RTU Life Extension & Migration Strategy
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Agenda

• Xcel Energy Company Profile
  – RTU install base
• RTU end of life concerns
• RTU designs – Past & Present
  – 2012 Pilot projects
  – Swing Door Replacement
  – I/O Peripheral upgrade
• RTU Life Extension & Migration Strategy
  – Design examples
  – Lessons learned
• Summary
Company Profile – Xcel Energy

- Xcel Energy is an electric and natural gas company, with annual revenues of $11.4 billion. Based in Minneapolis, Minn., we have regulated operations in eight Midwestern and Western states, and provide a comprehensive portfolio of energy-related products through four operating companies.

- **Employees**: 11,865
- **Natural gas operations**
  - Customers: 2.0 million
  - Transmission: 2,209 miles
  - Distribution: 35,112 miles
- **Electricity operations**
  - Customers: 3.6 million
  - Transmission and Distribution: 219,841 miles
## Substations/RTUs

- **1400+ Substations**
  - 80% have Remote Terminal Units (RTUs) communicating to EMS/SCADA

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**Key**
- Red – Obsolete, Blue - Aging
Problem Statement - RTUs at end of life

Many of these RTUs were installed in 1960s to 1980s

- Spare parts are no longer available & some vendors are long gone
- 3rd parties can no longer repair since components are unavailable
- Proprietary and obsolete protocols.
- Data limitations (8 bit vs 16 bit vs 32 bit) – better resolution/increment - Modbus 8 bit analog (0-4095) vs DNP3 16 bit (0-65535)
RTU replacement – pilot projects in 2012

11 sites - CDC 44-500, C7003 and C8000
• Range from 65 to 400 I/O points
• Budget $250k to $500k/site
• Install a new RTU panel next to existing
• Outages on field device to move wiring/test functionality (Project 5-10 weeks)

Results
• Upgraded telco circuit difficulties
• 50% projects on budget/on time
• Outages difficult to get
• Some outage 2-4x times longer
• Referred to as the Brute Force solution
RTU replacement - Swing door replacement

Bird Island Substation – C2000
• 75 I/O points, Budget $150k
• 15 AIs replaced with Bitronics M650s
• Projected RTU Outage 1-2 weeks

Process
• Old RTU taken out of service
• Swing door stripped clean/swapped out
• New equipment installed & wired to terminal blocks not impacting field wiring
• Control test switches opened & program functionality tested
• RTU placed back in service
RTU replacement - Swing door replacement

Results
• Completed in 1 wk & on budget
• Works fine for small RTUs

Concerns with this design
• Large RTU could consist of 5/6 PACs with cabling getting unruly
• Many RTUs have active components on termination panels (parts issue)
• Operations wants shorter RTU outage
RTU replacement – Wish list

• **Start with new RTU panel (HMI/PAC)**
• **Replace** (active components not passive)
  – RTU, control cards, processor, old power supply, read relays
  – Active – EEPROMs, transistors, SCRs, TRIACs, vacuum tubes – difficult to buy
  – Passive – resistors, caps, inductors, diodes, transformers – easy to buy
• **Retain** (I/O termination to limit outage/retesting time)
  – control relays and wiring
  – discrete digital and analog input terminations
• **Ultimate Goal**
  – RTU outage of 1-2 days – complete in 1 wk
  – Fraction of the cost & significant reduced field time
  – High-speed serial/Ethernet communication/SOE
• Next - examine the ACS D20 I/O Peripheral upgrade
GE D20 Architecture

- Each D20 unit communicates to a number of IO peripherals.
- There are different IO peripherals for different purpose (Analog In, Dig In, Relay Out, Combo.)
- An average of 5 to 6 IO’s/peripherals per substation, large substations could go up to 60.
- D20 Link Configuration tool is complex.
GE D20 I/O Peripheral upgrade (ACS NTX U20)

New NTX based module

Keep the Westerm modules

Keep the GE WESTERM

ACS Upgrade module
GE D20 I/O Peripheral upgrade (ACS NTX U20)

D20 A Analog Input Peripheral Panel & ACS NTX-U20/A Upgrade

D20 S Status Input Peripheral Panel & ACS NTX-U20/D Upgrade

D20 K Control Output Peripheral Panel & ACS NTX-U20/K Upgrade

D20 C Combination I/O Peripheral Panel & ACS NTX-U20/C Upgrade
GE D20 I/O Peripheral upgrade (ACS NTX U20)
GE D20 I/O Peripheral upgrade – Wheaton sub

Before

After

CDC 44-500 Adapters
GE D20 I/O peripheral upgrade

Results
• Our ultimate goals were achieved with plug and play design
• RTU out of service 1 day and projected finished with 1 wk
• Reduced engineering/field labor

Struggles
• GE D20 was an upgraded CDC 44-500
  – Caught early during site visit and worked with ACS to get control adapters
RTU Life Extension & Migration Strategy

• ACS retrofit advertise – reduced cost by 59%
  – Reduced engineering/field labor of 90%
• Comparing ACS offering and Xcel Energy's inventory (past/present)

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*ACS supports retrofit/upgrade
RTU Life Extension & Migration Strategy

Xcel and ACS partner to develop CDC 44-500 upgrade

- Field visits to several large 44-500
- Ship spare 44-500 to ACS labs
- Original spec/dwgs reviewed
- Agree on design & new specs
- Engineering - teams up
  - Working on issues, day to day
- Factory test performed
- Spare 44-500 becomes our test unit
- 1st project tested in lab
44-500 I/O Peripheral upgrade – RTU (NTXIO12)

Before front

After front
44-500 I/O Peripheral upgrade – (NTXIO12)

Before RTU back

After
44-500 I/O Peripheral upgrade – AI card

Before

After
44-500 I/O Peripheral upgrade – Control Cards

Before

After
44-500 I/O Peripheral upgrade – DI Cards

Before

After
CDC 44-500 I/O Peripheral upgrade

Results
• Our ultimate goals were achieved with plug and play design
• RTU outage 1-2 days and projected finished with 1 wk
• Reduced engineering/field labor

Next Step in our Migration path
• Work with ACS to develop designs similar for C7000/C8000
  – Same ultimate goal and wish list
  – Adding a requirement of using same components when possible
C8000 I/O Peripheral upgrade (ACS NTXIO12)

Front of RTU before

After
C8000 I/O Peripheral upgrade (ACS NTXIO12)

Back of RTU before

After
C8000 I/O Peripheral upgrade – AI Cards

Before

After
C8000 I/O Peripheral upgrade – Control Cards

Before

After
C8000 I/O Peripheral upgrade – DI Cards

Before

After
C7000 I/O Peripheral upgrade – (NTXIO12)

Front of RTU

Back of RTU
C7000 I/O Peripheral upgrade – AI Cards

Before

After
C7000 I/O Peripheral upgrade – Control Cards

Before

After
C7000 I/O Peripheral upgrade – DI Cards

Before

After
Results/Lessons Learned - I/O Peripheral Upgrade

- Projects went extremely well – mat’l $50k
- RTU outages 1-2 days/finished in 1 week saving engineering and field labor time
- Analog Input 5k resistor is now internal, ensure some unusual scaling doesn’t exist
- Work with ACS on cable management to ensure custom ribbon cables are correct length
  - Double RTU cabinets
  - Missing I/O cards - understand impact
- Review the User/Install Manuals
- ACS is an migration path, during outages/upgrades move points to PACs to follow new standard
  - Seekirk alarm scheme not replaced
  - New standards 2-3x more AI/DI – consider ethernet to M650s, relays, etc
- 2017 – 27 ACS I/O peripheral upgrades ordered
RTU Life Extension & Migration Strategy (Summary)

Full RTU replacement (brute force method)
• Control House replacements & Extensive Substation upgrades
• I/O Peripheral upgrade not an option (active components)

Swing Door RTU replacements
• I/O Peripheral upgrade not an option (passive components)
• Small amount of I/O (investigate upgrading AIs)

I/O Peripheral upgrade (great choice when available)
• Project installs a new standard RTU Panel
  – Control/DI exceed 60 points (investigate upgrading AIs)
  – Device outages allow wiring to new PACs (migration path)
• Questions?
Lessons Learned - I/O Peripheral Upgrade

General issues

• RTU/HMI need different DNP Port Addr 20000/20001 setting to match ACS device (symptom – only one RTU updates)
• Many boards are daisy chained to one control board and then brought to the main board, an internal failure can cause similar 3rd point on all boards not functioning
• Analog Inputs – original scaling is non-standard – match that scaling to speed up checkout
• Recommend replacing old power supplies
• New board layout vs. old board layout doesn’t match (ex – C7000 original AI is 10 point vs. new is 8pt, DI original is 24pt vs new 32 pt – 8 not used)
• After loading ACS unit with new program, all IO slowed to a crawl – reboot of ACS resolved issue
Lessons Learned - I/O Peripheral Upgrade

D20s issues
• Most D20 RTUs were originally something else that was retrofit, review the IPRs from the old RTU and work with ACS to verify the interfacing

44-500 issues
• 19” rack is non-standard & very narrow causing issues with mounting RTU/ACS equipment
• MOD A/B points are wired backwards from EMS DNP – need to swap in ACS/RTU
Lessons Learned - I/O Peripheral Upgrade

**C7000/C8000 issues**
- ACS is setup for Trip/Close group of 16, Conitel RTUs have groups of 12 – 4 not used
- C7000 is setup for outputs of 12 Trip/4 unused/12 Close/4 unused, next group
- C8000 is setup for outputs of 12 Close/4 unused/12 Trip/4 unused, next group

**C8000 (C-2040) issues**
- DI boards are mounted horizontally need longer board-board ribbon cable
- Old C-2040 IPRs are 24vdc driven by I/F card need to modify the I/F to bring in 24vdc
RTU panel

• 36”w x 30”d - in panel row
• Two Orion LXs RTU/HMI – same program
  – Can run on 1 during failure
  – Redundancy to SCADA (future)
• 112 DI, 128 DO (60 ctl pts)
  – DO run to Test Switch (30 vs 32)
  – Isolation during programming/testing
• All device ethernet/DNP – pre-assigned IP
• DNP data collection – relays, meters
  – Relay Malfunction alarms hard wired
  – Devices with no DNP - hardwired
• Large substation – 2nd RTU panel
  – Duplicate PAC01-05 becoming PAC06-10
**Terminal Cabinet**

- 44”w x 22”d - against exterior wall
- 192 DI, 16 AI
- All yard equipment alarms
  - Breaker, ckt switcher, transformer alarms
- Gathering wired analog values
  - Transformer oil & winding temps
  - Battery DC value with alarm logic
Feeder panel

- 28”w x 23”d – in panel row
- Only used for distribution feeders
  - 6 feeder w/SEL-351s built in PBs/display
- 16 DI, 32 DO (15 ctl pts) – PAC11
  - DO run to Test Switch (30 vs 32)
  - Isolation during programming/testing
  - Only location besides RTU with outputs