Touchless Substation Project

Eric Rosenberger, PE
Megan Coyle
What is Touchless Substation?
What is Touchless Substation?

• Deploy On-line condition monitoring
• Redefine maintenance processes to incorporate new technology
• Prove the value of this technology to our business
• Create the design standard that can be scaled
Agenda

- Initial Research
- Business Case & Project Plans
- Equipment Proposals
- Installation Details
- Communication Design
- Compliance Strategy
- Lessons Learned
- Next Steps
Current Industry Trends

• Improving reliability to customers
• Reducing O&M costs
• Major capital investments into the grid
• Technology advancements
• Improving business operations with data
• Condition based maintenance
• Higher need for situational awareness
• Improved event response
Substation O&M Expenses Breakdown

Actual O&M Breakdown for Substation Maintenance

- **O&M used to correct problems**: 34%
  - Correct it before it’s too late
- **O&M used to fix problems or repair damage**: 14%
- **O&M used to prevent and/or find issues before they cause problems or damage**: 52%

- Preventative Maintenance
- Repair Maintenance
- Unplanned Maintenance

Get it back in service

Insurance Policy
Ideal Expense Breakdown

Ideal O&M Breakdown for Substation Maintenance

While Reducing Total Cost + Improving Reliability

Minimum planned maintenance. Do what needs to be done to keep assets operating

Prevent failures

Correct issues before they become failures or emergencies

Preventative Maintenance
Repair Maintenance
Unplanned Maintenance

25%
75%
0%
Wants

• “I don’t want to have to go to my substation in order to collect inspection and testing data”
• “I want my substation to tell me when it needs to be maintained”
• “I want more real time data on all of my substation assets”

• “What technology is available that can help us with this?”
Goals

- **Reduce planned maintenance without sacrificing reliability**
  - Collect inspection data more efficiently and often
  - Reduce outage needs to collect testing data
  - Convert to Condition Based Maintenance Triggers
  - Reduce manual trips to substations

- **Collect more asset data that can be used for data analytics**
  - Better assess Asset Health insight
  - Improve work prioritization and planning
  - Improved data quality & consistency

- **Detect failure conditions quicker**
  - Prevent catastrophic failures
Typical Substation Planned Maintenance

Planned O&M Procedures by Equipment Type

- Capacitor Banks: 49.7%
- Circuit Breaker: 25.7%
- DC System: 8.0%
- Disconnect Switches: 6.1%
- Lightning Arrestors: 5.7%
- Transformer: 3.5%
- Instrument Transformer: 0.8%
- Sub in General: 0.5%
Plan of Attack

• Install Equipment monitoring at one substation on as many of the major assets as possible
• Understand current maintenance practices and data needs
• Determine possibilities – “Do the Research”
  o New procedures
  o CBM ideas
  o Technology solutions
• Improve maintenance processes
Remote Substation Inspection System

- Proposal
  - Keep crews out of harm for emergency events
  - Install a remote or autonomous inspection system at the substation
  - The system would contain a highly maneuverable high resolution visual and infrared camera
  - Replace manual physical inspections with remote inspections
- Yard walk down inspections
- Thermal IR Inspections
  - Provide operators and maintenance responders immediate situational awareness
    - Remote restoration after fault events
    - Assess site conditions during/after weather events
  - Capture operating event data for event analysis
Remote Substation Inspection System

- About 30% of the industry is at least considering remote inspection systems (visual & thermal)
- PTZ Visual & Thermal cameras

- Maintenance analytics will alert on hot spot and other detectible conditions
• **Proposal:**
  - Replace monthly, annual and 5 year testing and inspections with continuous monitoring, alarms and predictive replacement.

• **NERC Standard PRC-005-6 monitor and alarm for:**
  - High/Low DC Supply Voltage
  - Electrolyte Level
  - Unintentional Grounds
  - Charger float voltage
  - String continuity
  - Intercell Resistance of entire Battery
  - Internal Cell Ohmic Values or Float Current (must compare to baseline values)
  - All alarms and monitoring paths must be verified once a year or be automatically monitored.
Batteries / Chargers Monitoring

- ALBER UXIM battery monitoring system
Lightning/Surge Arrestors

Proposal
- Replace 8 year Doble Testing with Leakage Current monitoring (LCMs), alarms, and predictive replacement.
- Use the remote inspection system to routinely measure the thermal signature of the LA.

- Reduce planned outages and cost of testing LAs

Real time, Operation Data:
- Counts of high current conductance events
- Continuous leakage current
- Routine thermal signatures

- Prevent unplanned outages by trending data to determine replacement needs
Lightning/Surge Arrestor Monitors

- Siemens ACM key data points:
  - Surge Counts
  - Third Harmonic Leakage current

- Handheld device collects data locally (no real time monitoring)

- Eliminates outages for testing

- Data collection at any time
Power Transformers

• **Proposal**
  - Replace 8 year Doble & Service, Annual Cooling Equipment Maintenance, and Semi-Annual DGA tests with DGA Dynamic Ratings Monitoring and Condition Based Maintenance

• **TCUL’s**
  - Replace 4 year Overhaul with Operations Monitoring, alarms, and condition based maintenance.
  - Targeting 75% reduction in testing interval while maintaining to Manufacturers recommendations with a safety factor of at least 2.
Transformer Monitors

- Dynamic Rating E3 Unit for Transformer Sensor processing

DR BAU
Bushing Monitor

TCUL

Qualitrol
Temperature Monitor

Serveron TM8
8 Gas Oil Monitor
Gas (SF6) Circuit Breaker

- **Proposal**
  - Replace 4/6 year Service & Overhaul with Condition Based Maintenance and Monitoring
  - Monitor Health using on line condition monitors
  - Install CB Monitor to Remotely monitor CB conditions

- **Collect Valuable Condition Data:**
  - Timing Data from real operations
  - SF6 Gas monitoring + Trend Alarms
  - Contact Wear
  - Run times
  - Mechanical Operation Parameters
  - Electrical Operation Parameters

- **INCON OPTIMIZER 3**
  - (9) 69kv and (4) 230kv CBs (ABB & Siemens)
CCVTs

- Replace 4 year Double Testing with online monitoring
- PHKV is the vector sum of CCVT voltages
- PHKV value alarmed for 5% of the phase-phase operating voltage

- Monitoring and alarming is performed directly in TMS
- PPL has successfully prevented several failure events through this monitoring capability
- Looking at similar solutions for single phase CCVTs
CCVT Monitor Examples
Network Configuration

- Room for future additions and quick repair
- Limit CAT6 for reduced maintenance
Data Collection and Management

- Health Trending Algorithms
- Alerting and Maintenance Triggering

Monitoring Devices at the Substation

PPL EU Network

Select Data

CARE

Maintenance Engineers

CASCADE
Compliance Strategy

- Monitoring and control function segregation
- No physical connection
- Control and restrict access

Monitoring Equipment

PPL EU NET

Maintenance Management System

Operations Management System

Operations & Control Equipment
Lessons Learned So Far…

• Some technologies will need to improve
  o Motor operated switch monitoring
  o LA monitors

• Robotic substation inspection system
  o Concerned about snow and weather navigation

• More learning to come
Our Next Steps

• Condition Monitoring Procedures
• Evaluating Project success and value
• Business Case for scaling up on the system
Questions?