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AN EXELON COMPANY

NASPI Virtual Task Team Meeting
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ADP 2.0: Falling Conductor Pilot to Enhance Grid Modernization and Public Safety

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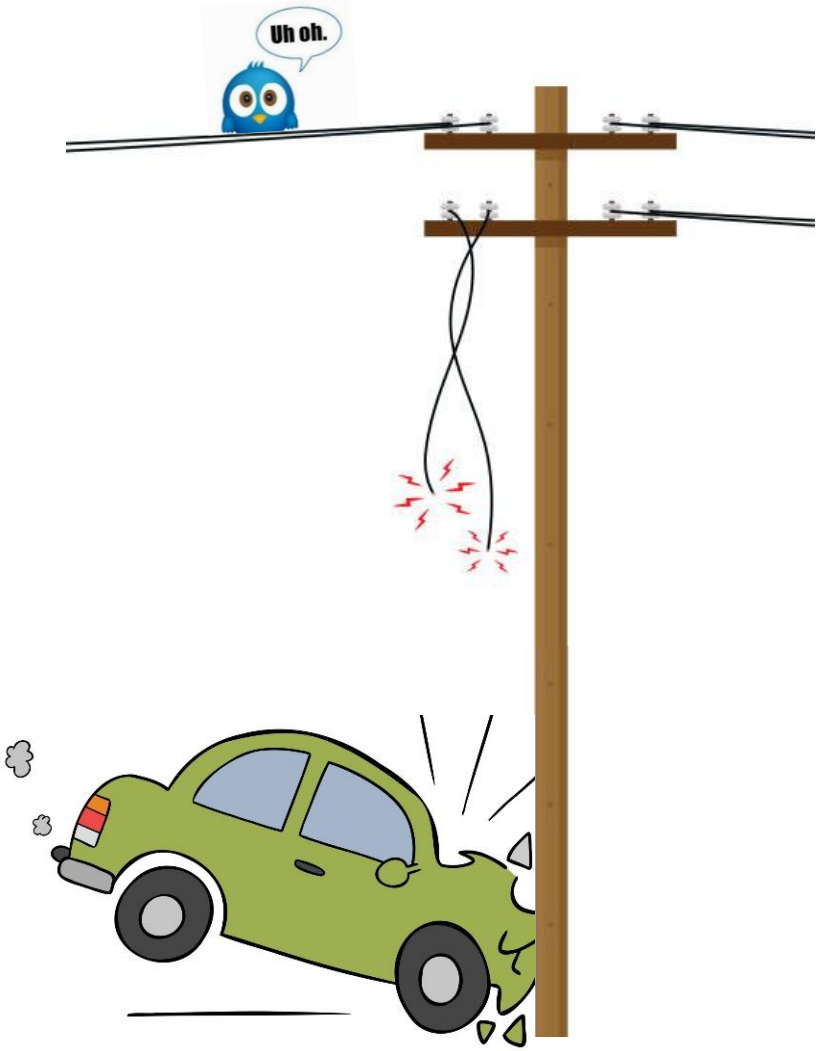
Agenda

- Exelon & ComEd Distribution Automation Overview
- Conductor Failure
- FCP: ComEd Pilot Summary
- GOOSE Protection Layering and Falling Conductor (FCP) Solution Overview
- ComEd Communication Scheme
- Infrastructure Development
- Hardware-in-the-Loop Lab Testing
- Field Testing & Post Deployment Strategy
- Q&A



Who is Exelon?

6 T&D-only utilities
Operate across seven regulatory jurisdictions

4 major metro areas served
Including Chicago, Philadelphia, Baltimore, D.C.

18,700
Employees across our operating companies

10.5 million[1]
Electric and gas customers served across our service territories

25,600
Square miles of combined service territory across our jurisdictions

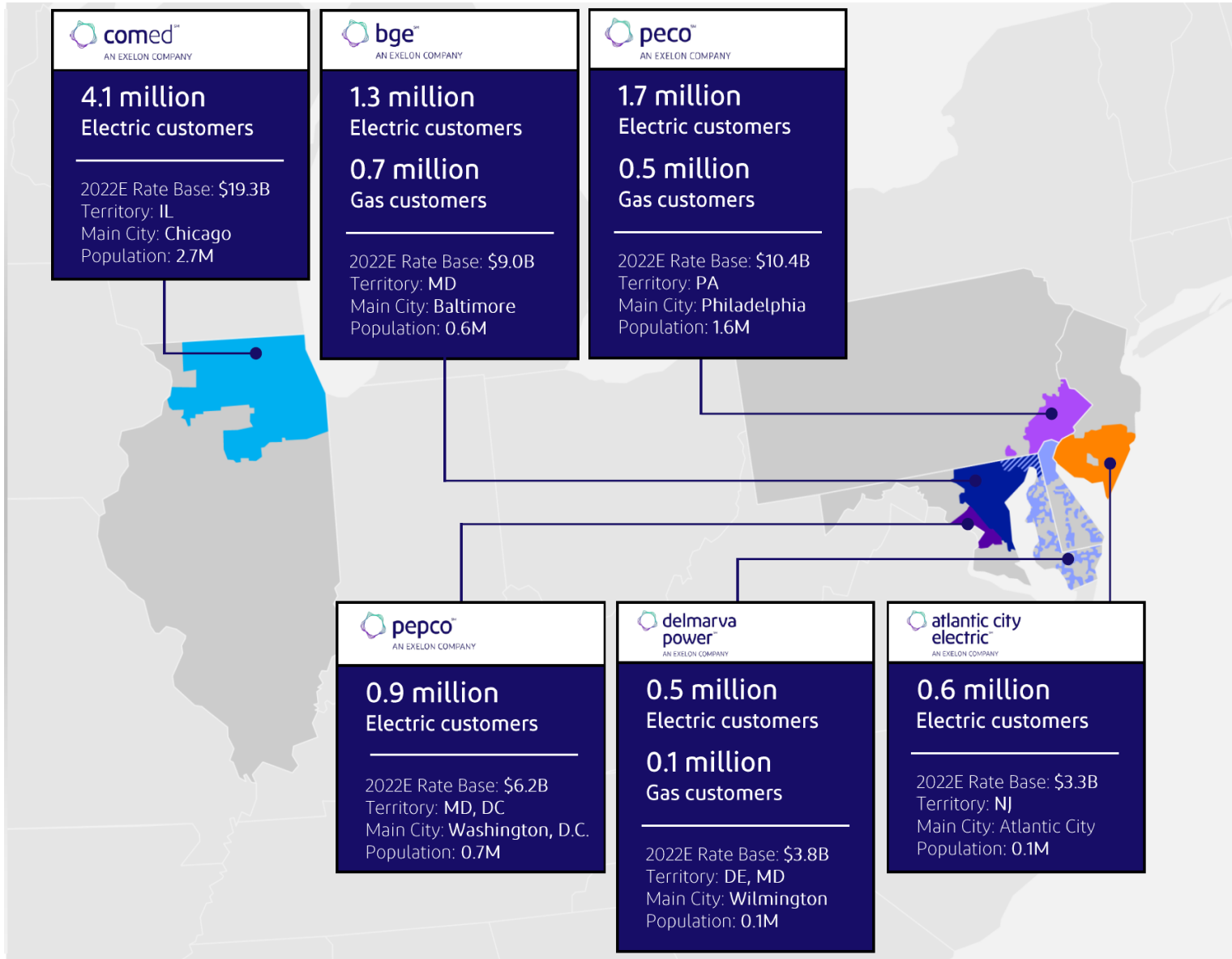
182,550
Circuit miles of electric and gas distribution lines

11,150
Circuit miles of FERC-regulated electric transmission lines

$18.0 billion
Operating revenues recorded at our utilities in 2021

$52.0 billion
Rate base estimate for 2022

$29.0 billion
Projected capital investment through 2025



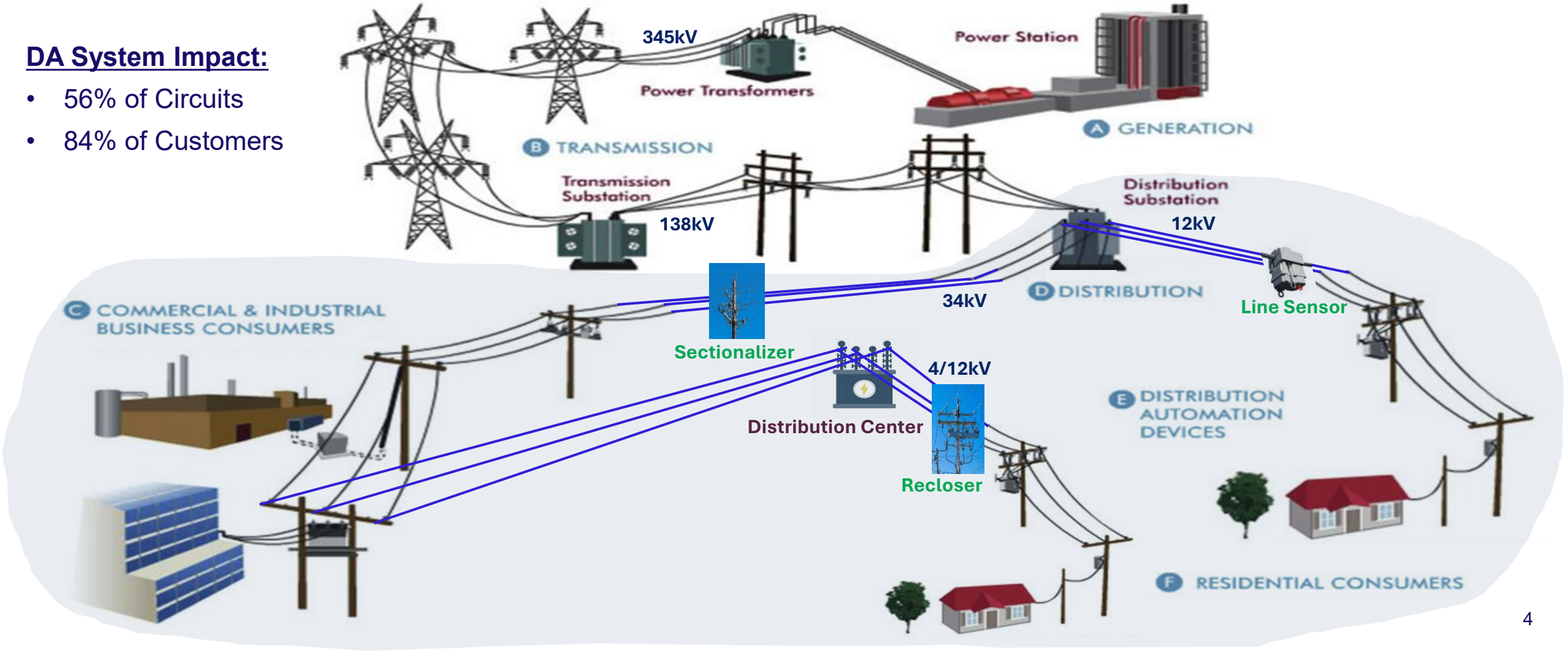
(1) Customer count reflects the sum of Exelon's total gas and electric customer base; Exelon consolidated customer count may not sum due to rounding

ComEd Distribution Automation Overview

ComEd powers 70% of Illinois population with an 11,400 square mile service territory and more than 90,000 miles of power lines. Within ComEd, the Distribution Automation (DA) group utilizes over 10,000 protection devices on the 34kV, 12kV, and 4kV lines to protect customers from disturbances via event isolation and automatic restoration.

DA System Impact:

- 56% of Circuits
- 84% of Customers



Causes of Conductor Failure

Defects and aging

Corrosion

Fatigue

Fretting, etc.

Electrical Arc Annealing

Localized damage

Power arcs

Lightning strikes

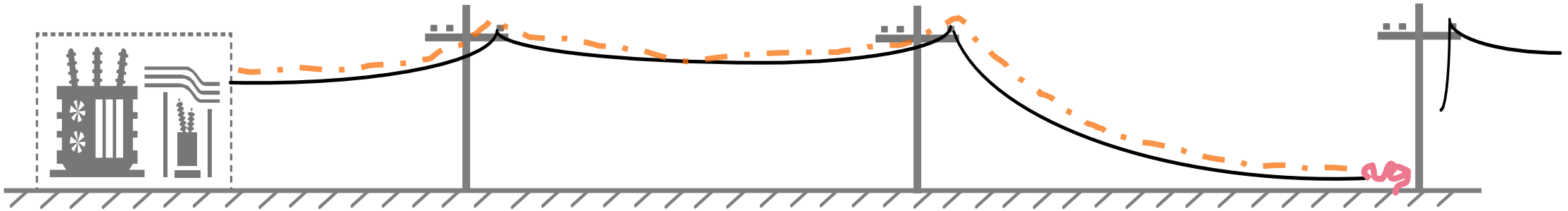
Hardware abrasion

Gunshots

Fires

Tree strikes, etc.

Effects of a Downed Energized Conductor



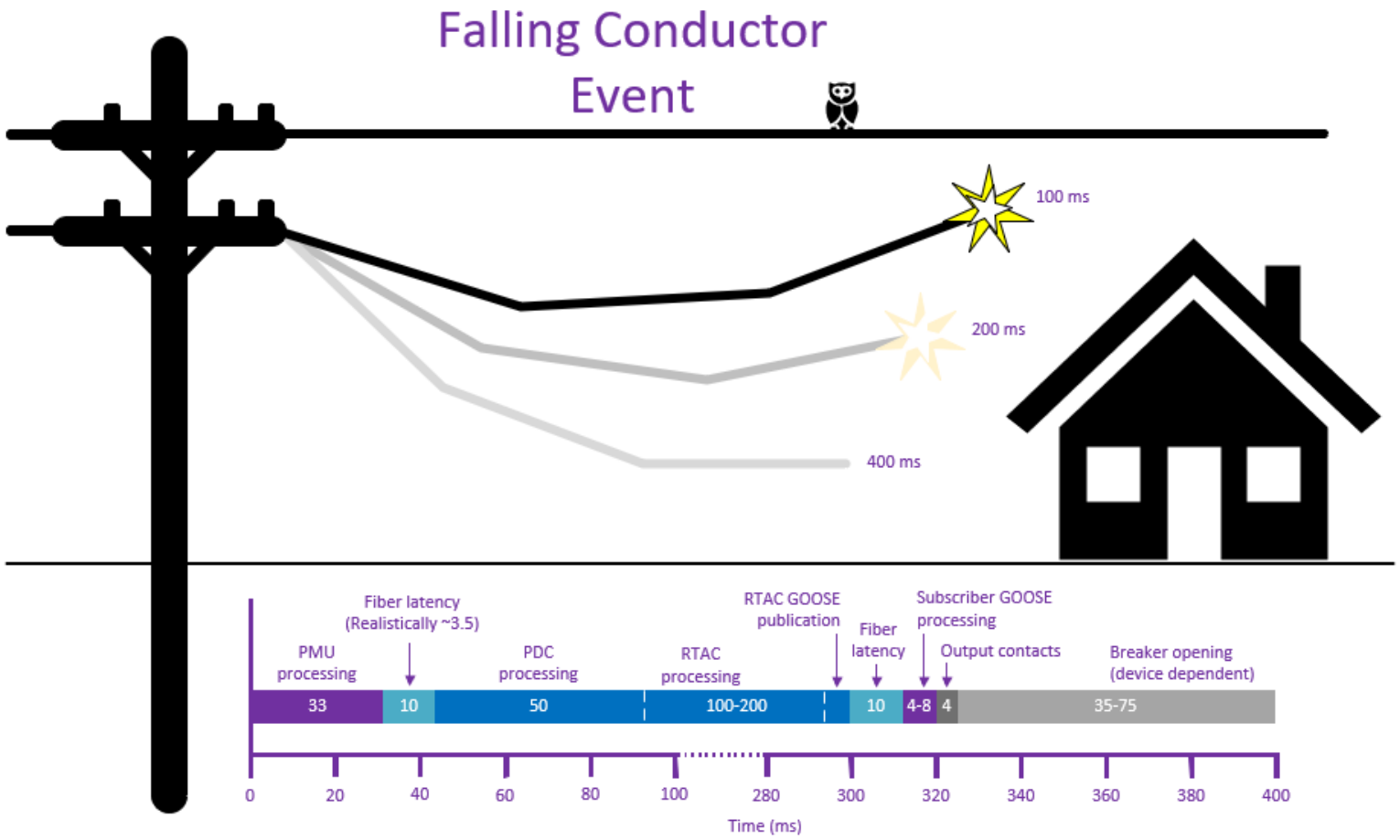
- High Impedance Fault (HIF)
  - May take from seconds to minutes to detect
- Energy is released in the form of arc

Falling Conductor Protection: ComEd Pilot Summary

DA is piloting the Falling Conductor Protection System on REACTS low latency fiber to ideally de-energize the conductor within 400 milliseconds before the conductor touches the ground or property.

The pilot includes multiple fiber-enabled 12kV feeders with Substation Circuit Breakers and DA Reclosers that contain GOOSE Curve Blocking Advanced Distribution Protection (ADP) logic for short-circuit events.

The deployment of Falling Conductor will be the first time ComEd uses two independent ADP schemes on a feeder.

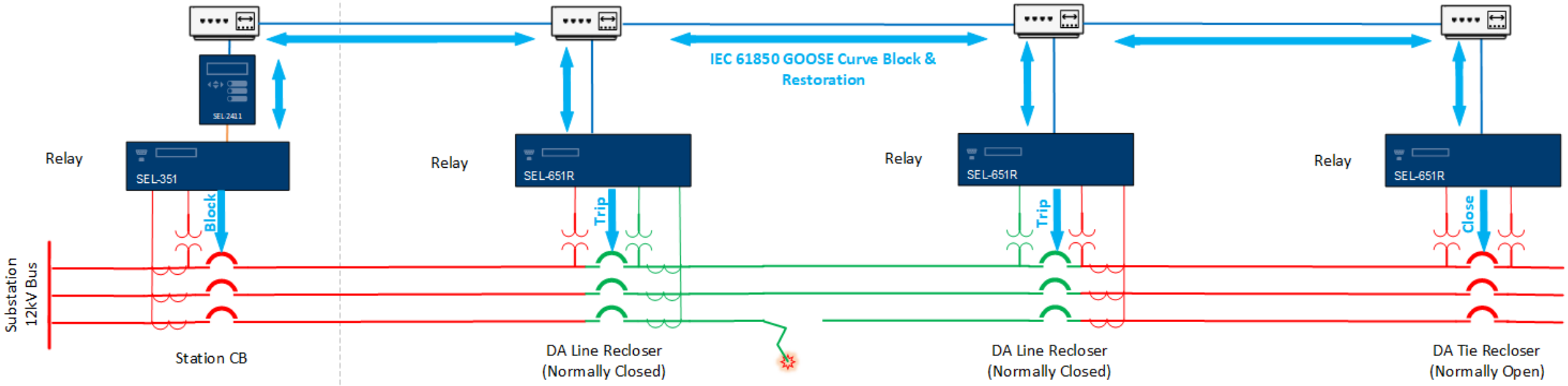


GOOSE Layering – Curve Blocking

ComEd Distribution Substation

Relay fault detection blocks FCP tripping allowing feeder to attempt clearing temporary faults through reclosing and curve blocking prevents momentary customer interruptions upstream of the affected segment.

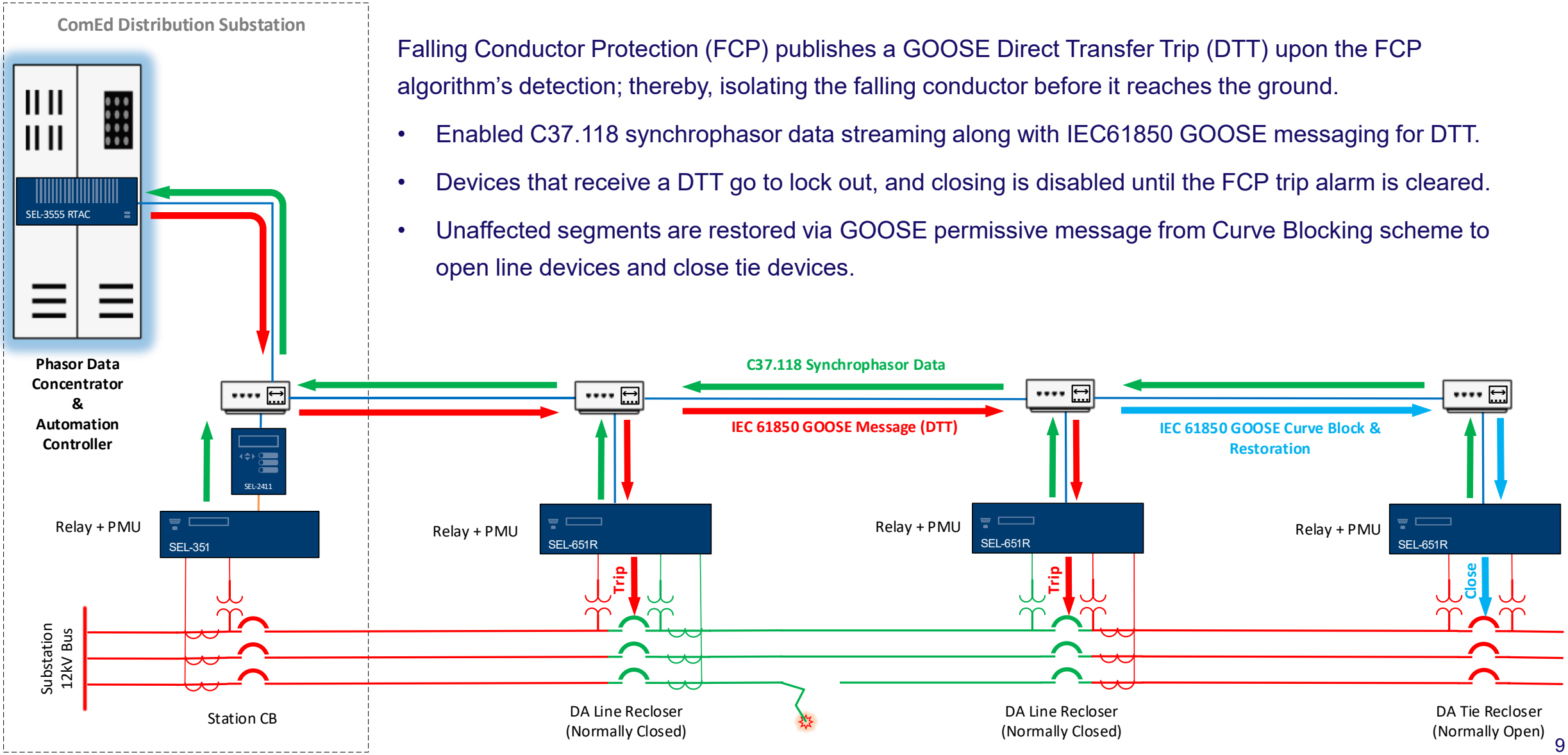
- Enabled peer-to-peer communication on electrically adjacent relays via IEC61850 GOOSE messaging.
- Curve blocks only the faster TOC trip on relays upstream of impacted recloser preventing momentary interruptions.
- Line recloser locks out after completing reclose attempts and downstream reclosers restore un-affected segments.



GOOSE Layering – Falling Conductor Protection

Falling Conductor Protection (FCP) publishes a GOOSE Direct Transfer Trip (DTT) upon the FCP algorithm's detection; thereby, isolating the falling conductor before it reaches the ground.

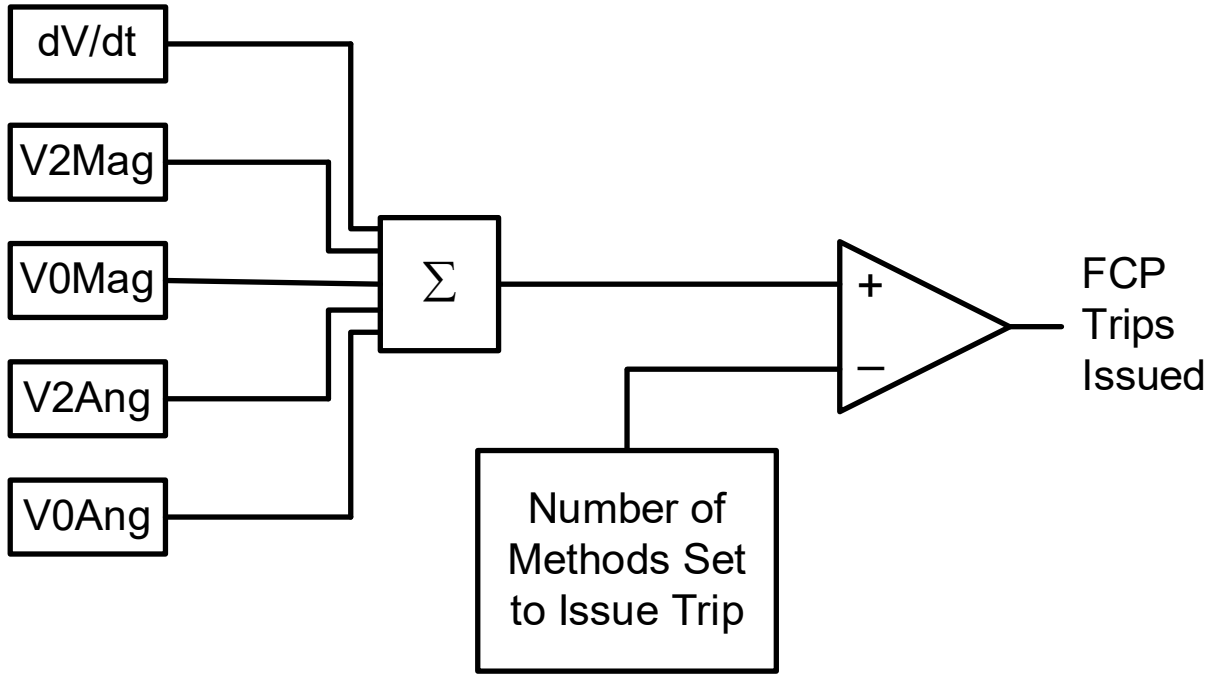
- Enabled C37.118 synchrophasor data streaming along with IEC61850 GOOSE messaging for DTT.
- Devices that receive a DTT go to lock out, and closing is disabled until the FCP trip alarm is cleared.
- Unaffected segments are restored via GOOSE permissive message from Curve Blocking scheme to open line devices and close tie devices.



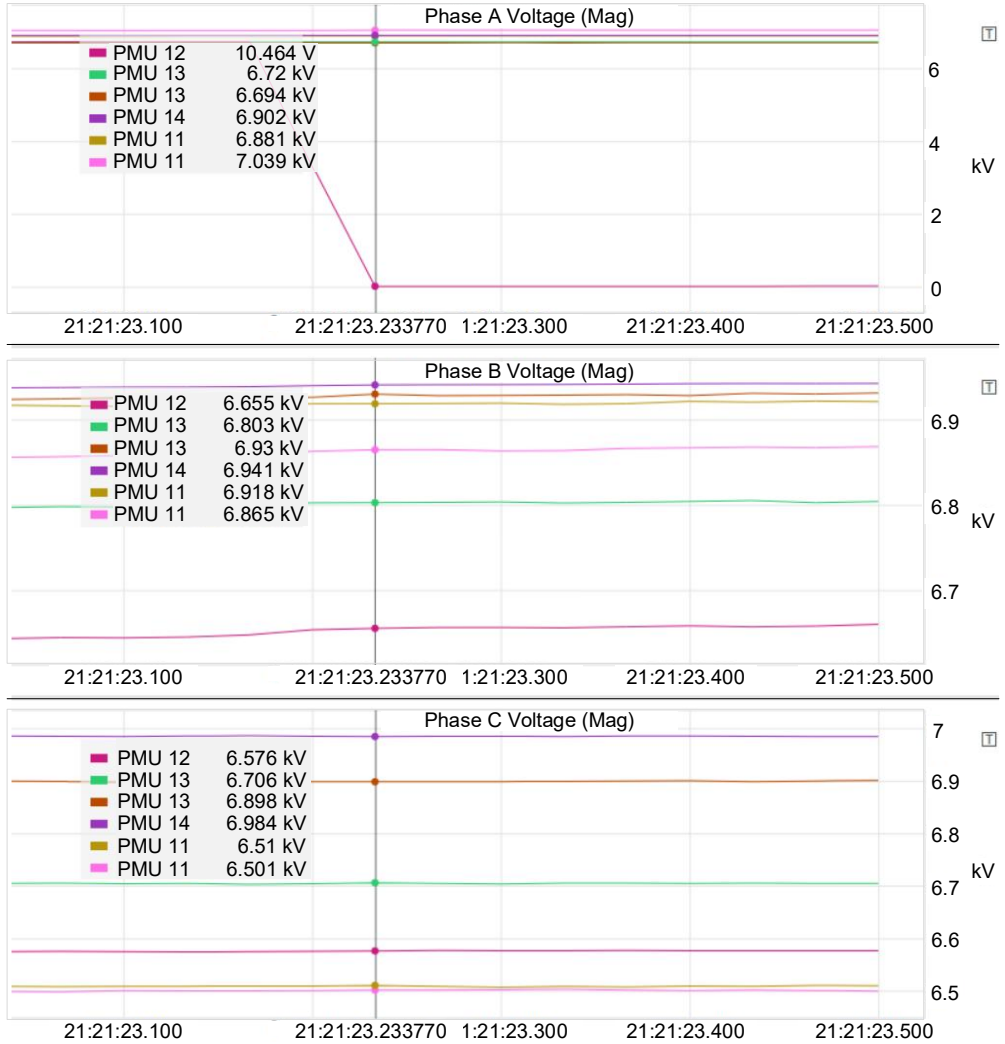
Falling Conductor Detection Overview

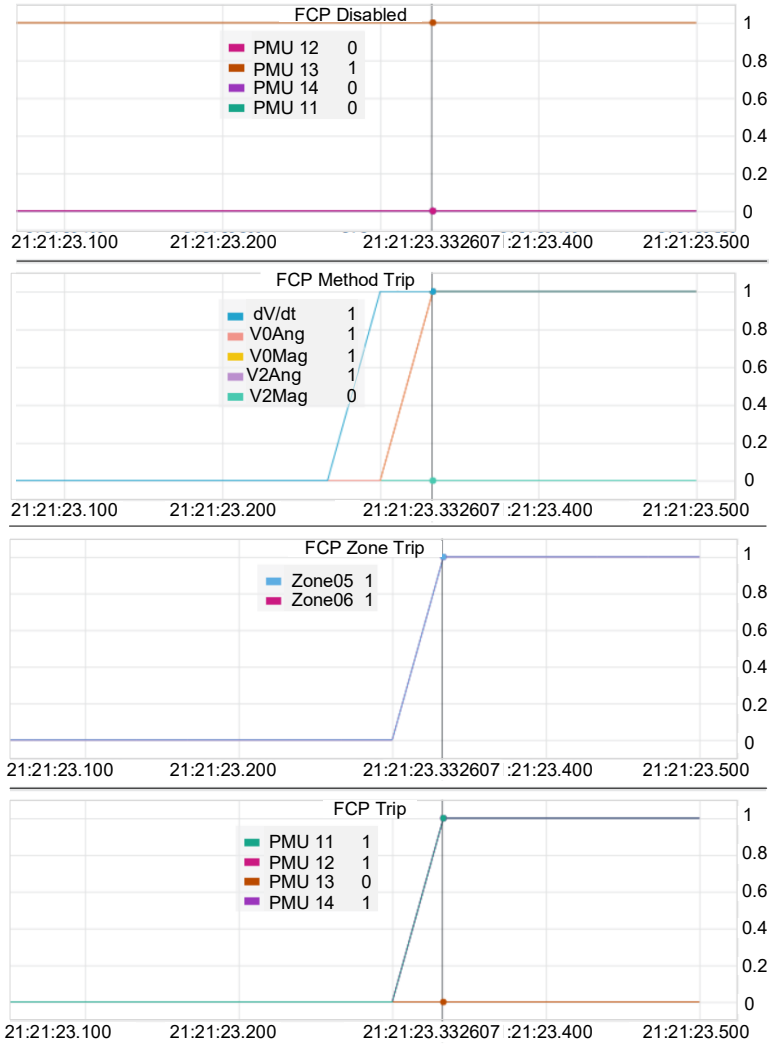
5 Methods of Detection

- Methods require 100ms verification
- dV/dt supervised by V0Mag
- V0 and V2 angles supervised by respective magnitudes
- >10% voltage magnitude pole to pole deviation on DA devices prevents FCP participation

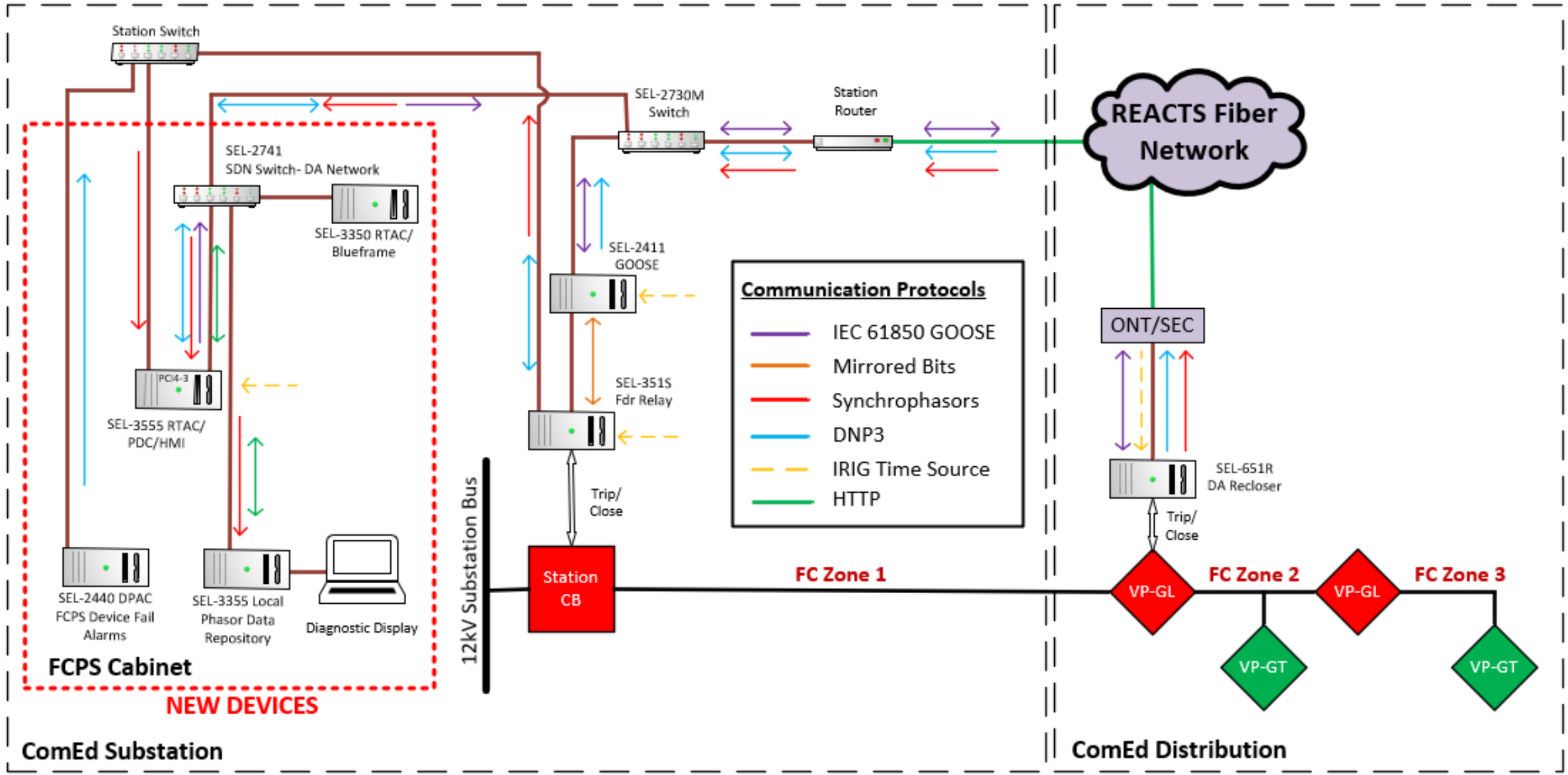


Wide-Area Monitoring using Synchrowave Software





Falling Conductor Communication Scheme



Infrastructure Development

Distribution Automation Updates

- SEL-651R relay logic reprogramming
- SEL-651R C37.118 Synchrophasor enabling

Substation Updates

- New Station Aux Switch
- SEL-351S relay logic reprogramming
- SEL-351 Mirrored Bit update & C37.118 Synchrophasor enabling
- Station battery upgrade to support FCP cabinet 3.6A DC load
- Relay package upgrade for FCP compatibility
- Station GPS clock upgrade to supply IRIG-B to FCP cabinet components and SEL-2411 relays
- New 24” x 34” FCP Cabinet with Human Machine Interface (HMI)

FC PDC Cab. Relays

FC Phasor Data Concentrator Cab. w/ HMI

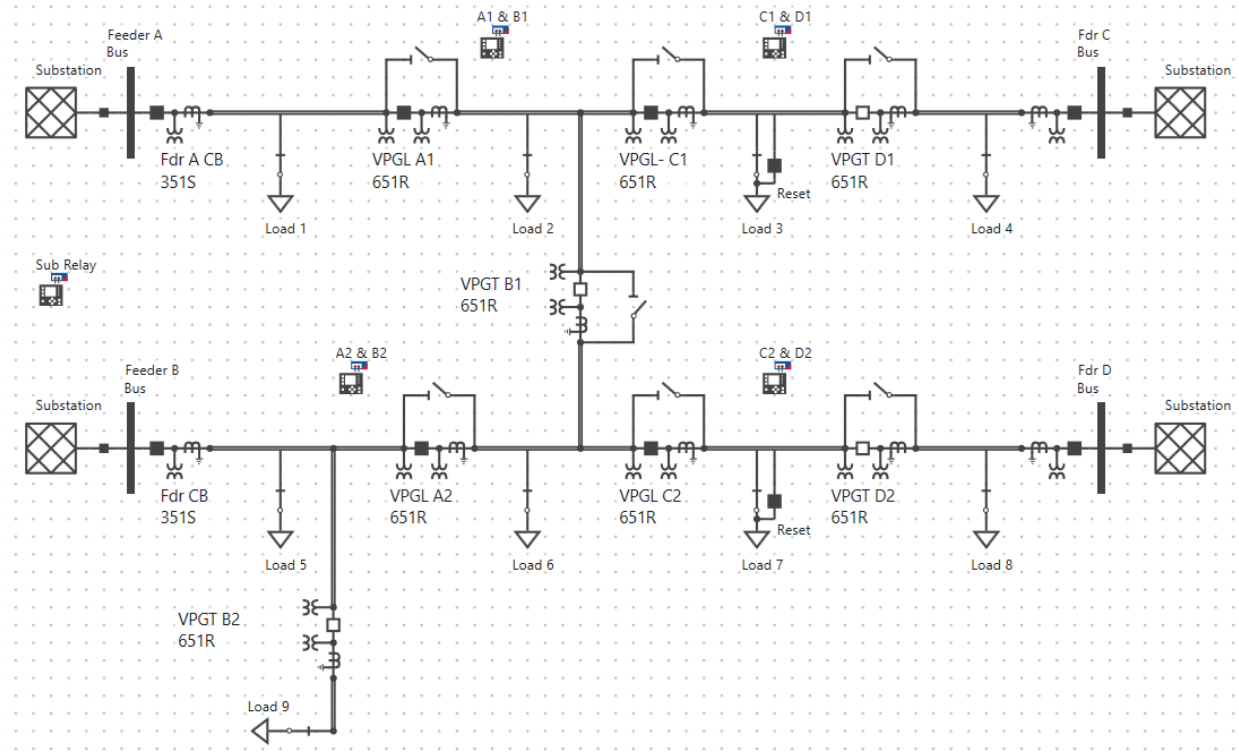
ComEd Lab RelaySim Testing

ComEd hardware-in-the-loop testing was performed to validate the operational results of the SEL FAT, ensure non-ADP and GOOSE Curve Blocking ADP operations are still correct after the SEL Relay logic re-organization and updates, and identify any latency related issues before field deployment.

Initial testing was performed using an approximation of the field conditions designed into Omicron RelaySim with the hardware relays connected to CMC 356s for voltage and current injection.

Phase 1 was used as a baseline to verify lab connections and expected operations were correct. Each subsequent testing phase added a new test type or communication medium to identify and correct issues before moving on to the next phase.

- Phase 1: Non-ADP short circuit fault protection on Local Area Network (LAN)
- Phase 2: GOOSE Curve Blocking ADP on LAN
- Phase 3: Falling Conductor ADP on LAN
- Phase 4: GOOSE Curve Blocking ADP on REACTS Fiber
- Phase 5: Falling Conductor ADP on REACTS Fiber



ComEd Lab - Functional Test Setup w/ RelaySim and CMC 356s

ComEd Lab RTDS Testing

ComEd performed Falling Conductor RTDS lab testing to comprehensively validate the SEL FAT results. The ComEd testing mimicked the SEL FAT with key modifications:

- ComEd lab testing includes 10 hardware components to simulate the Substation Feeder Relays and DA Recloser Relays vs the 3 hardware and simulated device system used for the SEL FAT.
- The SEL developed RSCAD developed from ComEd CYME topology was modified for additional hardware.
- Additional scenarios were considered including abnormal system conditions and momentary vs sustained fault conditions.

FC RTDS is a cross-collaborative effort between Substation, Distribution, and Communication departments to ensure the functional setup and operations are correct before field deployment.

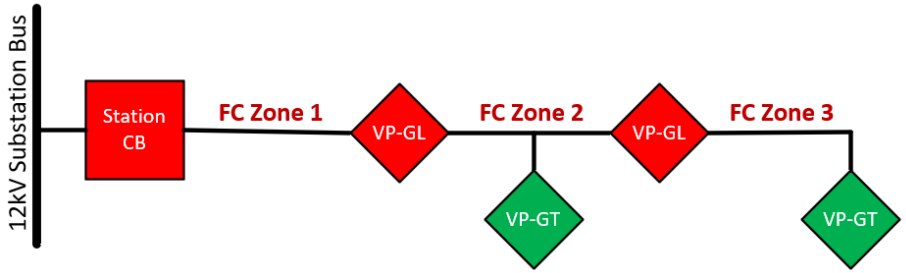
ComEd Lab - FCP Performance Test Setup w/ RTDS

Field Deployment Testing

During testing, all feeder reclosing and automatic restoration functions will be disabled, and distribution line reclosers will be bypassed. Falling Conductor detection logic will remain enabled on all feeder PMU relays, with trip functions removed, allowing verification of expected operations without customer impact. The Falling Conductor condition will be simulated by either disconnecting a secondary phase-voltage lead at the downstream PMU relay terminal or temporarily lifting the primary conductor at the tie reclosers.

Field Tests Include:

- Test Mode Enable/Disable via SEL-3555 RTAC
- Falling Conductor Enable/Disable via SEL-3555 RTAC and SCADA
- FC Trip test by zone
- Disable participating PMU for zone expansion



G&W Viper Recloser w/ SEL-651R Controller

Once field testing is complete, ComEd will enter the “Monitoring Mode” period where we will track system events and verify correct FCP operations using SynchroWAVe Monitoring Software, DNP status points and RTAC logs for true wire down events while avoiding customer interruption for false-positives.

Post Deployment Strategy

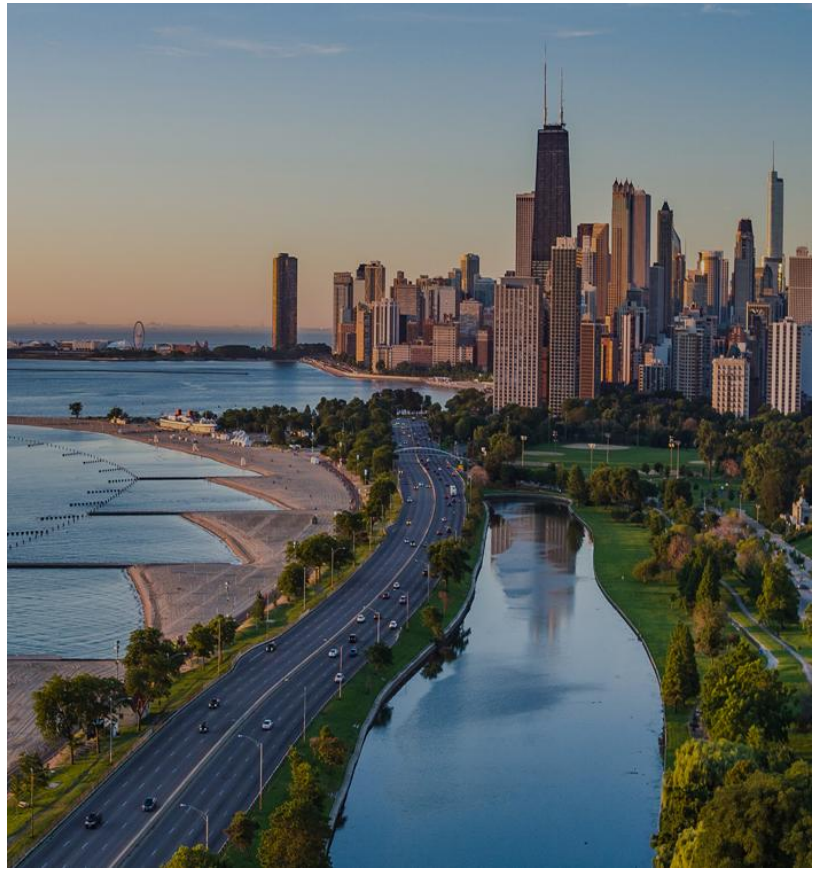
ComEd DA intends the Falling Conductor Protection System to be in Monitor Mode for a minimum of one year post deployment. The completion of the monitoring period will depend on the confidence level obtained from the initial success metrics data below. Any events that don't meet the criteria below will require re-evaluation of the monitoring period timeline.

Initial Success Metrics:

- Detection and correct DTT publishing for true wire-down events
- No false positive operations due to FCPS algorithm or recloser sensor accuracy
- FC Disable operations implemented when short-circuit protection is required
- Reduction in response time to wire-down events

Future Testing & Deployment:

- FCP communication and operation speeds on REACTS Private LTE Network
- Integrate non-SEL PMUs including the S&C IntelliRupter and Intellinode



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Q&A

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