Using Digital Fault Recorders As Phasor Measurement Unit Devices

Notes from Mehta Tech DFR field installations

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Acknowledgment and Disclaimer

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- SGIG Synchrophasor Project – Current Status (Slide 5)
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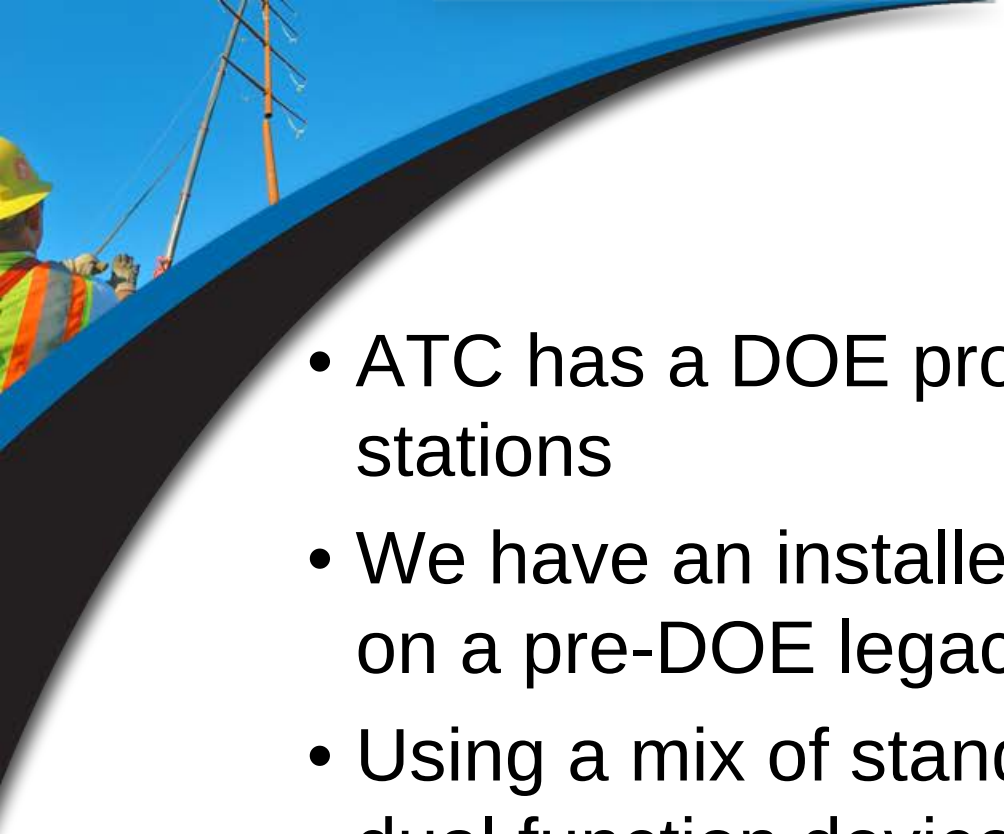
- Where Do We Go From Here? (Slides 23 and 24)

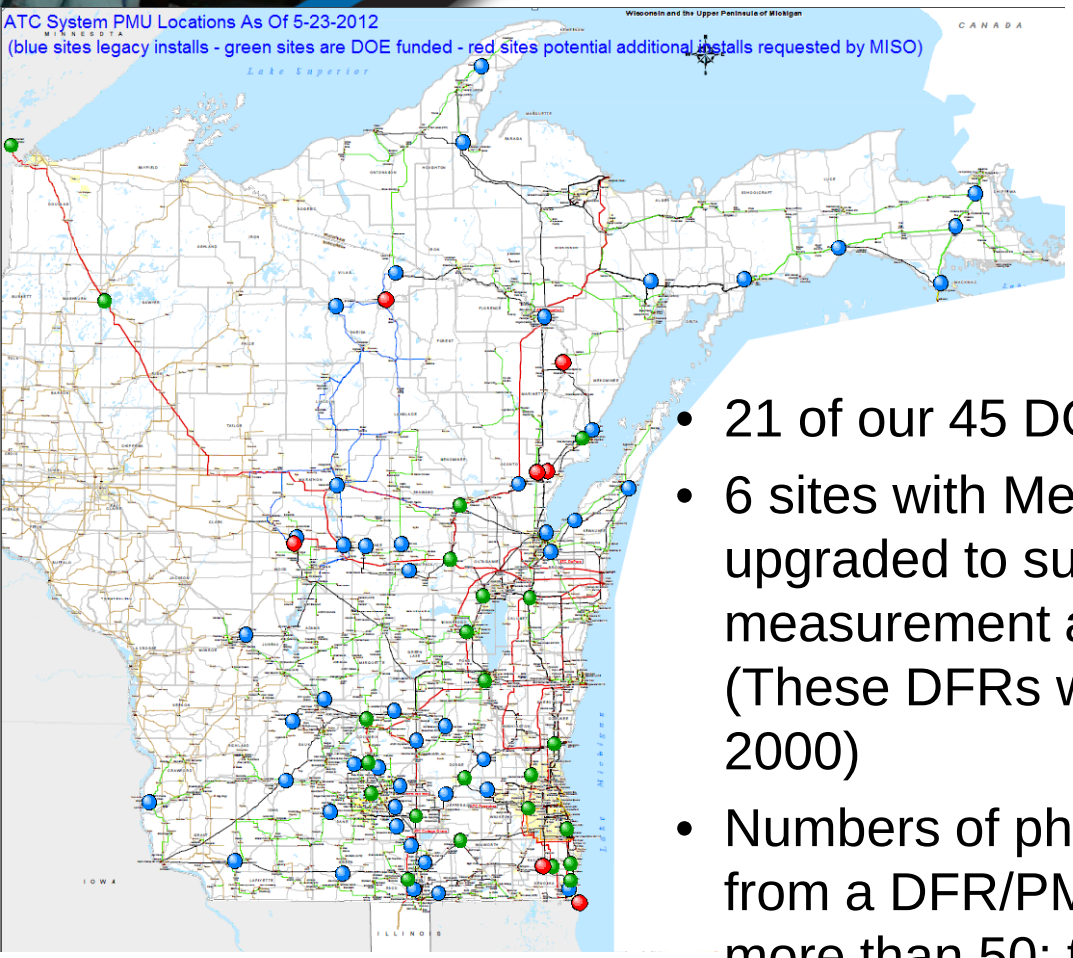


Background

- ATC has a DOE project to install PMUs at 45 stations
- We have an installed base of PMUs based on a pre-DOE legacy project
- Using a mix of stand alone PMU installs and dual function devices
- We have completed the upgrade of 6 Mehta Tech Digital Fault Recorders and wanted to share our experiences with others

SGIG Synchrophasor Project

Current Status



- 21 of our 45 DOE sites operational
- 6 sites with Mehta Tech's DFRs have been upgraded to support synchrophasor measurement and phasor data streaming (These DFRs were installed between 1992 and 2000)
- Numbers of phasor measurements streamed from a DFR/PMU range from as low as 26 to more than 50; three to five times the typical capacity of PMUs installed in other ATC sites (a magnitude/angle pair = 1 phasor)

Installation Issues

- Channel Database
- Connection and Wiring
- Reverse Polarity
- Cross Signal Interference
- Low Level Current Input Inaccuracy
- Odd Signal Monitoring
- Local Substation PDC Integration

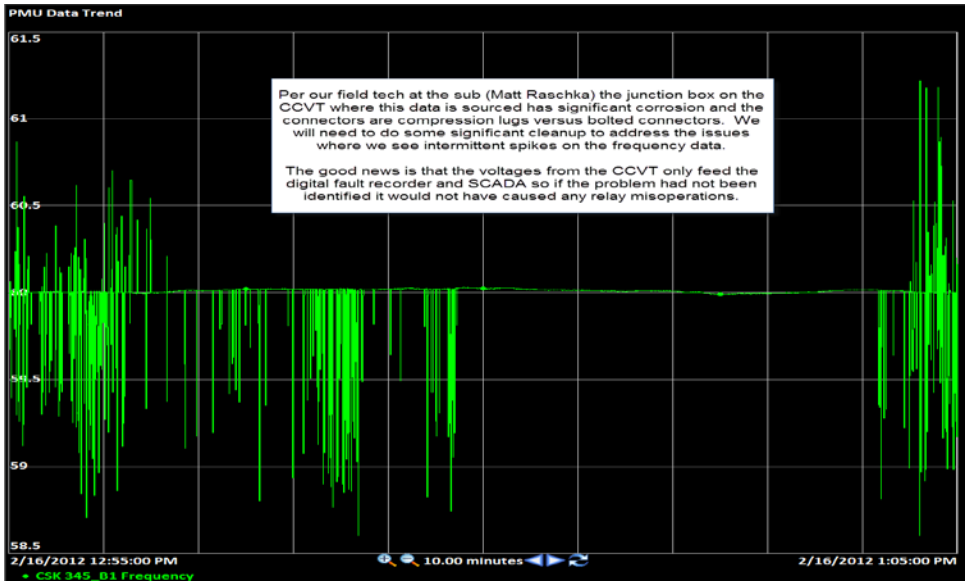
Installation Issues – cont'd
Channel Database

- CT ratio errors identified which required recalibration – some conversion factors fat fingered when programming the DFR – some CT ratios were not updated when field changes were made
- Equipment naming did not always reflect current system state (line renames not captured)
- Some points were configured in the DFR database but were not wired to the device

Installation Issues – cont'd

Connection and Wiring

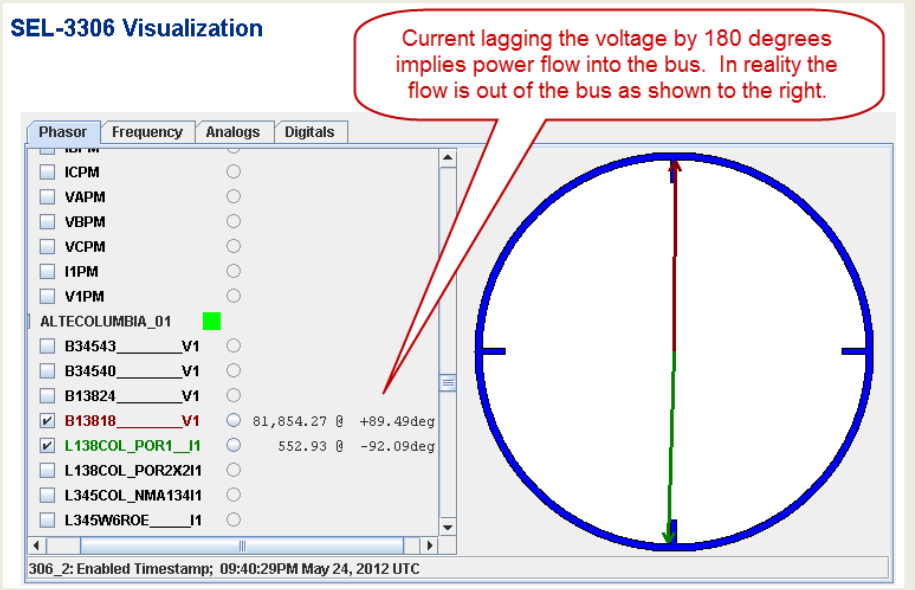
- Identified connection issues in a 345 Kv CCVT based on spikes in frequency and voltage data. This data is used as an input to our reclosing logic. The problem is being addressed in the field.

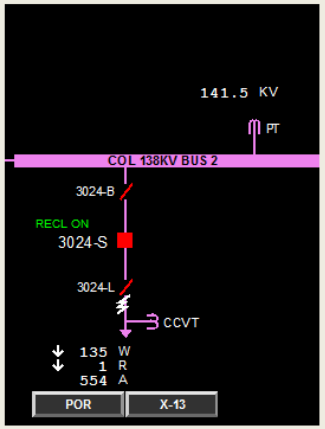


Installation Issues – cont'd

Reverse Polarity

- We have found a number of sites where current polarities were reversed resulting in calculated MW and Mvar flow data having an incorrect sign. We are working to correct these wiring issues.

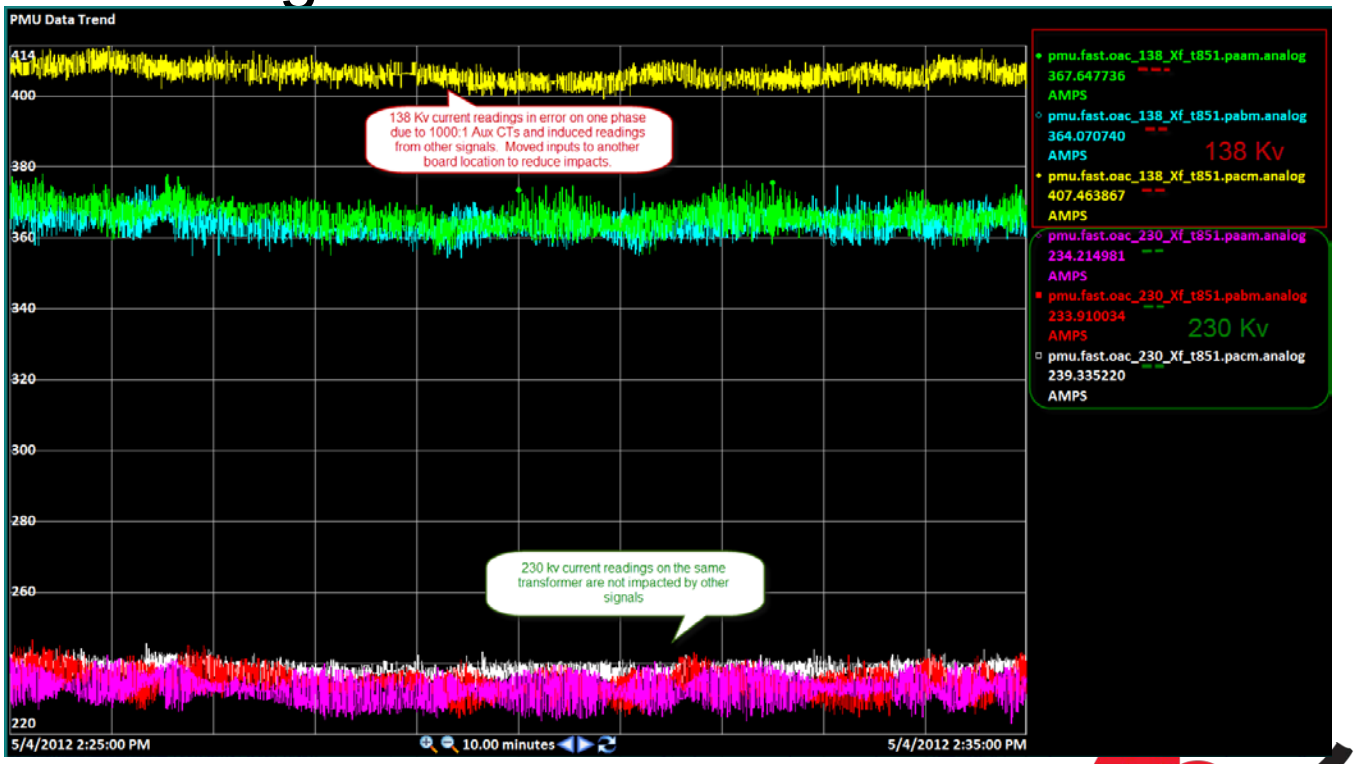




Installation Issues – cont'd

Cross Signal Interference

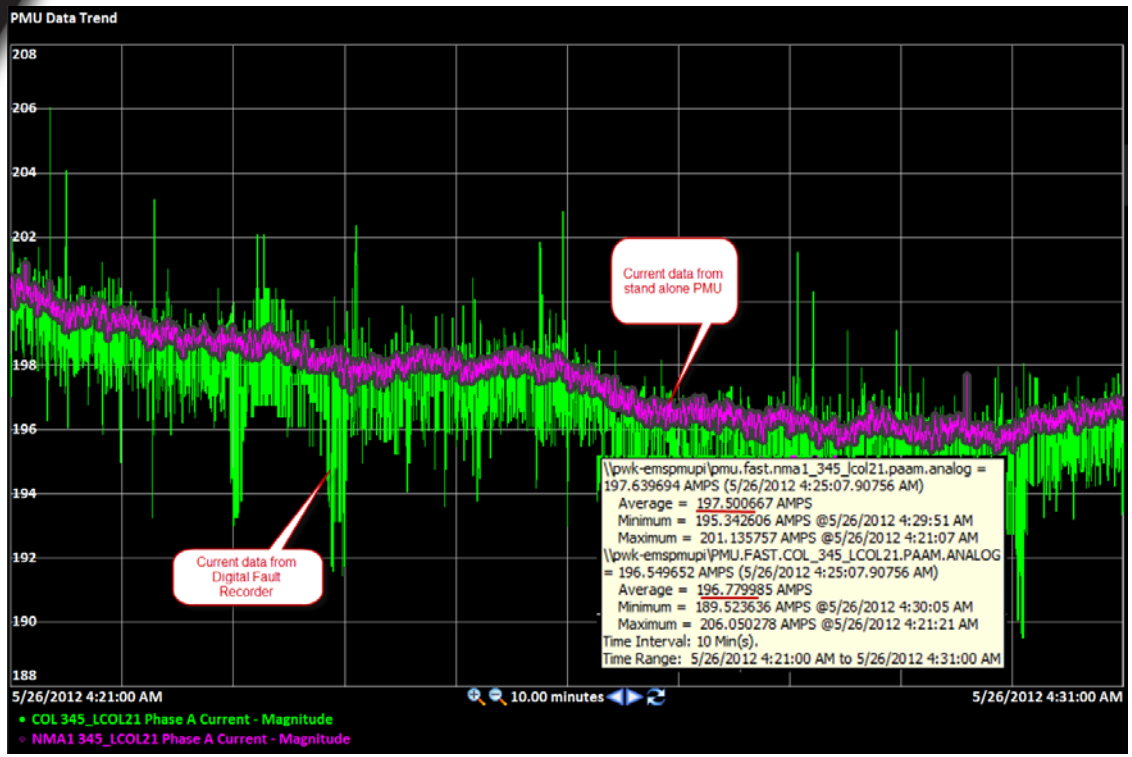
- Problems with cross signal interference when 1000:1 aux CTs were used for fault recording.



Installation Issues – cont'd

Low Level Current Input Inaccuracies

- Determined that accuracy was not what we expected for low level current signals.



DFRs built to display data for faults (thousands of amps) which impacts how things look when operating in the 0 to 100 amp range

Installation Issues – cont'd

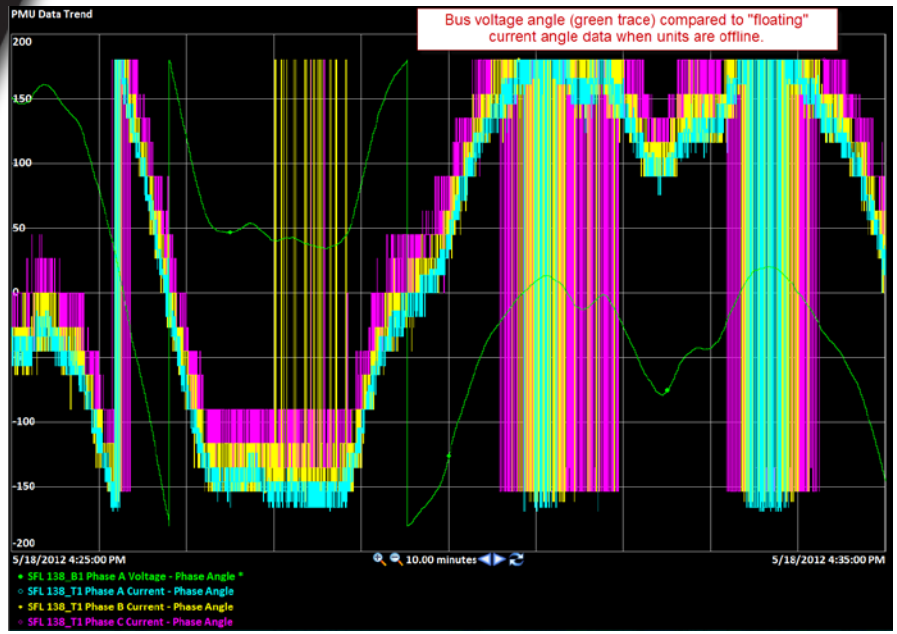
Low Level Current Input Inaccuracies

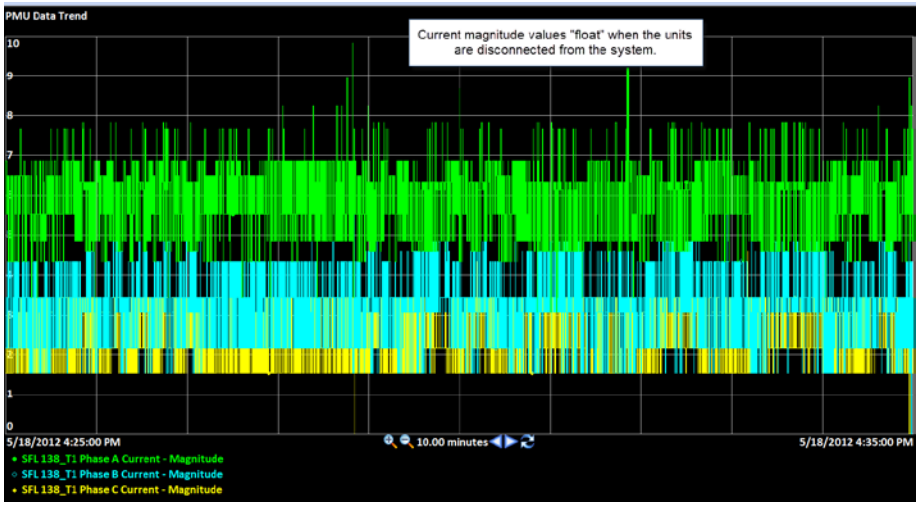
Observed unexpected current phase angle differences at low load levels

Installation Issues – cont'd

Odd Signal Monitoring

- Some signals float under normal operating conditions (For example GSU currents when unit offline). Can synchrophasor based applications deal with this?

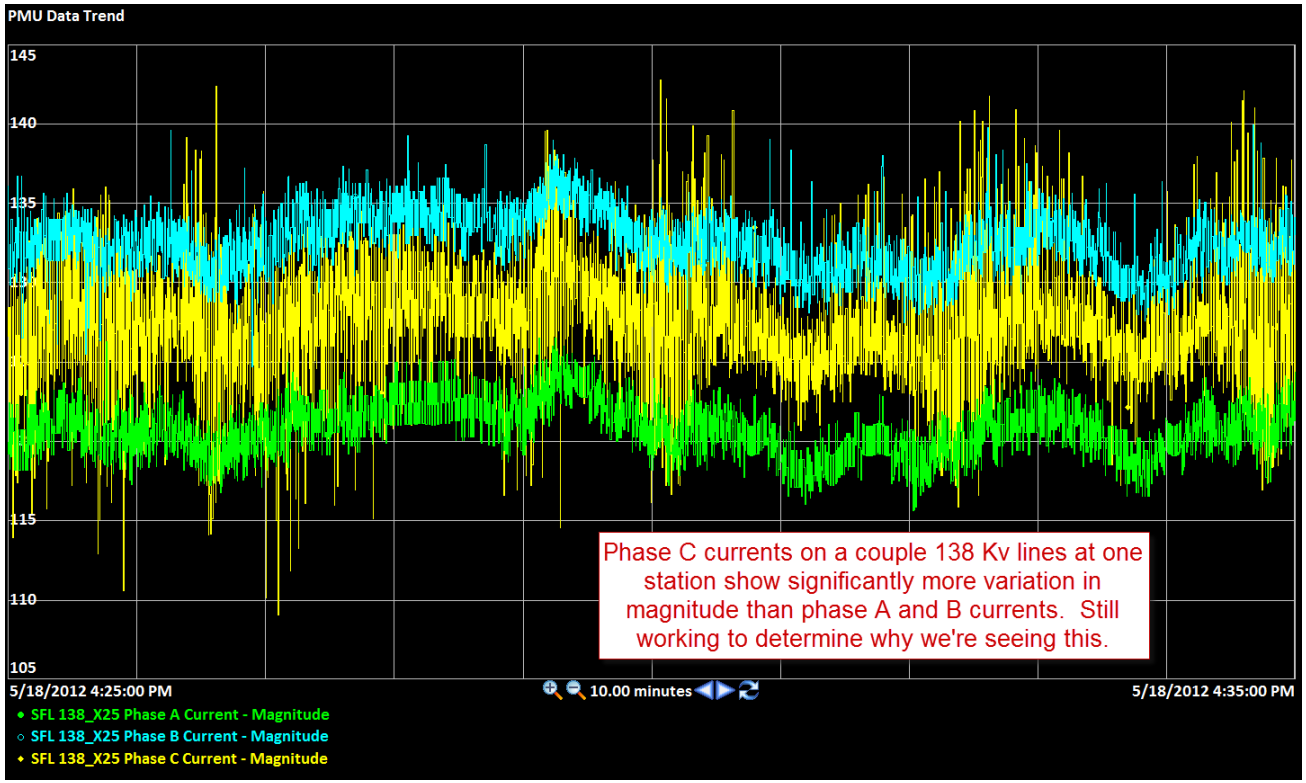




Installation Issues – cont'd

Odd Signal Monitoring

- Signal "oddities" identified but causes yet to be determined



Installation Issues – cont'd

Local Substation PDC Integration

- Integration with our substation PDC had some problems that needed to be resolved (for example the loss of 20% of data between PMU and PDC due to network buffering parameter settings on our PDC)
- Additional complexities introduced with planned security implementation and necessary access for DFR configuration and record access

Lessons Learned
Challenges and Surprises

Challenges faced and addressed/being addressed

- Field wiring and database (external, understandable, but under-estimated)
- Low level and special signal monitoring (need for attention is greater)
- Coordination among multiple vendors (expected but still defies planning)

Lessons Learned – cont'd

Challenges and Surprises

Value Proposition Surprises

- Project engineering and checkout (we were surprised and pleased with efficiencies once we got the process refined)
- Economics of DFR-based PMUs (on average we get more signals per dollar spent when using the DFR option)
- Integration of DFR/PMUs information in system operation (access to signals that we couldn't easily get as a TO with a new stand alone device)
- Value of DFR/PMU information ("Clean" DFR configurations when done with upgrade)

Lessons Learned – cont'd

"Mr. Obvious" Moments

- Test set calibration is important
- Multifunction equipment testing – PMU and DFR - Don't forget the DFR is a ***Fault Recorder*** when testing. The PMU functionality is a benefit not the primary function for the device.

Lessons Learned – cont'd

Smarter With Each Install

- Field engineering procedures have been possible to stream-line just after first three start ups and it now takes only two to three days for check-out and start up of a large DFR/PMU system
- Much of the field time is taken up by issues mentioned above that are external to the DFR/PMUs themselves. Changed processes to catch issues sooner to avoid rework.

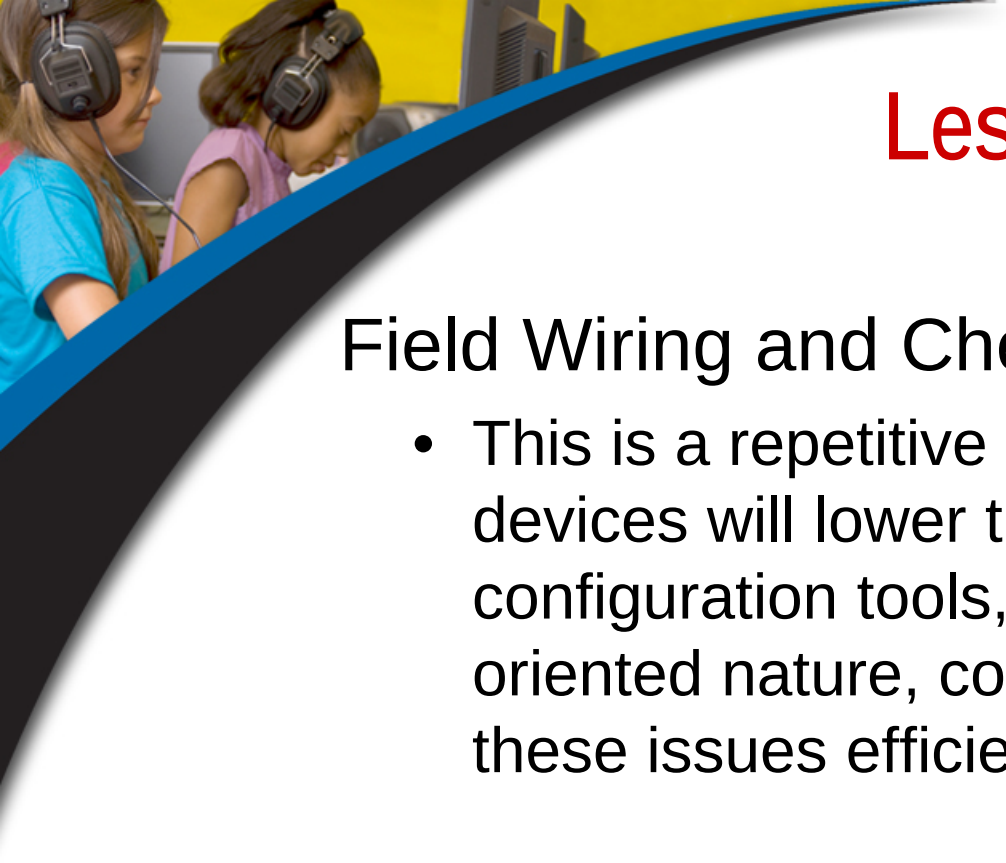
Lessons Learned – cont'd
Data Communication Surprise

- Communication bandwidth usage was significant but less than anticipated based on vendor supplied bandwidth calculator (still working to determine why)
- Matched more closely with estimates from RAPIR report below but not exact

Table 3.1— Approximate bandwidth (kbits/sec) as a function of PMUs and sampling rate

Samples per Second	Number of PMU's			
	2	**10**	**40**	**100**
30	57	220	836	2,085
60	114	440	1,672	4,170
120	229	881	3,345	8,340

Values in kilobits per second (kbits/s)
Assumes 20 measuremetns per PMU (16 are used for 8 phasors)



Lessons Learned – cont'd

Resolution of Open Issues

Field Wiring and Checkout

- This is a repetitive cost item – lesser number of devices will lower the cost; Mehta Tech's configuration tools, because of their system oriented nature, contributed to the resolution of these issues efficiently

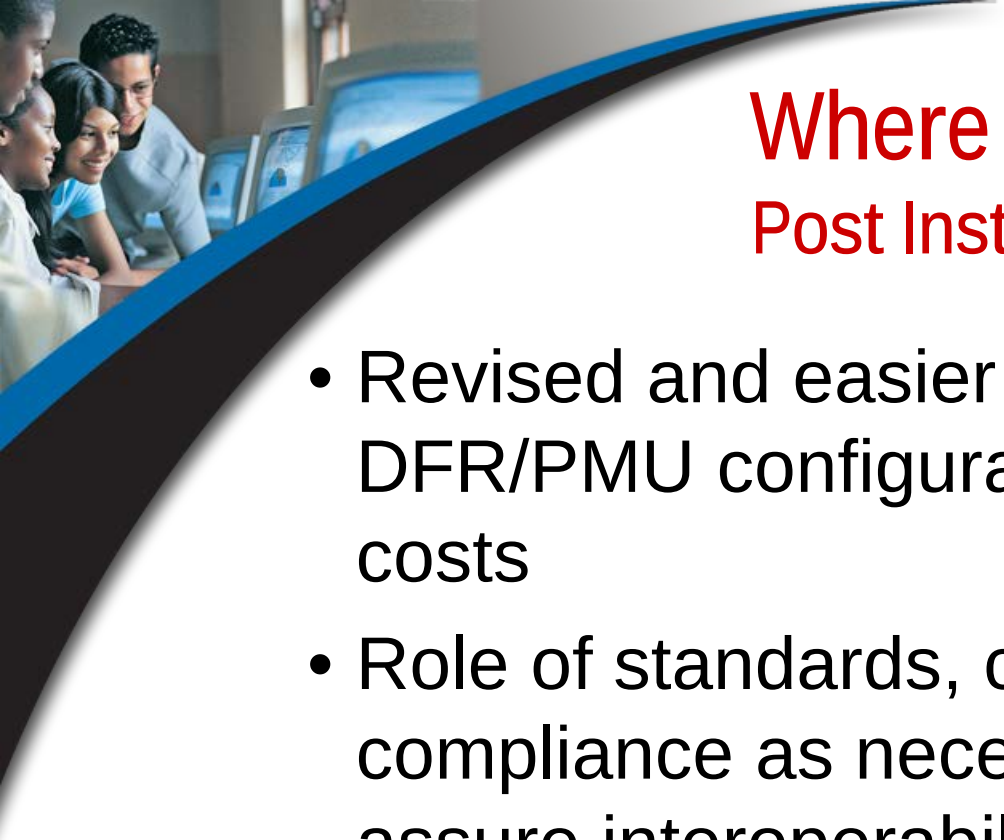
Low Level and Special Signals

- These inputs need further attention – provide an opportunity to use phasor measurements to meet currently unrecognized user needs; Mehta Tech is working on innovative solutions

Lessons Learned – cont'd
Resolution of Open Issues

PMU/PDC Integration

- Configuration information exchange issues between a PMU and substation PDC are many, are vendor specific and defy standardization.
- We have successfully tested Mehta Tech's DFR/PMUs for direct connection to ATC's central site PDC without going through substation PDC to verify the capability to support configurations where local PDC may not be used



Where Do We Go From Here?

Post Installation Continuing Activities

- Revised and easier justification for DFR/PMU configuration based on reduced costs
- Role of standards, conformance testing and compliance as necessary requirements to assure interoperability or an unintentional barrier to new innovations

Where Do We Go From Here?

Post Installation Continuing Activities

- Upgradability and legacy issues – this is where the cost reduction potential is the highest
- Need for a Measurement and Configuration Data Expert
- Benefits in formation of a User-Vendor Substation Measurement Interest Group

Questions?