Substation Integration and Automation – Approaches and Best Practices

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John McDonald
KEMA Consulting
Overview – Approaches and Best Practices

• System Architecture
  – Substation Integration and Automation Levels
  – Primary and Secondary Substations
  – Architecture Functional Data Paths
  – New Versus Existing Substations
• Communication Protocols
  – IED Standalone Capabilities
  – IED Integration Capabilities
• Utility Case Study
  – Functional Architecture
  – Vendor Installed Architecture
  – Equipment Photographs
Intelligent Electronic Device (IED)

• Any device incorporating one or more processors with the capability to receive or send data/control from or to an external source (e.g., electronic multifunction meters, digital relays, controllers)
# Substation Integration and Automation Levels

<table>
<thead>
<tr>
<th>Utility Enterprise</th>
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<td><strong>Substation Automation Applications</strong></td>
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<td><strong>IED Integration</strong></td>
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<td><strong>IED Implementation</strong></td>
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<td><strong>Power System Equipment</strong> (Transformers, Breakers)</td>
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Substation Integration

• Integration of protection, control and data acquisition functions into a minimal number of platforms to reduce capital and operating costs, reduce panel and control room space, and eliminate redundant equipment and databases.
Substation Automation

- Deployment of substation and feeder operating functions and applications ranging from SCADA and alarm processing to integrated volt/VAR control in order to optimize the management of capital assets and enhance operation and maintenance (O&M) efficiencies with minimal human intervention.
Example of “Primary” Substation and “Secondary” Substation

Primary Substation

Secondary Substation
Primary Substation Automation System
Secondary Substation Automation System
# Architecture Functional Data Paths

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<td>SCADA Data to MCC</td>
<td>IED Integration Via Data Concentrator/Substation Host Processor</td>
<td>Power System Equipment (Transformers, Breakers)</td>
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<td>Historical Data to Data Warehouse</td>
<td>IED Implementation</td>
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<td>Remote Dial-In to IED</td>
<td></td>
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</table>
Web Pages with:  
- Real-time values  
- Relay settings  
- Fault records  

Fault records, summaries and waveform data from relays (and settings)
New Versus Existing Substations

• New Substations
  – IEDs With Digital Communications
  – PLCs for Direct I/O
  – No Conventional RTUs

• Existing Substations
  – May Integrate IEDs With Existing RTUs (Not Support Non-Operational and Remote Access Data Paths)
  – Integrate Existing RTU as IED or Eliminate Existing RTU and Use IEDs and PLCs for RTU I/O
Protocol Fundamentals

• Communication Protocol
  – Allows Two Devices to Talk to Each Other
  – Each Device Must Have the Same Protocol Implemented, and the Same Version of the Protocol

• Both Devices From Same Supplier, and Protocol

• Both Devices From Same Supplier, with Industry Standard Protocol

• Devices From Different Suppliers, with Industry Standard Protocol
Protocol Considerations

• North American Electric Utilities Specify the IEDs to be Used in a Substation
  – Chosen Based on IED’s Standalone Capabilities (Relay for Protection of Power System) and Not IED’s Integration Capabilities
  – IEDs From Various Vendors (Will Not Accept Turnkey Approach From One Vendor With All IEDs From that Vendor)
Protocol Considerations…
(continued)

- Once IEDs Specified by Utility Based on Standalone Capabilities, Then Consider Each IED’s Integration Capabilities
  - IED Protocol Support
    - Modbus, Modbus Plus, DNP3
    - UCA2 MMS
    - May Lose Some IED Functionality When Choose Other Than IED’s Native Protocol
  - IED Networking Support
    - RS-232 and RS-485 (Serial)
    - Ethernet
IEC TC57 Harmonization with UCA2

- X - Y
- 7-4 Compatible data objects
- 7-3 Data Templates for Substations
- 7-2 Abstract Communication Service Interface (ACSI)
- 8-1 Mapping to MMS

GOMSFE
- Device Models
- Device Models
- Device Models
- Common Class Definitions
- Standard Data Types and Common Components

Common Application Service Model (CASM)

UCA2

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North American Projects

- Omaha Public Power District (OPPD) – Two Substations and One Training Simulator
- MidAmerican Energy Company (Iowa) – Two Substations and One Training Simulator
- Los Angeles Department of Water and Power – 179 Substations, Two Development Systems, One Training Simulator Over Five Years
- EPCOR Utilities (Edmonton) – Two Substations
- Minnesota Power – Strategic Plan
- Potomac Electric Power Company (PEPCO) – all 4kV, 13kV, 69kV and 230kV Substations
- Frankfort Electric and Water Plant Board (Kentucky) – Sixteen Substations and One SCADA System With Two Dispatch Centers
Omaha Public Power District (OPPD)

- EPRI Tailored Collaboration (TC) Project
- Two Substations, One Training Simulator
- Require all IEDs with UCA Capability to be Integrated Using UCA2 MMS Protocol and Ethernet Networking
- Discovered that IEDs Thought to Have UCA Capability Did Not (Beckwith M2002B LTC Control)
- Discovered that IEDs Achieve UCA Capability By Adding a Separate Box (Rather Than Integrating Into IED) (RFL 9745 Teleprotection)
- Integrators Not Need SEL 2030 Communication Processor – Integrate SEL Relays Directly
- One Substation System and Training Simulator System Being Installed
OPPD Simplified SA Functional Sketch

**EMS Network**
- SCADA
  - DNP 3.0/C2020 Protocol Converter
  - 1200 bps C2020

**Substation 912**
- SCADA Interface
- Data Concentrator
- Protective Relays
- Trf. LTC Monitor
- Trf. LTC Annunciator
- Trf. Temp Controller
- Direct I/O

**Corporate WAN**
- Data Warehouse
  - ORACLE

**Corporate WAN** (through a firewall)
- Router
  - 10 Mbps
  - Router/Firewall

**T1 Network Connection**
- Frame Relay (QWEST)
- 56 Kbps leased Frame Relay Connection
- SA Sub

**EMS**
- Dial In
- GPS Time Reference

**DMZ**
- Can break connection with Corporate if needed
Simplified OPPD SA System