RTU Life Extension & Migration Strategy

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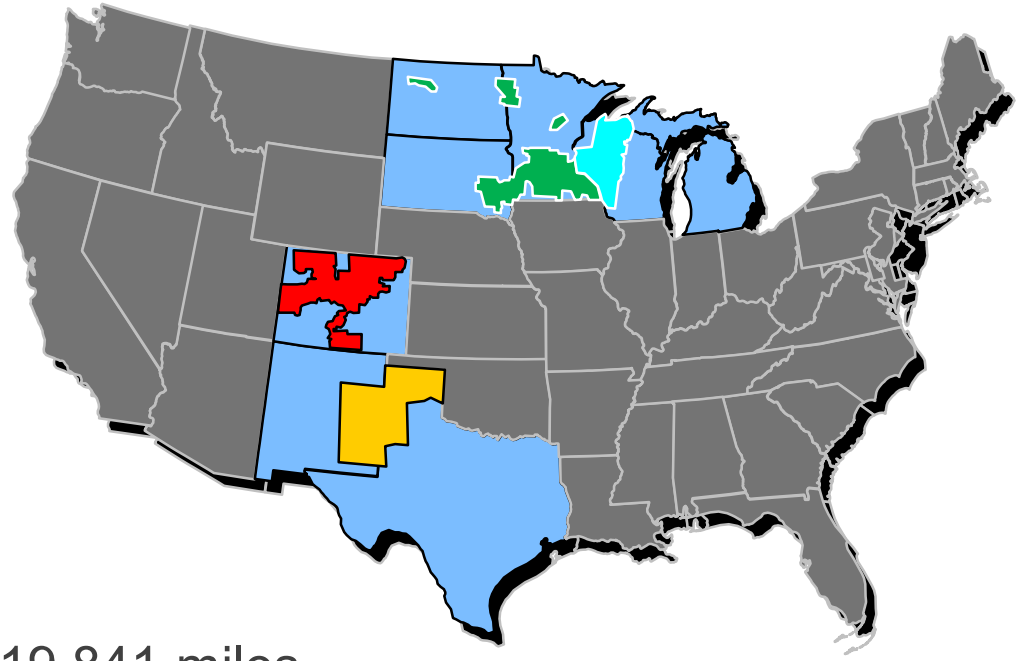
Agenda

- 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

NSP (MN & WI)

CDC 44-500 (2)
C2045 (4)
C2000 (17)
C200 (7)
C7003 (24)
C8000 (75)
GE D20 (40)
Modicon PLCs (112)
Orion 5/5r/LX (260)

PSC (CO)

C2010 (1)
C300 (1)
L&G 5520 (36)
L&G 5500 (15)
L&G 5320 (5)
GE D20 (158)
Orion LX (47)

SPS (TX)

Telegyr 9000/5520 (23)
Micro (17)
Station Supv 5700 (50)
Station Mgr 5700 (197)
Orion LX (56)

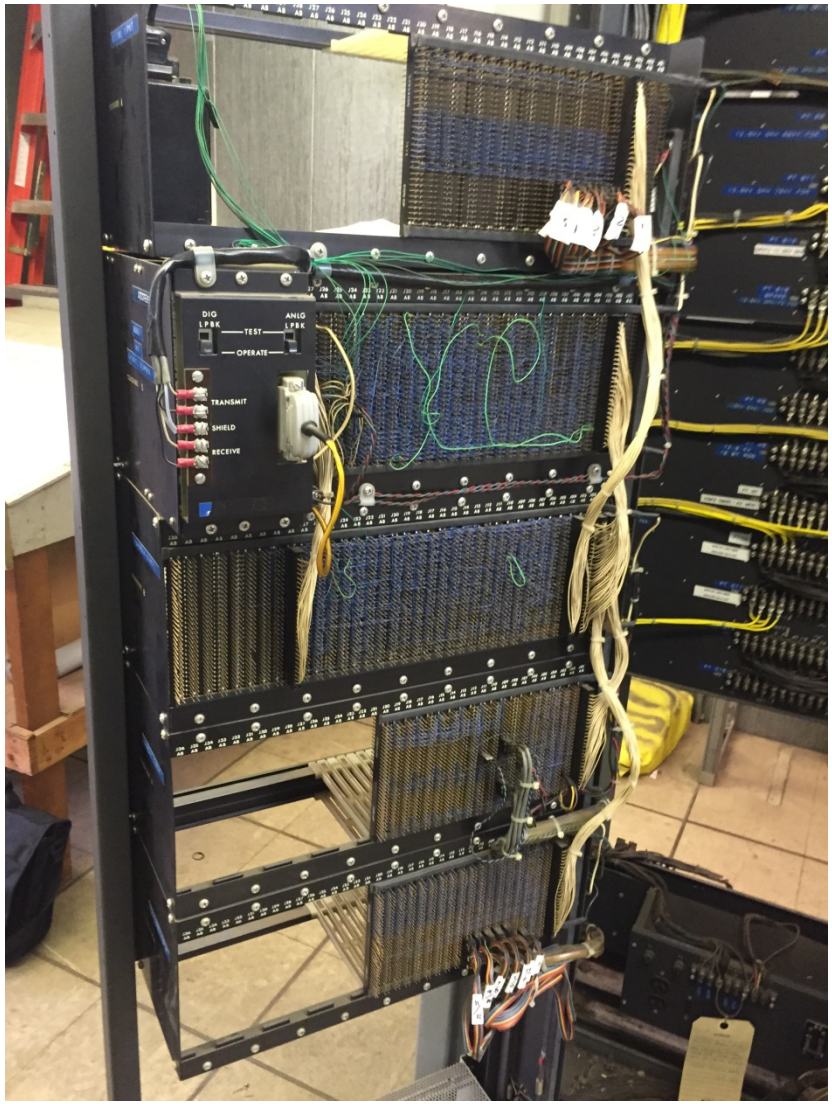
Key

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

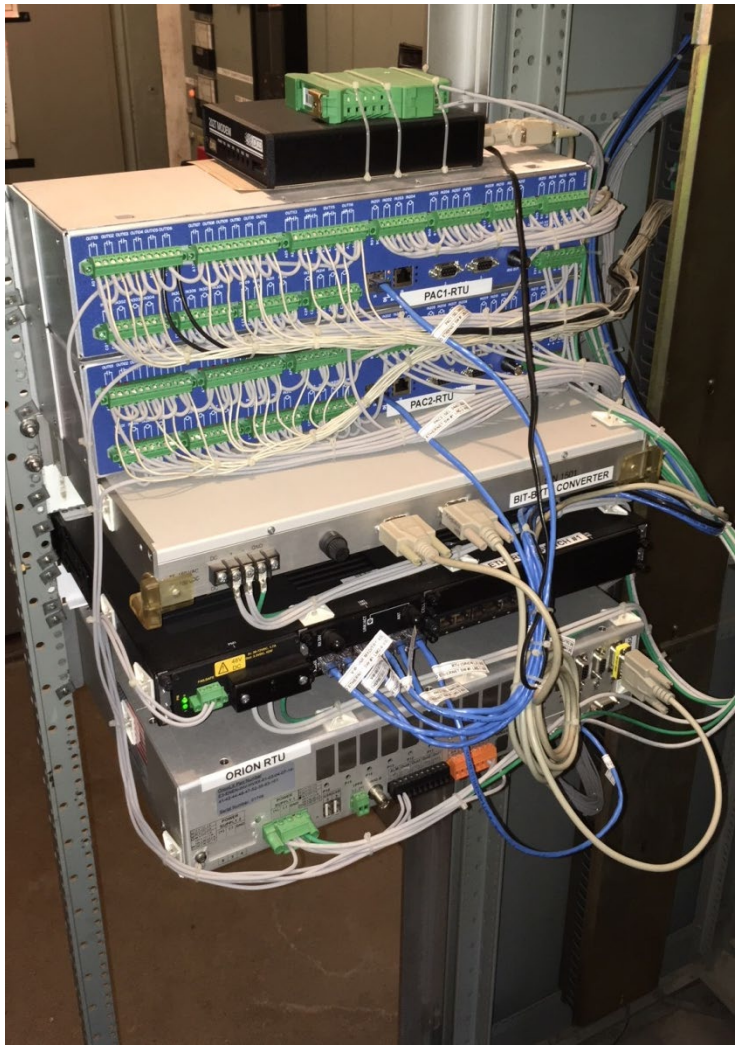
RTU replacement - Swing door replacement

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/SOEs
- Next - examine the ACS D20 I/O Peripheral upgrade

GE D20 Architecture

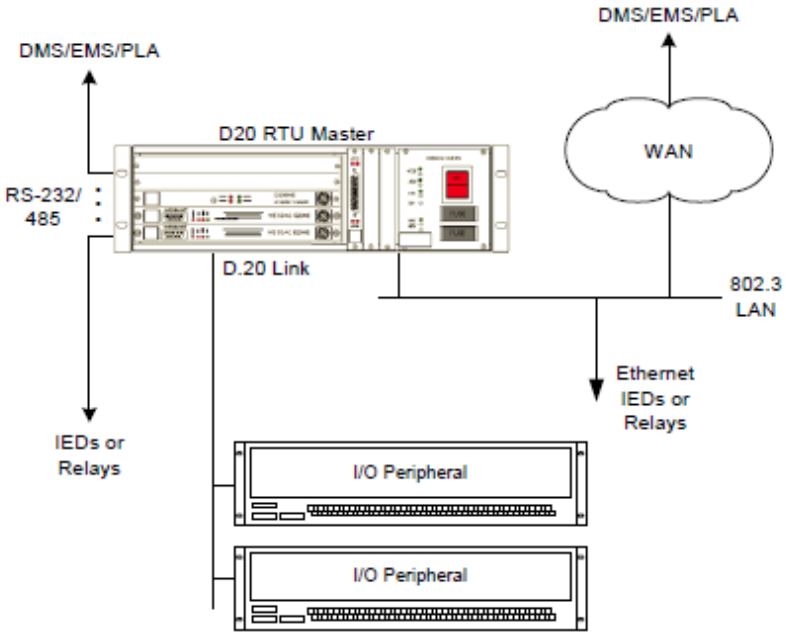
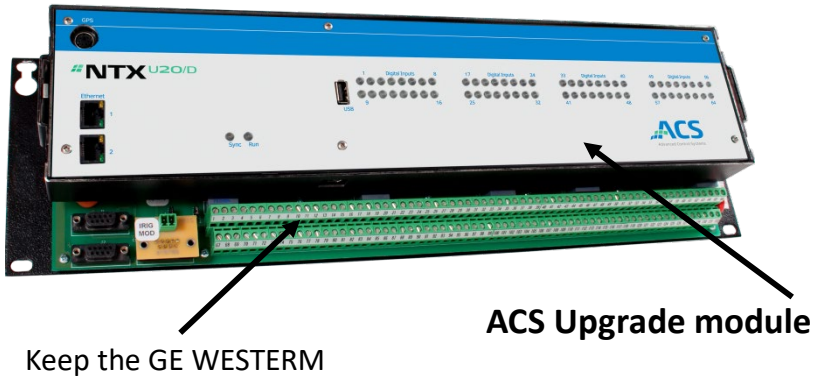
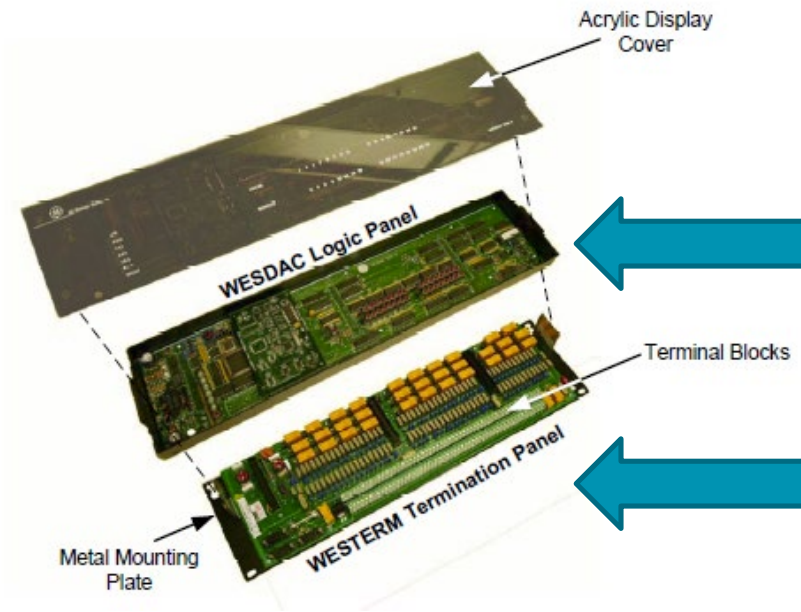


Figure 4 D20 System Architecture

- 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

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

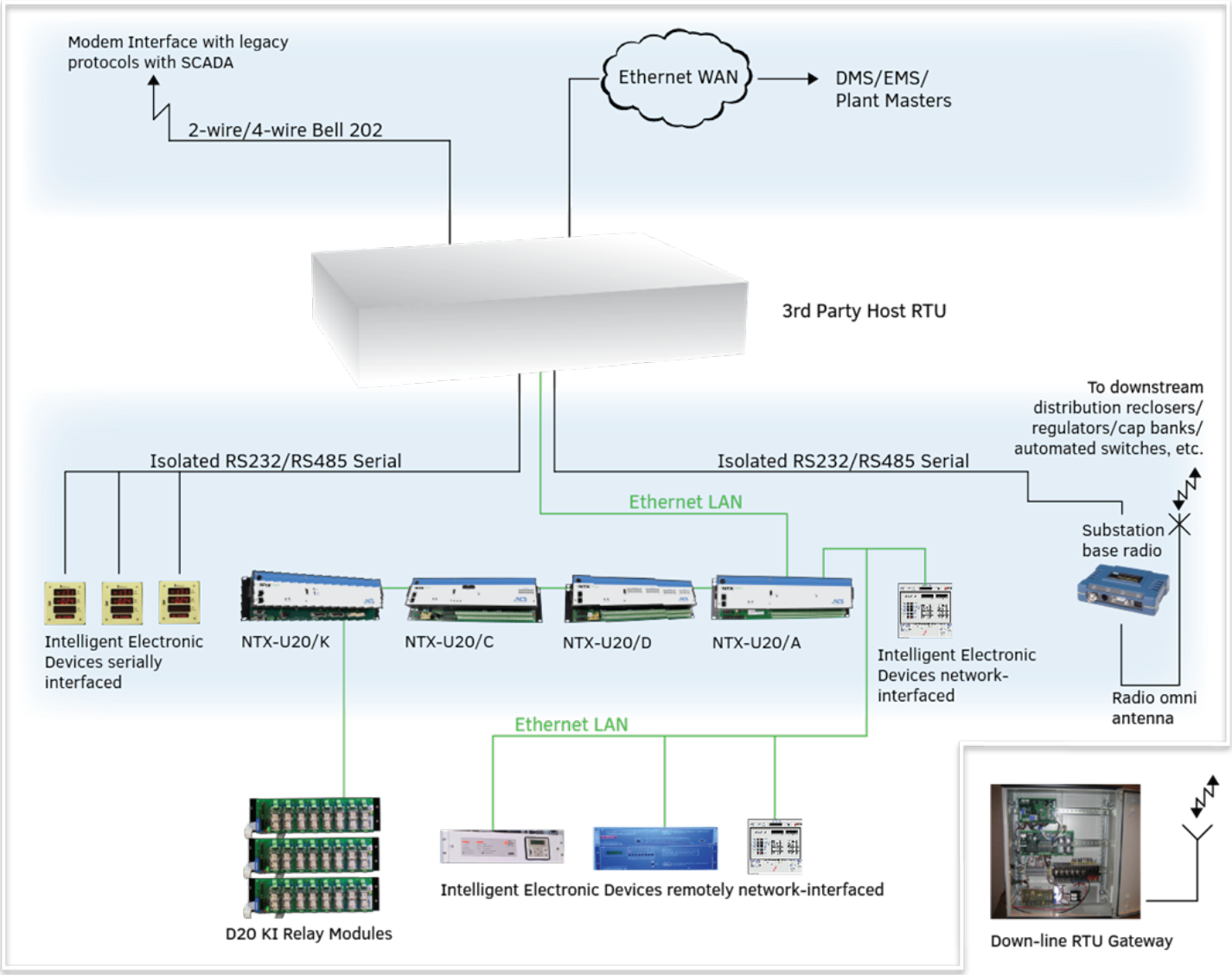
D20 A Analog Input Peripheral Panel
& ACS NTX-U20/A Upgrade

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

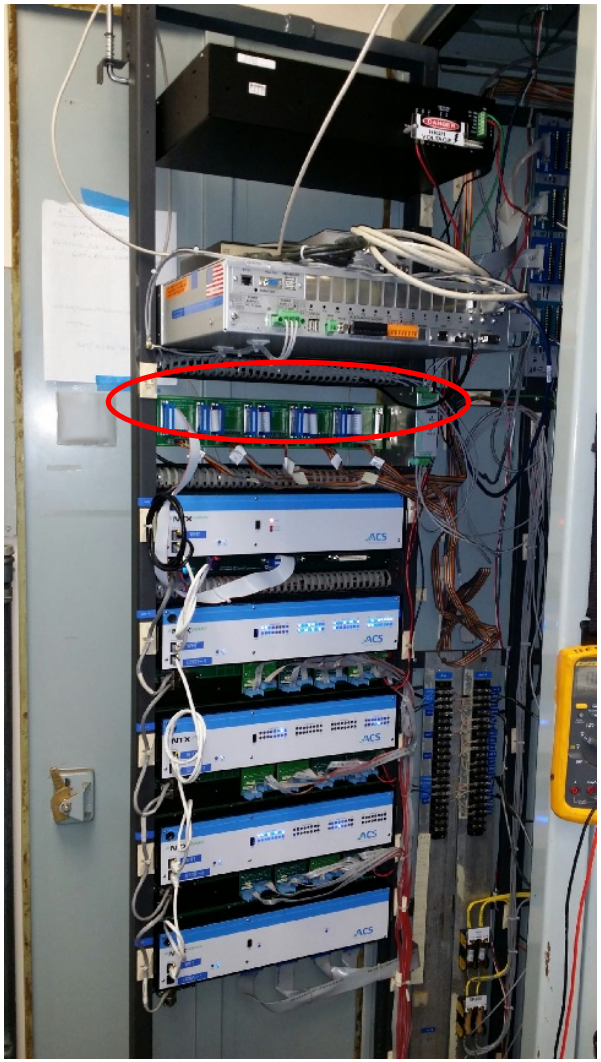
GE D20 I/O Peripheral upgrade (ACS NTX U20)



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)

NSP (MN & WI)	(Past)
Arcoms (1)	(15)
CDC 44-500 (2)	(28)
C2045 (4)	(5)
C2000 (17)	(25)
C200 (7)	(15)
C7003 (24)	(39)
C8000 (75)	(105)
*GE D20 (40)	(48)
Modicon PLCs (112)	(136)
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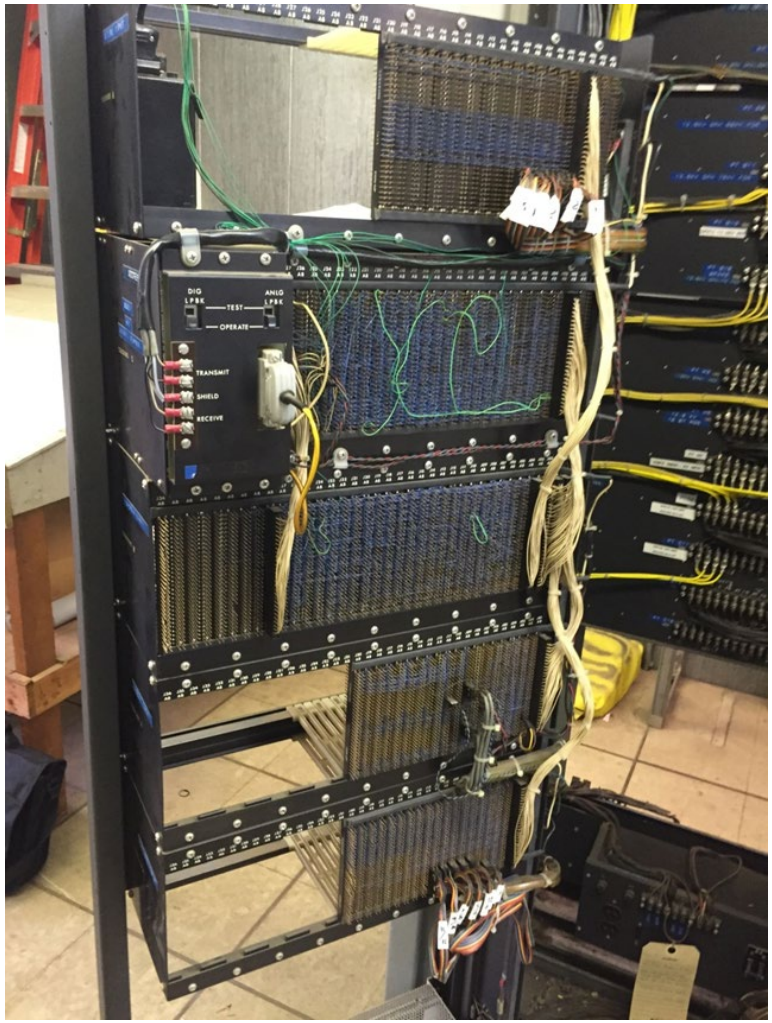
Key

Red – Obsolete, Blue - Aging
*ACS supports retrofit/upgrade

RTU Life Extension & Migration Strategy

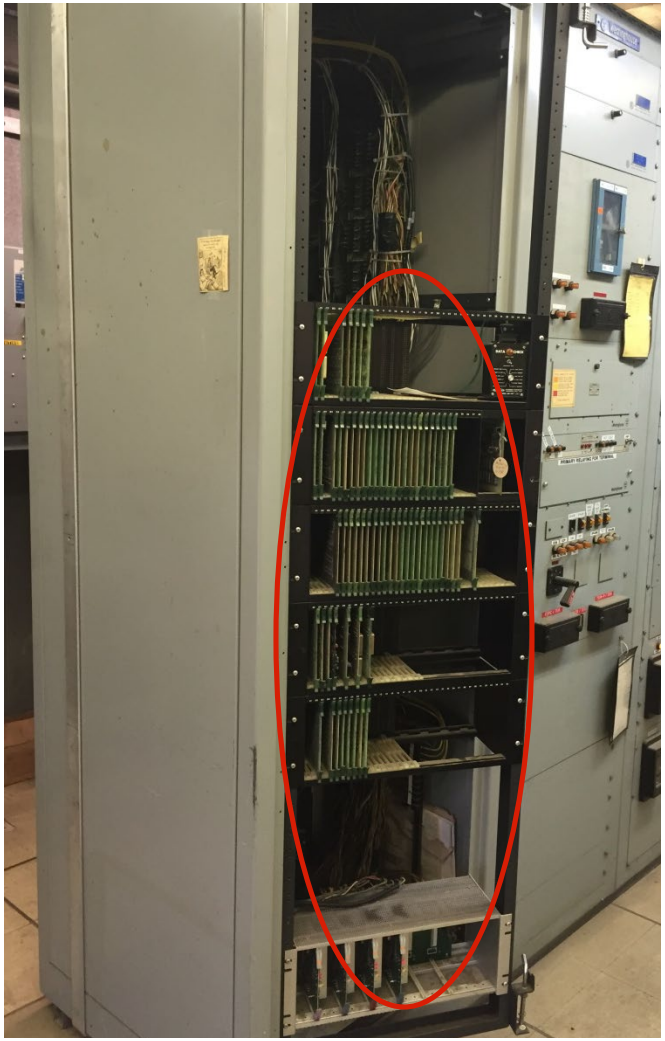
Xcel and ACS partner to develop CDC 44-500 upgrade

- 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

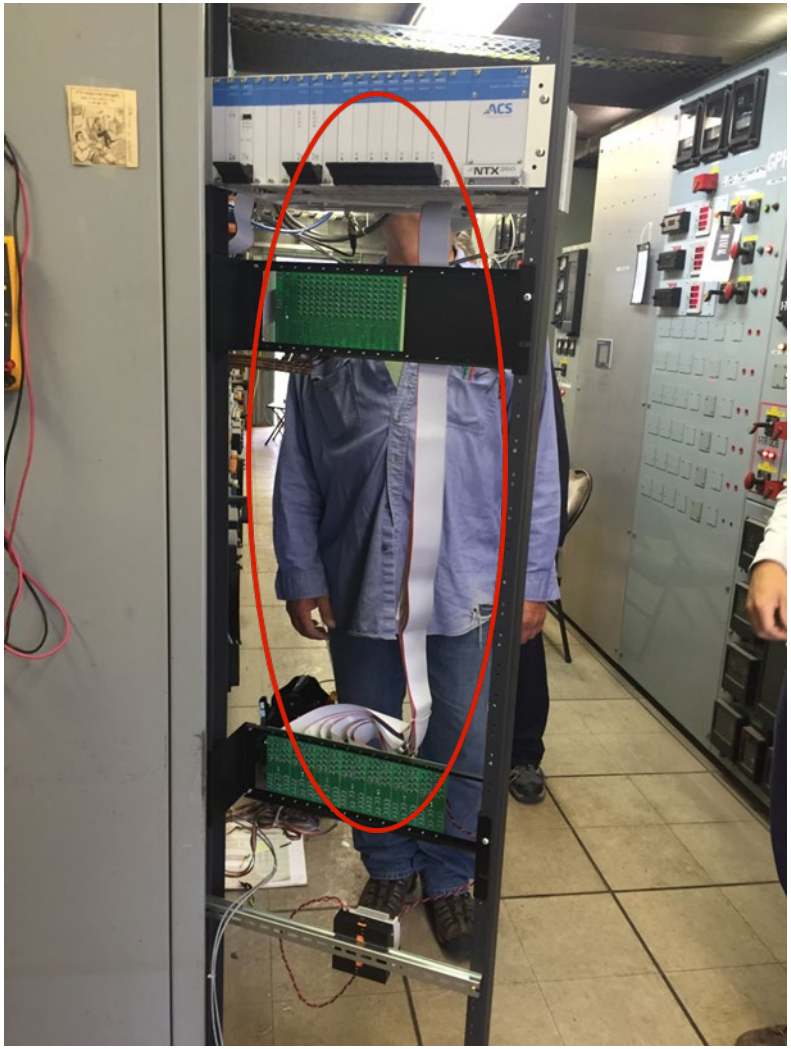


44-500 I/O Peripheral upgrade – RTU (NTXIO12)

Before front

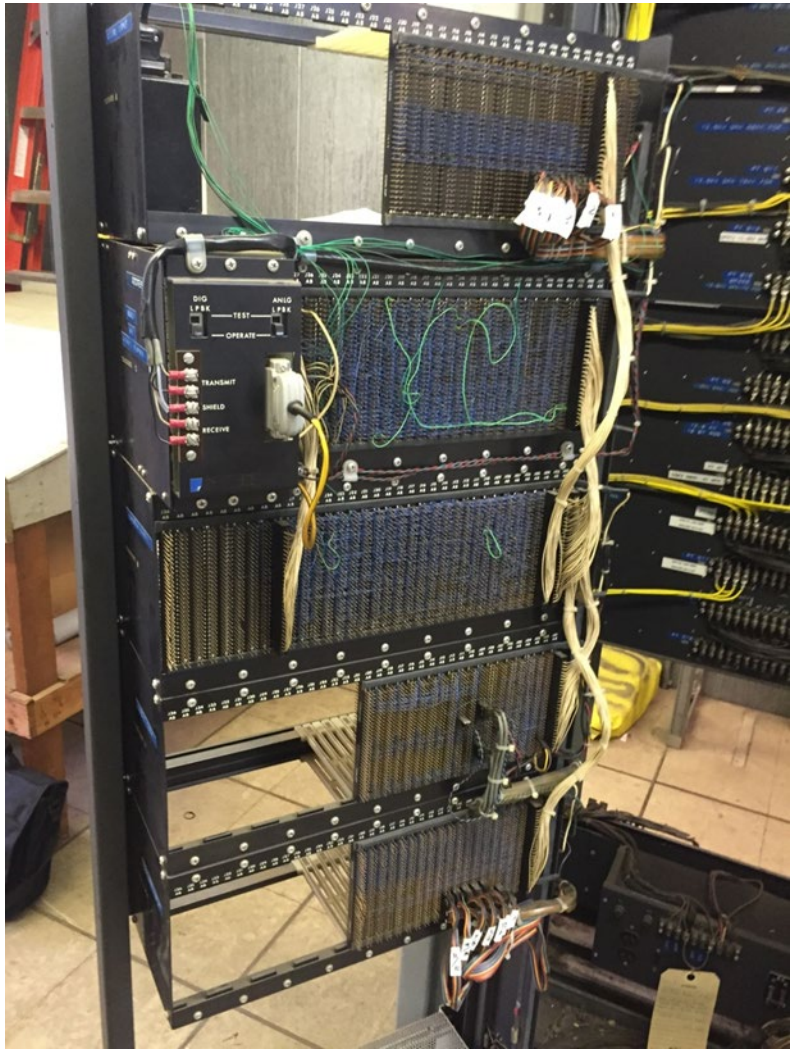


After front

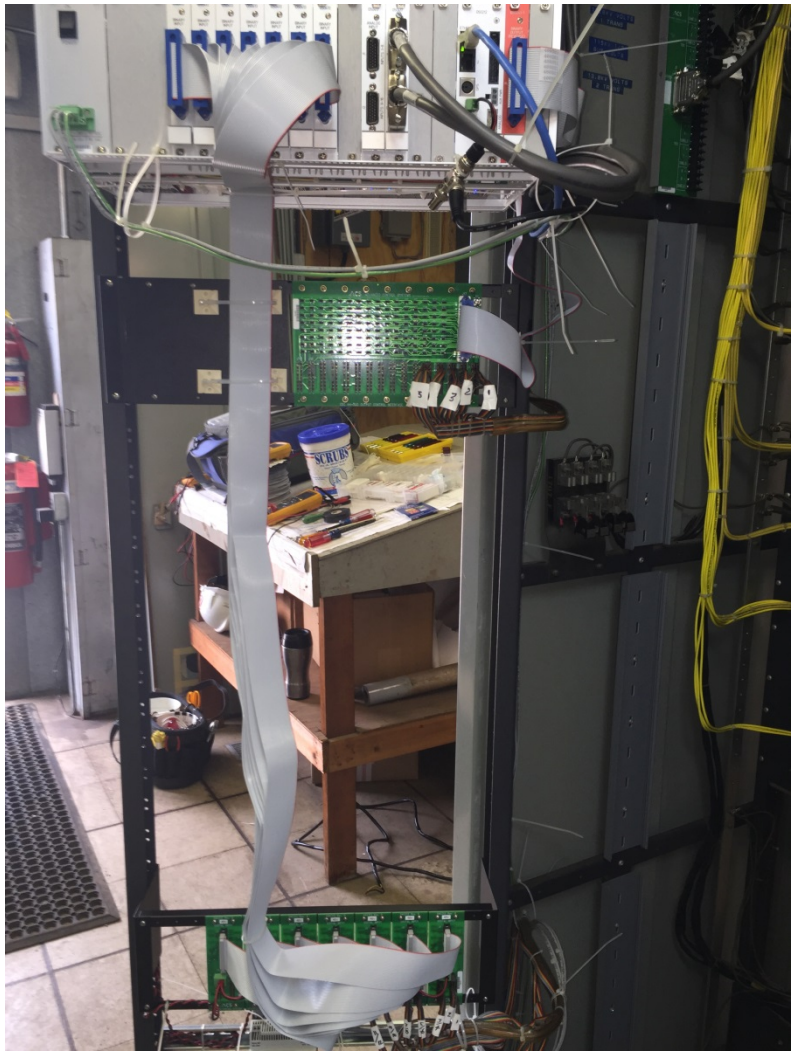


44-500 I/O Peripheral upgrade – (NTXIO12)

Before RTU back

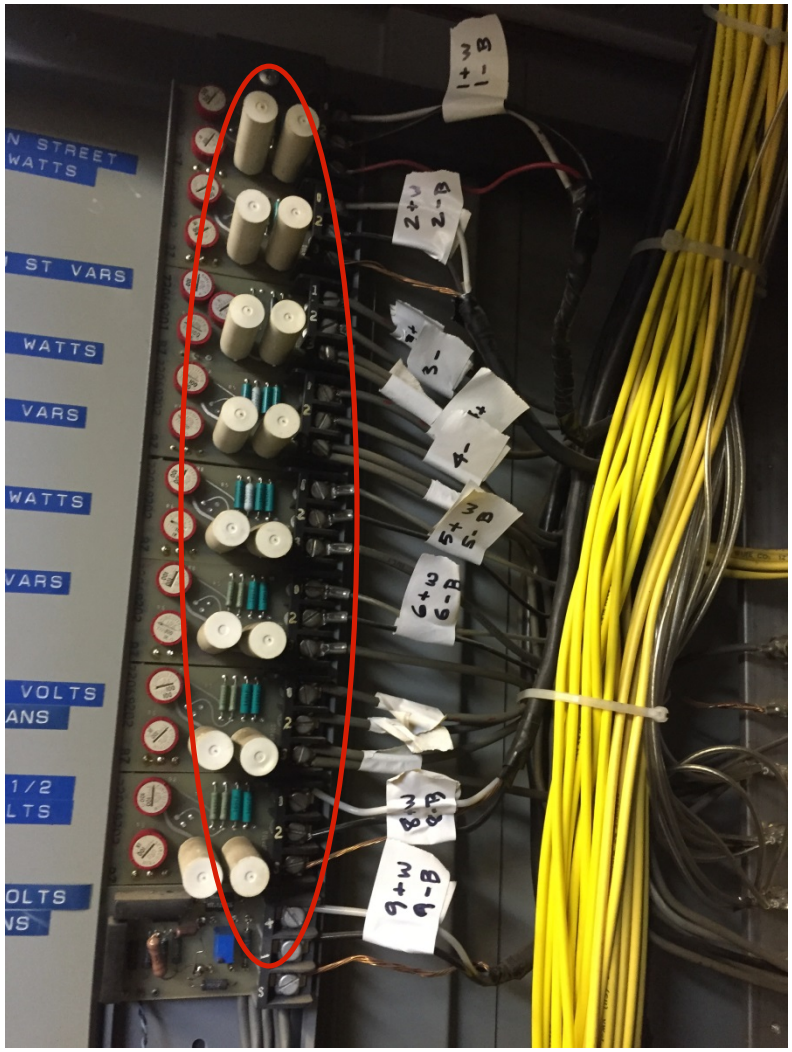


After

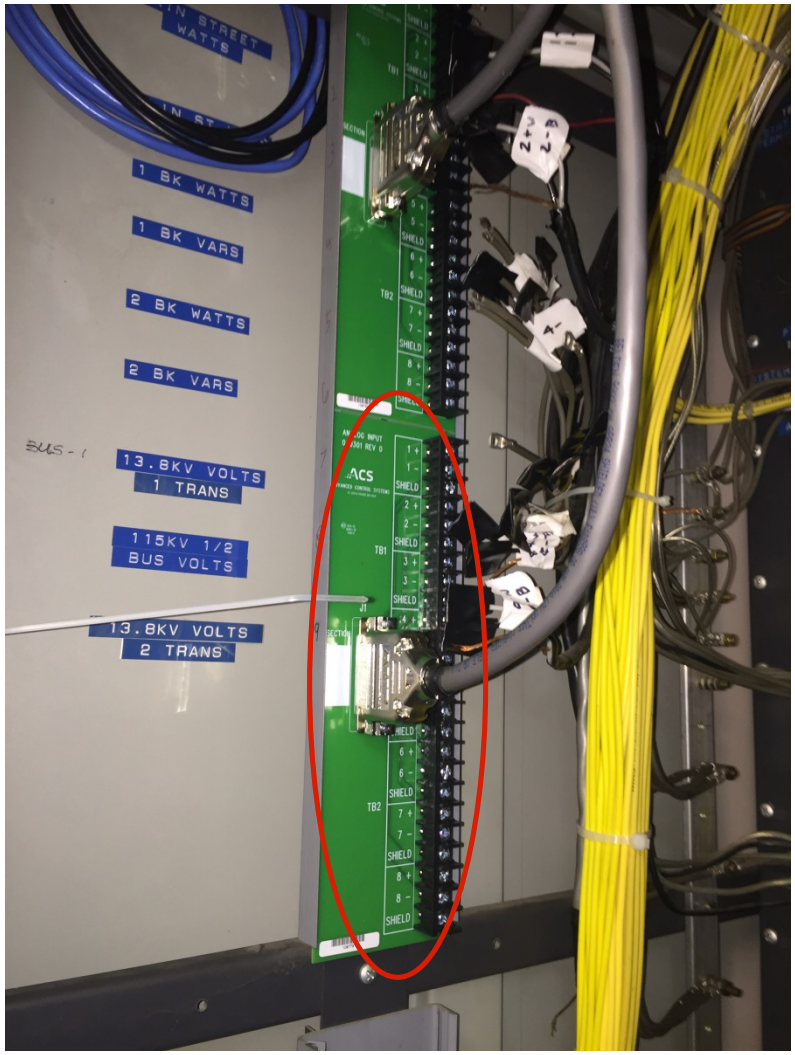


44-500 I/O Peripheral upgrade – AI card

Before

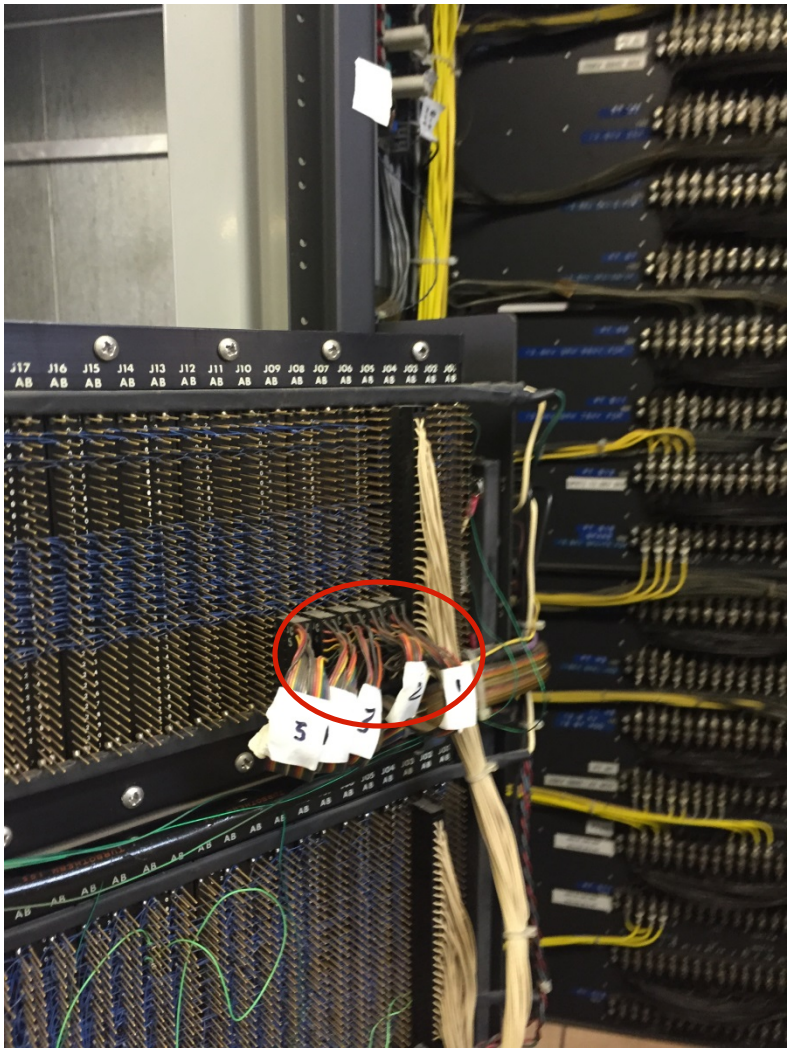


After



44-500 I/O Peripheral upgrade – Control Cards

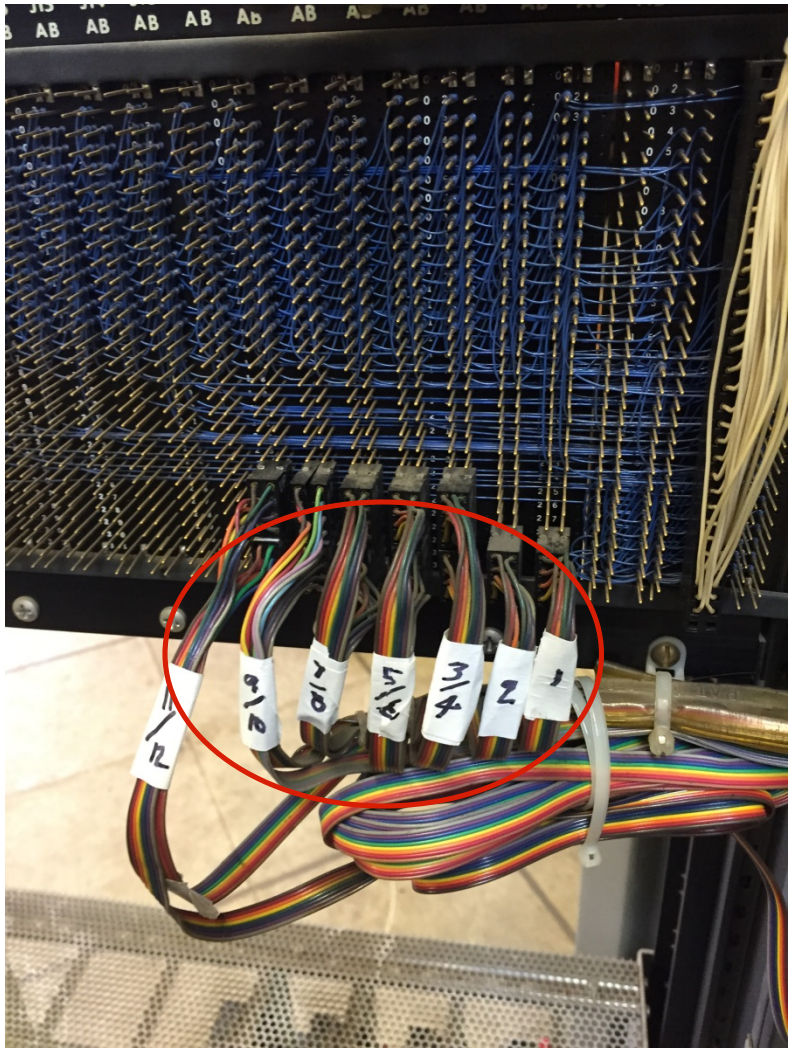
Before



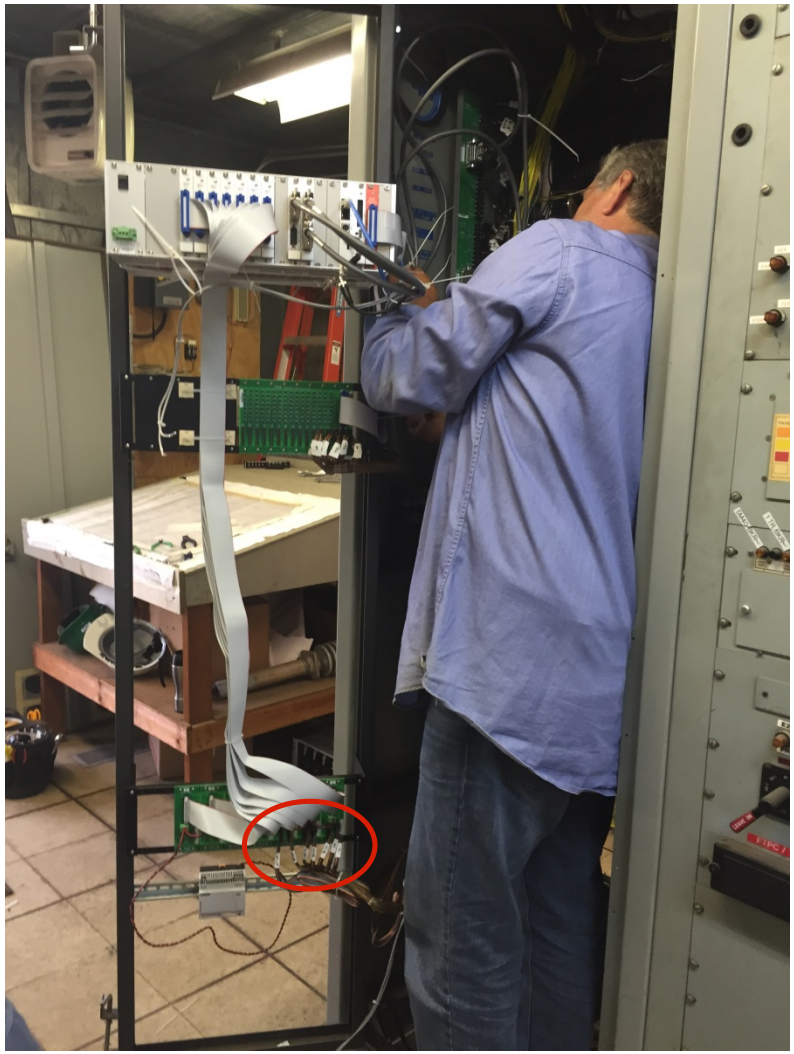
After

44-500 I/O Peripheral upgrade – DI Cards

Before



After



CDC 44-500 I/O Peripheral upgrade

Results

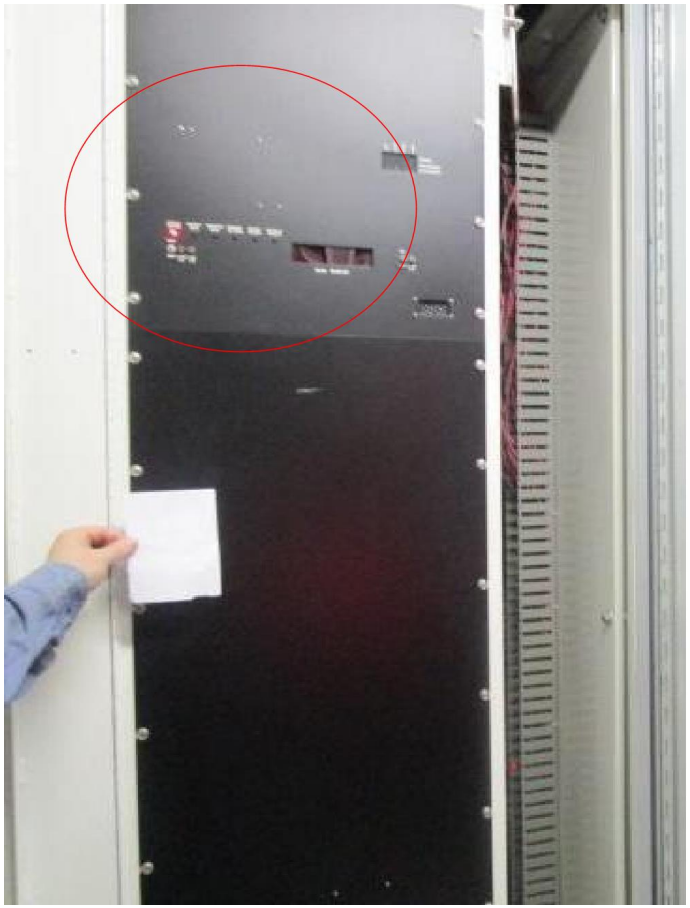
- Our ultimate goals were achieved with plug and play design
- RTU outage 1-2 days and projected finished with 1 wk
- Reduced engineering/field labor

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

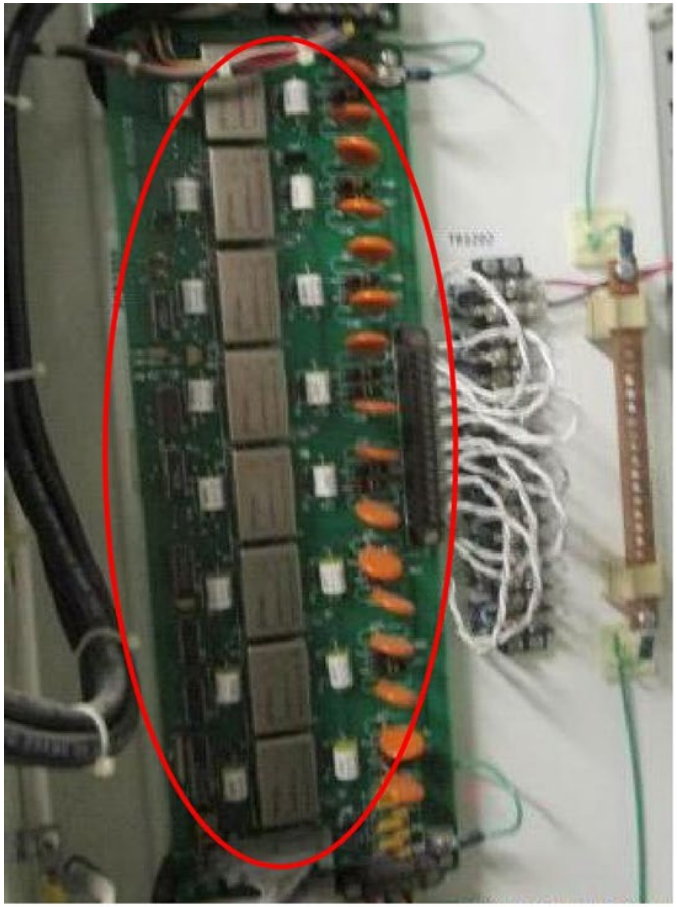
C8000 I/O Peripheral upgrade (ACS NTXIO12)

Back of RTU before

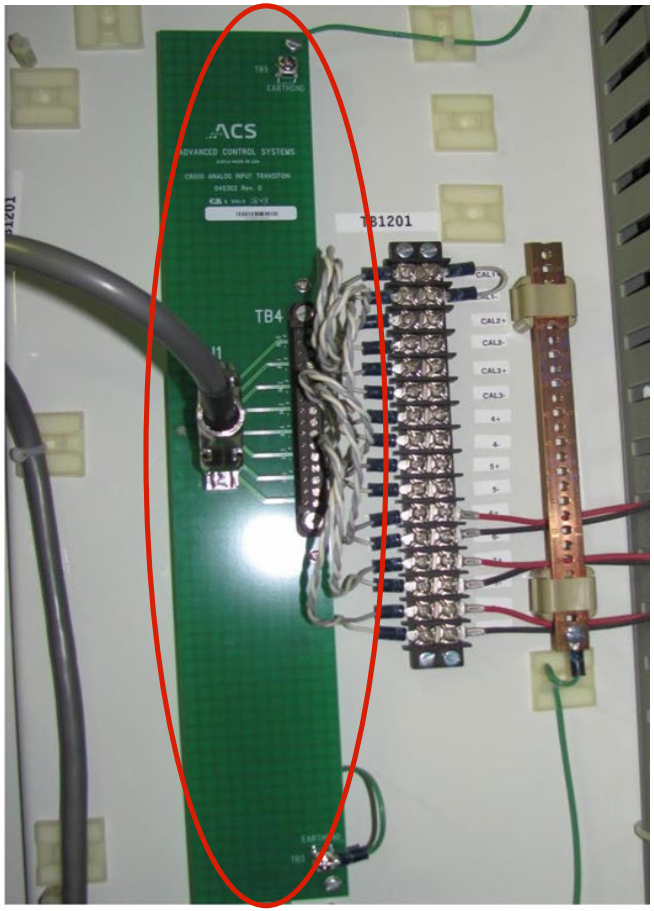
After

C8000 I/O Peripheral upgrade – AI Cards

Before

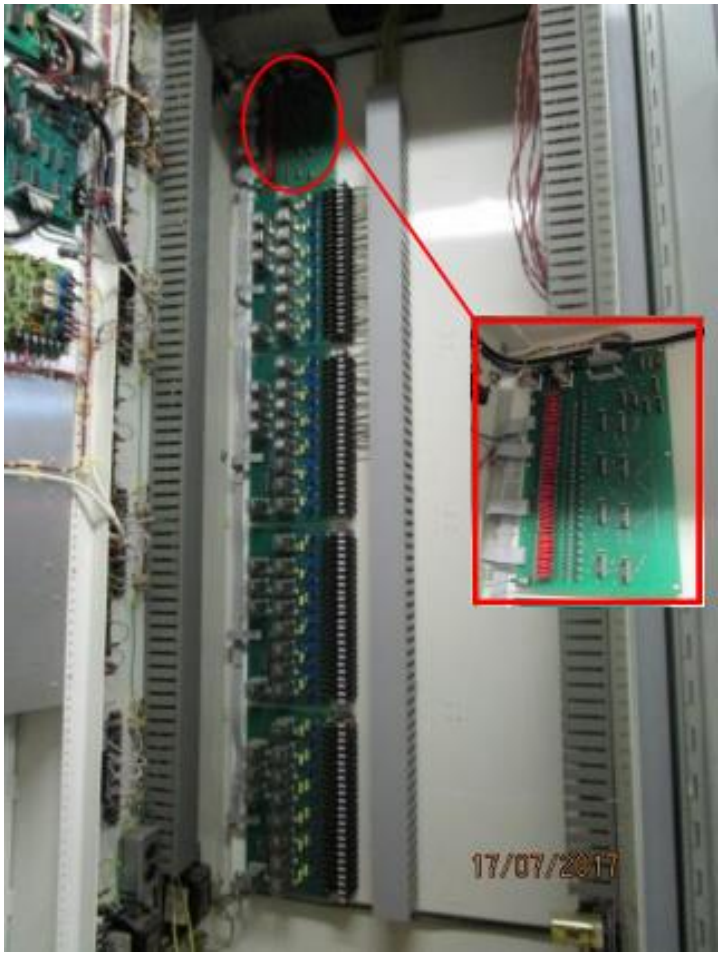


After

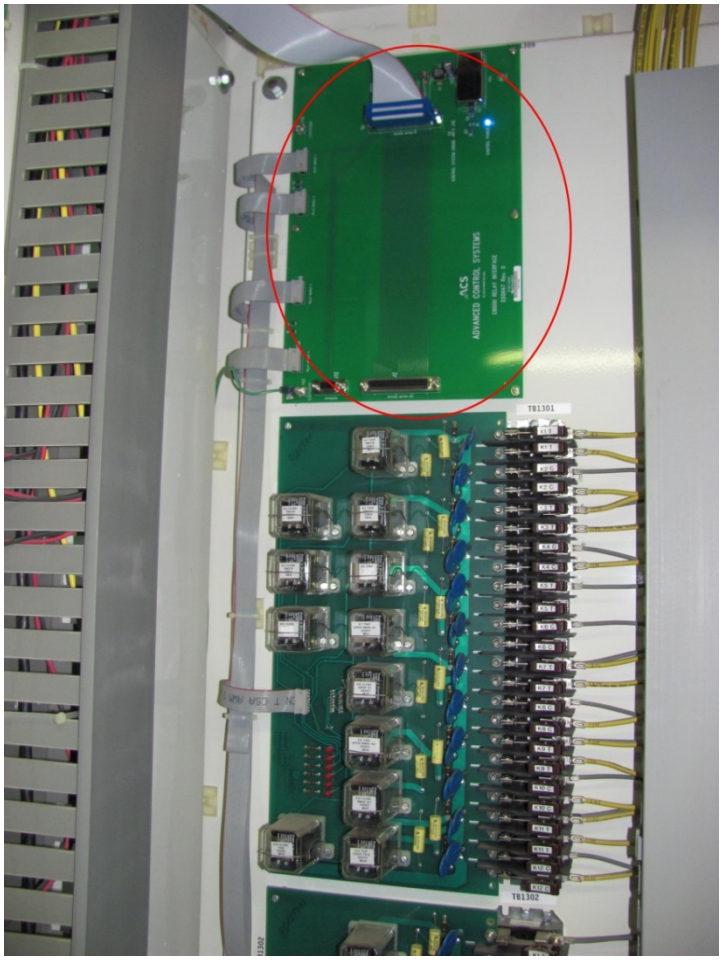


C8000 I/O Peripheral upgrade – Control Cards

Before

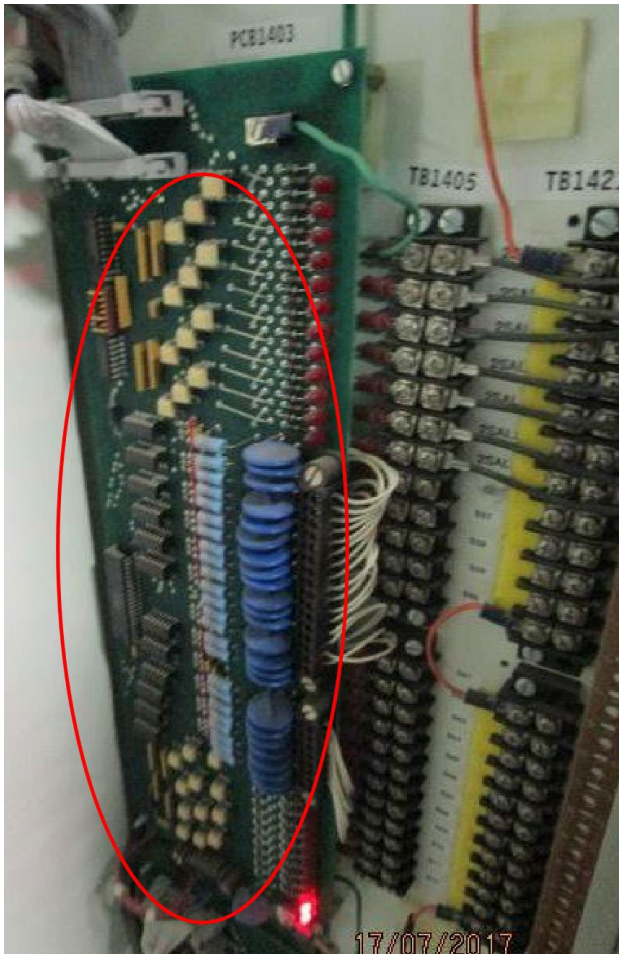


After



C8000 I/O Peripheral upgrade – DI Cards

Before



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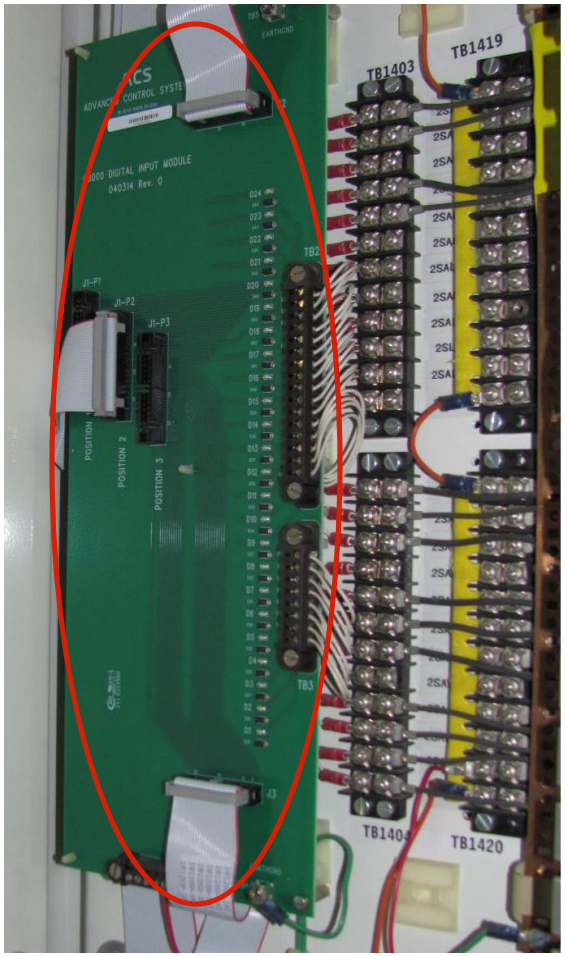


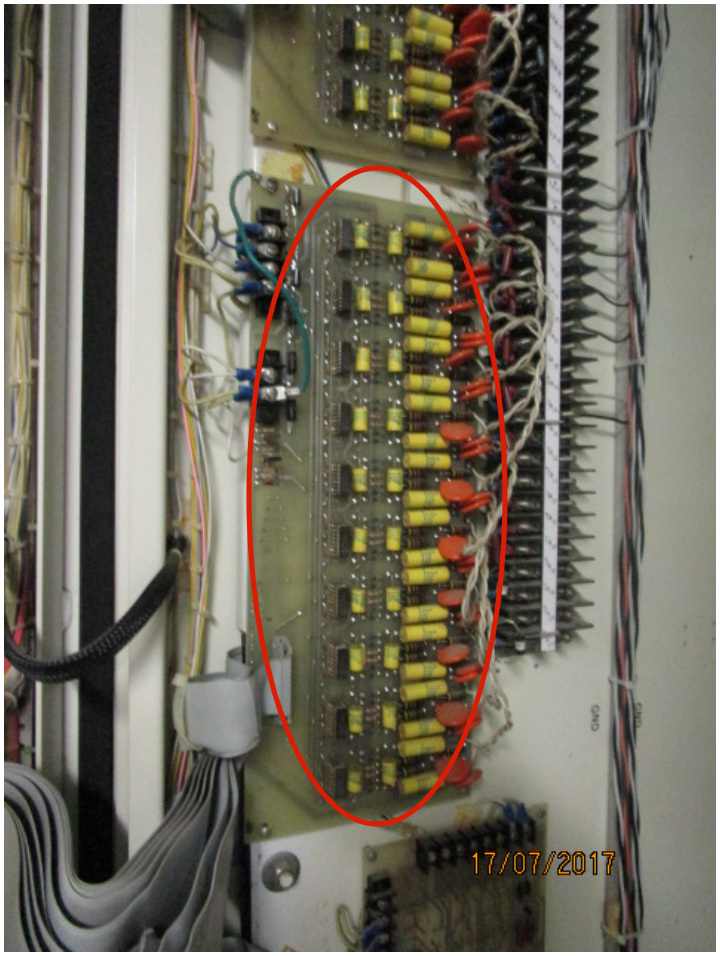
C7000 I/O Peripheral upgrade – (NTXIO12)

Front of RTU

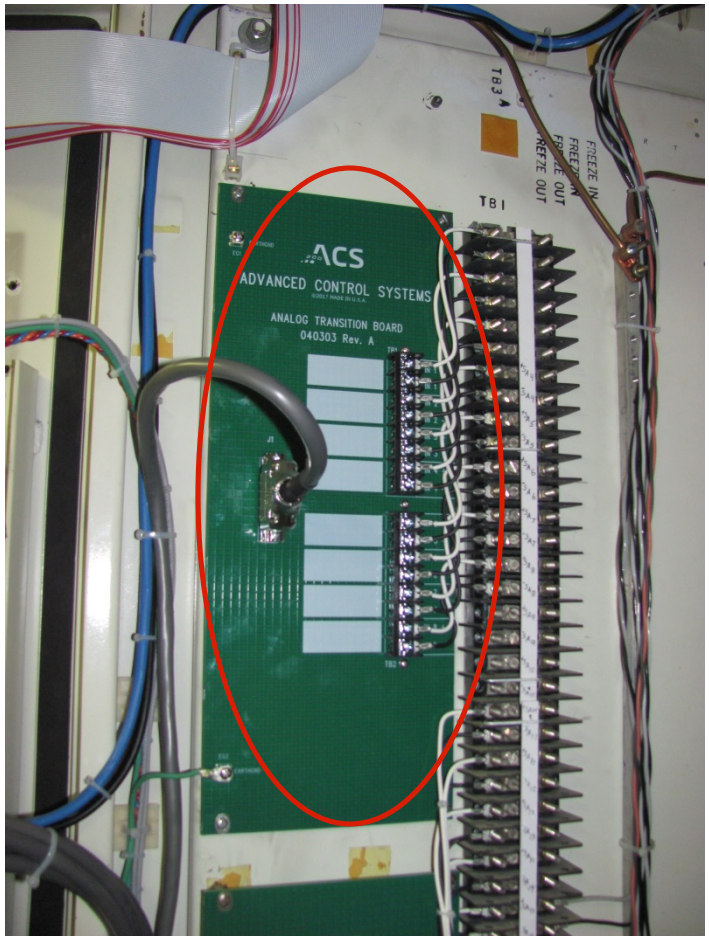
Back of RTU

C7000 I/O Peripheral upgrade – AI Cards

Before

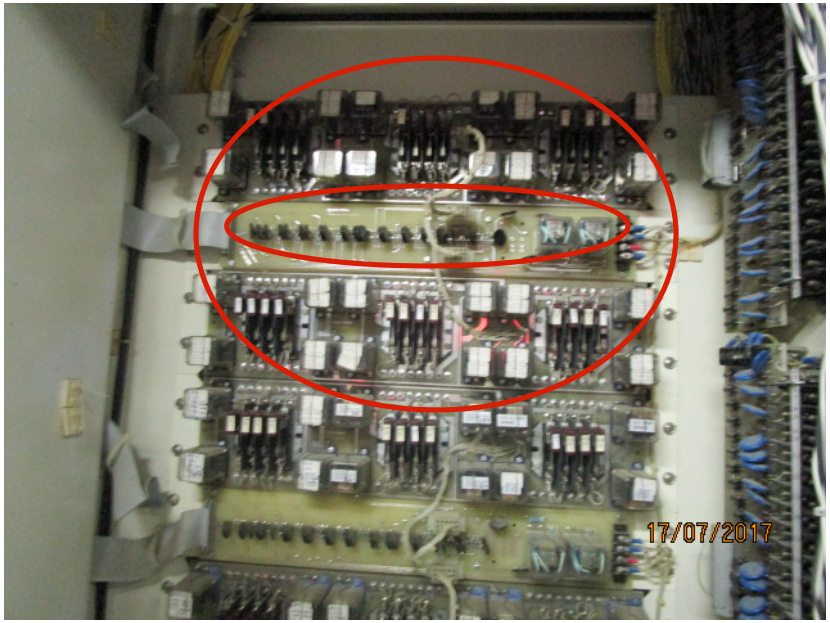


After



C7000 I/O Peripheral upgrade – Control Cards

Before



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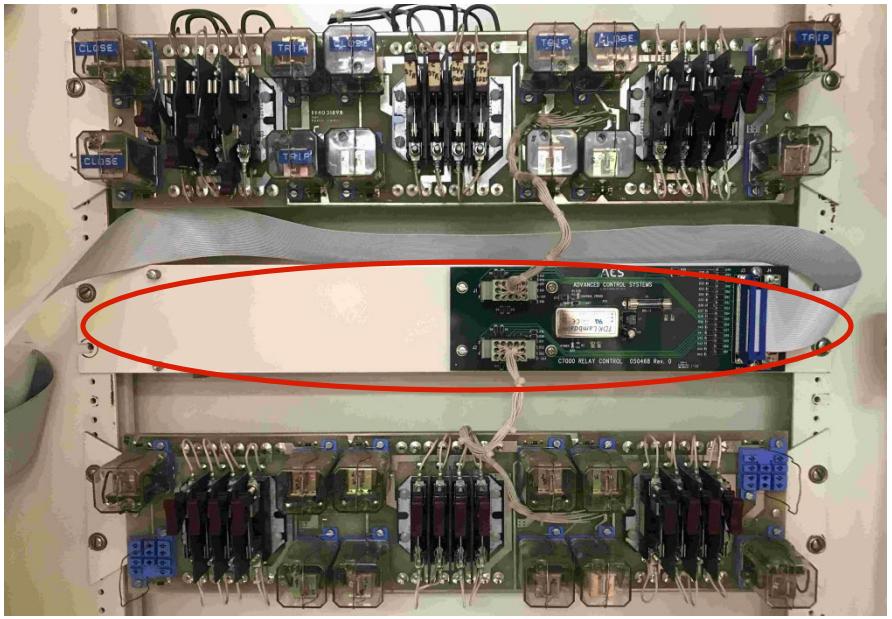
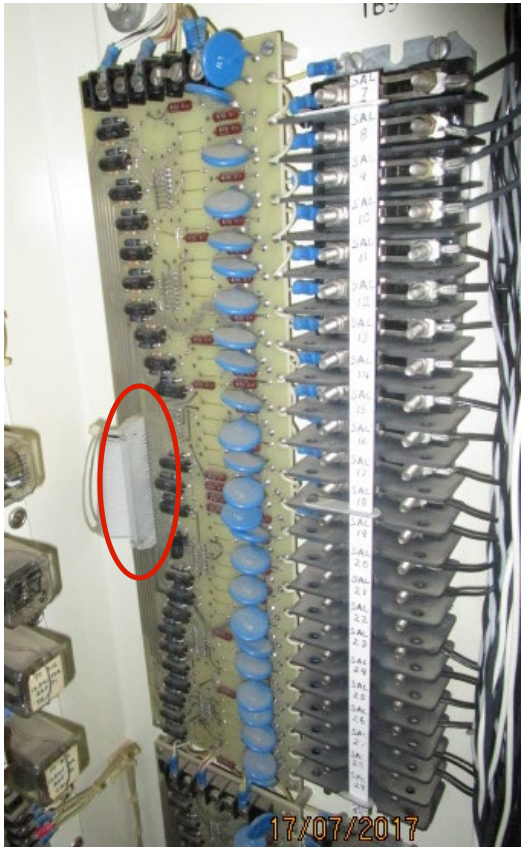


C7000 I/O Peripheral upgrade – DI Cards

Before



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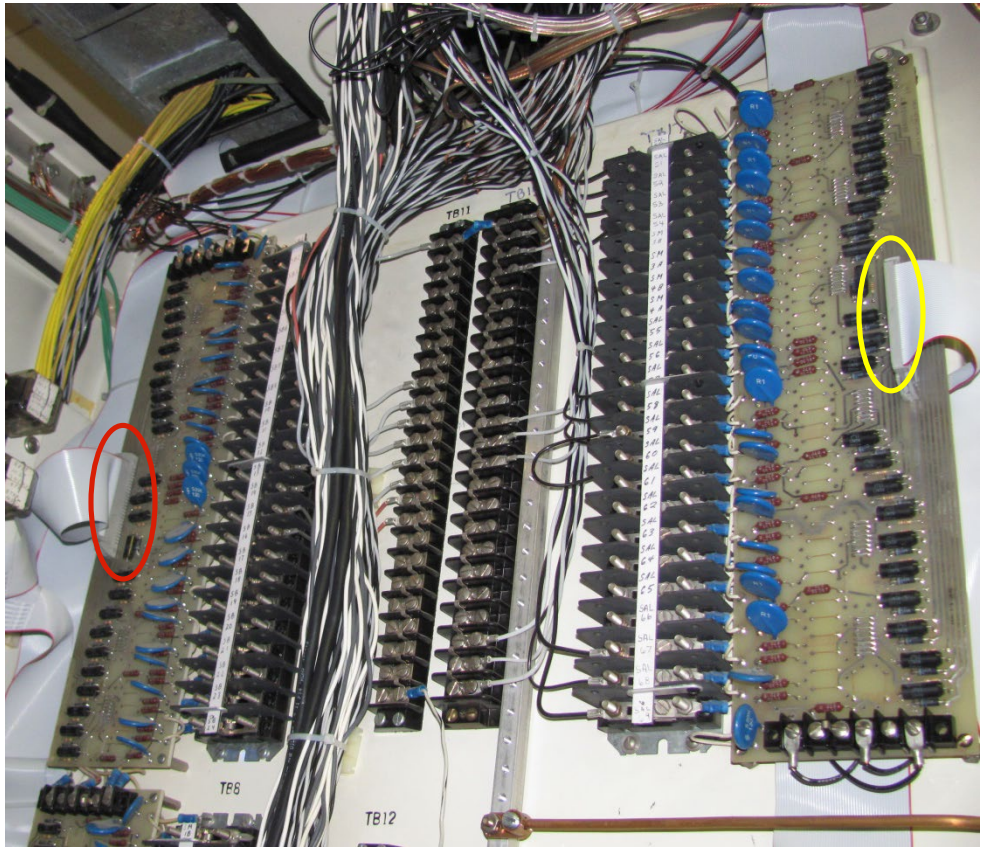


Results/Lessons Learned - I/O Peripheral Upgrade

- 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

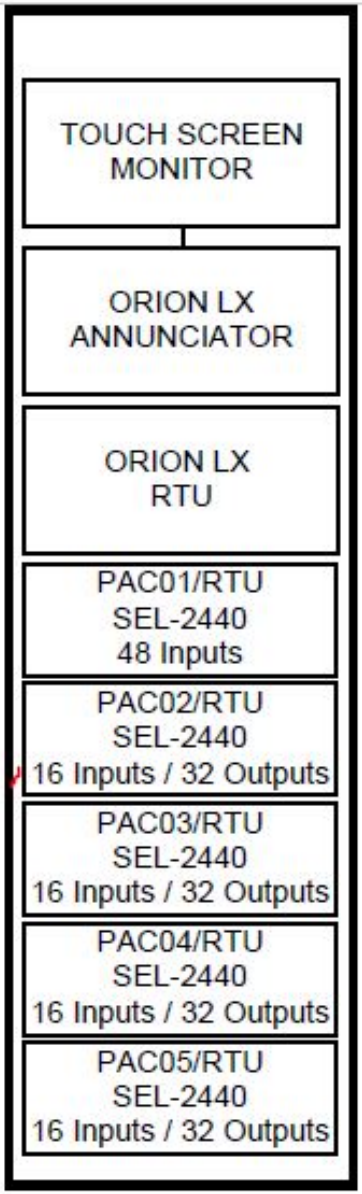
- ACS is setup for Trip/Close group of 16, Conitel RTUs have groups of 12 – 4 not used
- C7000 is setup for outputs of 12 Trip/4 unused/12 Close/4 unused, next group
- C8000 is setup for outputs of 12 Close/4 unused/12 Trip/4 unused, next group

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

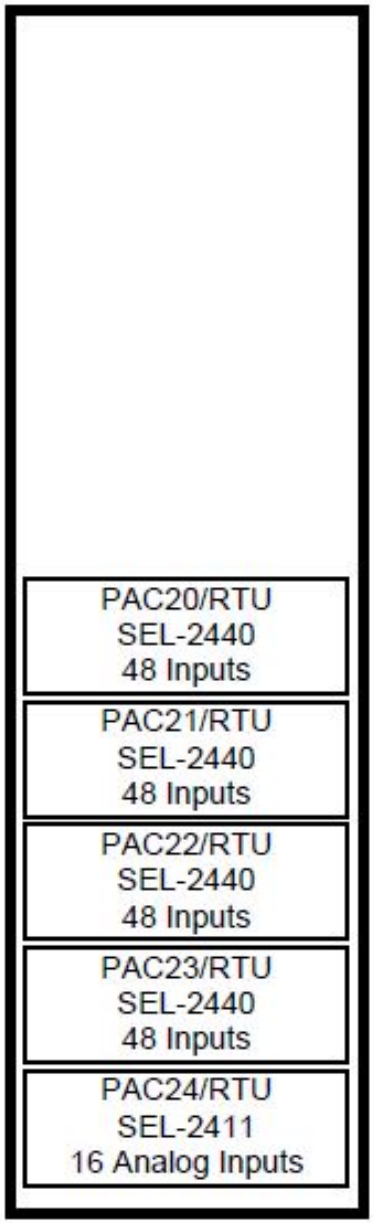
RTU panel

- 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