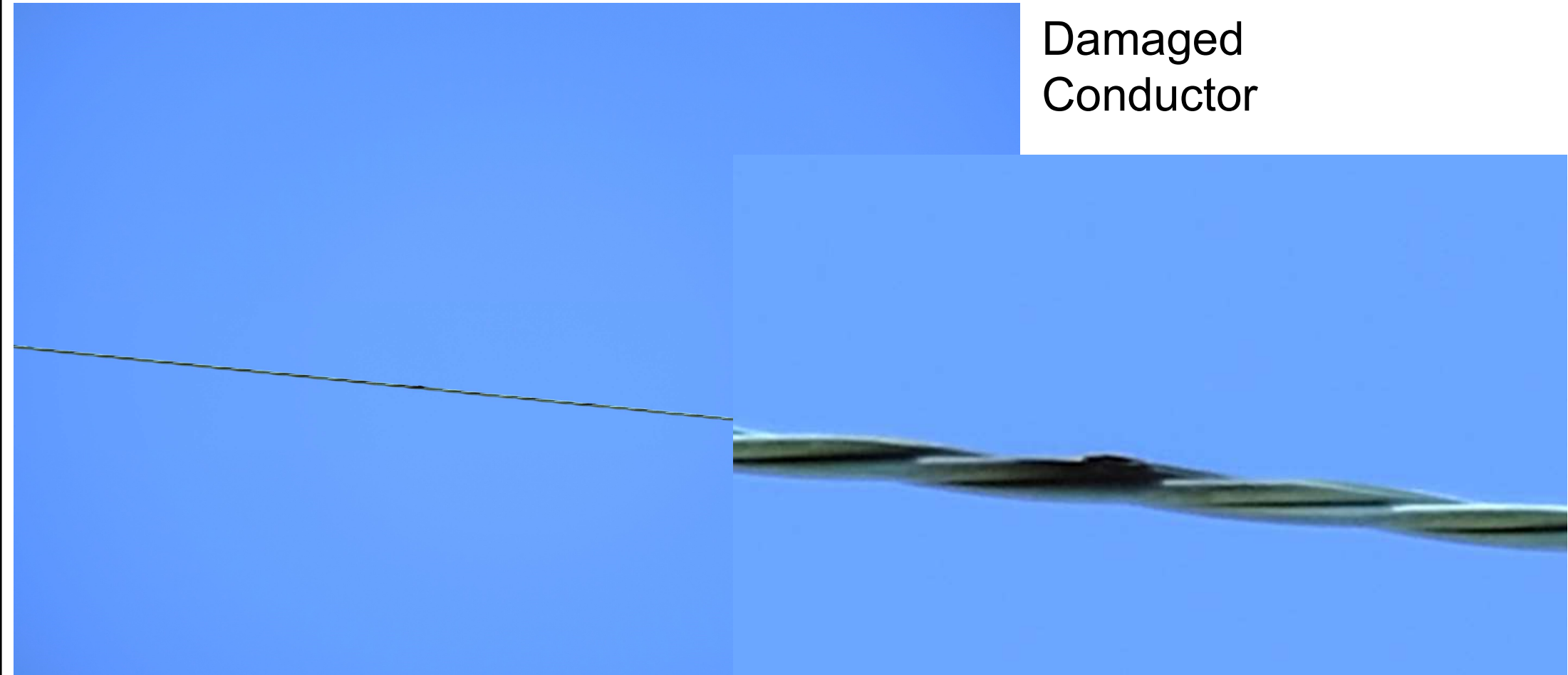
△ CBF5141



△ CBF5142

Early Fault Detection Damage Detected

Damaged
Conductor



View Downstream from C211 Nodes 7 & 10



Potential Transformer



The Ugly

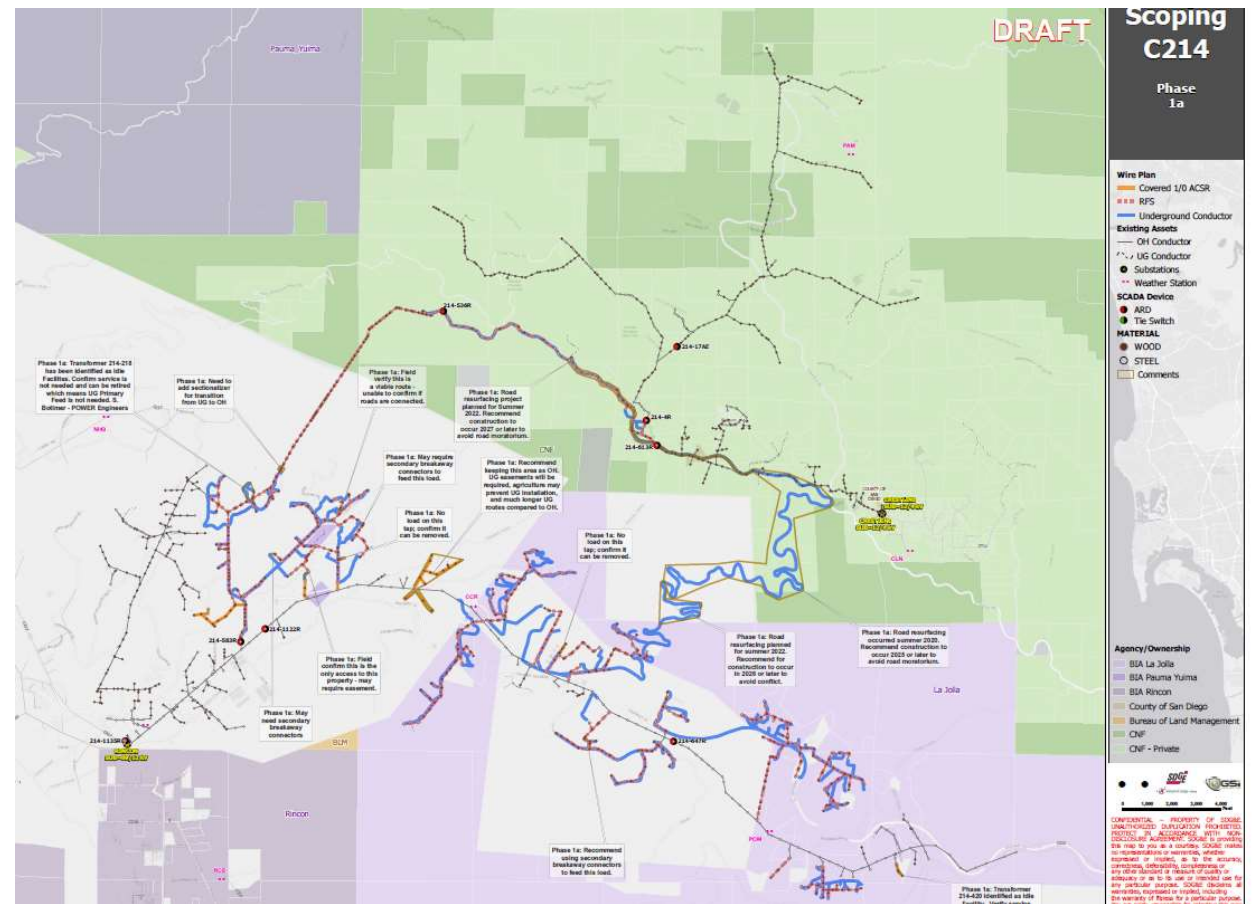
- Strategic Undergrounding
 - C445, 214, 217 de-scoping



The Ugly



- Strategic Undergrounding
 - C445, 214, 217 de-scoping



Project Status



Circuit	HFTD	No. of Locations	No. of Locations Completed	% completed
Warners C211	3	15 OH	15 OH	100%
Cameron C448	3	20 OH	20 OH	100%
Lilac C350	3	27 (24 OH, 3 UG)	24 OH	88.89%
Jamacha C75	3	10 (8 OH, 2 UG)	7 OH	70%
Jamacha C524	3	22 (13 OH, 9 UG)	13 OH	59.09%
Lilac C354	3	12 (9 OH, 3 UG)	5 OH	41.67%
Avocado C521	3	22 (20 OH, 2 UG)	6 OH	27.27%
Boulevard East C445	3	21 (19 OH, 2 UG)	In construction	
Total		149 (128 OH, 21UG)	90 OH	60.04%

Budget and Cost per Widget



Budget	2020	2021	2022
Planned	\$1.0 M	\$2.0 M	\$2.5 M EAC (\$2.8M)
Actual	\$1.2 M	\$2.4 M	\$1.84 M (YTD)

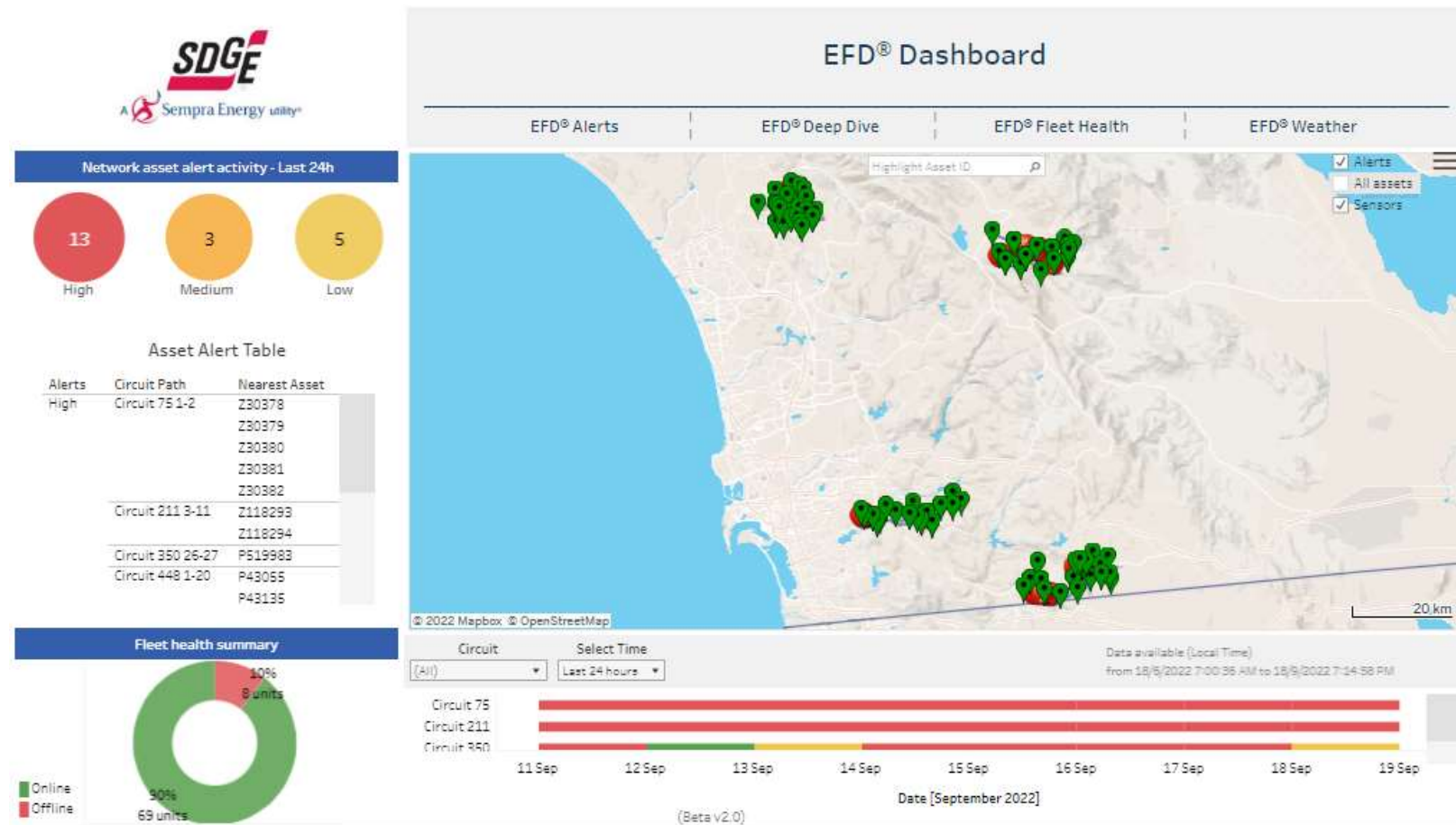
- Per unit for solar assembly - \$45,000
Per unit for PT assembly - \$34,000

Lessons Learnt

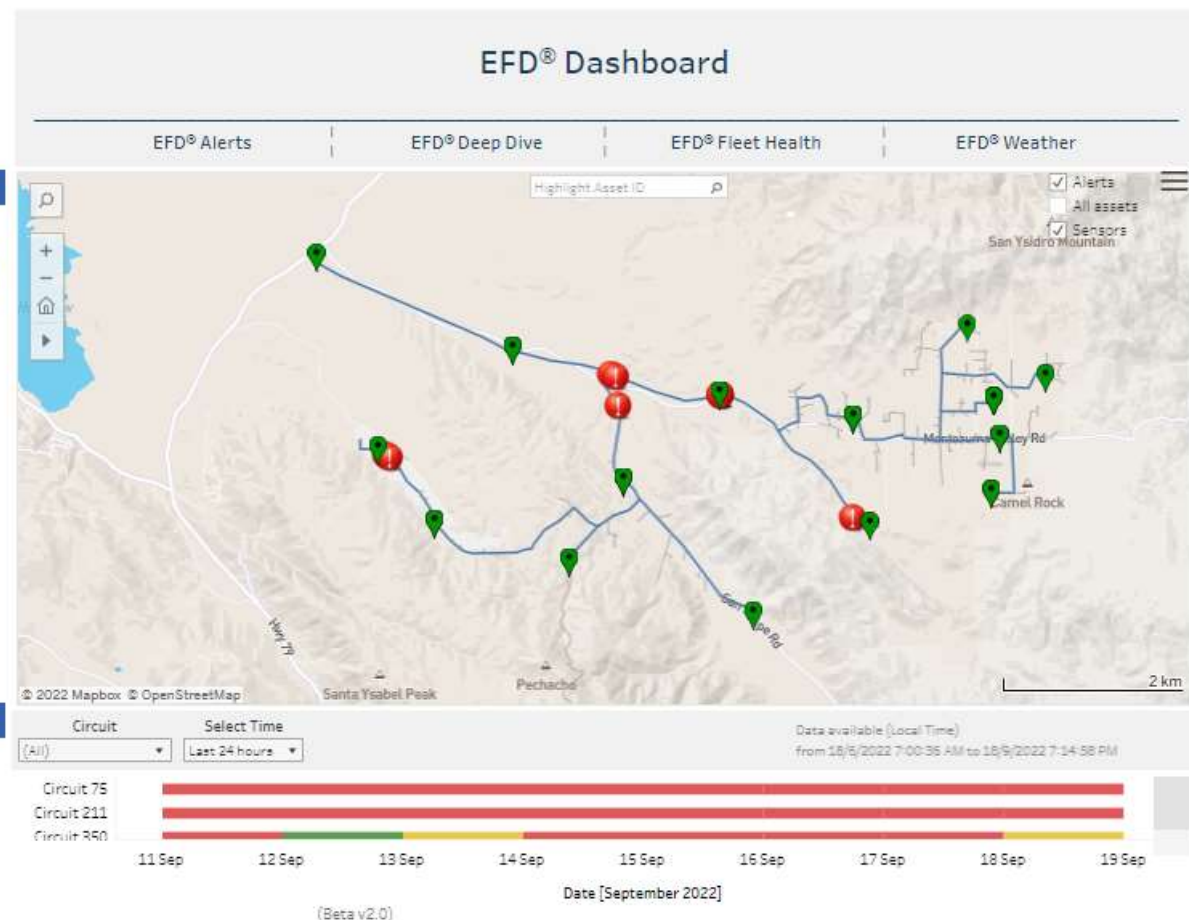
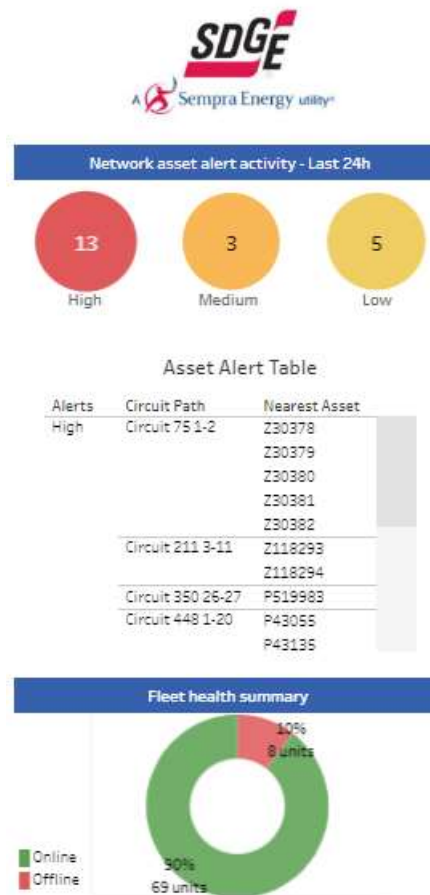
- C211 – Initiated the circuits with potential transformer, lead to intercepting new poles in the infrastructure.
- Design challenges – Standard approvals, Pole load calculation delays, land access, conflicts with Falling Conductor Protection.
- Material and Logistics.
- Multiple Gen variation challenges.

IND.t reports and discoveries

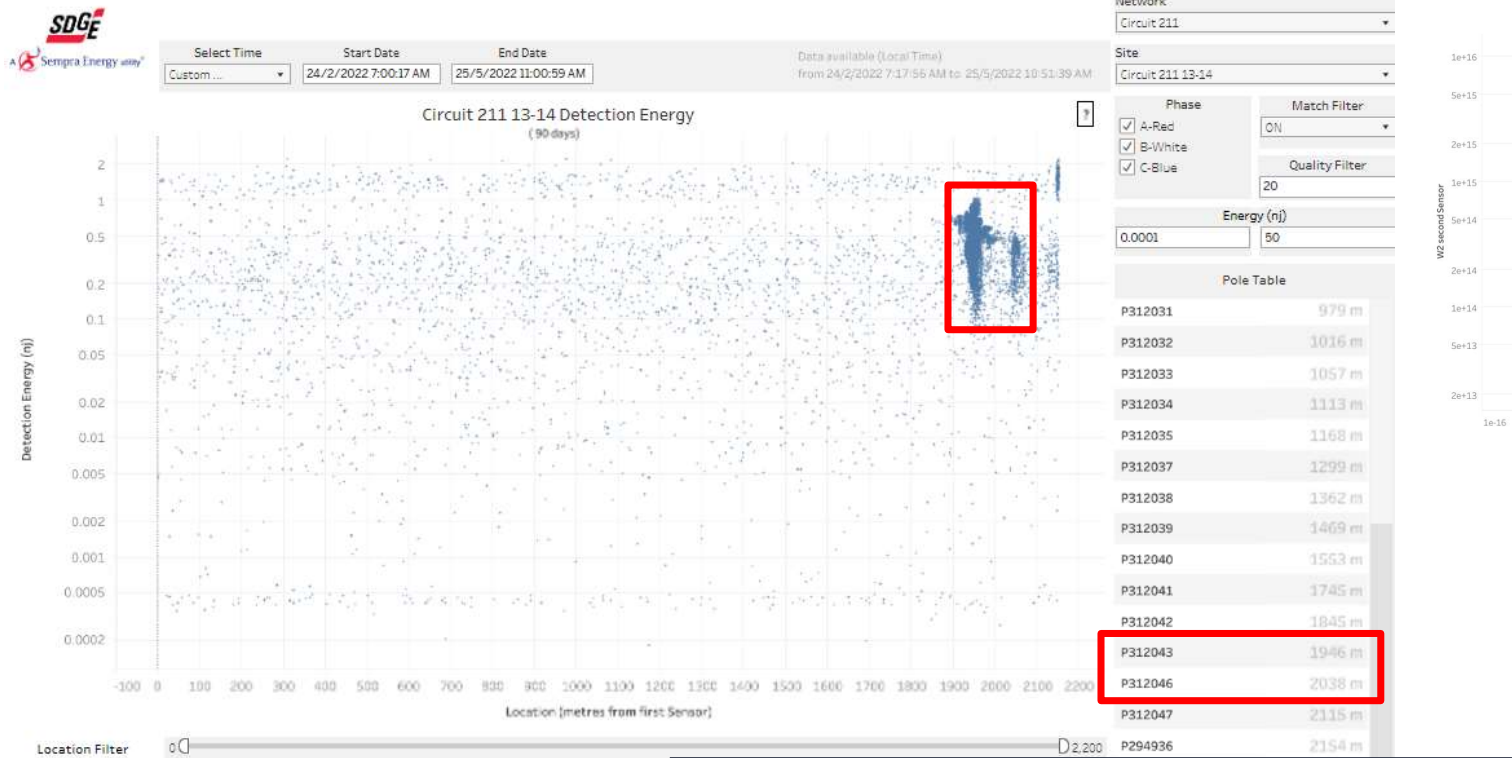
SDGE EFD System - Overview



SDGE EFD System - Circuit 211



SDGE EFD System - Zoomed in on the data



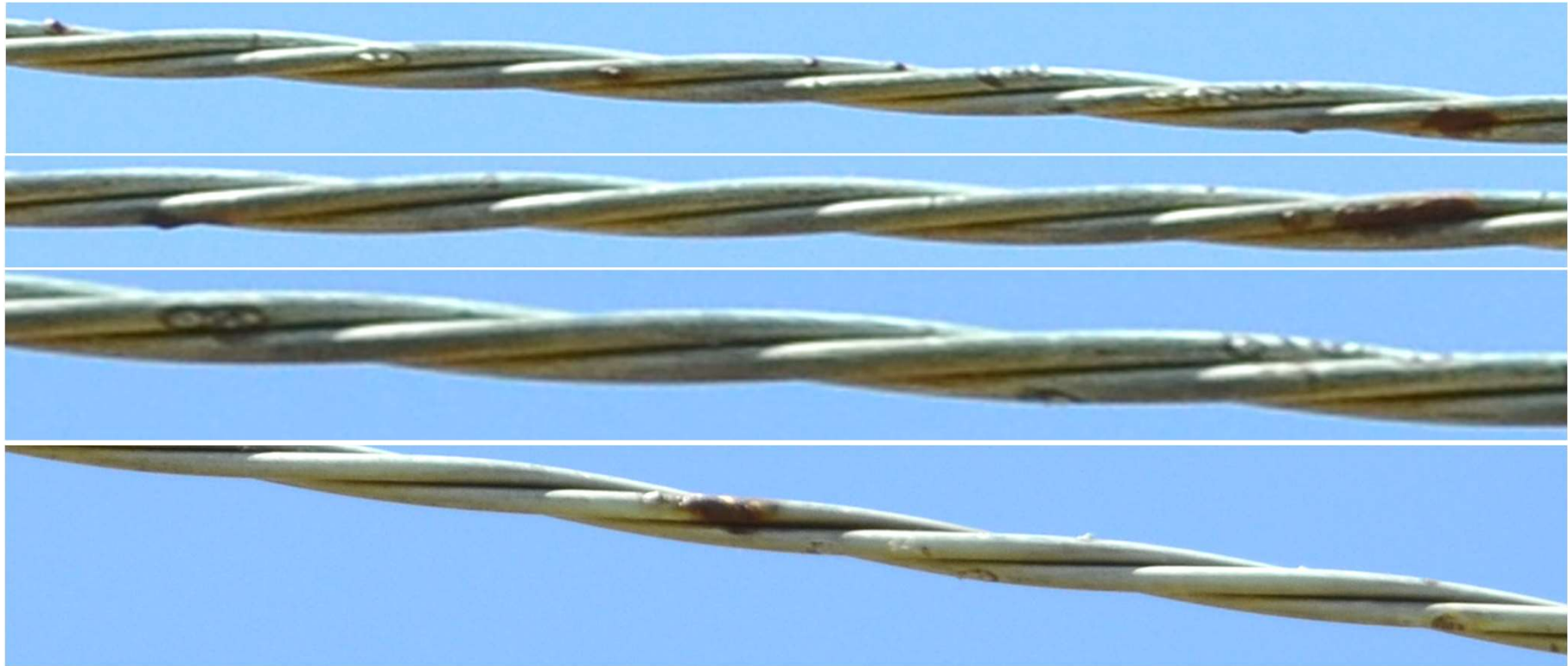
Detection Energy chart, above left, focused the Team's inspection on poles P312043, P312046 and the span in between. The Frequency-Time chart, above right, horizontal pattern gives the indication of conductor damage.

SDGE EFD System - Zoomed in on the data



Location of the inspection.

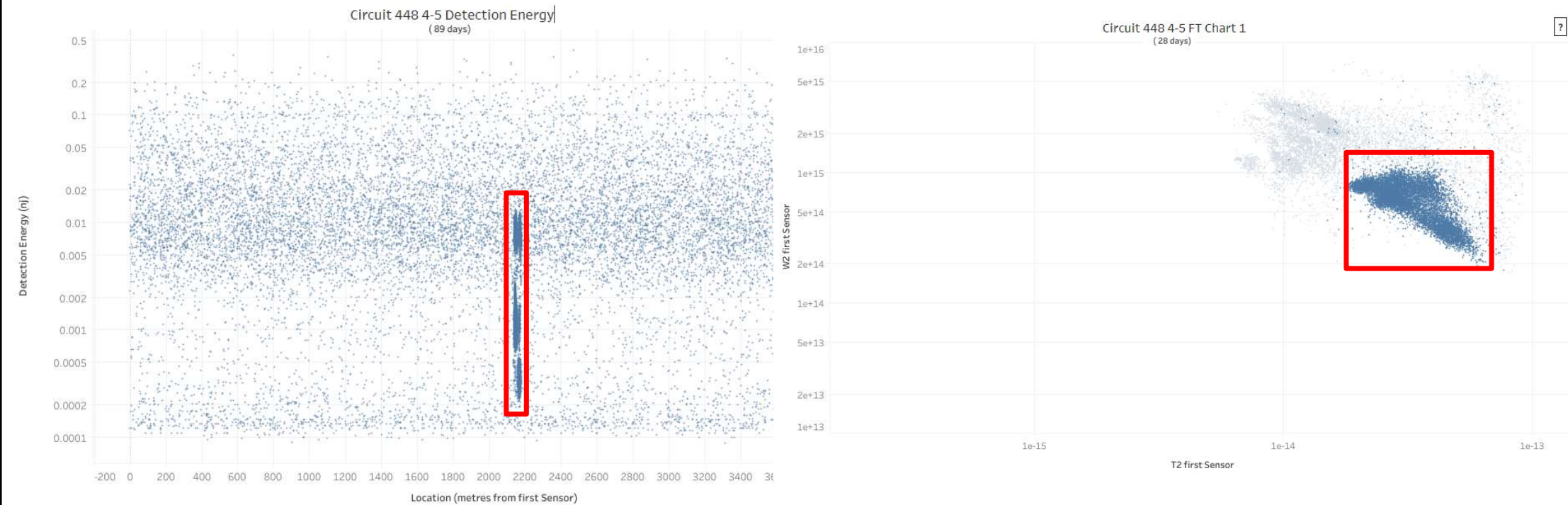
SDGE EFD System - Zoomed in on the data



Difficult to spot from the ground with the naked eye.

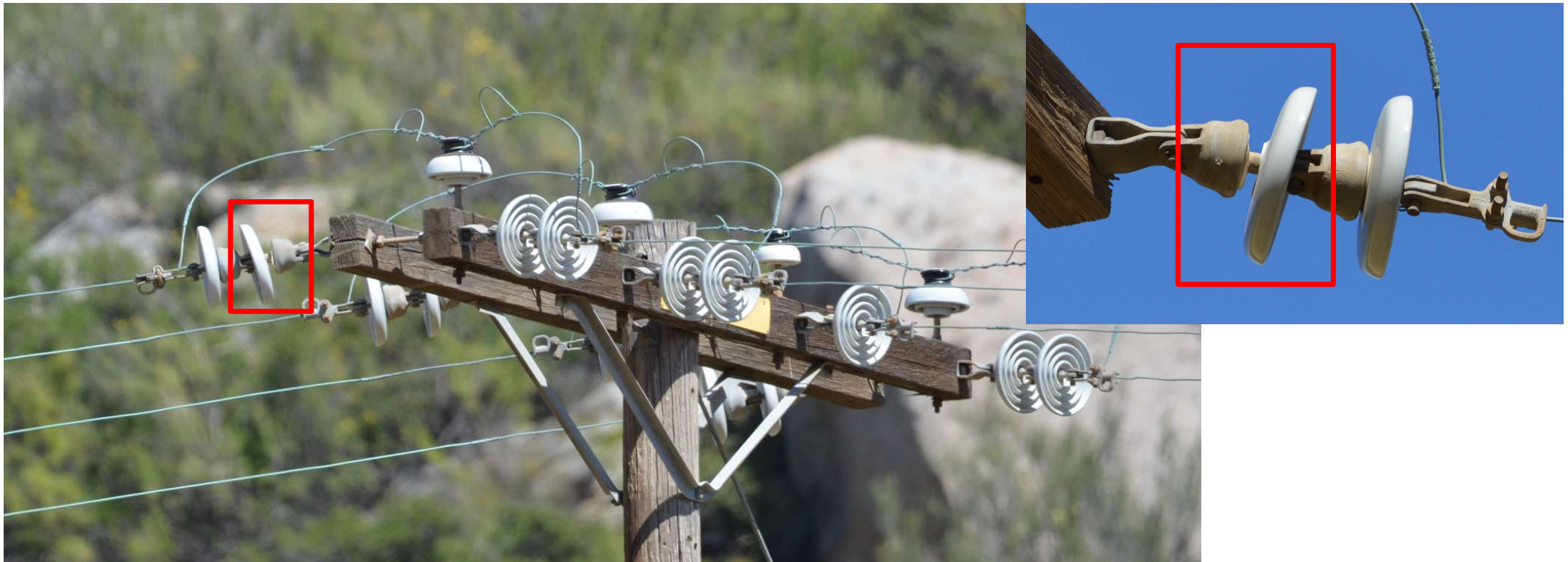
A SLR 600mm was able to assist in determining the cause of the EFD alert and record the asset condition.

SDGE EFD system – another example, subtle defect



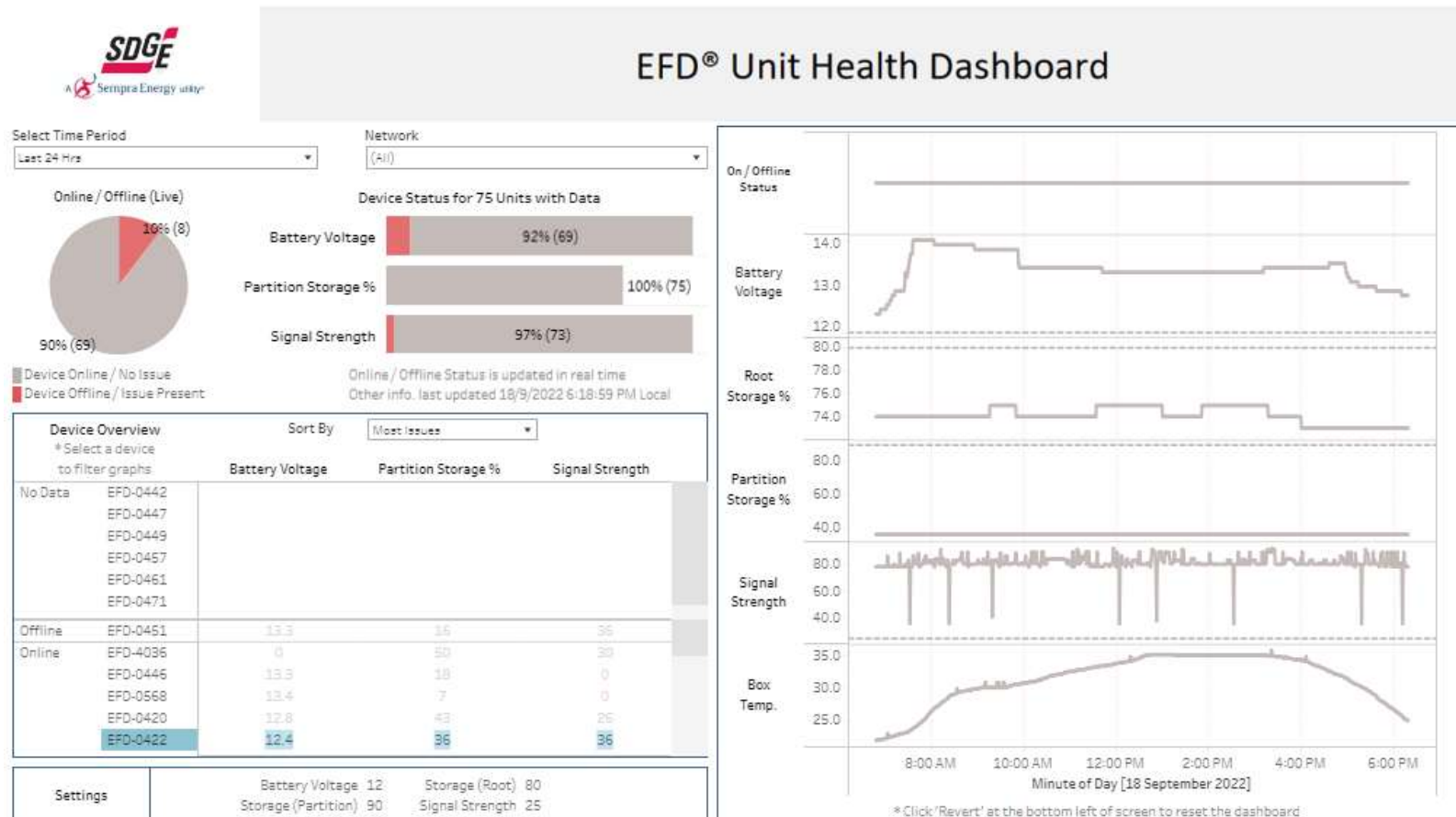
Clear location at the pole, single phase and unique FT pattern.

SDGE EFD system – another example, subtle defect



Clear location at the pole, single phase and unique FT pattern.

The EFD system – fleet health



The EFD system – regular reporting



EFD® Alerts

Alerts last updated: 19/9/2022 3:24:12 AM

Alert Type: Burst Alert Status: [All] Search Parameter: Primary Alert Search Text:

353
New

98
Reported

0
Closed

Select Time: Custom Start Date: 31/5/2022 End Date: 19/9/2022

Alert Table Click on an alert to edit it (the form will open in a new tab)

Alert ID	Circuit	#	Status	Path Or Sensor	Alert Type	Last Activity Date	Closest Structure
1955	Circuit 211	!	New	3-4	Burst Alert	1/8/2022 12:25:05 PM	Z118341
2110	Circuit 211	!	New	7-8	Burst Alert	8/8/2022 4:48:42 PM	P210882
2122	Circuit 211	!	New	7-8	Burst Alert	8/8/2022 4:40:58 PM	P210882
2129	Circuit 211	!	New	7-8	Burst Alert	8/8/2022 4:44:22 PM	P210882
2140	Circuit 211	!	New	7-8	Burst Alert	13/8/2022 4:15:57 PM	P210883
2163	Circuit 211	!	New	7-8	Burst Alert	8/8/2022 5:36:14 PM	P218208
2174	Circuit 211	!	New	7-8	Burst Alert	8/8/2022 5:22:49 PM	P218208
2176	Circuit 211	!	New	7-8	Burst Alert	8/8/2022 5:15:08 PM	P218208
2178	Circuit 211	!	New	7-8	Burst Alert	8/8/2022 6:46:53 PM	P218208
2182	Circuit 211	!	New	7-8	Burst Alert	8/8/2022 5:37:59 PM	P218207
2189	Circuit 211	!	New	7-8	Burst Alert	8/8/2022 5:24:50 PM	P218207
2191	Circuit 211	!	New	7-8	Burst Alert	8/8/2022 5:59:48 PM	P218208
2192	Circuit 211	!	New	7-8	Burst Alert	8/8/2022 7:29:30 PM	P218208
2207	Circuit 211	!	New	7-8	Burst Alert	8/8/2022 5:34:36 PM	P312460
2208	Circuit 211	!	New	7-8	Burst Alert	24/8/2022 3:07:34 PM	P312460
2221	Circuit 211	!	New	7-8	Burst Alert	8/8/2022 5:14:59 PM	P218206
2225	Circuit 211	!	New	7-8	Burst Alert	8/8/2022 5:59:44 PM	P218208
2276	Circuit 211	!	New	3-11	Burst Alert	15/9/2022 2:19:13 PM	P213121
2360	Circuit 211	!	New	7-8	Burst Alert	13/8/2022 1:56:59 PM	P210881
2361	Circuit 211	!	New	7-8	Burst Alert	13/8/2022 2:04:20 PM	P210881
2466	Circuit 211	!	New	3-4	Burst Alert	22/8/2022 3:16:24 AM	Z118329
2525	Circuit 211	!	New	5-7	Burst Alert	24/8/2022 3:24:33 PM	P419063
2526	Circuit 211	!	New	7-8	Burst Alert	24/8/2022 3:27:25 PM	P312460
2527	Circuit 211	!	New	7-8	Burst Alert	24/8/2022 3:16:52 PM	P316622
2528	Circuit 211	!	New	7-8	Burst Alert	24/8/2022 3:34:15 PM	P817135
2529	Circuit 211	!	New	7-8	Burst Alert	24/8/2022 3:42:26 PM	P817135
2552	Circuit 211	!	New	3-4	Burst Alert	12/9/2022 2:20:14 PM	Z118347

Transitioning from an excel monthly report to a Tableau finalized format.
The aim is to have this information available to be delivered via an API.

Operationalizing EFD – the challenges



Utility challenge

- New inspection standard required
 - Tools
 - Process (training?)
 - Information capture
- Triage
 - Faster and more precise decision making – required
 - Information direct to action takers in the field that can mitigate the risk

IND.T - EFD challenge

- Fault location (not just early fault detection)
 - High confidence – vegetation
 - Medium confidence – arcing faults
 - Unknown at this time – metal on metal
- Real time operation of the network
 - Burst alerts can play out over three hours down to a few minutes
 - Unlikely in the foreseeable future that EFD data will control network devices
 - More likely is post event information – 10/20 seconds

- Preliminary pilot report to be prepared and provided by IND.T in late October.



A  Semptra Energy utility®



Thank You!