

Entergy Development and Deployment of IEC 61850 Protection and Control Including Process Bus

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Entergy IEC 61850 development program

- Began early 2014 – can 61850 help storm/disaster resilience?
- *Drivers:*
 - Customer satisfaction as impacted by storm recovery, and service reliability overall.
 - Safety.
 - Economics and business case.
- Entergy lab testing and system integration with multiple vendors of relays, merging units, and test equipment 2014-2017.
- First field trial at Joliet 115 kV Substation (non-tripping one-feeder trial).
- 2017 lab buildup to create trial standard design with 61850 process bus, station bus, PRP network, and PTP time synchronization.
- Now designing for 2018 at Culicchia Substation live green-field demonstration.

Entergy plugfests

- Three tests in Kenner, LA lab with multiple vendors and industry expert participants – focus on process bus and relays.
- Needed all three to achieve interoperability of 5 vendors



Joliet 115 kV field trial

- 2 MUs and 3 relays, mixed vendors.
- PRP network
- Monitoring mode



Industry experience with IEC 61850

- Began in 1995 – a single international substation protocol to replace vendor-specific protocols.
- Interoperation over Ethernet network to replace wiring.
- Advanced to modeling the application elements (logical nodes and standard data objects) to simplify system engineering and configuration.
- Expanded across the entire utility grid.
- Thousands of turnkey one-vendor installations did not work out the interoperability bugs among vendors.
- Years ago, early US adaptors designed their own with mixed vendors and had integration challenges.
- Engineering tools were not integrating projects.

Since then...

Industry experience with IEC 61850

- Edition 2 overcame Edition 1 issues with modeling and service bugs and shortcomings, interoperability, and testing features.
- System engineering and product vendor configuration tools have improved.
- Three week-long UCA interoperability (IOP) tests uncovered design or interpretation problems and improved products.
 - IOP #3 Oct. 14-19 in New Orleans, hosted by Entergy.
- Senior utility leaders now demand business benefits of 61850, and push teams to develop standards.
- Many utilities developing trials and standards.
- New organizational skills, tools, and resources needed.
- Legacy P&C will become more difficult to sustain in parallel.



Entergy business case for IEC 61850

Hurricanes and superstorms – immunity, resiliency, and fast restoration are key.

- A few fiber connections – faster construction and faster restoration.
- Water-resistant construction with fibers and other features
- *With strong configuration management* – replacement and commission is far faster.
- Self-monitoring design exposes hidden failures, eliminates TBM, and speeds recommissioning (ref. NERC PRC-005-2/6).
- Risk of human errors is reduced.
- Exposure to hazardous voltages of IT circuits mostly eliminated.

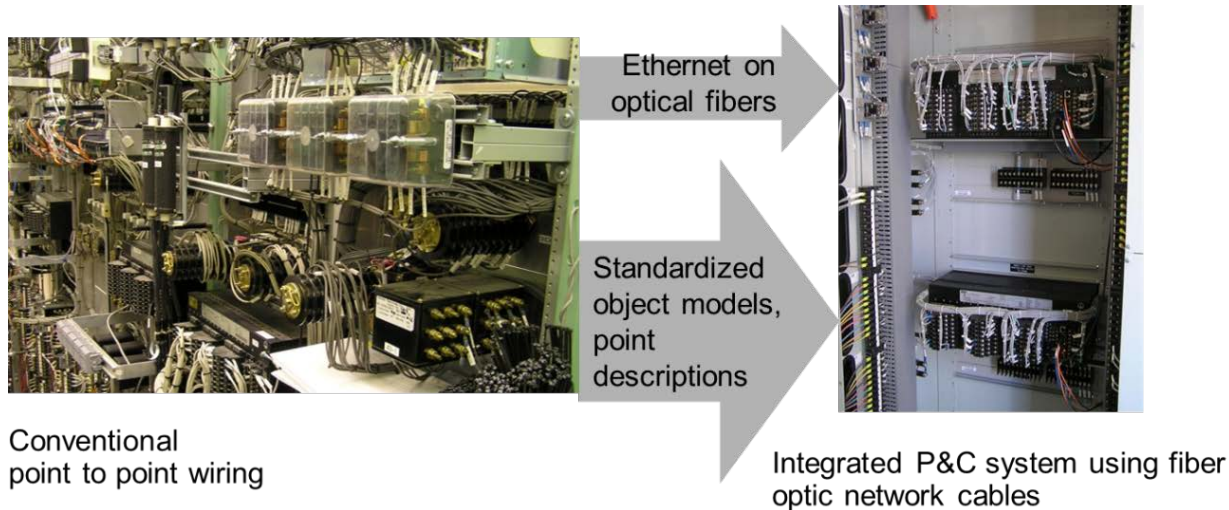


Entergy business case for IEC 61850

- Construction savings with waterproof blown-fiber conduits.
- Deployed 140 feet of fiber in 40 seconds.
- Improves safety.
- Fast fiber and/or conduit replacement in emergency situations.



Configuration management

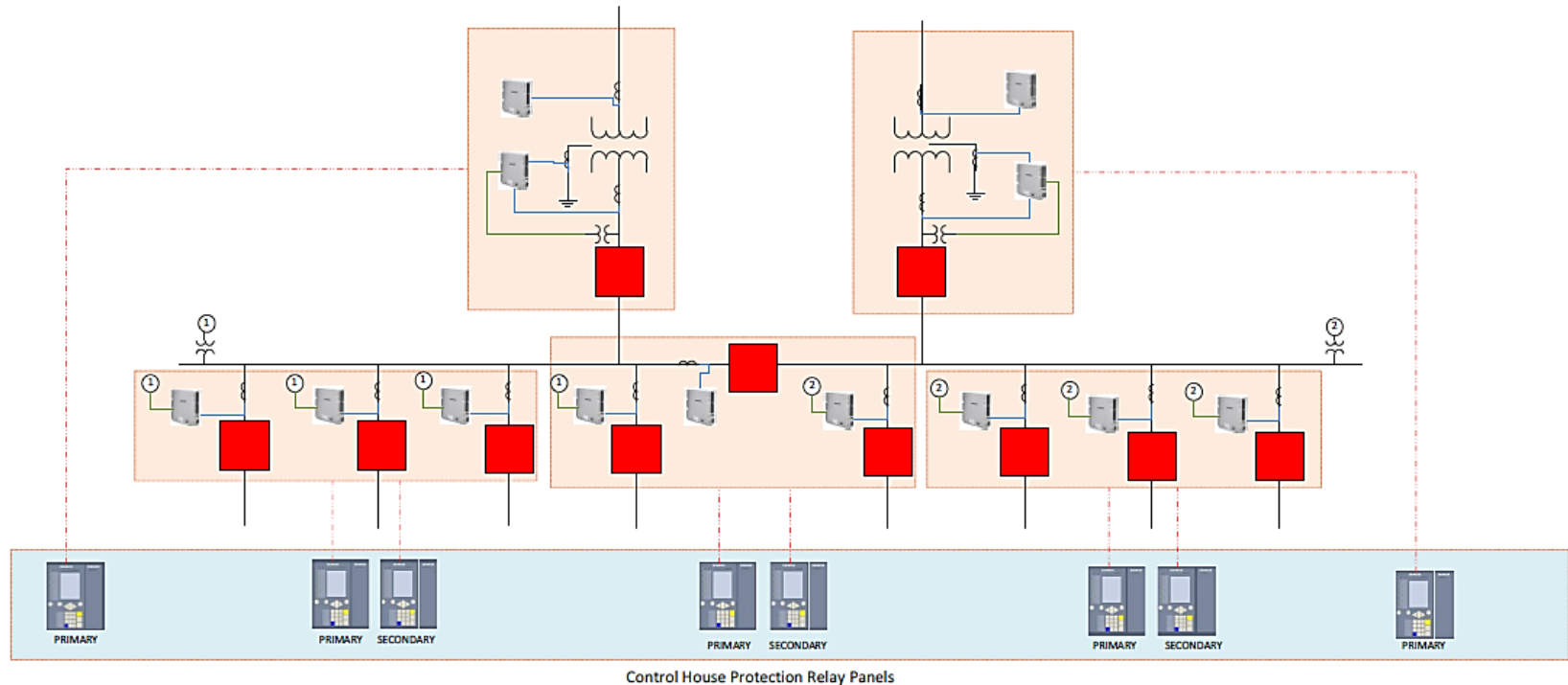


Every IEC 61850 vendor shows images like this!

- True, and stark panels are key to business case drivers.
- Functional complexity didn't go away...
- It is now contained in new setting files - more settings than ever.
- Also settings for communications devices, e.g. Ethernet switches.
- Need *rigid* configuration management (settings file control) to maintain, update, restore installations.

Entergy 2018 Culiccia green-field project

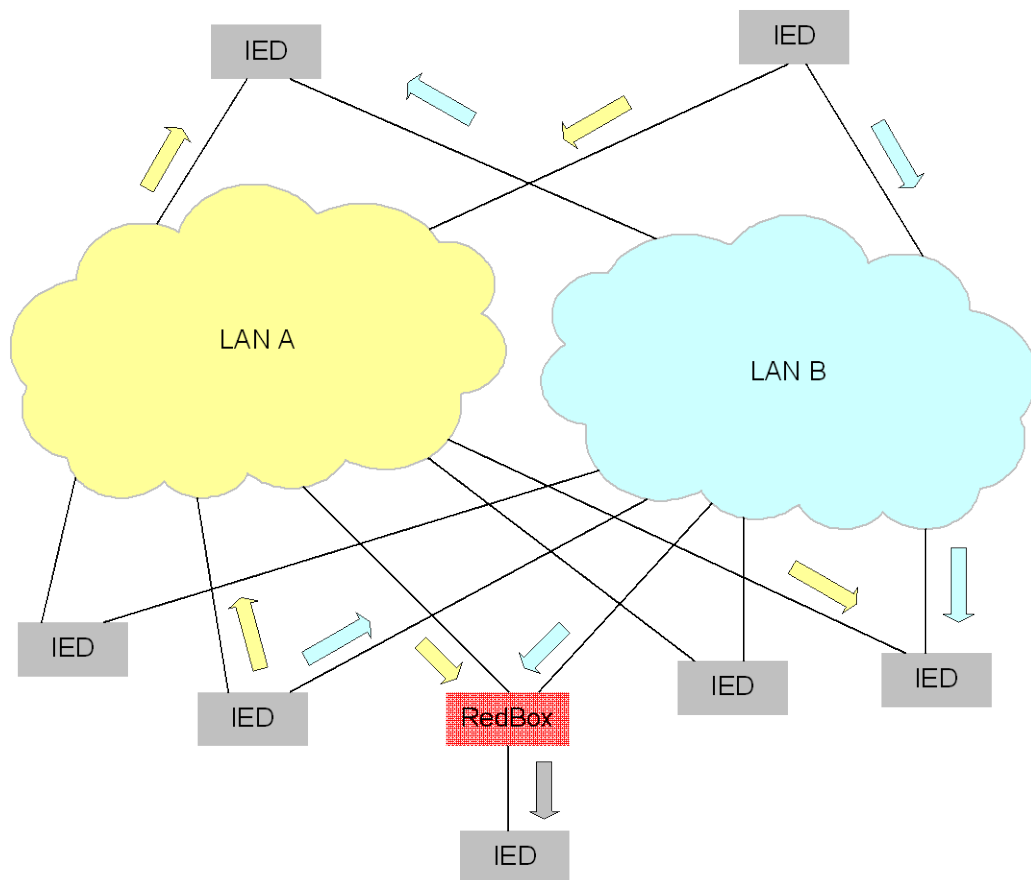
- Full 61850 services including process bus.
- 2 transformers, 8 feeders, bus split with tie breaker.
- Conventional relays for backup of live 61850 protection.



2018 Culiccia project features

- IEC 61850-8-1 GOOSE messaging – millisecond-speed status and control messaging over Ethernet station/process bus to eliminate control wiring.
- IEC 61850-9-2 and UCA 9-2 LE sampled value (SV) service on process bus – high-speed sampling of voltages & currents by MUs send data from switchyard to relays in control building.
 - Future IEC 61869-9 merging unit standard compliance.
- IEC 62439-3 parallel redundancy protocol (PRP) – bumpless failover for network component failures.
- Precision timing – dedicated PTP fibers as in 9-2 LE, or IEEE 1588 network precision timing protocol with 61850-9-3 and/or IEEE C37.239 profiles, as available in products. Timing fibers; transition to network synchronization to $<1 \mu\text{s}$.
- Multivendor direction, but single vendor in this project.
- Condition-based maintenance (CBM) per condition monitoring as per NERC PRC-005-6.

Parallel redundancy protocol (PRP)



- IEC 62439-3.
- No response bump for failure of fiber, connector, Ethernet switch, or optical interface.
- Avoids RSTP bump of 5-50 ms with rings.
- Does not cover need for IED redundancy.

Conclusions

- Project is a collaboration of Entergy P&C Engineering, field and construction personnel, multiple IEC 61850 product vendors, and industry experts working to develop a practical and interoperable system.
- Three years of laboratory development and plugfest testing lead to 2018 working installation in newly constructed substation.
- Business case built on storm resiliency and rapid customer restoration with full IEC 61850 design, along with construction savings, safety improvement, human error risk reduction.

Conclusions

- Condition based maintenance program takes full advantage of 61850 self-monitoring capabilities to expose hidden failures when they happen, while eliminating most time-based maintenance testing.

Suggestion to the industry...

- Extend these concepts of a standardized rapid-restoration design beyond the boundaries of one utility.
- IEC 61850 enables standardized designs and configuration templates – reduced development effort and faster organizational training.
- Emergency response for substations can be carried out with mutual support as we do for distribution circuits today.