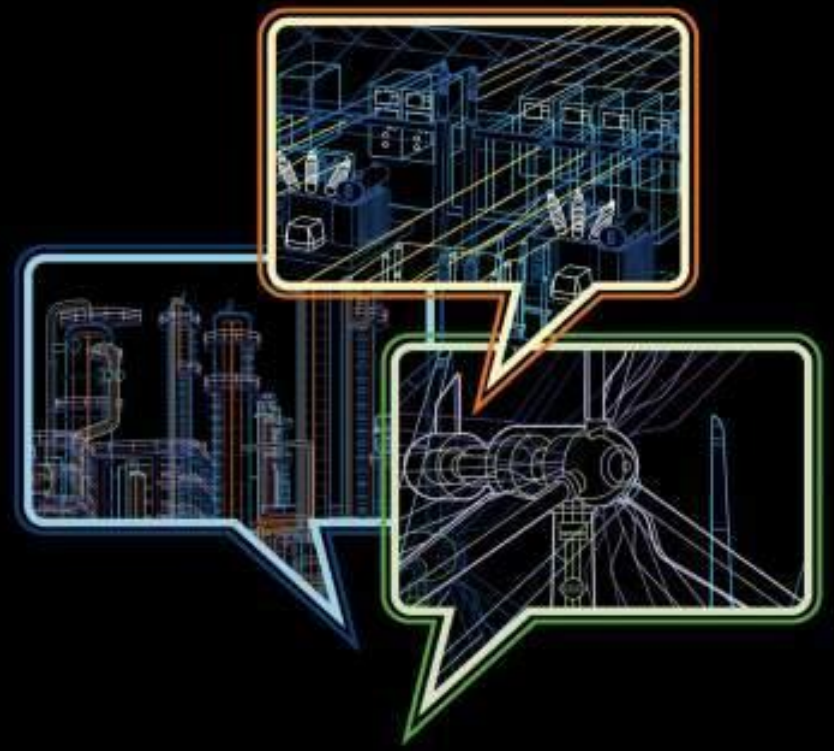


ABB Automation & Power World: April 18-21, 2011

WCS-118-1
Implementing Fault Detection Isolation Restoration & Incipient Fault Detection in Distribution Systems

WCS-120-1 (presentation code)
Title of presentation

- Speaker name: Dennis Stephens
- Speaker title: Director, Strategic Technologies
- Company name: Xcel Energy
- Location: Denver, CO

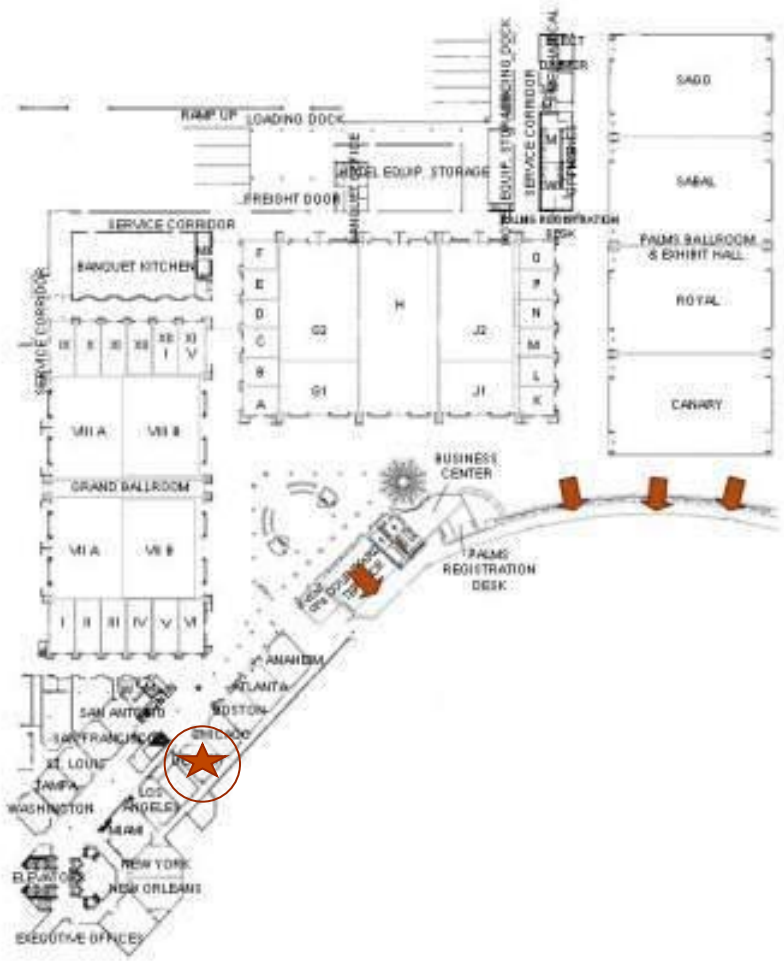
Co-presenter

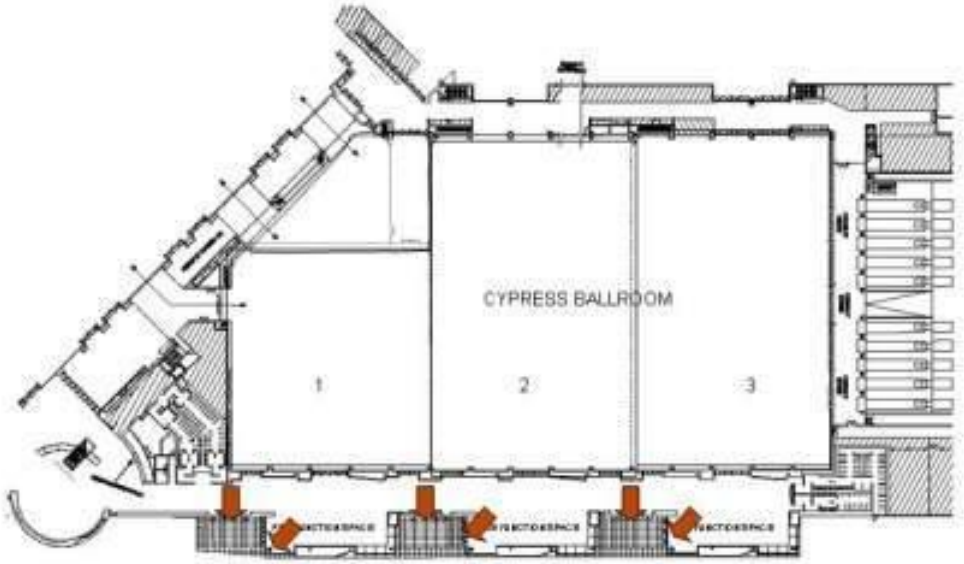
- Speaker name: John McGowan / Doug Voda
- Speaker title: Product Manager / Global Segment Leader Smart Grid
- Company name: ABB Inc.
- Location: Bethlehem, PA / Lake Mary, FL

Your safety is important to us
Please be aware of these emergency procedures

- In the event of an emergency please dial ext. 55555 from any house phone. Do not dial 9-1-1.
- In the event of an alarm, please proceed carefully to the nearest exit. Emergency exits are clearly marked throughout the hotel and convention center.
- Use the stairwells to evacuate the building and do not attempt to use the elevators.
- Hotel associates will be located throughout the public space to assist in directing guests toward the closest exit.
- Any guest requiring assistance during an evacuation should dial “0” from any house phone and notify the operator of their location.
- Do not re-enter the building until advised by hotel personnel or an “all clear” announcement is made.

Your safety is important to us
Convention Center exits in case of an emergency



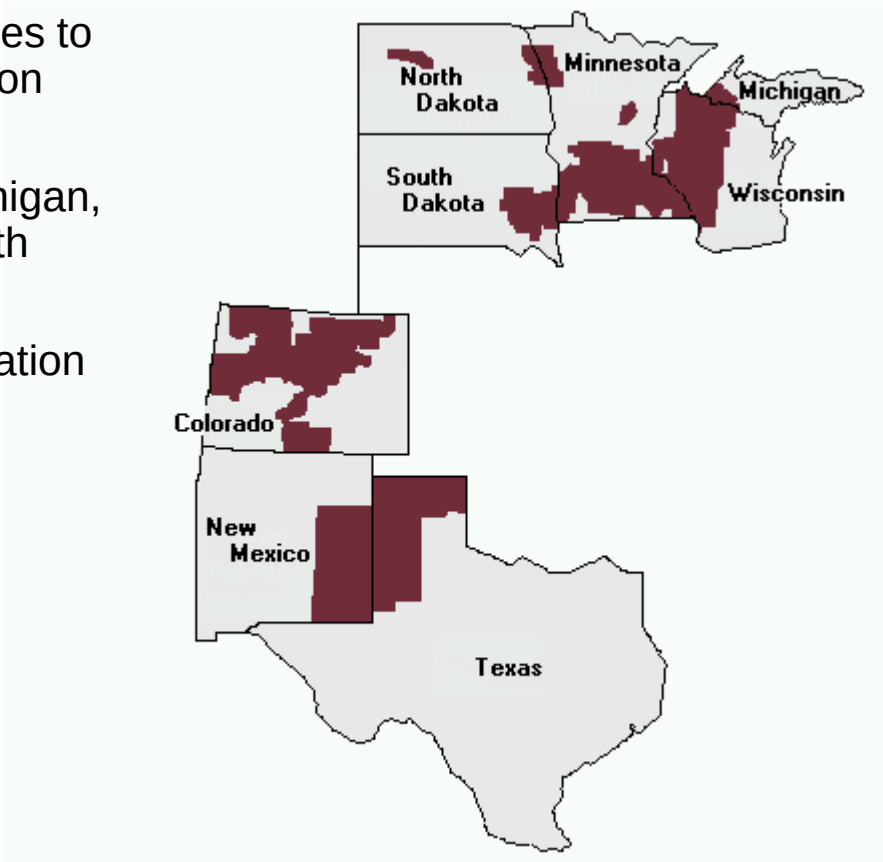


Workshop Takeaways

- Rapid detection, analysis and notification of distribution feeder events enables utilities to deliver more reliable power to their customers
- Replacement strategies of aged underground feeder cables take too long; insufficient as a complete strategy of managing that asset
- Aggressive, proactive cable failure monitoring using non-intrusive equipment is a viable addition to asset management techniques

Xcel Energy

- Provides energy-related products and services to 3.4 million electricity customers and 1.9 million natural gas customers.
- Have regulated operations in Colorado, Michigan, Minnesota, New Mexico, North Dakota, South Dakota, Texas, and Wisconsin.
- Operates 16,427 MW distribution and generation assets
- Annual revenues of $10.3 billion
- Over 12,000 employees
- No. 1 wind power provider in the nation
- No. 5 in solar power capacity
- Member of Dow Jones Sustainability Index
- 2010 Power Company of the Year (Platts)
- 2011 Energy Star Partner of the Year (U.S. EPA)



Xcel Energy Underground Cable Fault History

- First large-scale installations in 1970's
  - 500 MCM unjacketed, exposed concentric neutral cables
  - Direct buried
  - South-central Metro Denver
- 10,000 miles of underground cable entire system
  - 2000 miles of 500 MCM cable
- Annual cable failures
  - 3100 – underground residential distribution (URD)
  - 135 – main line failures
  - 60 – 500 MCM cables
- Activity follows seasons
  - Highest activity from May to August

Xcel Energy Underground Cable Fault Pains Location is Key

- Main-line faults
  - SCADA-EMS receives breaker operation indication
  - Dispatches crew
  - Re-closing attempts made to isolate fault location
    - Indirect degradation of assets, e.g., transformer and breaker
  - Restoration can take hours
- Lateral faults
  - No SCADA-EMS information
  - Dispatcher learns of outage from customer calls
  - Dispatcher sends either one or two Troubleman
    - If knowledge of fault in UG or OH section, know exactly how many to send
  - Refusing attempts made to isolate fault location
- OK on arrival
  - 40 percent of time dispatched crews find nothing

Asset Management Justification Example

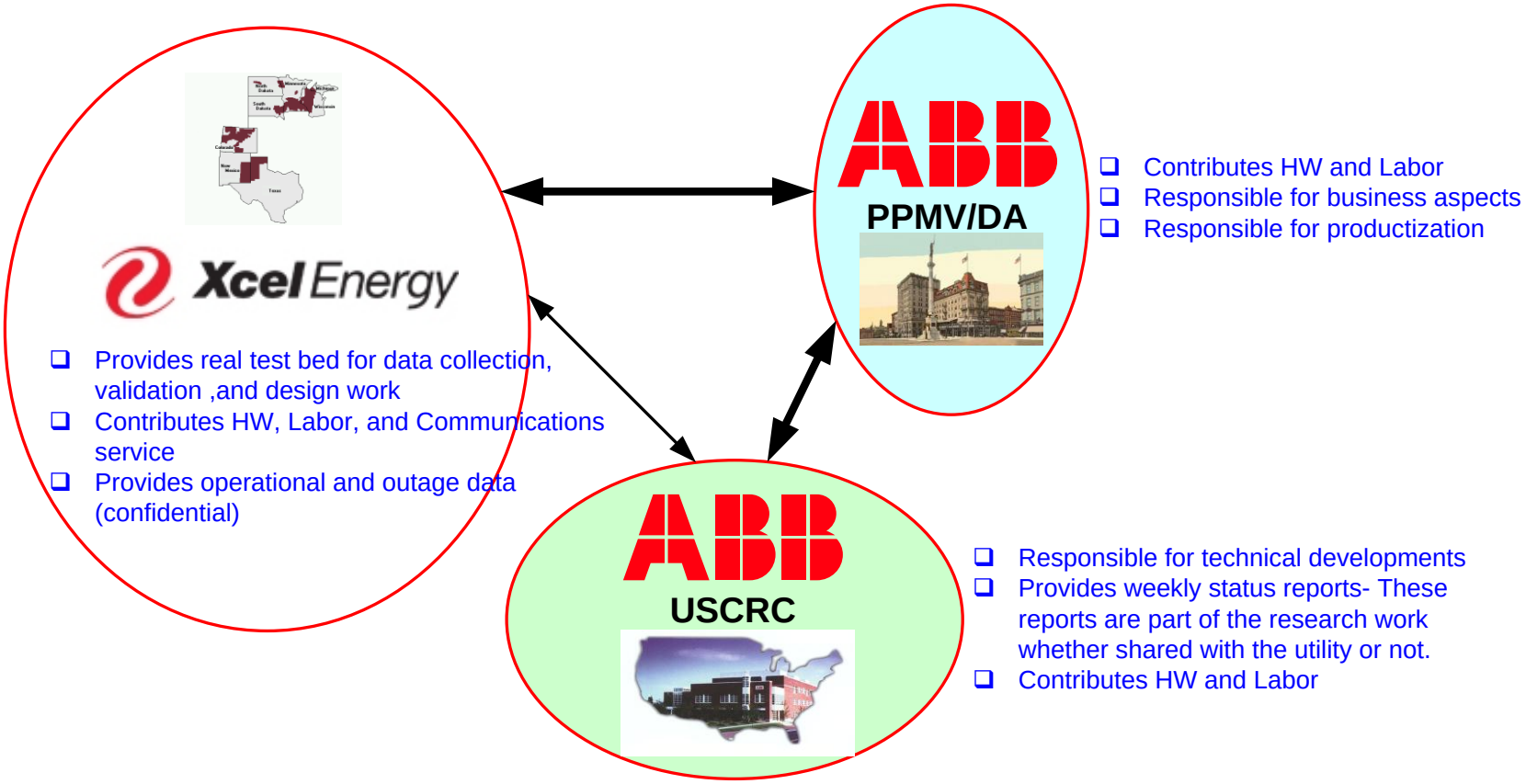
- Example value estimation
  - Utility with 3,300,000 customers
  - SAIDI – 90 minutes
  - 300,000,000 customer minutes out (CMOs) annually
  - Average Customer Minutes Out (CMO) costs $0.20 (estimate)
  - Outage duration reduced four minutes saves **3.0MUSD**
    - ($0.20/CMO)*(3,300,000 C)*(4 MO) = 2.64 MUSD
    - $ Savings = ($ / CMO)*(# of customers)*(# minutes saved)
- Qualitative value also beneficial and included in estimate
  - Limits negative news coverage from outages
  - Supports capital investment projects with PUC

Xcel Energy's Strategic Technologies Group

- Strategic Technologies uses the power of partnership and collaboration to enable new ways of doing business. We are focused on integrating technology to provide clean, reliable and safe energy at a reasonable cost today and into the future.
- Build technology frameworks to support business in the short- and long-term
- Assess commercial viability of emerging technologies
- Help accelerate adoption of promising technologies

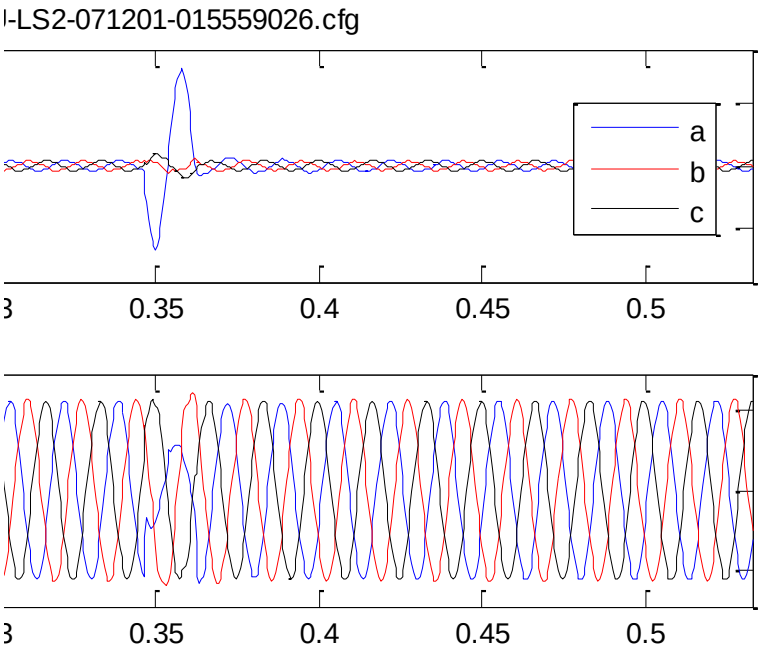
Xcel Energy-ABB 'Feeder Monitoring' Project

- What is it?



Phase I: Results and Conclusions (1/2)

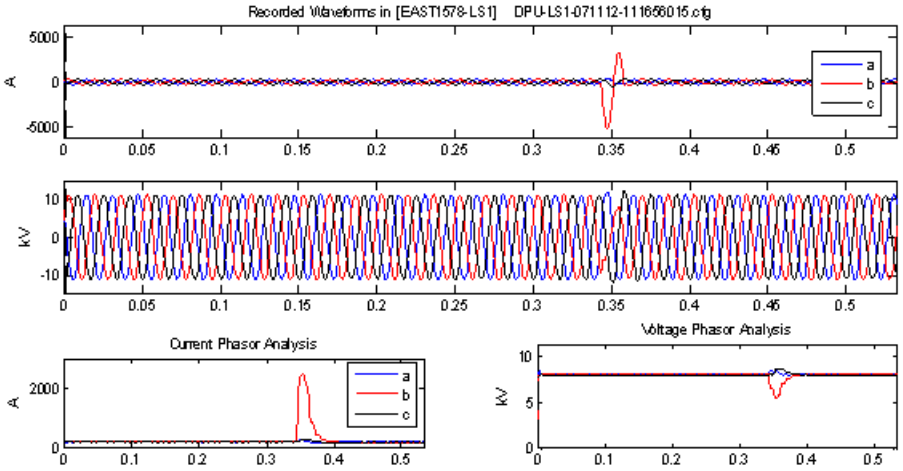
- Captured dozens of U/G cable faults
  - Self-clearing U/G cable faults
  - Permanent (fuse-cleared) cable faults
    - Underground and overhead faults
- Captured information on adjacent faults
- Captured information on upstream faults
- Validated ABB detection algorithm (offline)
- Captured numerous non-fault feeder events



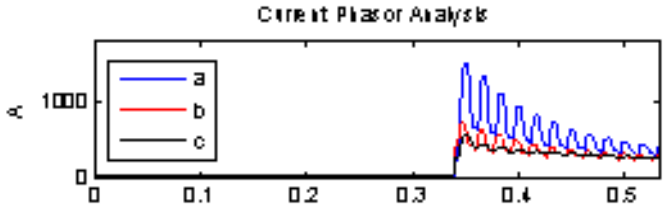
Feeder Event
Breaker failure
Cable fault on adjacent feeder
Cable fault on monitored feeder
Load pickup
Load shed
Switching transient
Transformer failure
Transformer inrush

Phase I: Results and Conclusions (2/2)

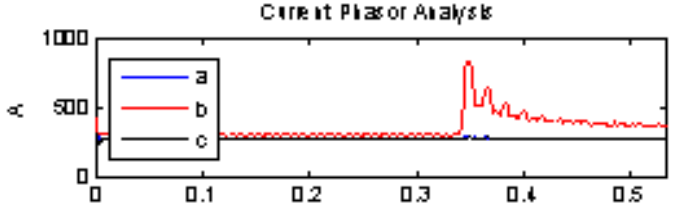
- Actual cable fault



- Potential 'false positives' – a good thing
  - A: Reclose into fault
  - B: Inrush



A



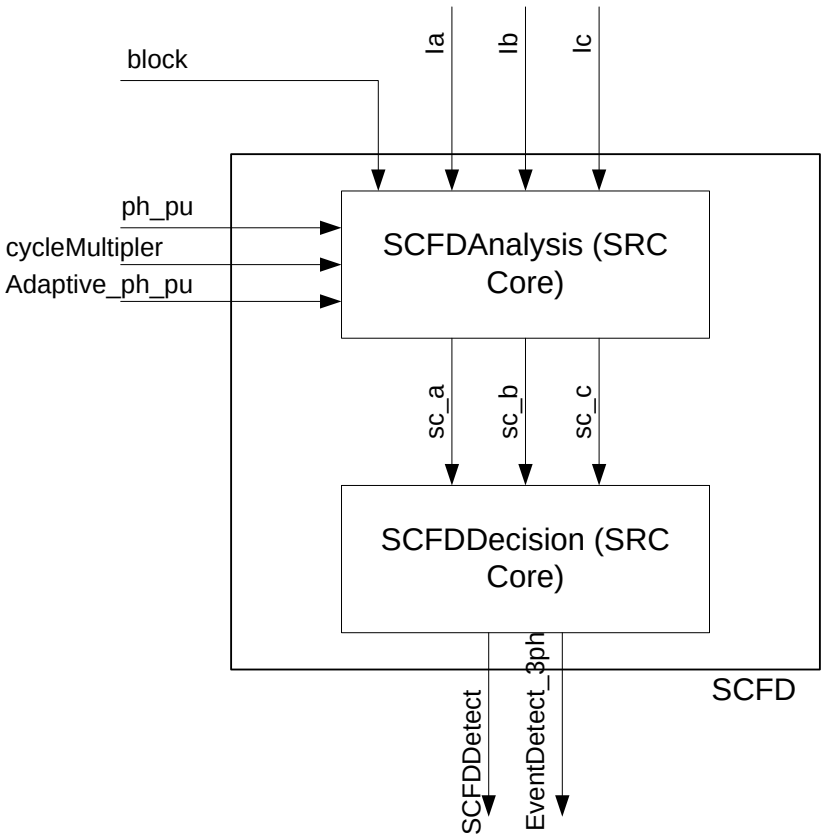
B

Phase II: Results and Conclusions

- More fault and non-fault feeder events captured
  - > 400 cable faults
  - > 19,000 feeder disturbances
- Information collected enabled research and development of more comprehensive feeder event analysis algorithms
  - Classification of feeder event
    - Non-fault – Cold load pickup, capacitor bank switching, etc.
    - Fault – short or long duration; upstream, primary or adjacent feeder
  - Identification of clearing device
    - Substation breaker, recloser or fuse
    - Fuse size
- Value realization for Xcel Energy requires real-time detection and notification of these feeder events

Feeder Event
Breaker failure
Breaker trip
Cable fault on adjacent feeder
Cable fault on monitored feeder
Capacitor bank switching
Load pickup
Load shed
Other faults
Other PQ events
PQ: sags, swells, interruptions
Reclose into fault
Switching transient
Transformer failure
Transfomrer inrush

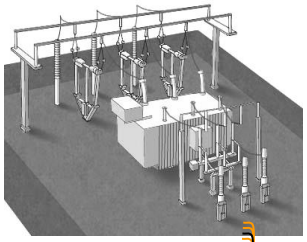
Phase III: Cable Fault Detection (CFD) Integration

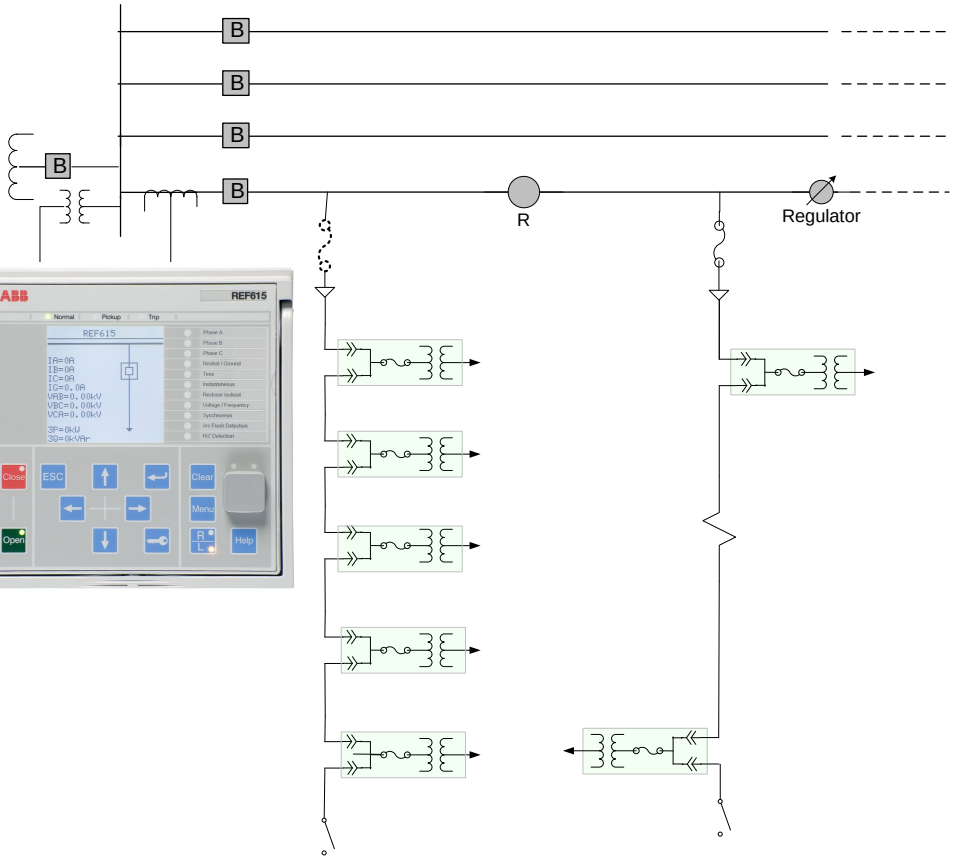


ABB's Relion® 615 series product

CFD Monitoring Unit Installation

- Four substations
- Eight feeders
- Test plugs – Metering circuits



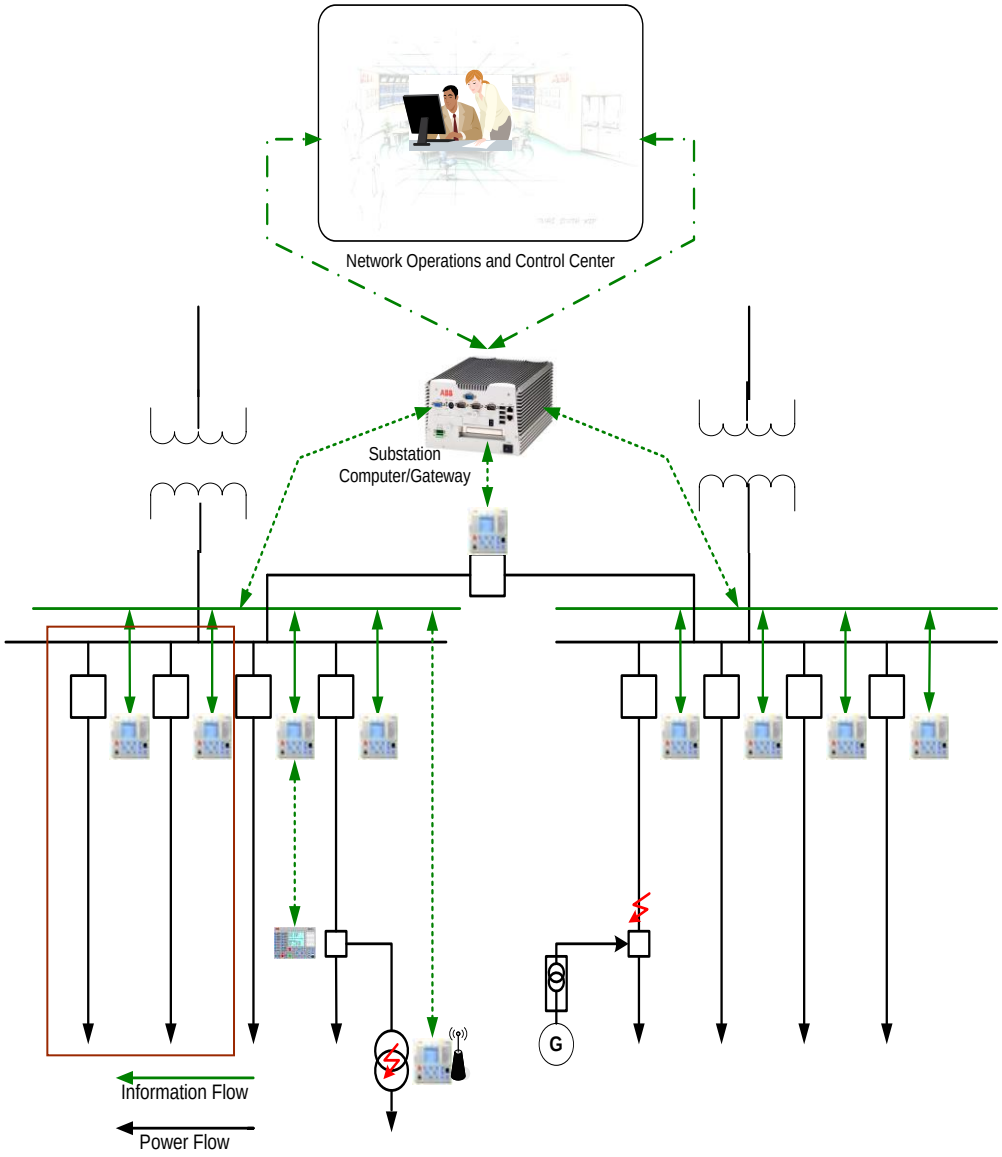


Sprint/Nextel Modem for Wireless remote dial up

Sprint/ Nextel WAN

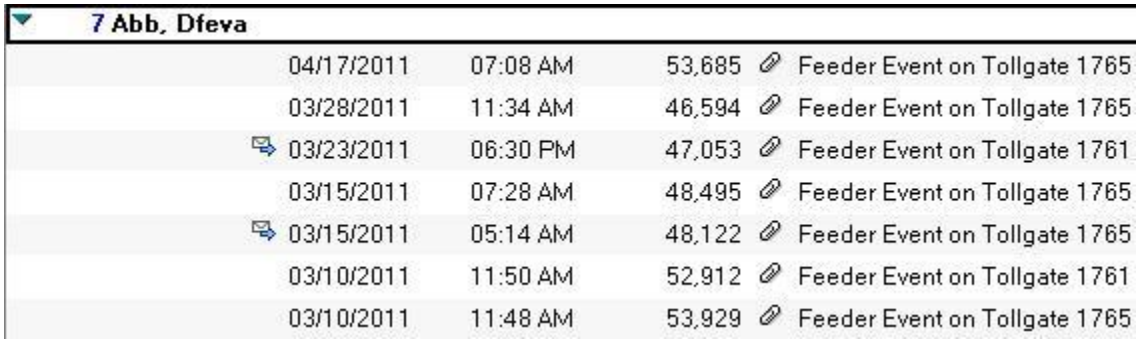
ABB/Xcel Energy e-mail recipients

Integrated Event Detection, Analysis, and Notification Enhancing Outage Management, Situation Awareness



Phase III: Results and Conclusions

- Real-time detections and notifications



7 Abb, Dfeva				
	04/17/2011	07:08 AM	53,685	Feeder Event on Tollgate 1765
	03/28/2011	11:34 AM	46,594	Feeder Event on Tollgate 1765
	03/23/2011	06:30 PM	47,053	Feeder Event on Tollgate 1761
	03/15/2011	07:28 AM	48,495	Feeder Event on Tollgate 1765
	03/15/2011	05:14 AM	48,122	Feeder Event on Tollgate 1765
	03/10/2011	11:50 AM	52,912	Feeder Event on Tollgate 1761
	03/10/2011	11:48 AM	53,929	Feeder Event on Tollgate 1765

- Historical recording
  - COM600 Web-server demonstration

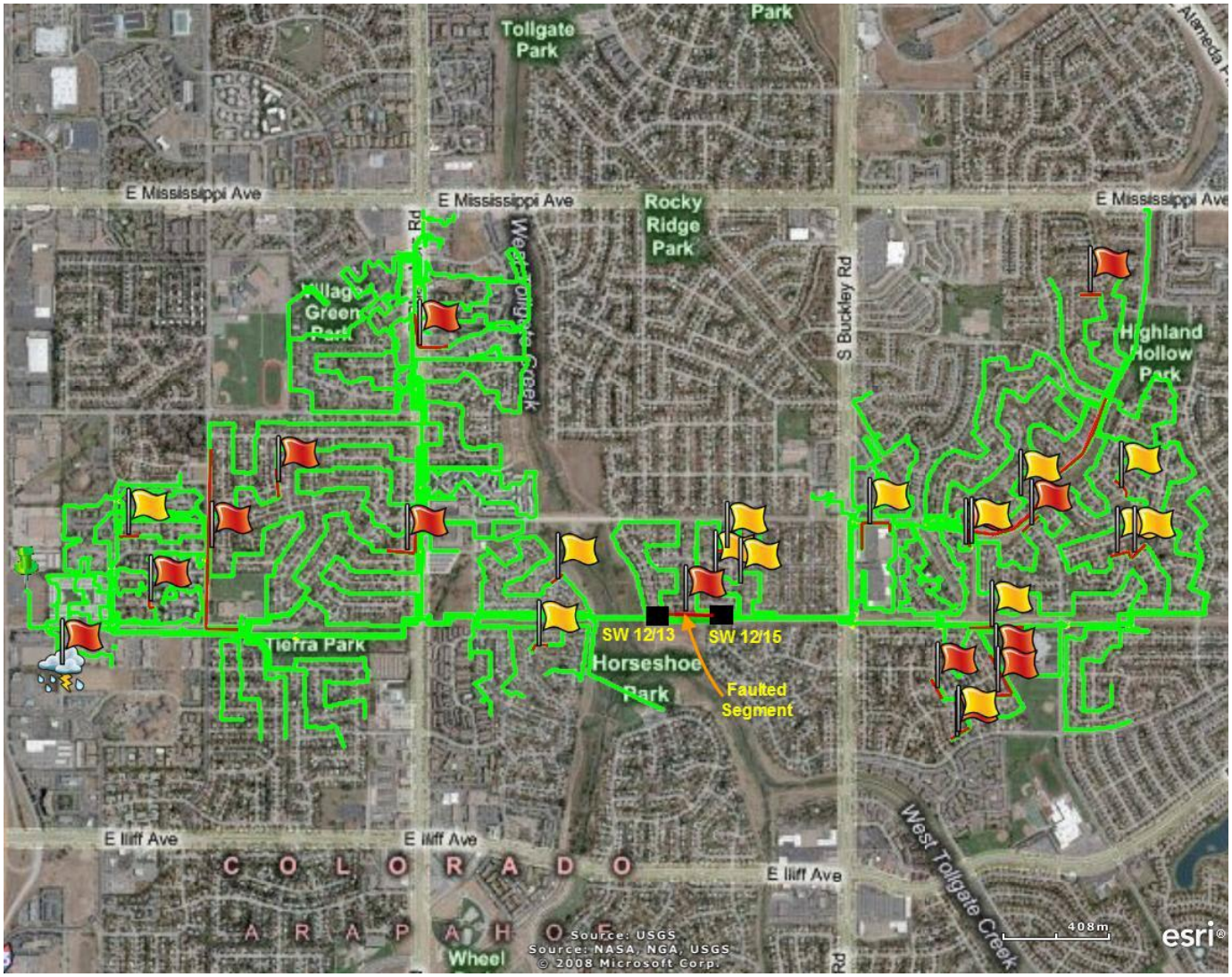
Starting DOE 'Feeder Management' Project Basics in a Nutshell

- Responded to DOE's FOA-0000313 for Area of Interest II, Jun 24, 2010
- This area calls for RDD projects addressing "*Prognostic Health Management*" and "*Distribution System Sensing*" Needs
- Proposal selected for an award on Nov 17, 2010 and entitled "*Real-time Distribution Feeder Performance Monitoring, Advisory Control, and Health Management System*" (1 of 5 awarded proposals out of >100 applications)
- A three-year project with two Phases of Exploration & Development and Demonstration

Integrated Event Detection, Analysis, and Notification Concept of What 'Done' Might Look Like

Operator Message:

A *Cable Fault* event on *B phase* has just been detected on *Primary feeder 1765* out of *XYZ substation* on *Dec 13, at 7:44AM* that could have been cleared by a *40A fuse (Rel. probability: High).*



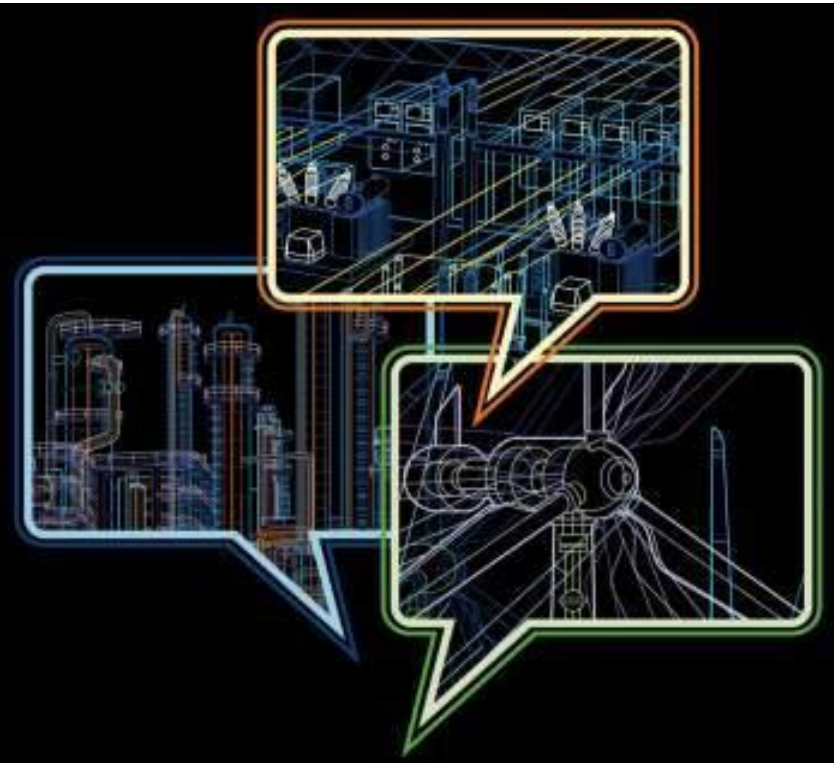


ABB Automation & Power World: April 18-21, 2011

WCS-118-1

Implementing Fault Detection Isolation Restoration & Incipient Fault Detection in Distribution Systems

FDIR Objectives

- Safety
- Reliability
- Security from intrusion (NERC/CIP)
- Predictability
- Fully interoperable (DNP/61850)
- Easy deployment
- Expandable

Distribution Smart Grid Landscape

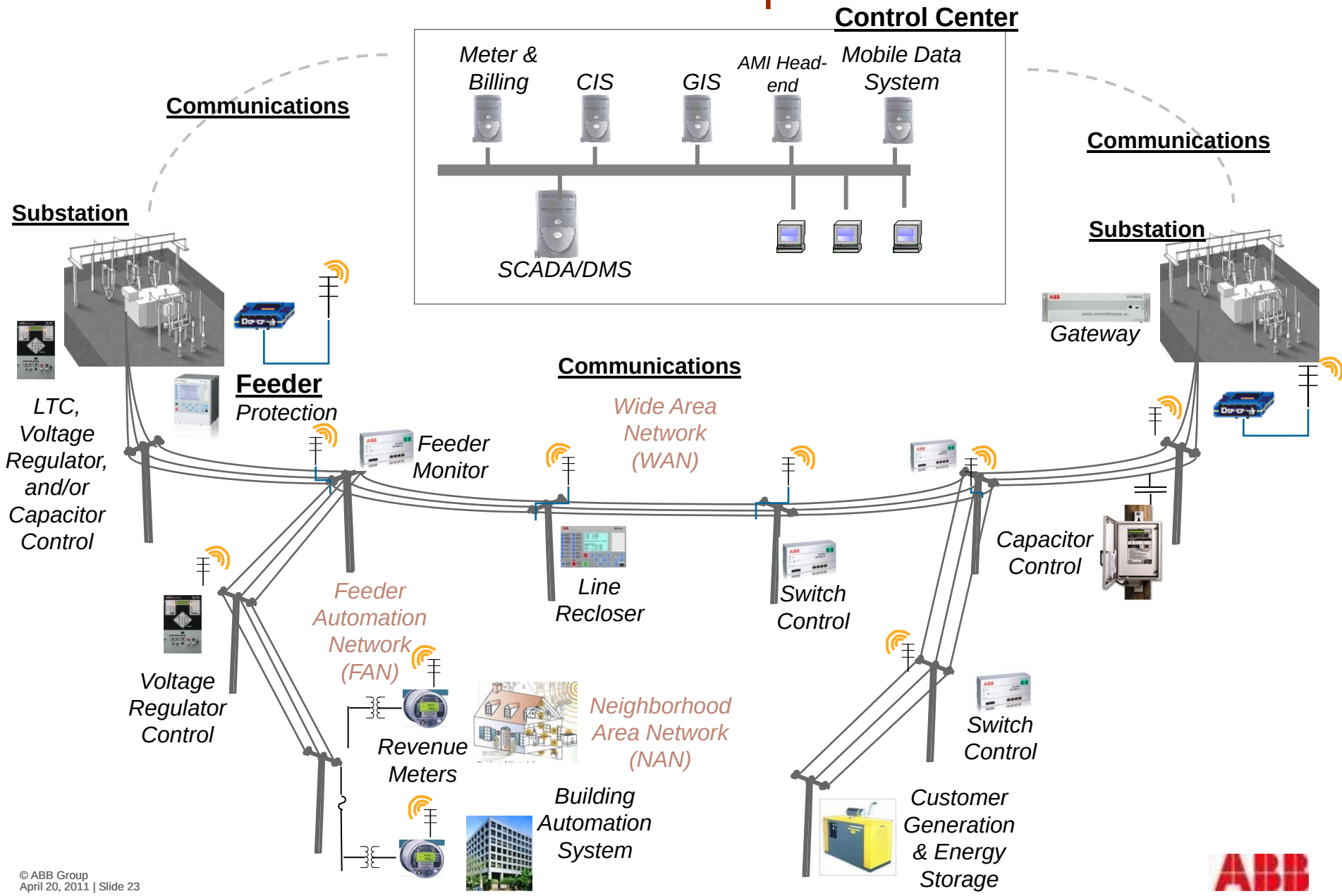
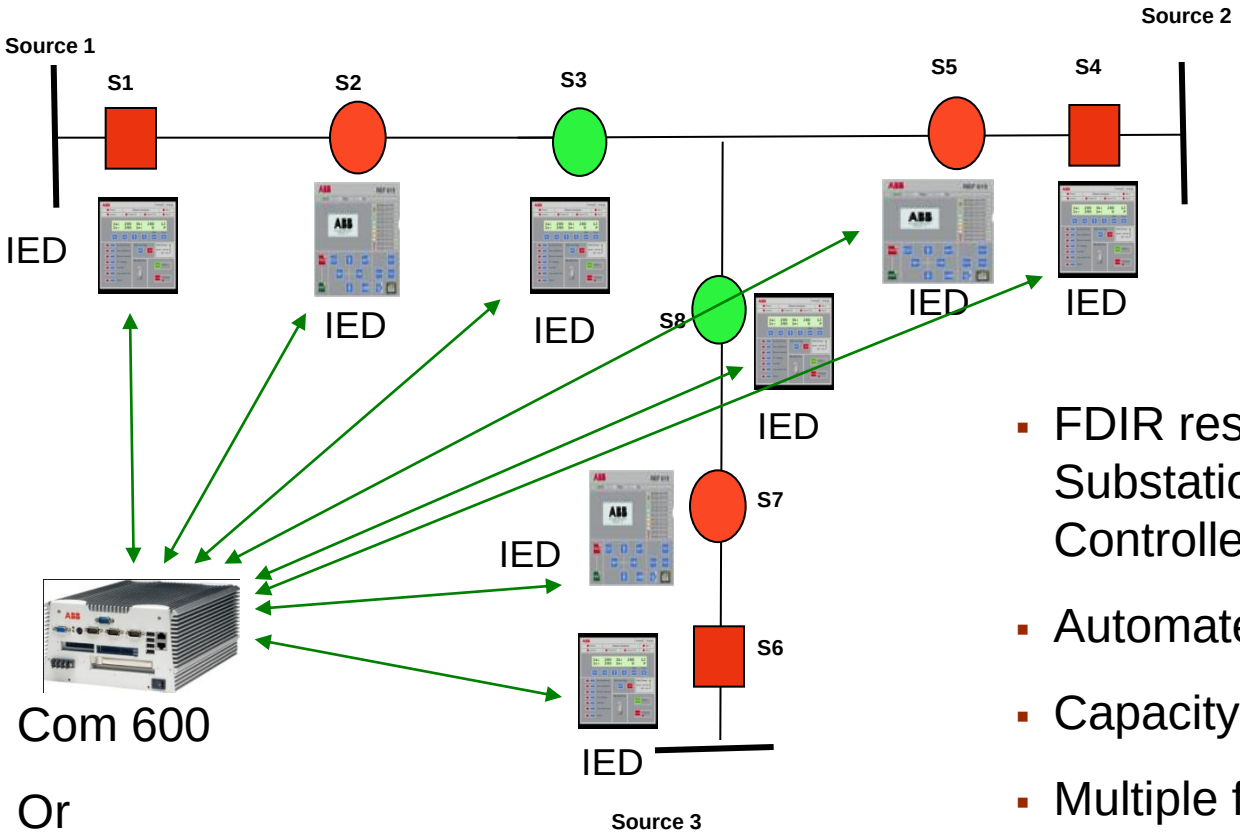


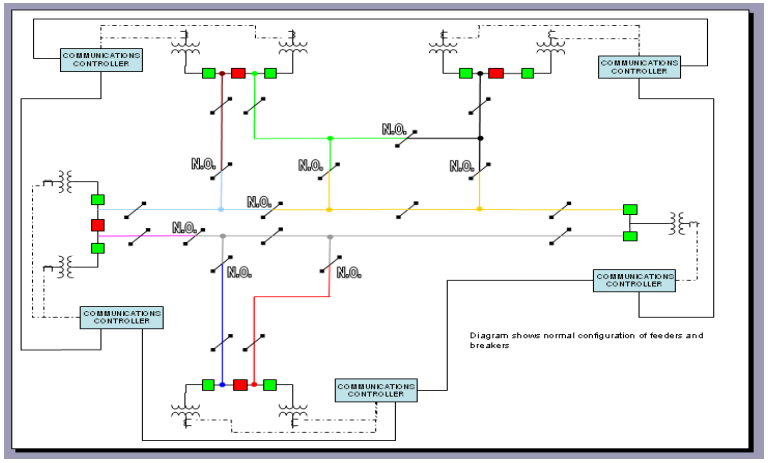
ABB Distributed Control – FDIR at Feeder or Substation



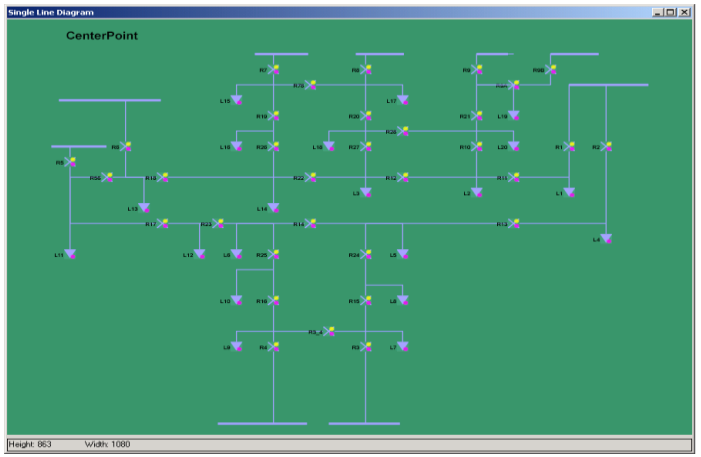
- FDIR restoration logic resides within Substation Controller or Feeder Controller
- Automated configuration of logic
- Capacity check
- Multiple fault restoration paths supported
- Simultaneous protocols supported

Modbus, DNP, 61850

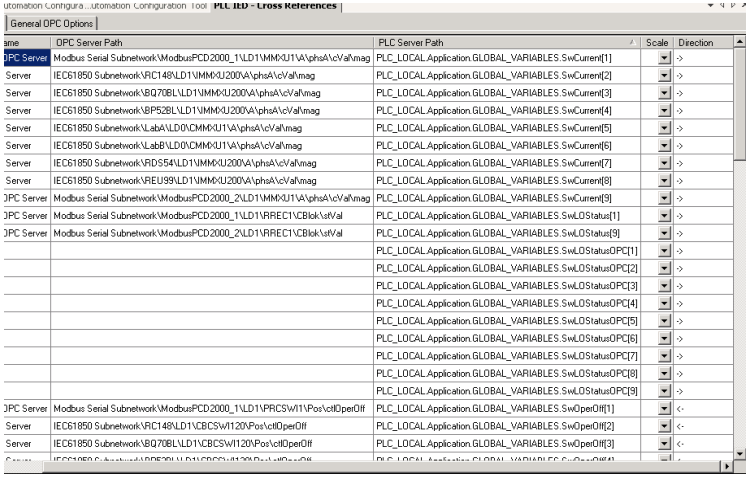
Auto-Configuration of Logic



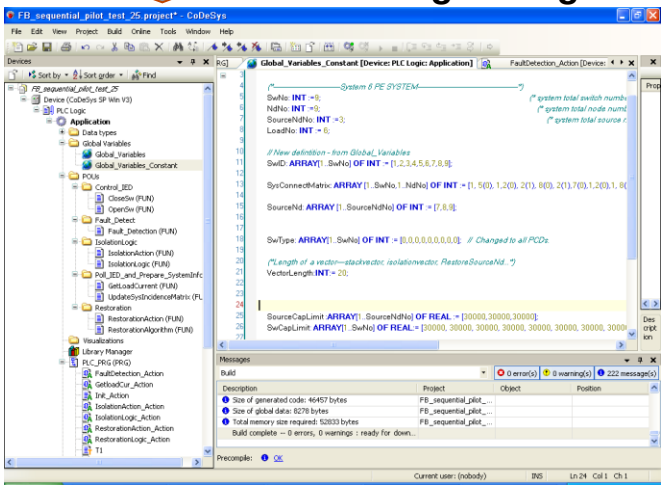
SAB600 Single Line Diagram



SAB600 Cross References Tool

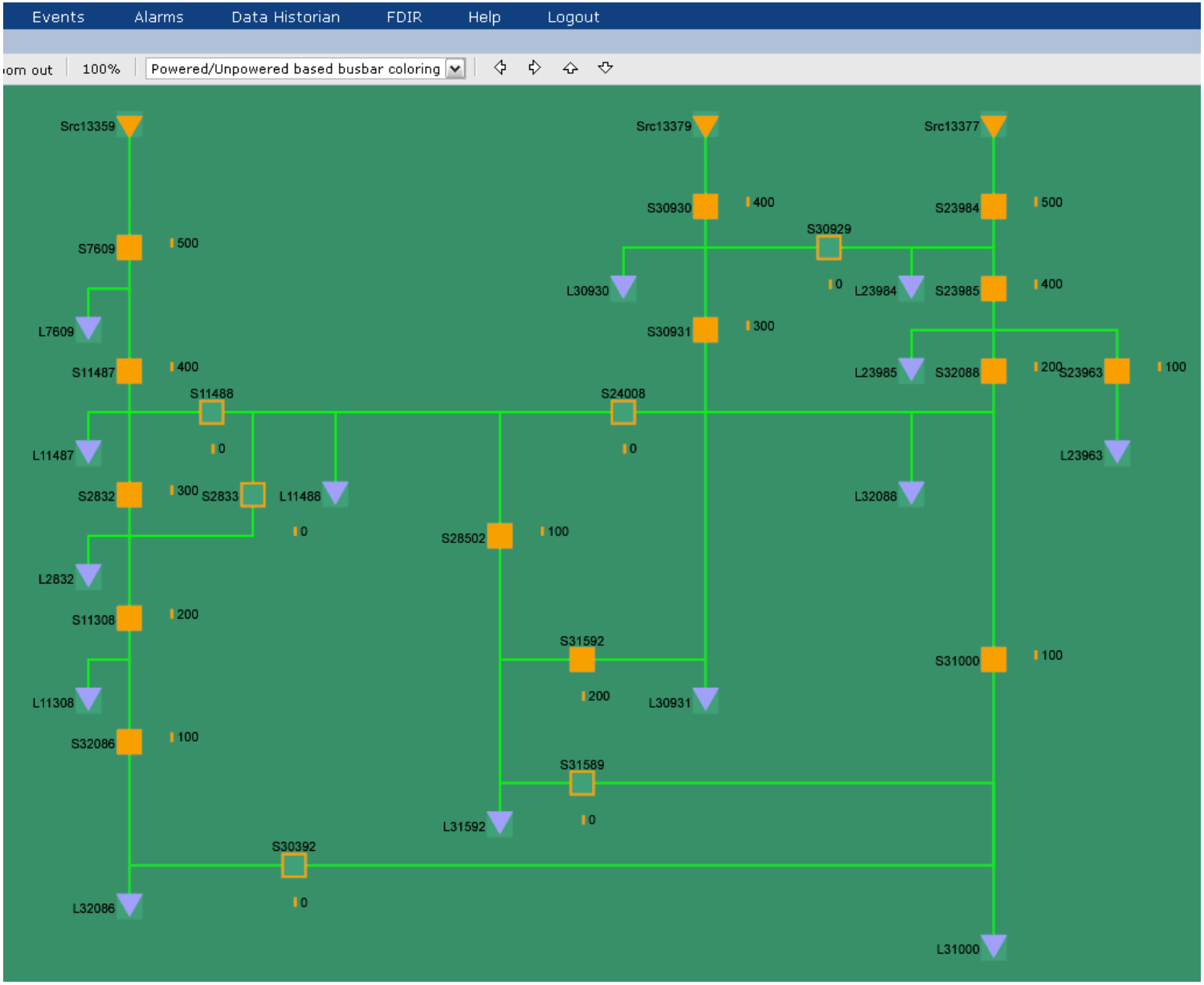


Active Logic Program

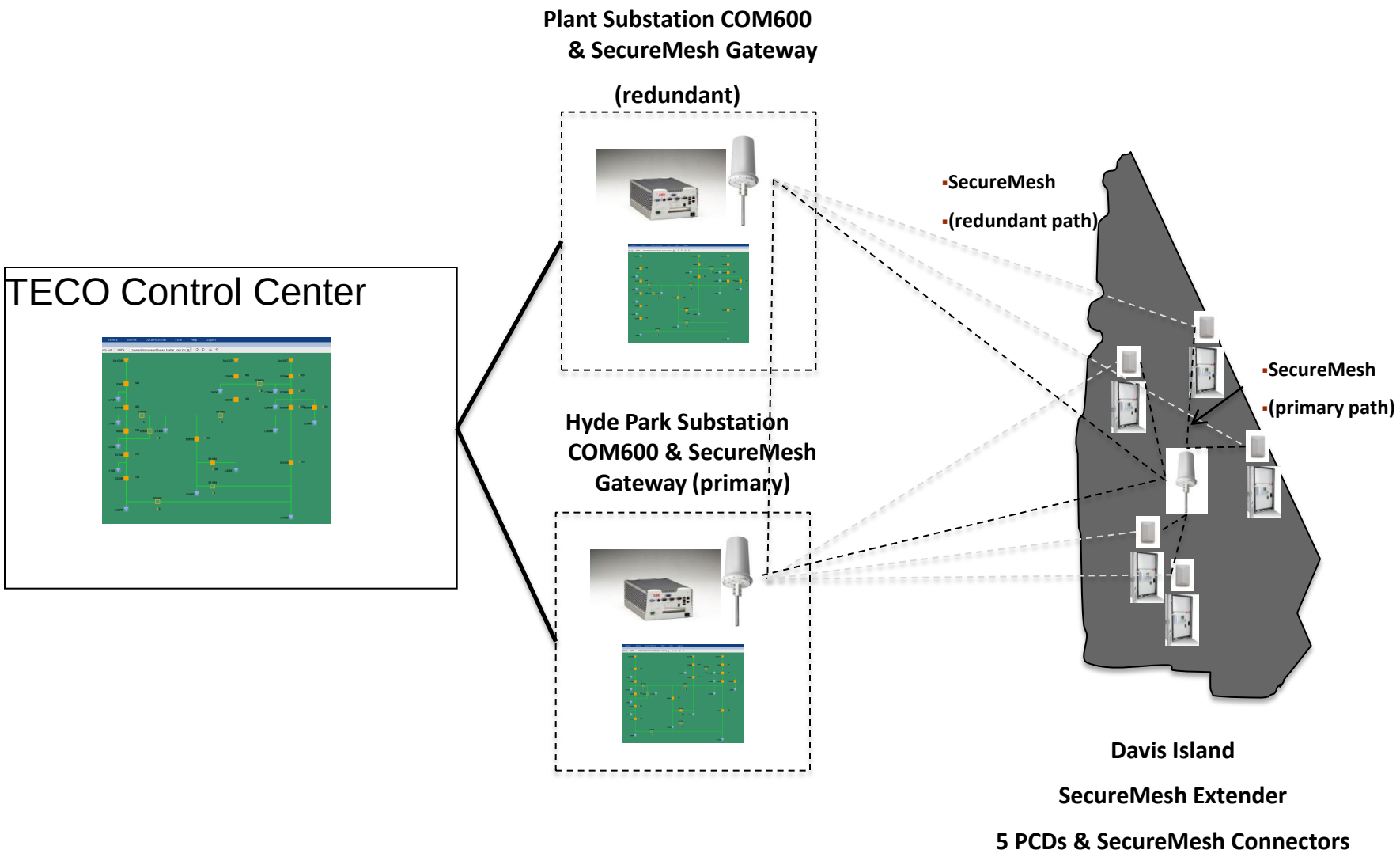


- System topology transferred to single line diagram of COM600 config tool (SAB600)
- Connectivity and IED data points/ commands (Cross References) automatically configured in Active Logic program using Feeder Automation Configuration Tool
- Isolation and restoration logic automatically configured based on connectivity and device statuses

Davis Island – One line diagram from COM 600

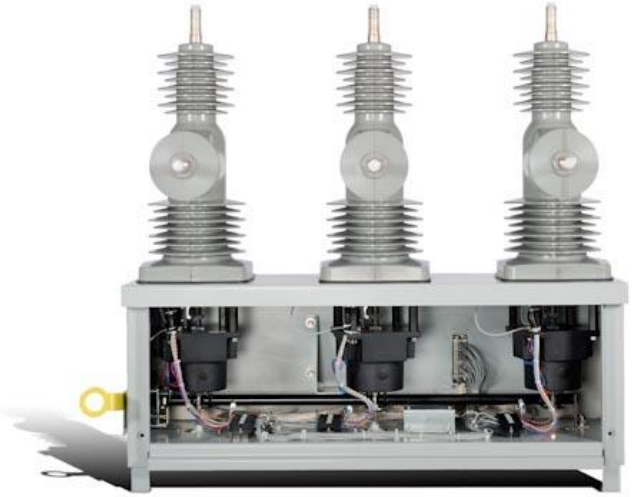


FDIR Example - Davis Island Solution



Recloser Portfolio – GridShield™ family

- GridShield Recloser
  - Similar high voltage design as OVR
  - Utilizes the RER620 Control with new advanced features



Reminders
Automation & Power World 2011

- Please be sure to complete the workshop evaluation
- Professional Development Hours (PDHs) and Continuing Education Credits (CEUs):
  - You will receive a link via e-mail to print certificates for all the workshops you have attended during Automation & Power World 2011.
  - BE SURE YOU HAVE YOUR BADGE SCANNED for each workshop you attend. If you do not have your badge scanned you will not be able to obtain PDHs or CEUs.

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