PI Server 2012 Webinar Series:

WAMS/Synchrophasor, PI Server 2012 and OSIsoft/Dell collaboration at Dell Solution Centers

Presented by **Matt Rivett-PJM, Jim Kleitsch-ATC, Rick Reeder-Dell**
Ann Moore-OSIsoft and Jay Lakumb-OSIsoft

Agenda

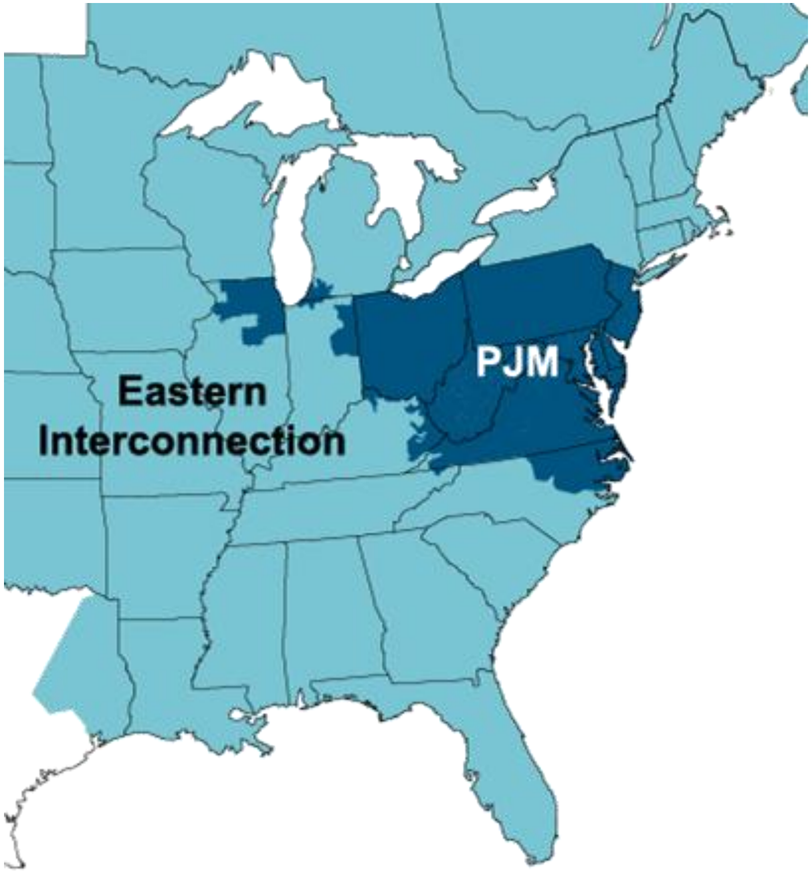
1. PJM Synchrophasor data in the PI System
   Matt Rivett
2. ATC WAMS/Synchrophasor
   Jim Kleitsch
3. OSIsoft PI System-based WAMS
   Ann Moore
4. Dell/OSIsoft Collaboration at Dell Solution Center
   Ann Moore and Rick Reeder
5. PI Server 2012 for WAMS
   Jay Lakumb
6. Conclusion
   Ann Moore
7. Q&A

1.

PJM Synchrophasor data in the PI System

Matt Rivett-PJM

PJM as Part of the Eastern Interconnection



21% of U.S. GDP produced in PJM

KEY STATISTICS	
Member companies	800+
Millions of people served	60
Peak load in megawatts	163,848
MWs of generating capacity	185,600
Miles of transmission lines	59,750
GWh of annual energy	832,331
Generation sources	1,365
Square miles of territory	214,000
States served	13 + DC

As of 9/7/2012

PJM – Focus on Just 3 Things

Reliability

1

- Grid Operations
- Supply/Demand Balance
- Transmission monitoring

Regional Planning

- 15-Year Outlook

3

Market Operation

- Energy
- Capacity
- Ancillary Services

2

PJM Vision Statement

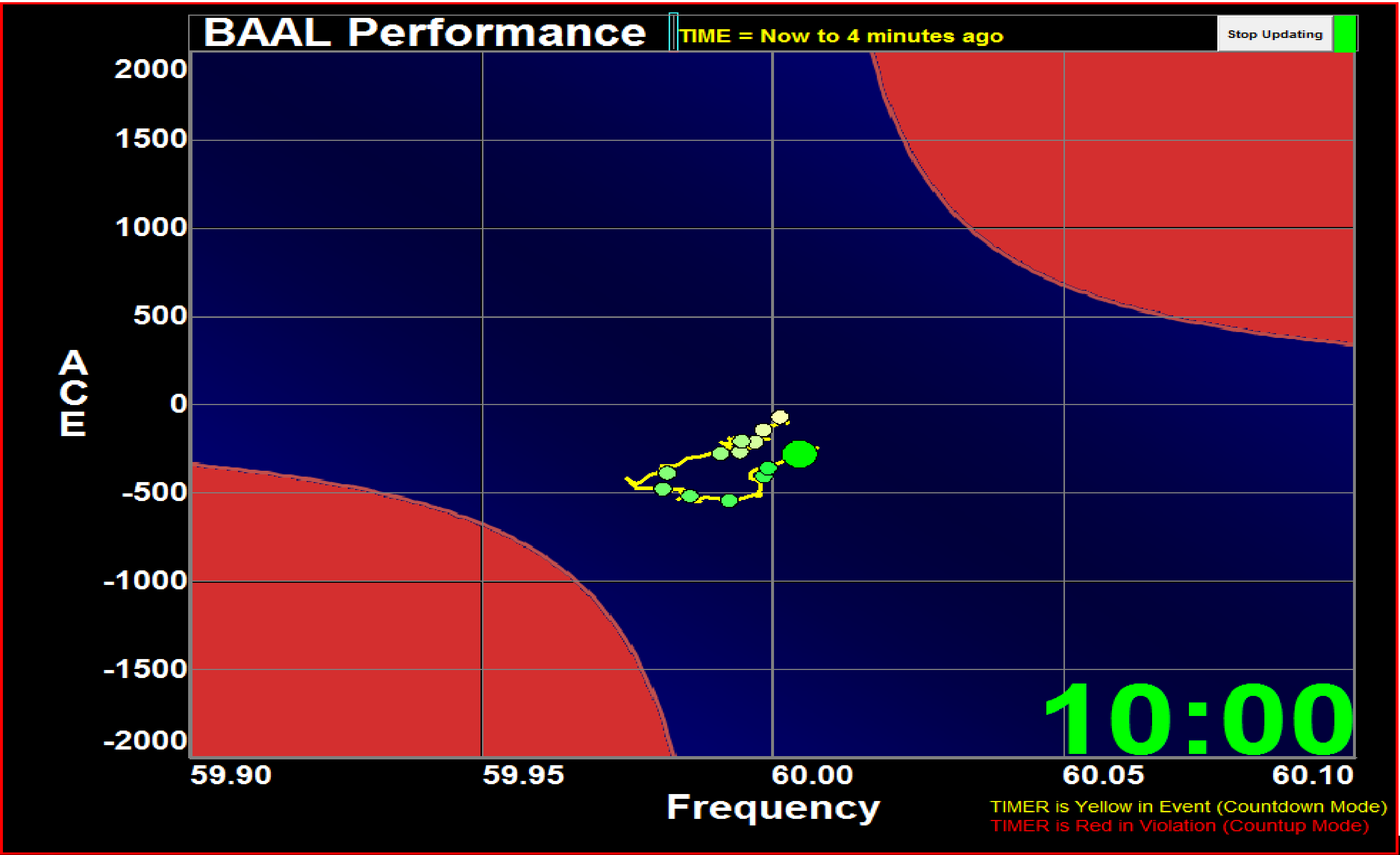
To be the electric industry leader – today and tomorrow – in reliable operations, efficient wholesale markets, and infrastructure development.

PJM’s Control Room

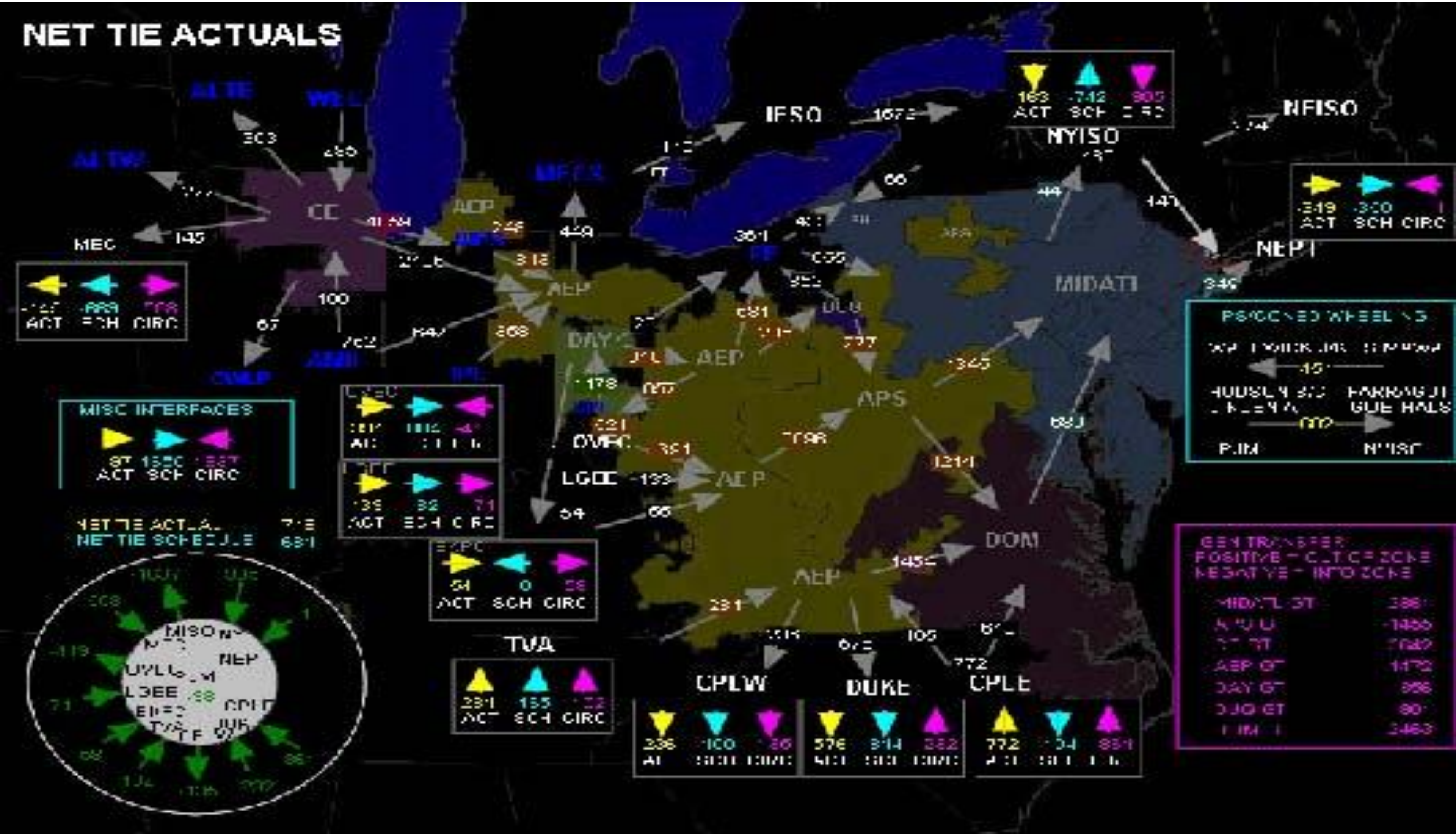
OSIsoft PI System at PJM

- Used for EMS since 2001
- Rolling 7 years of history
  - EMS Data of Record approx. 3TB of data
- Interfaces
  - Siemens Spectrum Interface
  - PI UFL
  - PI RDBMS
- 40 Production PI Servers including
  - PI Data Servers
  - PI AF, PI Notifications, PI Web Services
  - PI Interfaces
  - PI ACE

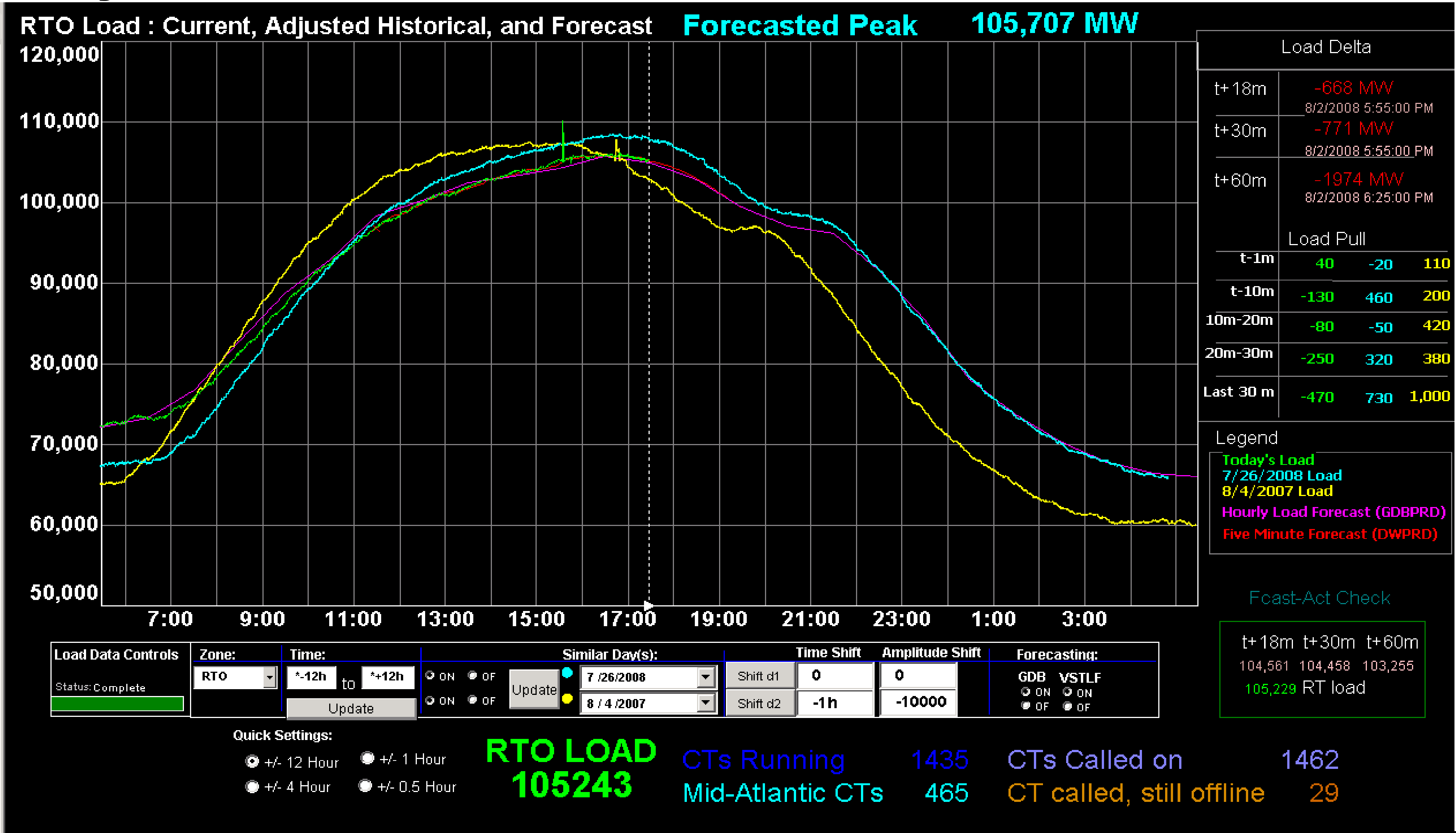
Balancing Authority ACE Limit (Area Control Error)



Internal and External Tie Line Flows

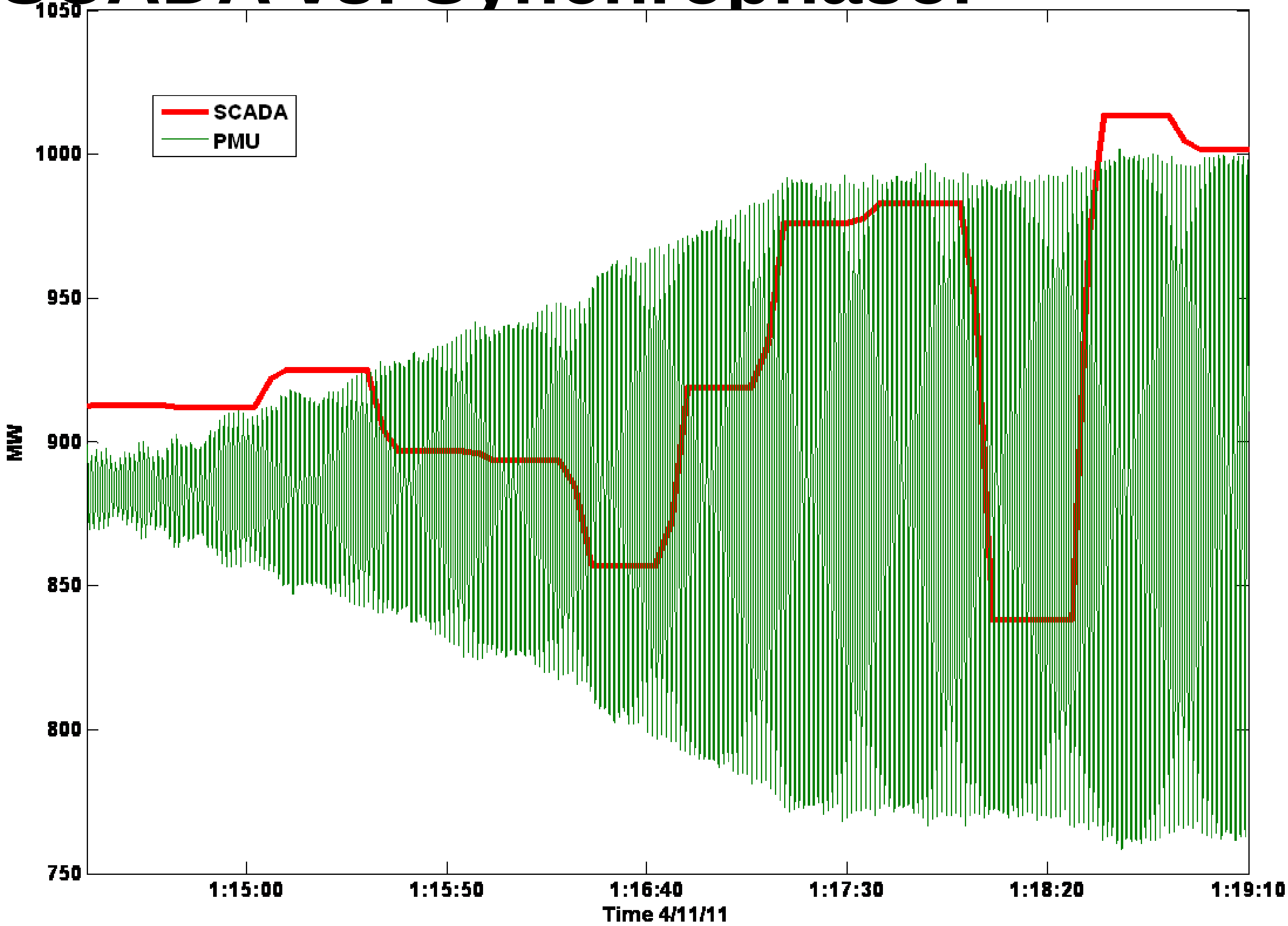


Loading Profile: Historical, Real-Time, Adjusted and Forecast



SCADA to Phasor Measurements from X-Rays to MRIs

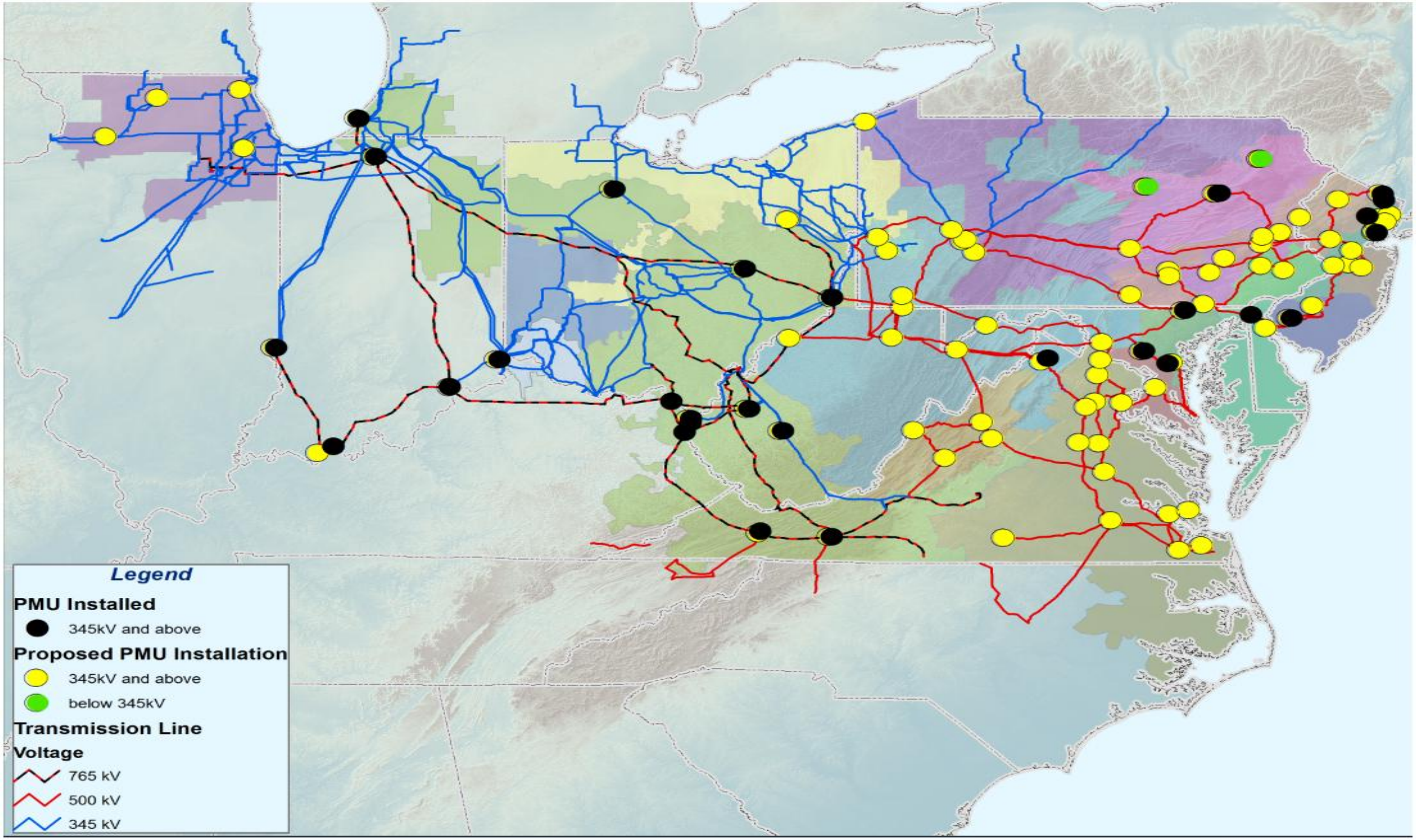
SCADA vs. Synchrophasor



Synchrophasors at PJM

- 360 PMUs installed in 90 substations by 2013
- Covering 10 states
- Total of 720 Measurements from all PMUs
- 4096 bytes per PMU Message
- 30 Messages per second - 1.2MB per second of data
- Estimated 1TB data per month collected
- 1,302,528 bytes of data, per second streaming from the PMUs to PJM
- 17 Phasor Data Concentrators to be deployed
- PJM will also collect phasor data from roughly 150 substations external to PJM

PMU Deployment



Synchrophasor for off-line Applications

- Forensic Event Analysis
- Oscillation and stability analysis
- Static system model calibration and validation
- Dynamic system model calibration and validation
- Generator & Load model calibration and validation
- System operating limits evaluation and design

Synchrophasor for on-line Applications

- Wide-area situational awareness
- Stability, oscillations and voltage monitoring
- Alarming
- Dynamic line ratings and congestion management
- System Restoration

Synchrophasor PI System Environment Planning

- Estimating storage requirements
  - OSIsoft TechSupport Site KB Article #2775OSI8

Desired years of history:	3

Theoretical

PMU						
Point Type	# of Points	Values/day	Record Size	Overhead	Compression	MBytes/Day
Float32 Points 8 RAW 4 Calc	12	2,592,000	12	5.0%	0.0%	374
Float32 Calc Points	4	86,400	12	5.0%	25.0%	3
Digital Points	8	2,592,000	9	5.0%	70.0%	56
Total						433

3 Years of storage			
	# of PMUs	TBytes/Year	TBytes/3Years
Current in PI	82	12	37
Existing	108	16	49
Planned	500	75	226

Synchrophasor PI System Environment

- Currently in stage environment at PJM
  - 3 TB storage allocated for Primary Server
- Collective with 2 members
  - PI Server 2012
- One ACE Server
  - Hourly statistical calculations regarding PMU data quality
  - **Missing** 108000 - Number of frequency values
  - **Stat<>0** Number of frequency values when status was not 0
  - **Data Invalid** Number of frequency values when data valid bit (15) was not Valid (0)

Synchrophasor PI System Environment

- **Time Suspect** Number of frequency values when Unlocked Time (05-04) bits were not Locked (00)
- **Late Data** Number of frequency values when total latency (time from PMU to PJM PDC calculated by our PDC) was greater than 200ms
- We use frequency as source because it has exception and compression turned off

- Two Interface Servers
  - Running PI C37.118
  - Collecting data from 82 PMUs
  - 1397 PI C37.118 PI Tags

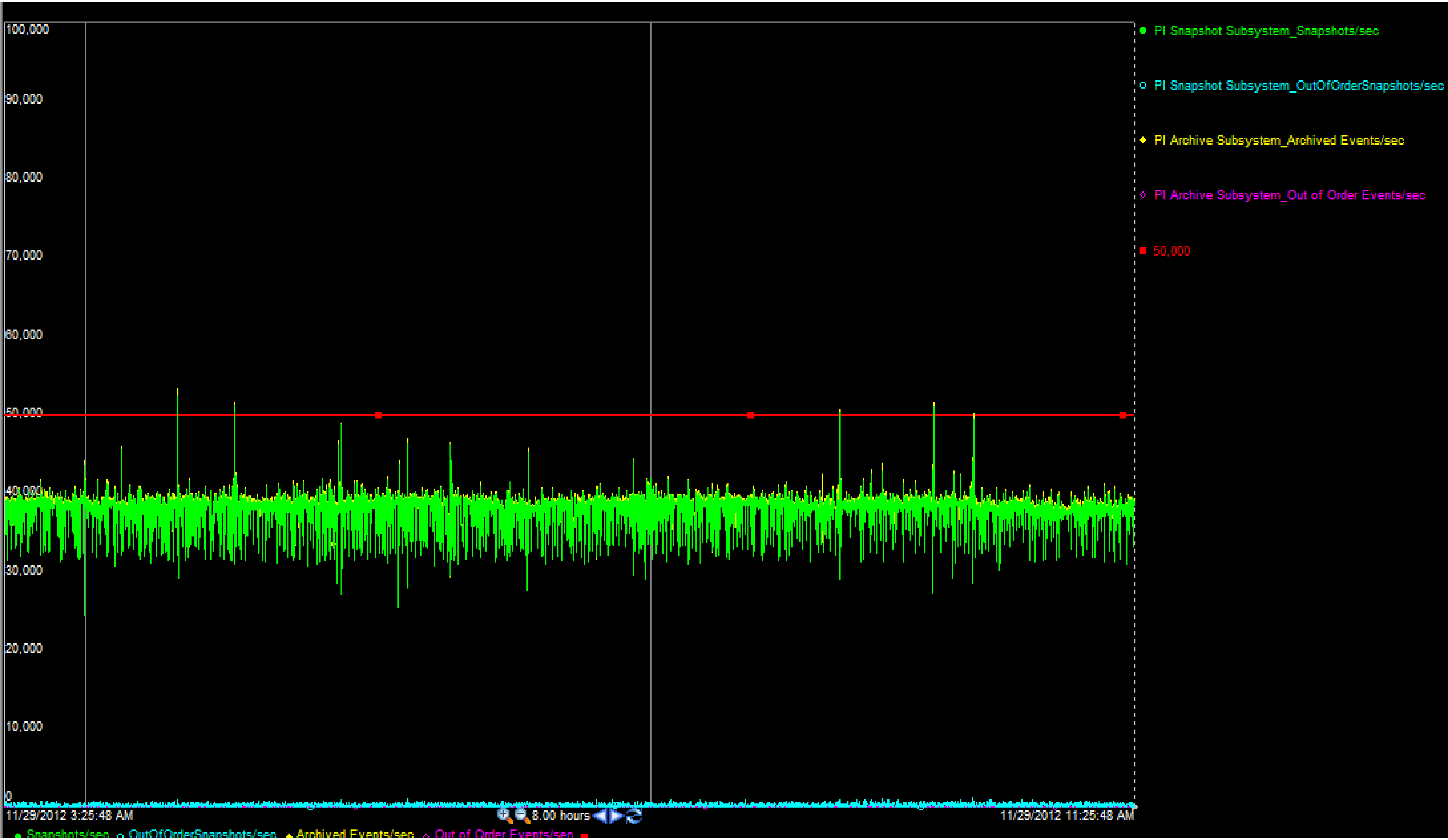
Synchrophasor PI Environment Planning

- Actual results to date

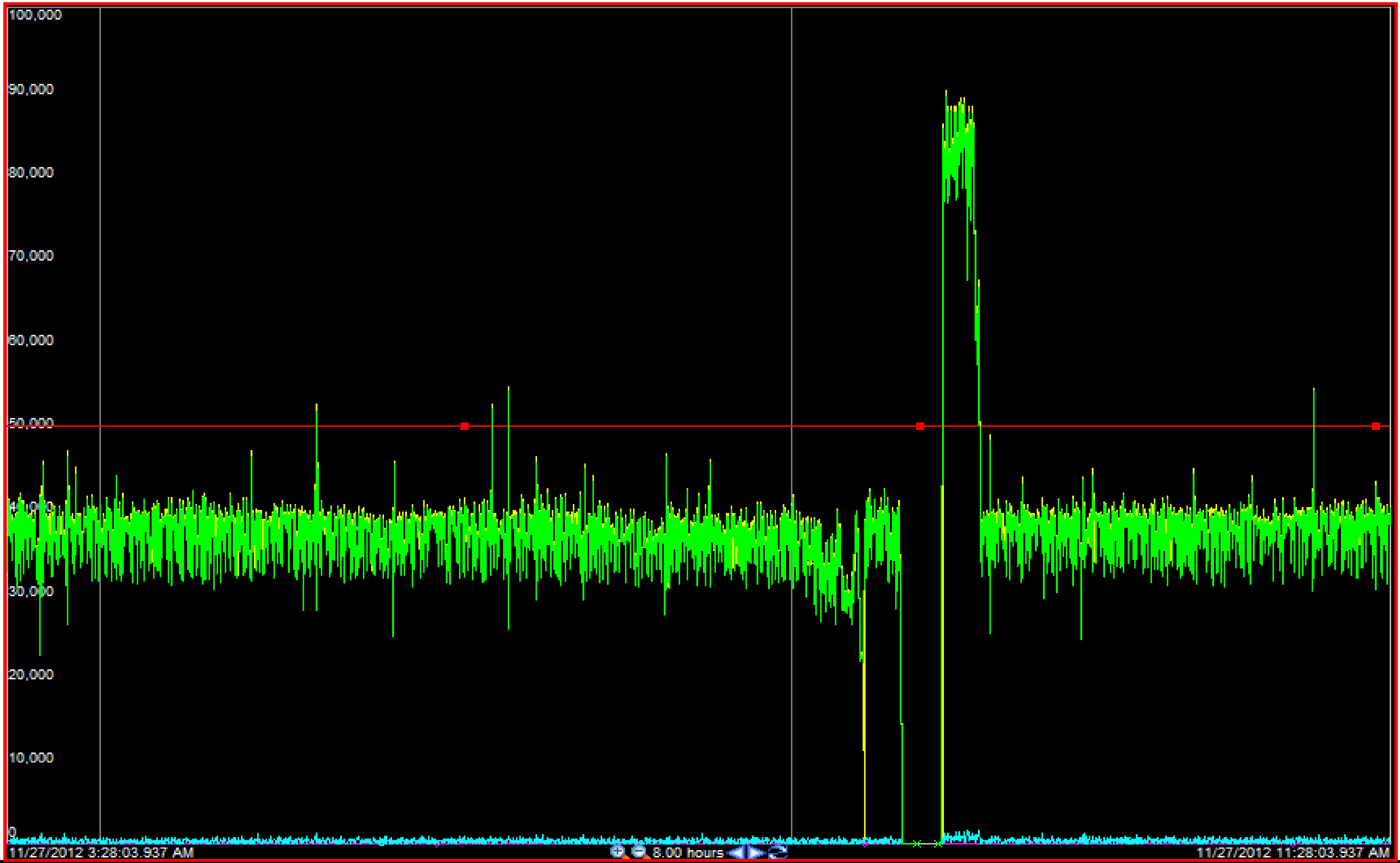
Actual					
PMUs	Archive Size (GB)	Archive Length (H)	GB/Day	TB/Year	TB/3Years
82	10	12	20.00	7.13	21.39
500			121.95	43.47	130.41

Status	Size (MB)	Start Time	End Time	Lifetime
Primary	10000	11/29/2012 9:17:58 AM	Current Time	0d 01:47:21.376..
Has Data	10000	11/28/2012 9:30:45 PM	11/29/2012 9:17:58 AM	0d 11:47:13.0
Has Data	10000	11/28/2012 9:53:56 AM	11/28/2012 9:30:45 PM	0d 11:36:49.0
Has Data	10000	11/27/2012 9:46:49 PM	11/28/2012 9:53:56 AM	0d 12:07:07.0
Has Data	10000	11/27/2012 9:57:05 AM	11/27/2012 9:46:49 PM	0d 11:49:44.0
Has Data	10000	11/26/2012 9:57:12 PM	11/27/2012 9:57:05 AM	0d 11:59:53.0
Has Data	10000	11/26/2012 10:00:16 AM	11/26/2012 9:57:12 PM	0d 11:56:56.0
Has Data	10000	11/25/2012 9:57:28 PM	11/26/2012 10:00:16 AM	0d 12:02:48.0
Has Data	10000	11/25/2012 9:51:57 AM	11/25/2012 9:57:28 PM	0d 12:05:31.0
Has Data	10000	11/24/2012 9:36:01 PM	11/25/2012 9:51:57 AM	0d 12:15:56.0
Has Data	10000	11/24/2012 9:25:14 AM	11/24/2012 9:36:01 PM	0d 12:10:47.0
Has Data	10000	11/23/2012 9:13:50 PM	11/24/2012 9:25:14 AM	0d 12:11:24.0
Has Data	10000	11/23/2012 9:06:53 AM	11/23/2012 9:13:50 PM	0d 12:06:57.0
Has Data	10000	11/22/2012 9:08:10 PM	11/23/2012 9:06:53 AM	0d 11:58:43.0
Has Data	10000	11/22/2012 9:07:48 AM	11/22/2012 9:08:10 PM	0d 12:00:22.0
Has Data	10000	11/21/2012 9:16:54 PM	11/22/2012 9:07:48 AM	0d 11:50:54.0

Normal Data Rates



Data buffer due to server patching

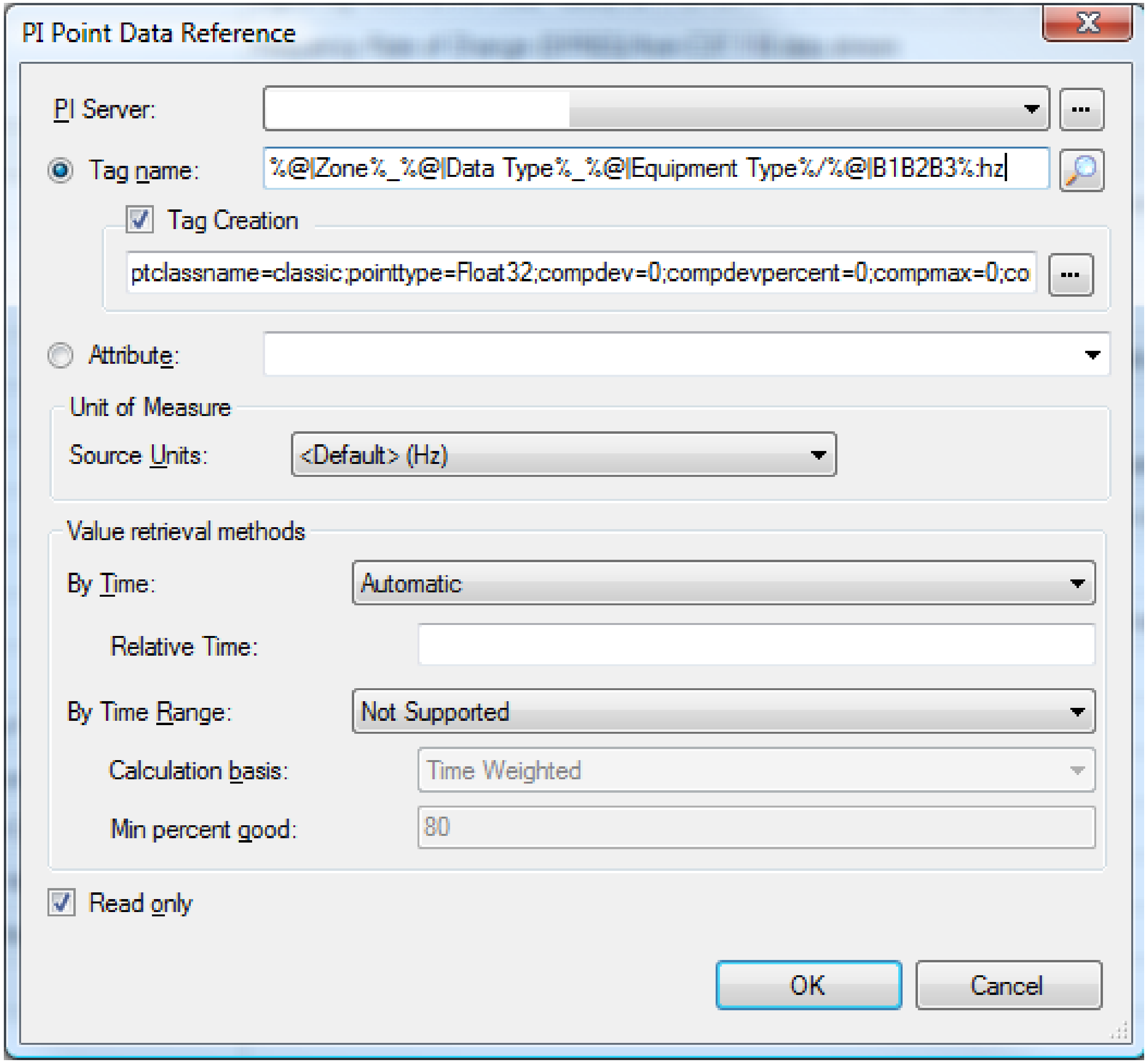


PI AF Templates

- PMU
  - Required attributes manually entered (hope to automate using SQL database as source)

Name	Description
B1B2B3	
C37118 Data Stream	
CFGCNT	Configuration change count (CFGCNT) from last CONFIG block
COMPOSITEQUAL	Digital tag receives a composite status from the Data Valid, PMU Error, Sync Error and Data Sortin...
CONFIGFLAG	Digital tag that is set to 1 when the configuration change flag (bit 10) in the STAT word is true
DATA_RATE	Date rate (DATA_RATE) from last CONFIG block
DATASORTING	Digital tag receives the Data Sorting bit (12) from the STAT word. A sample digital set definition file ...
DATAVALID	Digital tag receives the Data Validity bit (15) from the STAT word. A sample digital set definition file ...
DFREQ	Frequency Rate of Change (DFREQ) from C37.118 data stream
FNOM	Nominal line frequency (FNOM) from last CONFIG block
FREQ	System frequency (FREQ) from C37.118 data stream
FREQERR	Frequency error calculated from FREQ – Nominal Frequency as defined by FNOM (50 or 60)
LATITUDE	PMU Latitude (-90.0-90.0) from XML configuration file
LONGITUDE	PMU Longitude (-180.0-180.0) from XML configuration file
PMUERROR	Digital tag receives the PMU Error bit (14) from the STAT word. A sample digital set definition file PI...
STAT	
SYNCERROR	Digital tag receives the PMU Sync Error bit (13) from the STAT word. A sample digital set definition...
TIMELOCK	Digital tag receives the Unlocked Time quality bits (5-4) from the STAT word. A sample digital set d...
Total Latency	
TRIGGER	Digital tag receives the Trigger Reason bits (3-0) from the STAT word. A sample digital set definitio...
Calculations	
Bad Status 1 Hour Count	The number of stat values not equal to 0 received in the previous hour
Invalid Data 1 Hour Count	The number of datvalid values not equal to Valid received in the previous hour
Late Data 1 Hour Count	The number of totlate values > 0.2 received in the previous hour
Missing Values 1 Hour count	The number of stat values missed in the previous hour
Time Suspect 1 Hour Count	The number of unloctme values not equal to Locked received in the previous hour

PI AF Templates



PI AF Templates

- PI Tags created automatically using PI AF templates

Tag Creation Settings

Point Class: classic

Point Type: Float32

Import...

Point Attribute	Value
archiving	1
compdev	**0**
compdevpercent	**0**
compmax	**0**
compmin	0
compressing	**0**
convers	1
dataaccess	
datagroup	
dataowner	
datasecurity	
descriptor	**%@|STN%**
digitalset	
displaydigits	-5
engunits	
excdev	**0**
excdevpercent	**0**
excmax	**0**
excmin	0
exdesc	**%@|STN%:FR**
filtercode	0
instrumenttag	**PMU\FREQ**

location1	**%@|tag configuration|location1%**
location2	**%@|tag configuration|location2%**
location3	**%@|tag configuration|location3%**
location4	**%@|tag configuration|location4%**
location5	**%@|IDCODE%**
pointsource	**%@|tag configuration|pointsource%**
ptaccess	
ptgroup	
ptowner	
ptsecurity	
scan	**%@|Enabled%**
shutdown	1
sourcetag	
span	**2**
squareroot	0
step	0
totalcode	0
typicalvalue	**60**
userint1	0
userint2	0
userreal1	0
userreal2	0
zero	**59**

Synchrophasor ERD (Element Relative Display) - PI ProcessBook Display

Future Plans

- Production
  - PI Servers ready by end of 2012
  - 250 PMUs
  - 90 days PI historical data
  - Initially ordering 27TB for 2 PI Server collective
    - SAS 15K
    - 3 Gbps

2.

ATC WAMS/Synchrophasor

Jim Kleitsch–System Operations Engineer

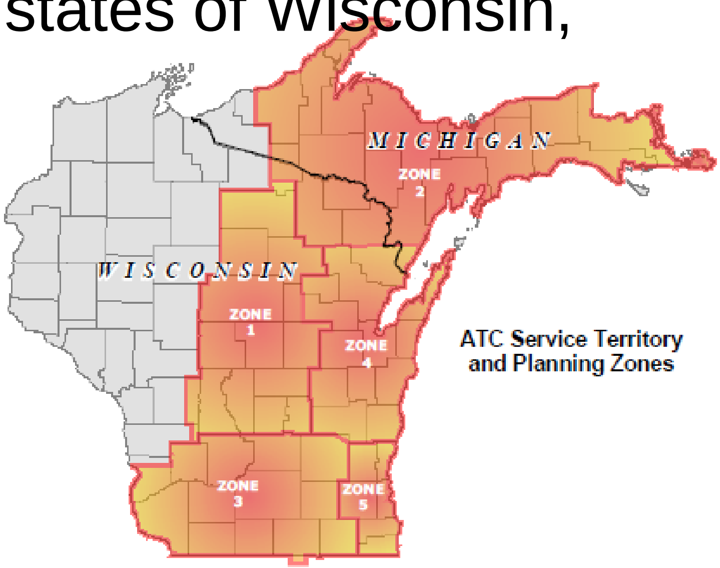
Discussion Topics

- Quick ATC Overview
- SCADA/EMS Specifics
- Information Management
- Synchrophasor Projects

ATC Overview

American Transmission Company [ATC] is a transmission-only electric utility located in the upper Midwestern United States

- 9,400 circuit miles of transmission line
- 510 substations (wholly or jointly owned)
- Peak demand in footprint: 13,170 MW
- Service area includes portions of the states of Wisconsin, Michigan, Minnesota, and Illinois
- Formed in 2001



SCADA / EMS Information (Alstom EMS)

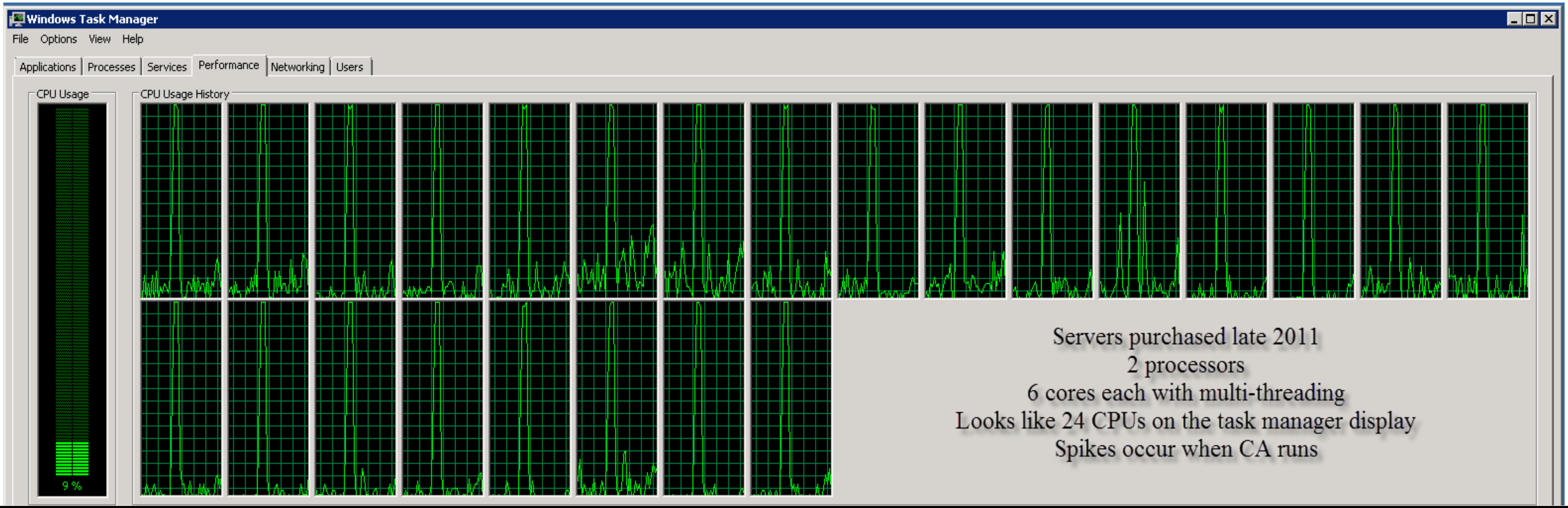
- All servers and workstations supplied by Dell
- Two live sites with hot standby configuration at each site
- Direct Scan over 400 RTUs using DNP protocol
  - Over 8,500 analogs and 43,000 status points
  - Over 3,000 controllable devices
- Inter-Control Center Communications Protocol [ICCP] links to 10 other entities including our Reliability Coordinator – Midwest ISO
- Total Point Counts (Includes ICCP, Calculations, direct scans, and pseudo status points)
  - 27,000 analogs / 78,000 status

SCADA / EMS Information (cont'd)

- Network Applications Summary
  - Real time State Estimator [SE] runs every 3 minutes
  - Real time contingency analysis runs every 3 minutes
  - Voltage Stability scenarios run every 10 minutes on Western and Southern ATC interfaces (Siemens PTI tools)
  - 7,000 bus / 10,000 branch / 100 GW load modeled

SCADA / EMS Information (cont'd)

- Network Applications Statistics
  - SE (State Estimator) solution on 7000 bus model takes 5-10 seconds
  - CA (Contingency Analysis) solution with full (no screening) processing on 2000 contingencies takes 25-30 seconds
  - Using Dell servers with multi-threaded processing to allow full PF for all contingencies



Information Management

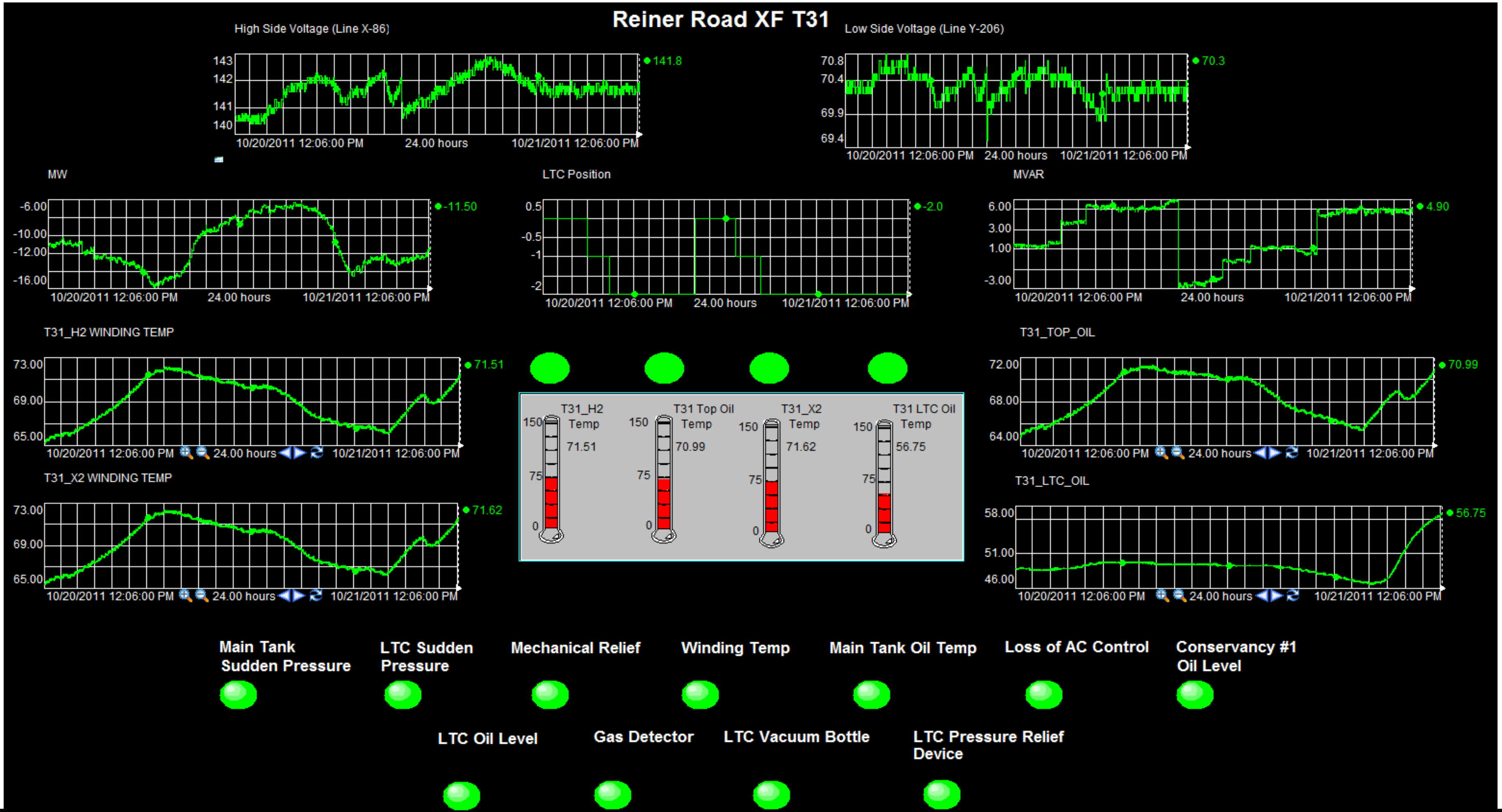
- ATC implemented OSIsoft's PI System in 2009 for all SCADA and PMU data
- PMU and SCADA data have their own PI Servers.
  - SCADA PI System licensed for 150,000 tags (unique data points). As reference MISO has implemented PI System with a 600,000 tag PI initially.
  - PMU PI Server licensed for 5,000 tags.
- Separate user interfaces for Operations/EMS network and Corporate network.
  - Operations/EMS users have direct access to data thru PI Clients (PI ProcessBook and PI DataLink Excel)
  - CITRIX clients and separate mirrored server used to manage corporate access (SCADA only)

Information Management (cont'd)

- SCADA Data backfilled from existing ALSTOM archive files thru 1/1/2006
- Advantages include data management and accessibility
  - Improvements in displays, increasing clarity while incorporating additional capabilities
  - Create new displays not currently possible
  - "One click" direct historical trend call-up through integration to our EMS displays
  - The ability to leverage the experience of large PI System users community worldwide.

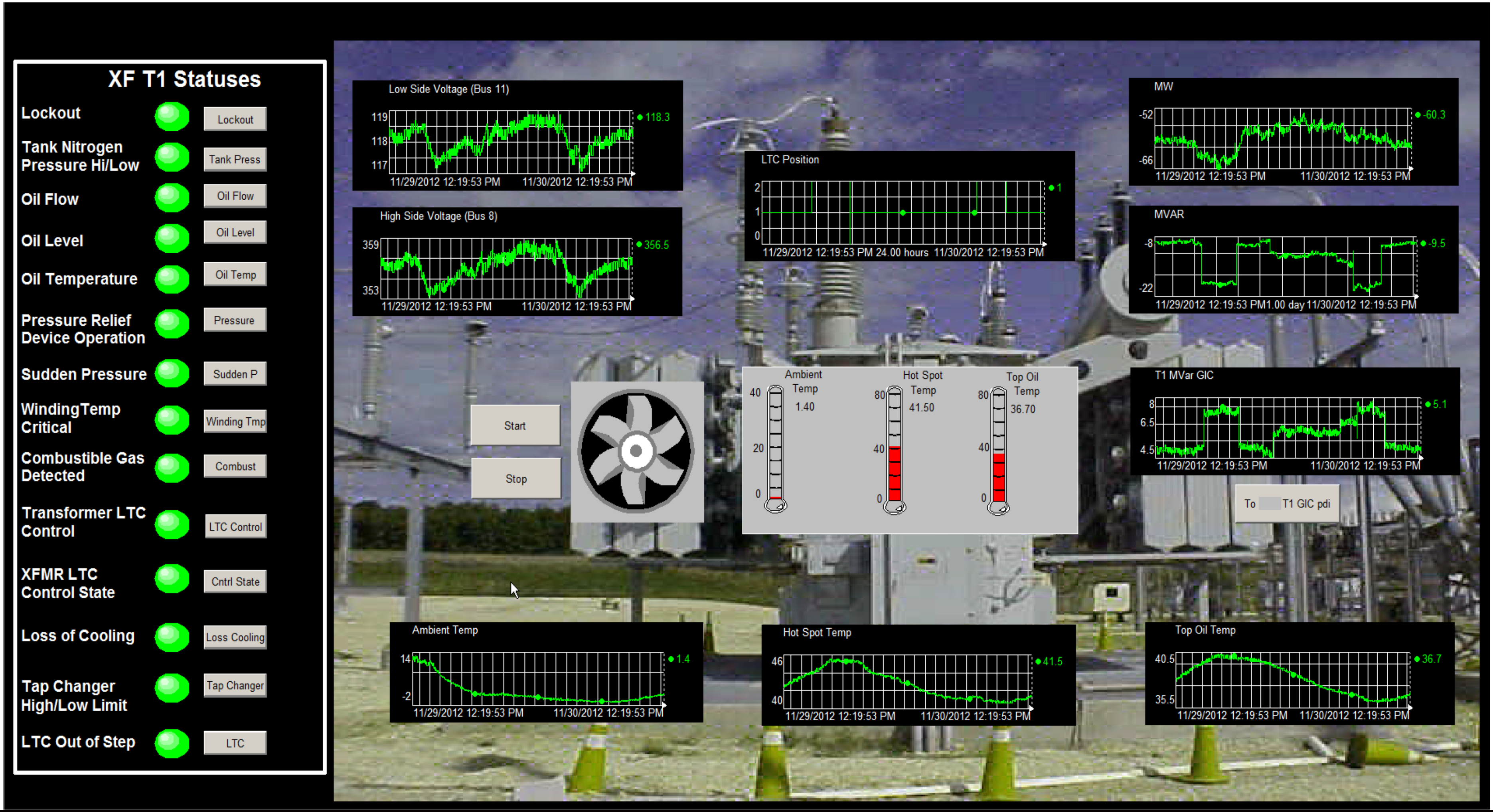
Information Management (cont'd)

- Sample PI Displays – Transformer Monitoring



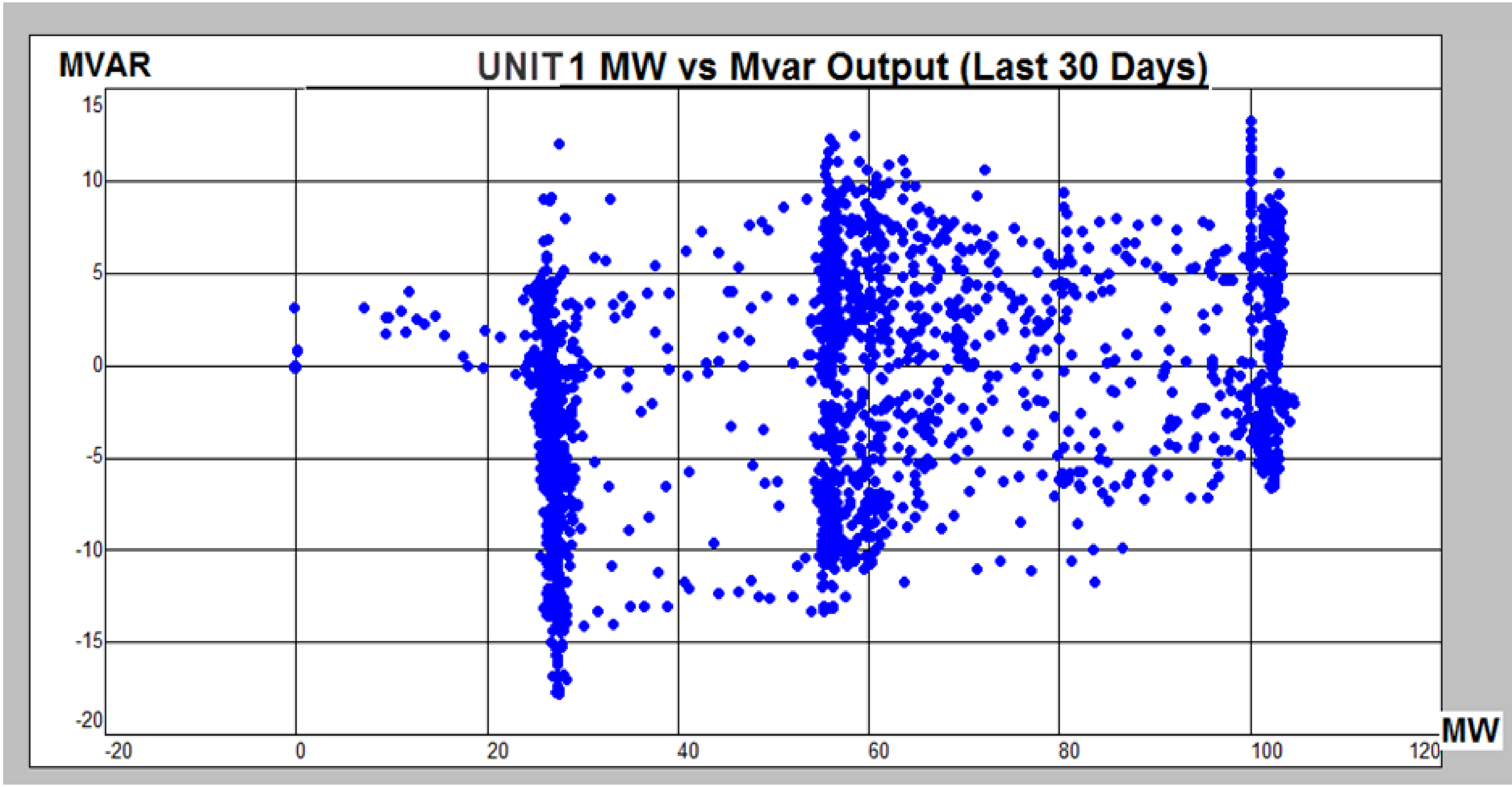
Information Management (cont'd)

- Sample PI Displays – Transformer Monitoring



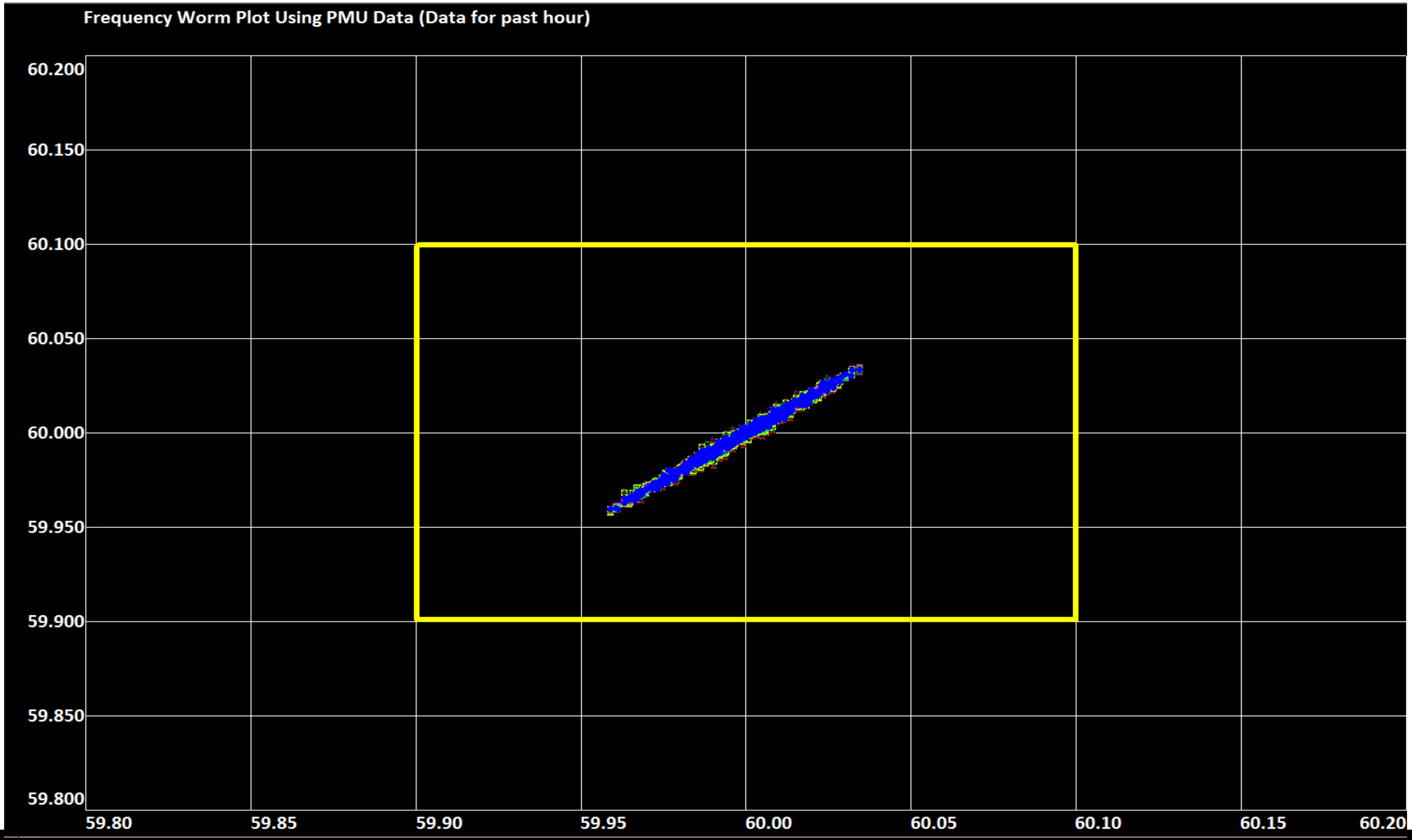
Information Management (cont'd)

- Sample PI Displays – Unit Mvar Capability Tracking



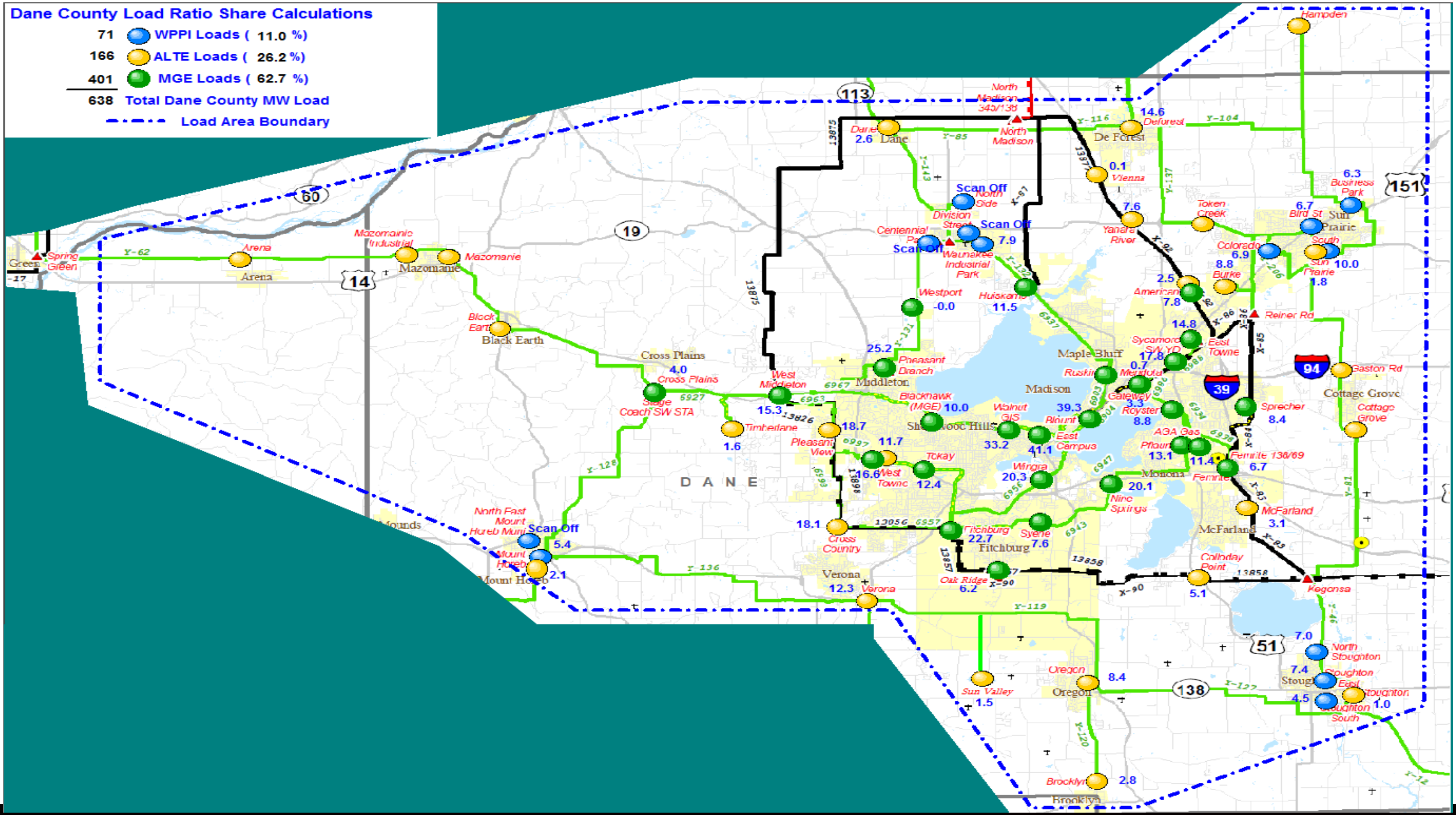
Information Management (cont'd)

- Sample PI Displays – Frequency Worm Chart



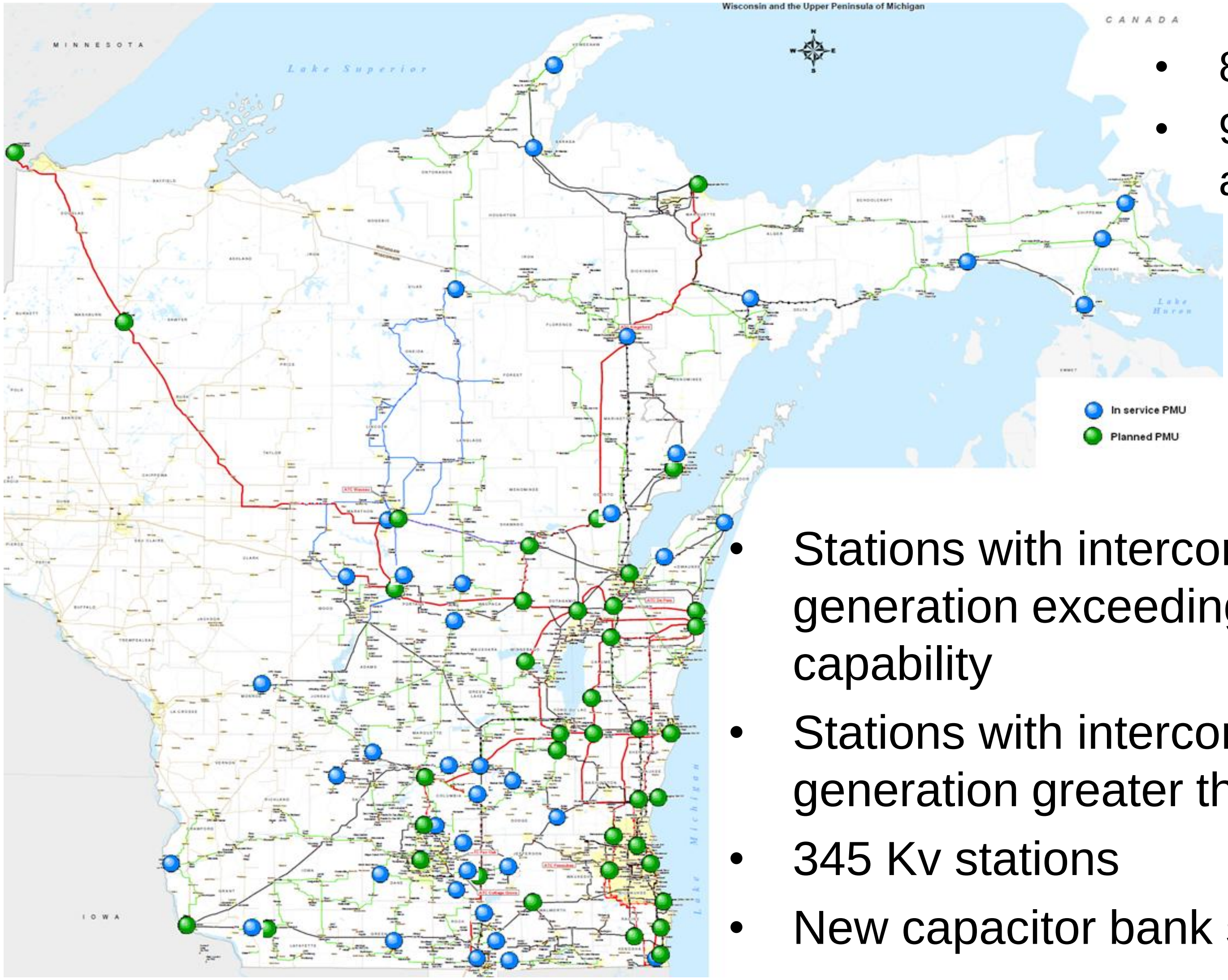
Information Management (cont'd)

- Sample PI Displays – Load Allocation Calculations



Synchrophasor Project

Combined DOE and Legacy Project Map



- 89 PMUs in service
- 900 phasors scanned at 30 sample/sec rate

- Stations with interconnected generation exceeding 200 MW gross capability
- Stations with interconnected wind generation greater than 50 MWs
- 345 Kv stations
- New capacitor bank sites

Synchrophasor Project (cont'd)

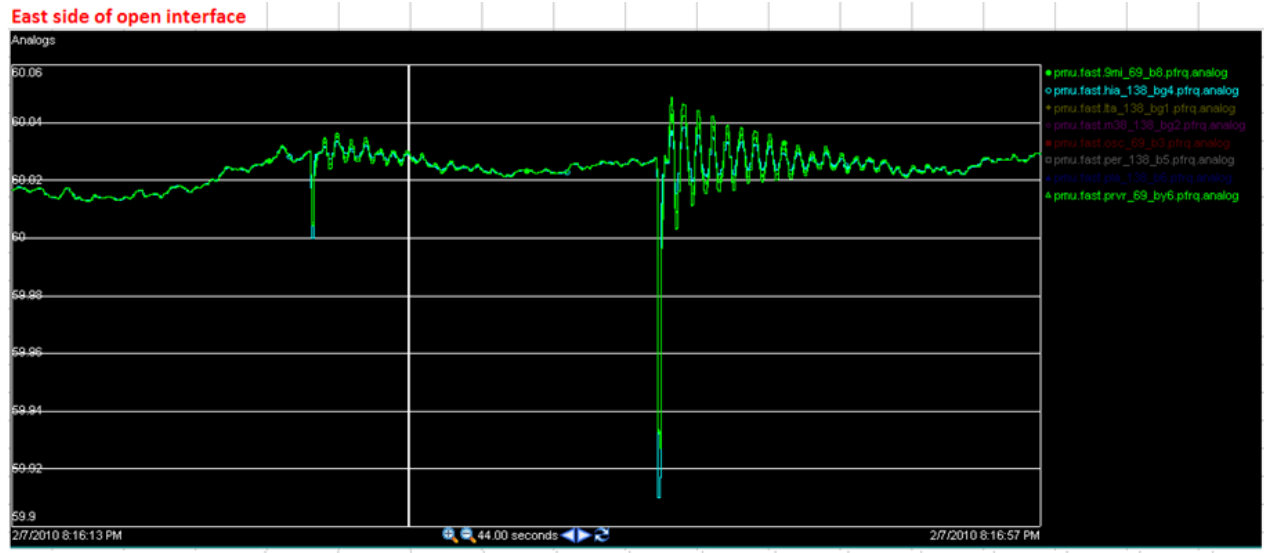
ATC Data Examples

Frequency *Oscillations during system* separation of our Upper Peninsula [UP] of Michigan system

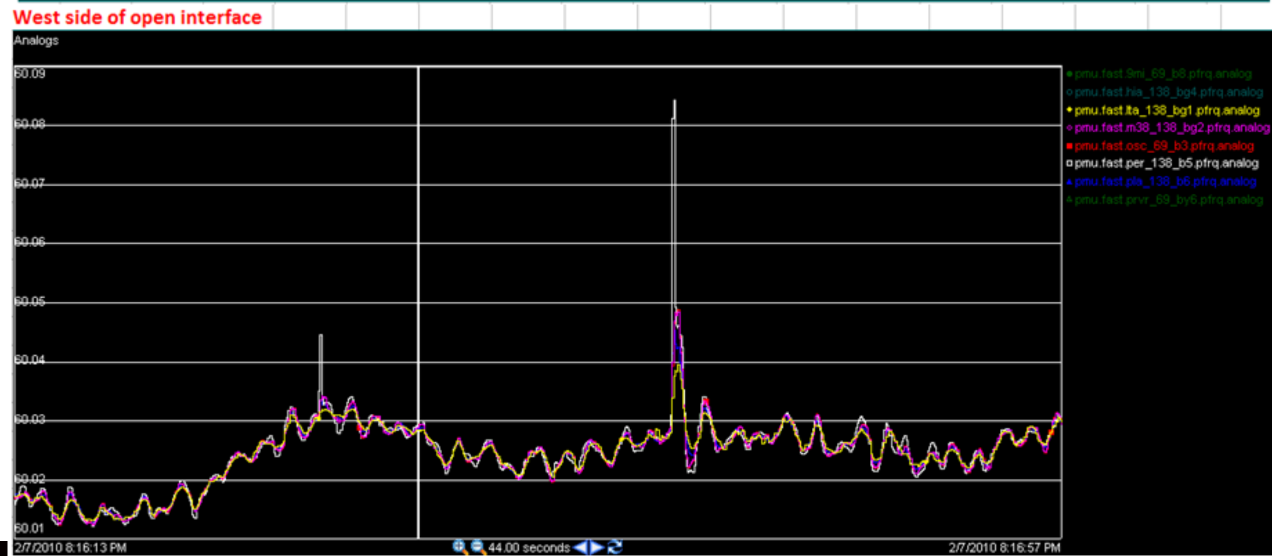
Synchrophasor Project (cont'd)

ATC Data Examples

East side frequency drops from ~60.03 Hz to ~59.91 Hz. Oscillations around EI system frequency occur for ~ 7 seconds

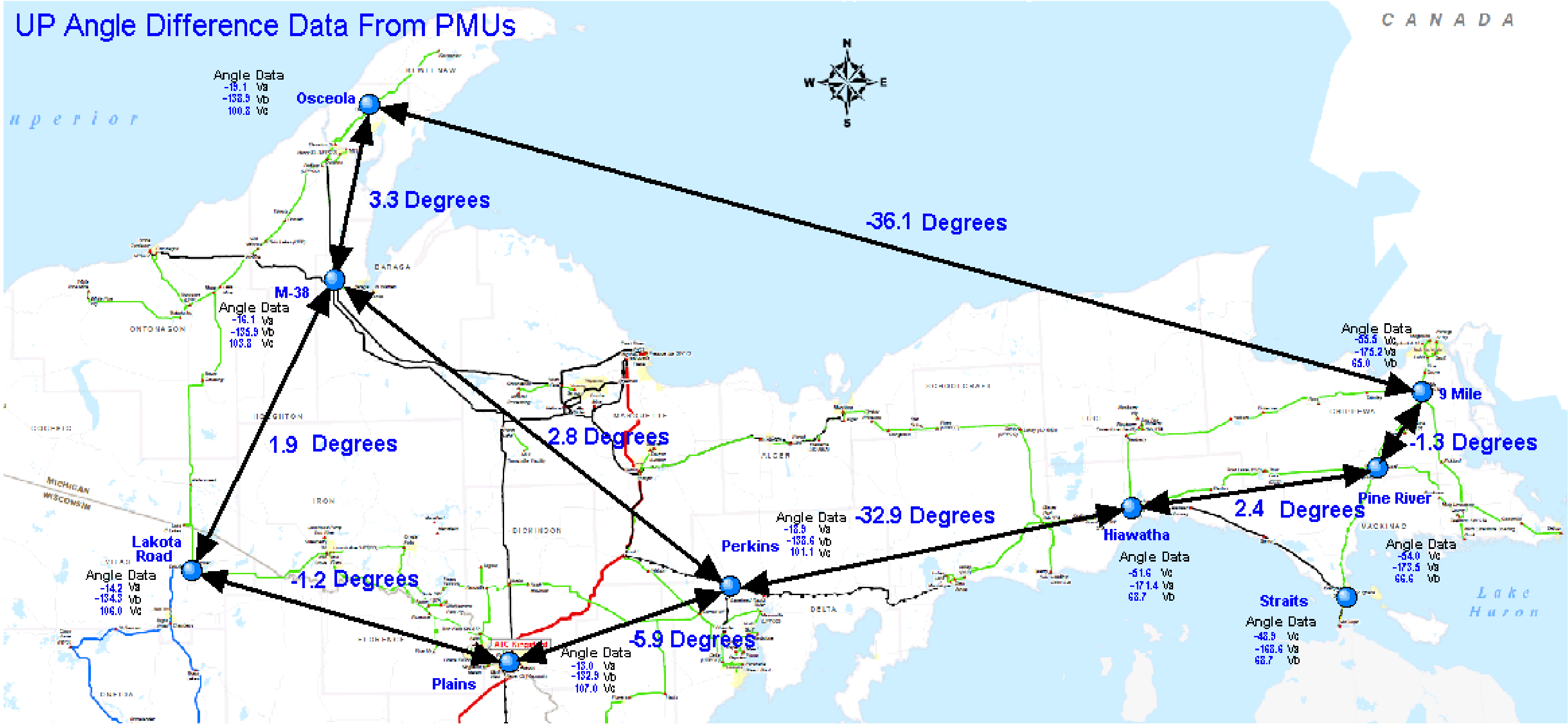


West side frequency rises from ~60.03 Hz to ~60.09 Hz. Oscillations gone within one second.



Synchrophasor Project (cont'd)

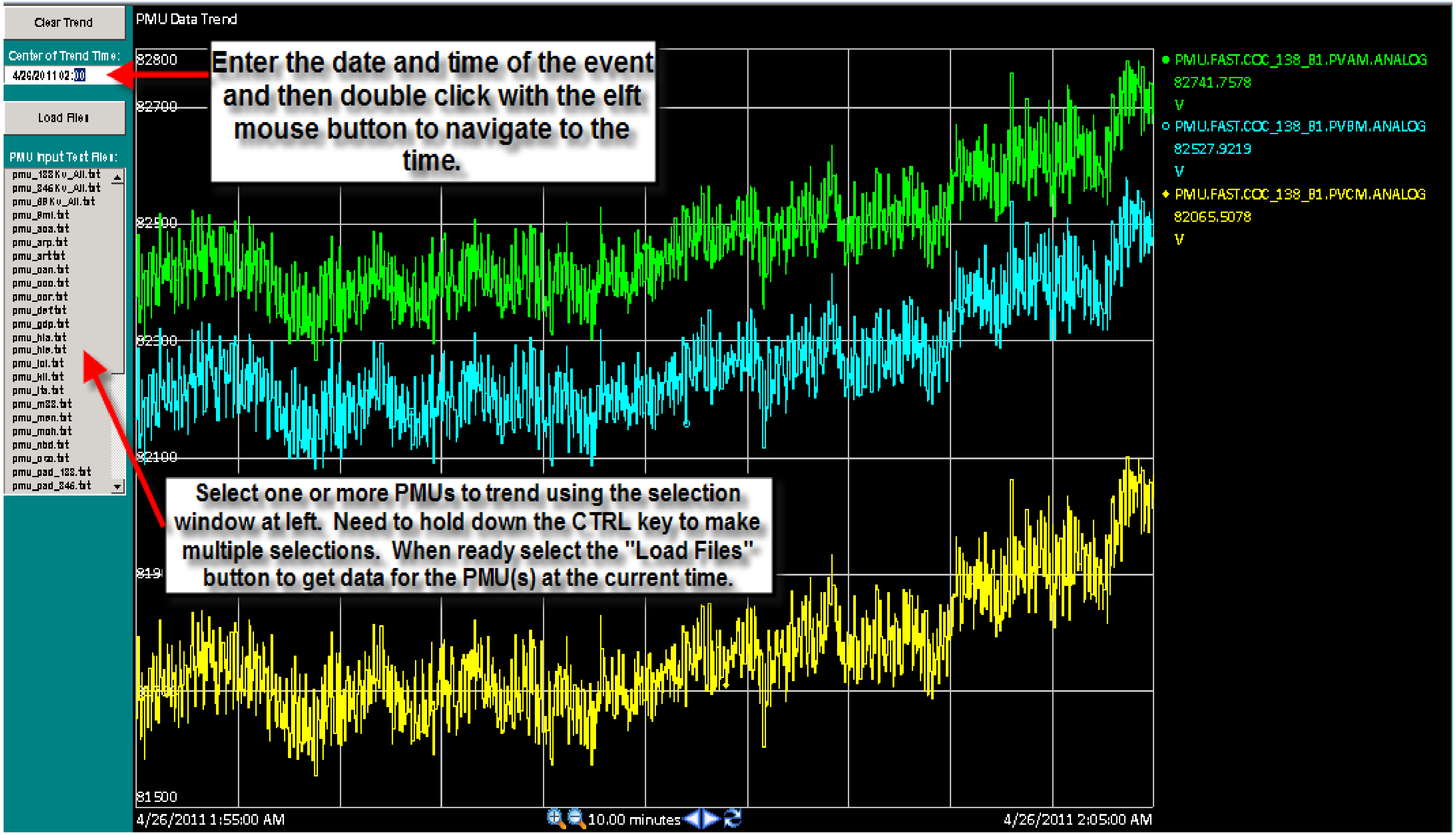
ATC Data Examples - Wide Area phase angle monitoring display



PI ProcessBook display could be used to monitor the difference in phase angles across a pre-defined system. In this example the UP is split and the phase angle across the split is around 35 degrees.

Synchrophasor Project (cont'd)

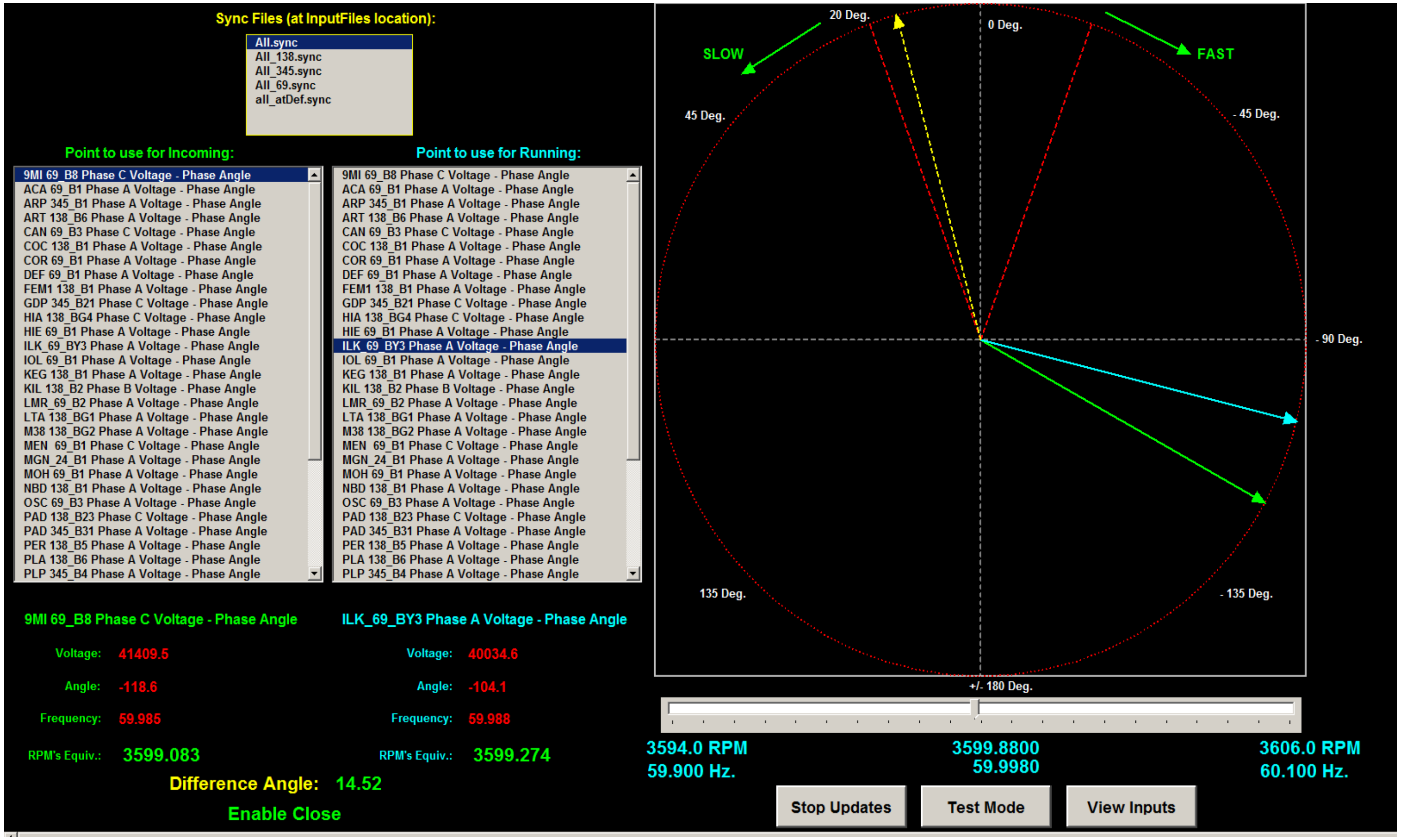
ATC Data Examples - PMU phase voltage data



PI ProcessBook display could be used to display phase voltage data for one or more PMUs.

Synchrophasor Project (cont'd)

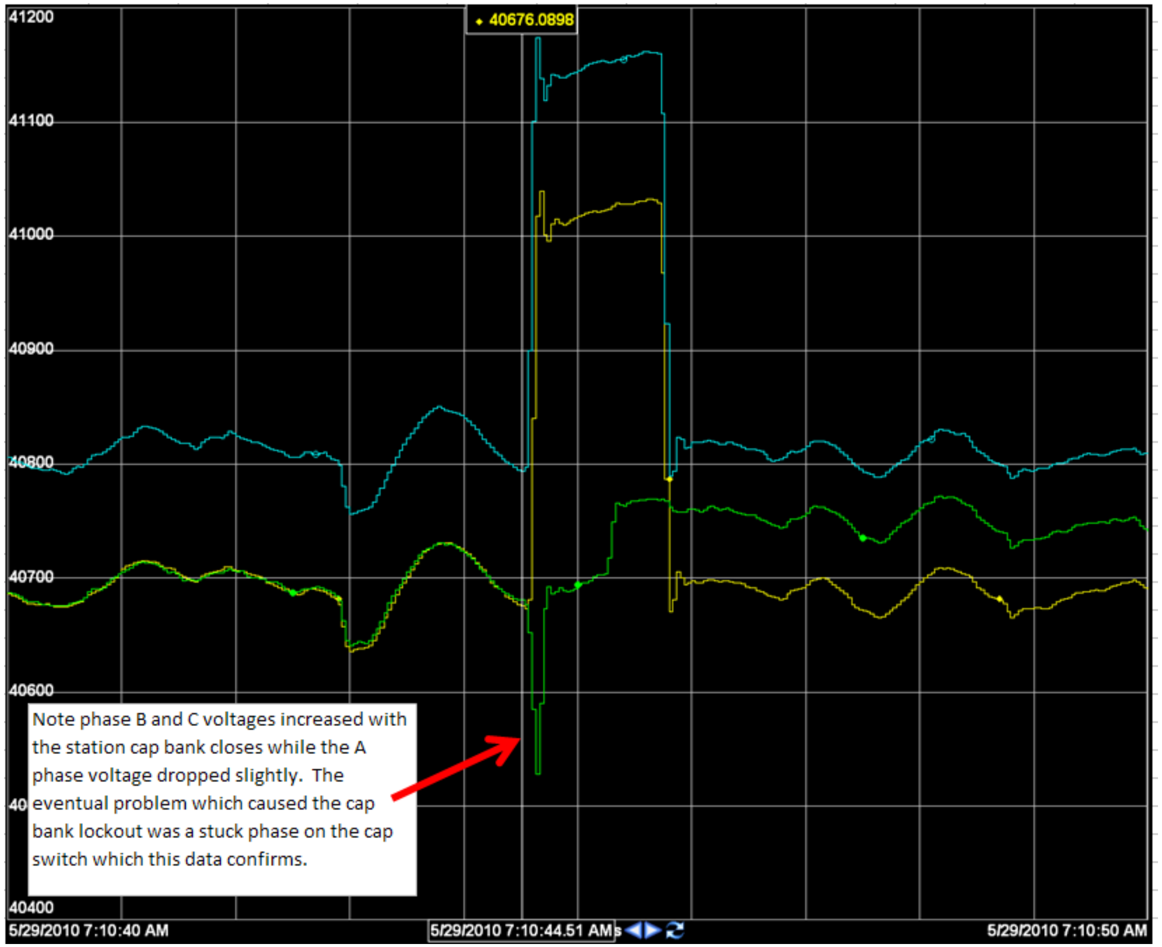
ATC Data Examples - Island monitoring display



PI ProcessBook display can be used to monitor the difference in phase angles between two sites. The chart at right is trending data from the 9 Mile sub in the eastern UP [cyan trace] against the Indian Lake substation in the central UP [green trace]. The yellow dashed trace is the angle difference between the two. This could potentially be used for reconnecting electrical islands.

Synchrophasor Project (cont'd)

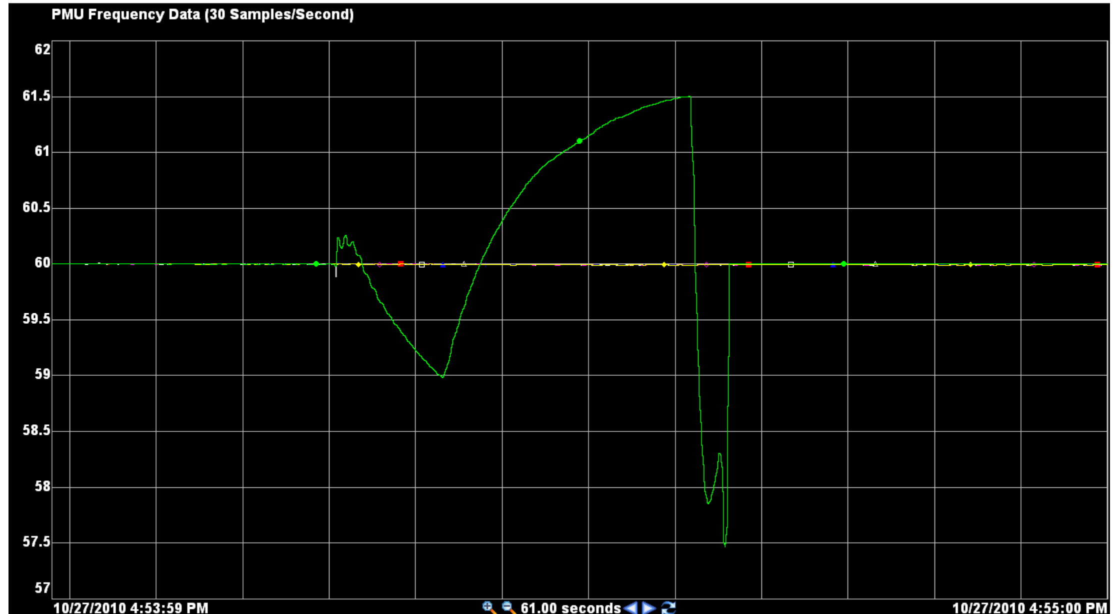
ATC Data Examples

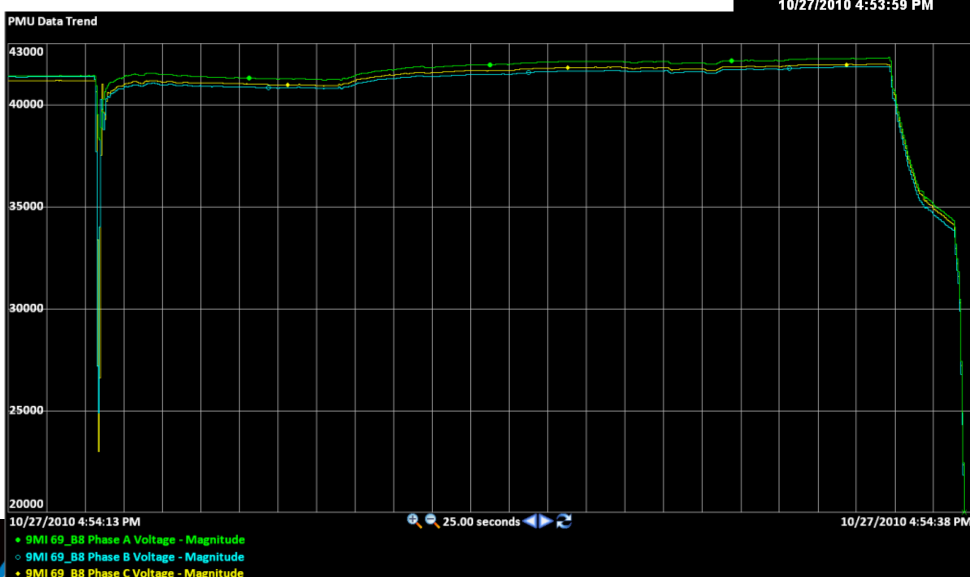


Voltage traces from a nearby station could have been used to identify a stuck phase on a cap bank switch that was closed in and eventually tripped back out.

Synchrophasor Project (cont'd)

ATC Data Examples - Eastern UP Islanding Event



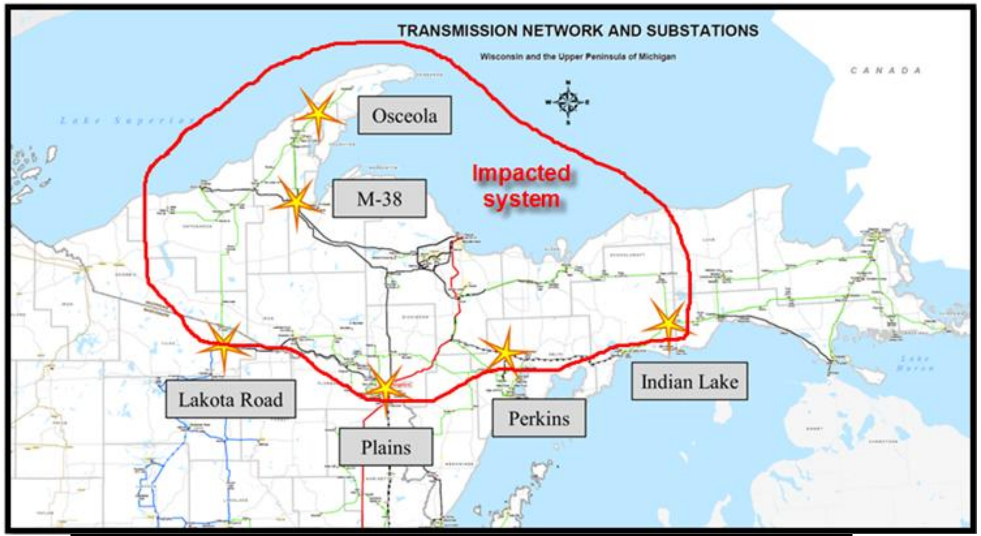


The island only existed for about 25 seconds. If the island had stabilized we could have monitored frequency and voltage using synchrophasor data.

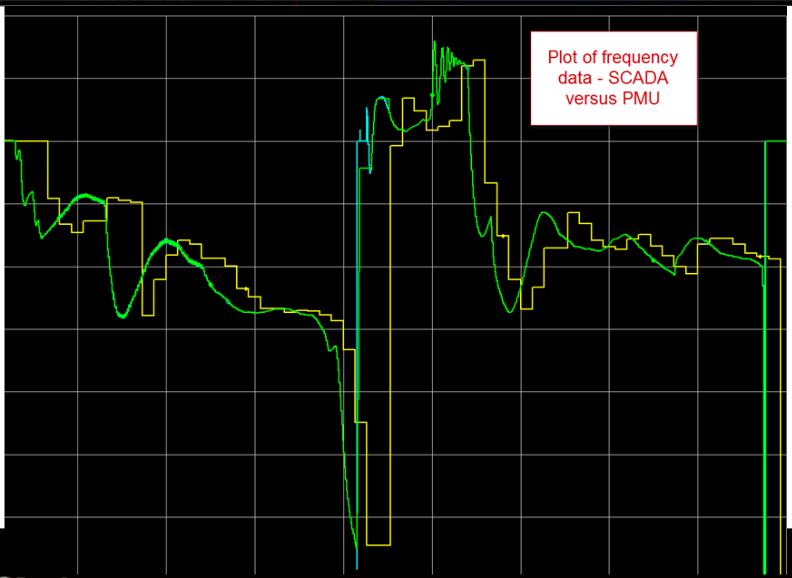
Synchrophasor Project (cont'd)

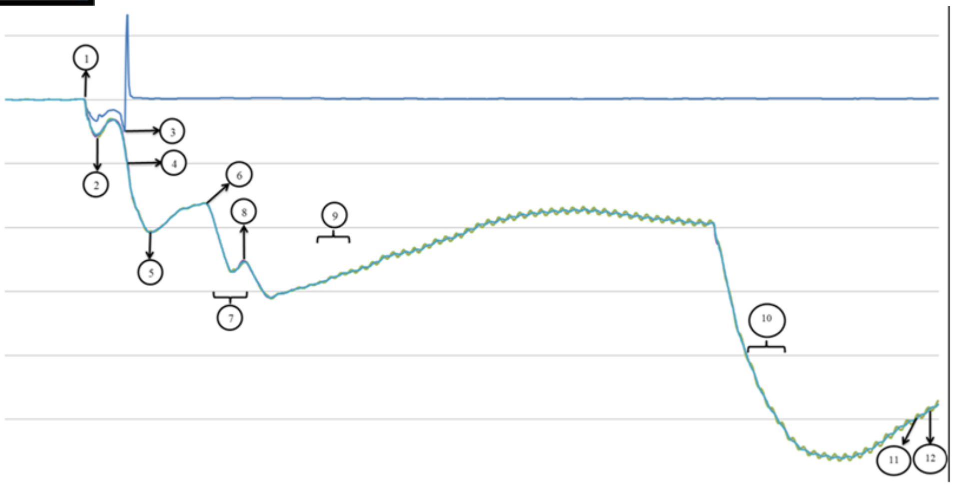
ATC Data Example

Post event analysis - 5/10/2011 event example



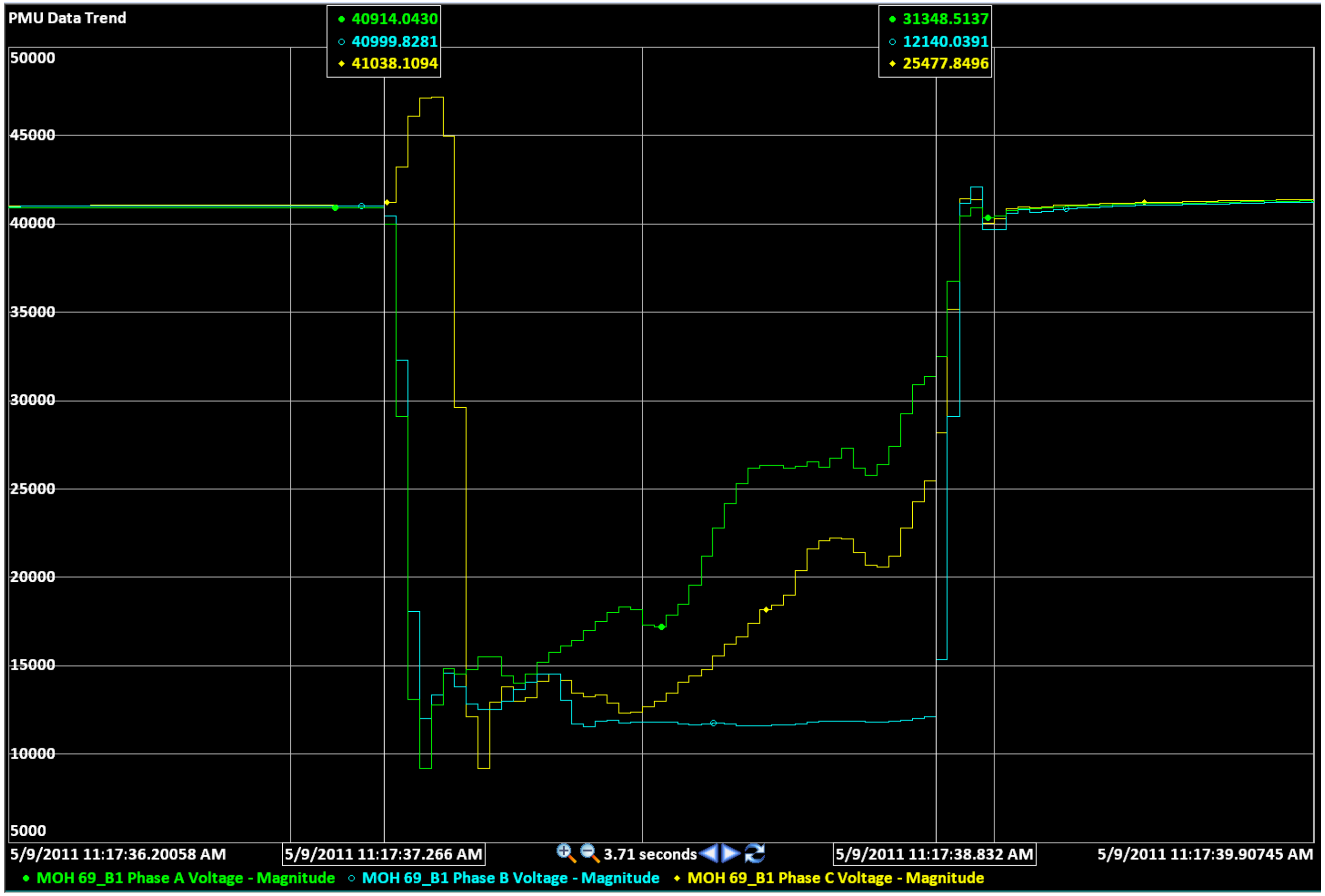
- PMU data was available from 4 sites within the island that was formed.
- Helped analysis team correlate unit trips and load shedding to synchronized time from PMUs.
- Frequency charts shown below:





Synchrophasor Project (cont'd)

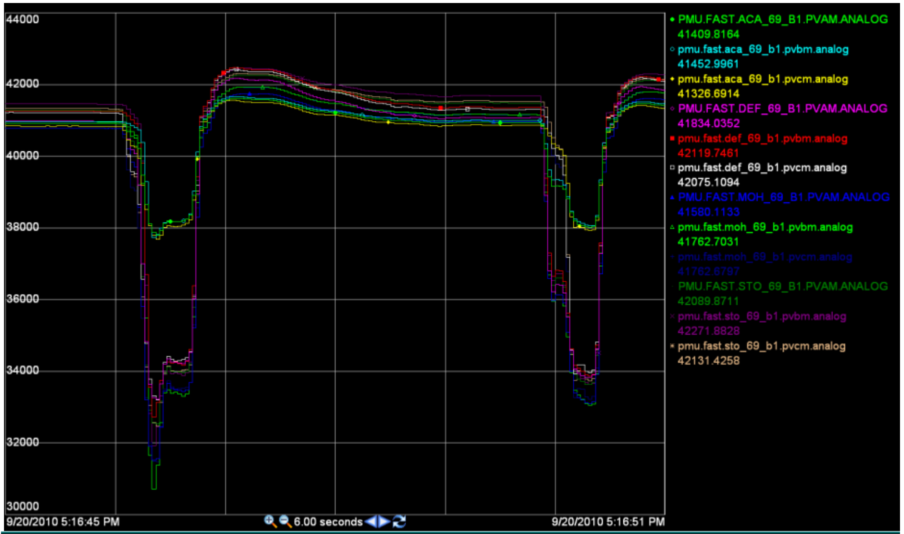
ATC Data Examples

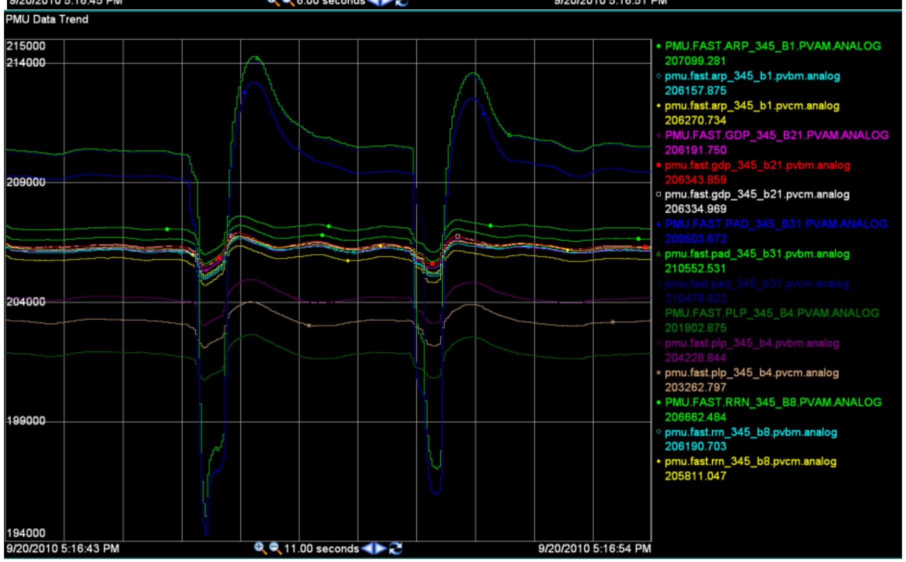


Voltage traces from a PMU located close to a line trip helped identify a slow breaker trip that was eventually traced back to a dirty breaker contact. We would not have seen this misoperation without the PMU data.

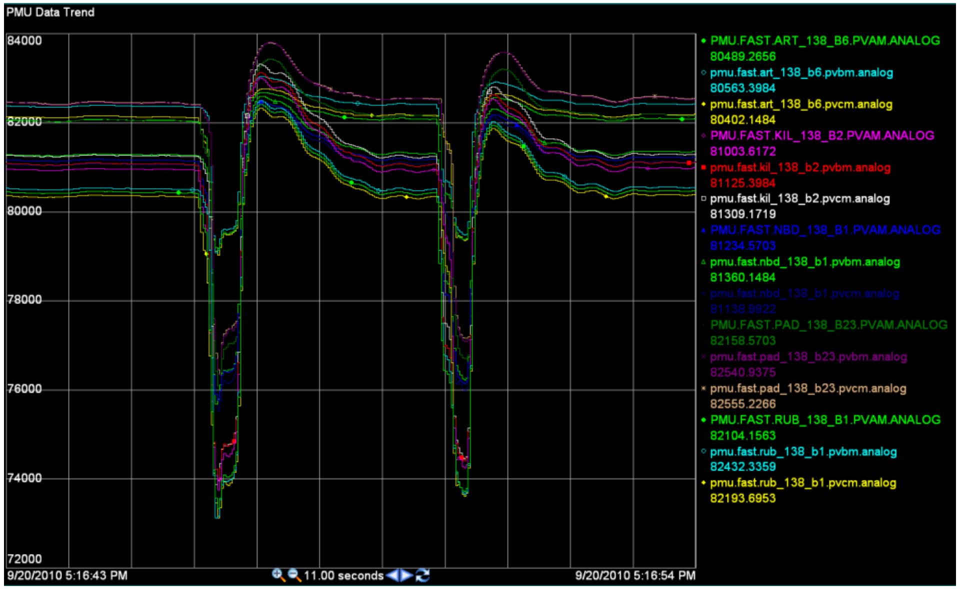
Synchrophasor Project (cont'd)

ATC Data Examples - Impacts of a 3 phase fault on Madison 69 Kv system





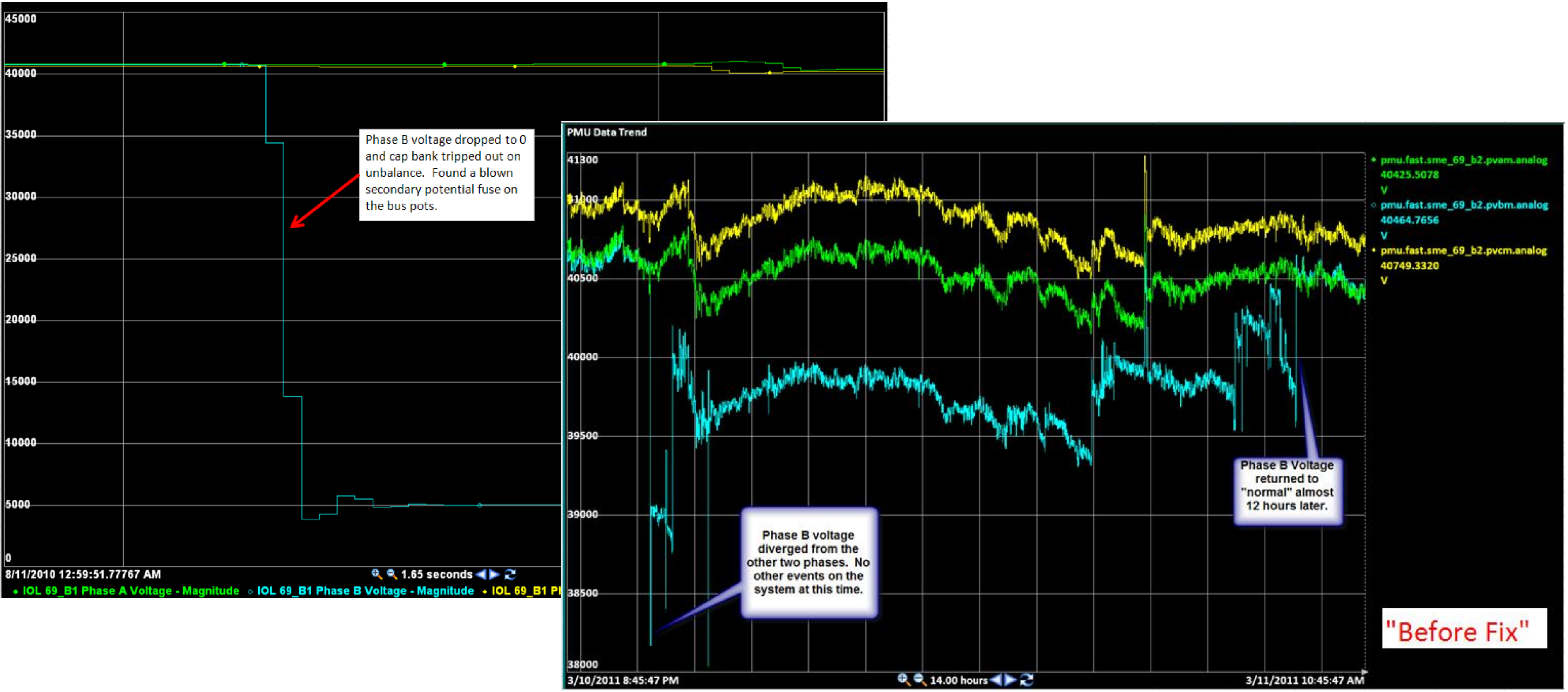
PMUs allow time synchronized view of the impacts of an event across the system



The effects of this fault were seen on the 138 Kv and 345 Kv traces from PMUs across our footprint.

Synchrophasor Project (cont'd)

ATC Data Examples - Voltage Issue Identification

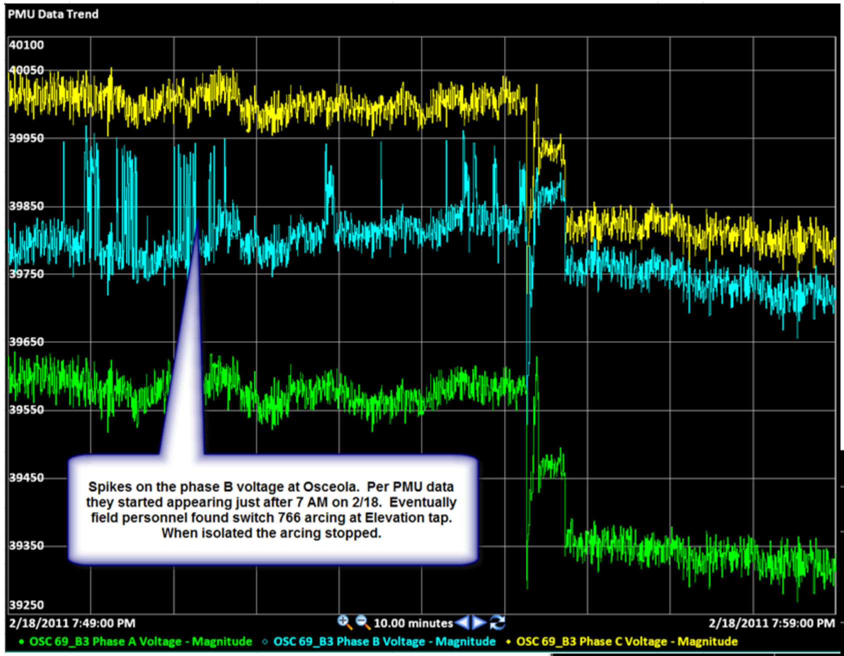


Anomalies in voltage trace data can be used to determine when there are issues with the voltage inputs used for relaying. If caught early we may be able to prevent relay misoperations due to PT fuse failures.

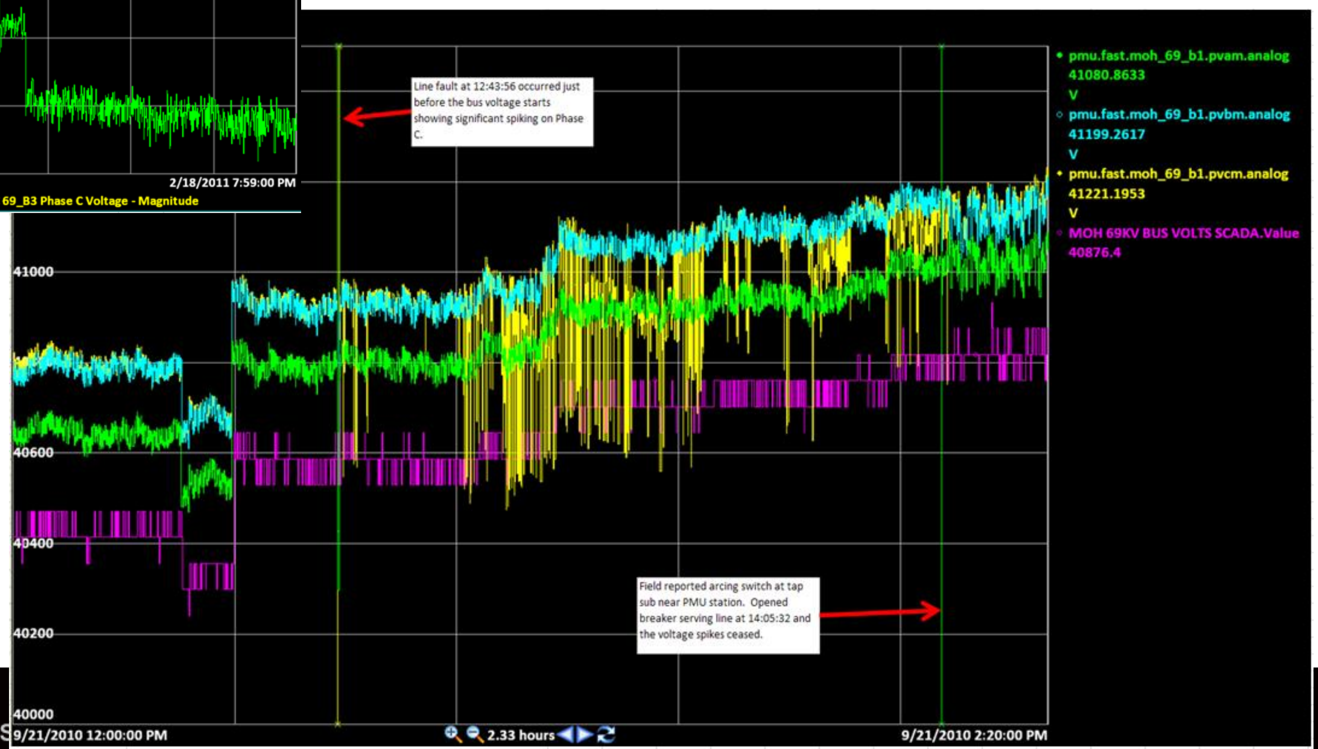
OSIsoft. Empowering Business in **Real-time.**

Synchrophasor Project (cont'd)

ATC Data Examples - Arcing switch identification

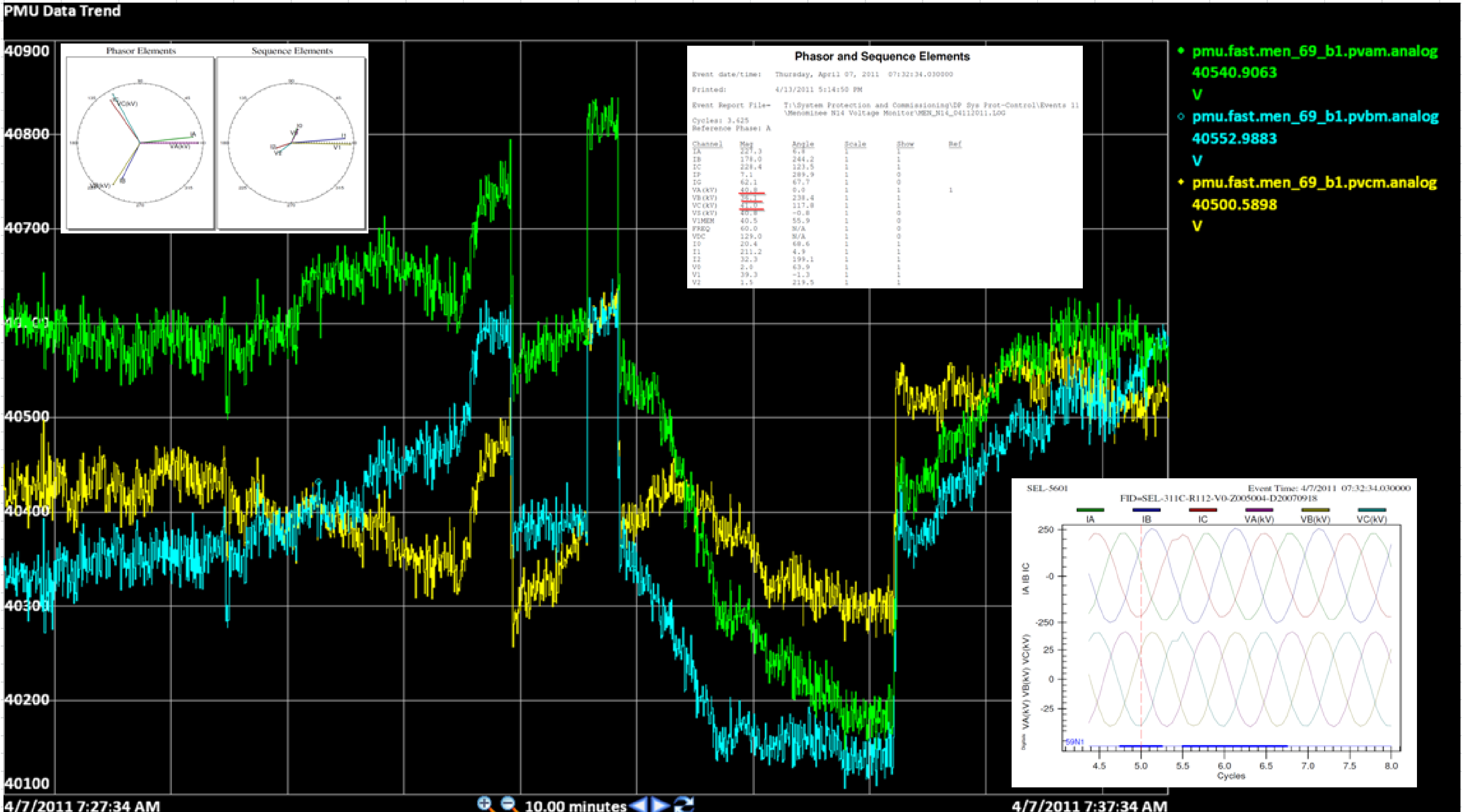


We've had two separate events where a voltage trace was displaying noise/spikes that were eventually traced back to an arcing switch.



Synchrophasor Project (cont'd)

ATC Data Examples - Voltage Unbalance Monitoring



We have been observing odd voltage behavior at the Menominee substation due to a foundry load located nearby. We are using SEL triggers to identify when unbalances occur and then using PMU data to help analyze the events.

Thank you for this opportunity to present.

jkleitsch@atcllc.com

3.

OSIsoft WAMS

Ann Moore-OSIsoft

WAMS/Synchrophasor Initiative

- 2009 US funding for SGIG demonstration projects
- DOE committed to accelerate the use of PMU data
- Total about $300 million
- Originally total of 800 PMUs now over 1,000 PMUs
- DFR (Digital Fault Recorder) or protection relay device generating synchrophasor data
- For Distribution
- For Renewable (wind, solar) and generation connection or integration to grid
- For Distributed Generation and Microgrids, etc.

Standard PI Infrastructure Components for WAMS

- PI Server
  - PI Asset Framework (PI AF)
    - PI Event Frames (formerly PI Batch)
    - PI Notifications
  - PI ACE (Advanced Computing Engine)
  - PI Data Access
- PI C37.118 Interface
- PI INT-FFT
- PI Clients
  - PI ProcessBook
  - PI DataLink
  - PI WebParts
  - PI Coresight

WAMS Analytics

- Two non-standard interfaces available on TechSupport site
  - PI IEEE C37.118 (PI-IN-OS-C37.118-NTI)
    - Raw PMU data
  - PI FFT (Fast Fourier Transform) (PI-IN-OS-FFT-NTI)
    - A PI Test Server needed for FFT
    - Compute FFT of unwrapped angle/frequency differences
    - Several window widths are required to pick up events of interest
    - Compute damping coefficients at each mode
- “PMU Simulator” available
- “Phasor Calculation
  - Unwrap discontinuous voltage angle (± 180)
  - Compute differences for:
    - Unwrapped angles
    - Frequencies
- PI FFT (product) and “Phasor Calculation” (including “Unwrap Angle” and “Angle Difference”) available as analytic tools on vCampus

Performance and Scalability are essential.

4.

OSIsoft/Dell Collaboration at Dell Solution Centers

Ann Moore-OSIsoft
Rick Reeder-Dell

Dell Press Release and Articles

Dell Official Press Release:

- http://content.dell.com/us/en/enterprise/d/secure/2012-10-01-dell-smart-grid-data-management.aspx
- http://content.dell.com/us/en/enterprise/d/large-business/dell-smart-grid-data-management-solution.aspx
- http://content.dell.com/us/en/enterprise/d/videos~en/Documents~smart-grid.aspx.aspx (video)

Article:

- http://www.greentechmedia.com/articles/read/dell-and-osisoft-build-smart-grid-platform-for-synchrophasor-big-data
- http://www.renewgridmag.com/e107_plugins/content/content.php?content.9006 (Dell Rolls Out Smart Grid Data Management Solution)

Background (Nov. 2011)

- One PI System customer, an SGIG utility recipient requires optimal hardware and reference architecture
- To test/run a POC in Dell Solution Centers (DSC) in Austin
- Objectives:
  - Determine quantitative speeds for typical data mining queries of large databases containing high sampling rate data
  - Validate PI Server 2010 and further test PI Server 2012 - alpha
- Technical Outline:
  - Dell to establish multitier disk storage system consisting of SSD and multiple types of HDD. Total volume is expected to be 50 TB. The tiers might be organized as follows: daily, weekly, monthly, yearly. Six high end servers will be required (PI Server Compressed, PI Server Uncompressed, PI FFT Server, Interface Server, Simulator Server, SharePoint PI WebParts).
  - Dell to establish accurate clocks on all servers (accurate to better than 1 mS, preferably better than 1 microsecond (GPS clock and IEEE 1588 software)

Dell Solution Centers Overview

- 12 Centers Worldwide
- “Trusted Advisors” – to quickly address your most complex business challenges
- No charge – a free Dell Service
- Single point of contact into all relevant areas of Dell

DSC Footprint – 12 Centers and 2 Satellite locations

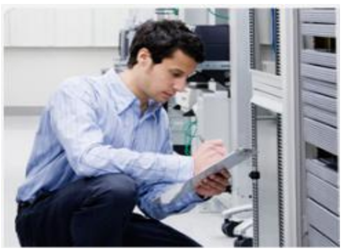
- Highly **scalable infrastructure, labs** all **connected** via a new **global network**
- Core **domain/product experts** supporting **customer use-cases**
- **Local Market** focused**,** standardized **global tools** and **processes**
- Integrated with **PG/Domain** teams for complex product requirements
- Solution **Showcase/Demo's** in every DSC, including demos.dell.com - "Living Lab" of Dell's products and solutions
- Ease of **access** for **customers** and teams. **Physical** and **Virtual**

What do the Dell Solution Centers offer?

Build

Engage

Integration



- Vertical/use-case Solution integration, test and validation.
- Use-case specific Reference Architectures
- Partner Certifications

Dell Demo Portal

- Range of Solutions & Enterprise demos
- On-Line and Simulator
- Available to customers via Account teams

Briefings

- Technology overviews
- Solution updates and presentations
- Virtual & Physical
- Collaborate with Dell Solution Architects

Architectural Design Sessions

- Customer use-case focused
- Whiteboard sessions
- Architectural design sessions
- Prelim Solution Design

Proof of Concept

- Customer “hands-on” experience, your requirement on our solutions.
- Enterprise proof of concept
- Validation and benchmarking

5.

PI Server 2012

Jay Lakumb-OSIsoft

PI Server Metrics

	2012	2010	Delta
Max Point Count	20M+	2-3M	5-10x
Startup Time	<30 sec/Mpts	>10 min/Mpts	20x
Point Creation	500-2K pt/sec	<100 pt/sec	5-200x
Tag Searching	Linear	Non-Linear	N/D
Max Update Signups	10M+	<200K	50x
Update Signup Rate	>100K/sec	<2K/sec	50x
Data Out (Archive)	>10M ev/sec	<1M ev/sec	10-20x
Data In (Snapshot)	>1M ev/sec	<200K ev/sec	5-10x
Data In (Archive)	>500K ev/sec	<100K ev/sec	5-10x
Archive Shifts	<10 sec/GB	>1 min/GB	6-12x
Online Archives	>50K files	<10K files	5-10x
Backup Speed	<1 min/GB	>5 min/GB	5-10x
Offline Reprocessing	30 sec/GB	>15 min/GB	30x

OSIsoft/Dell Benchmark Testing

- Joint testing during Q3 2012 at Dell Solution Center
- PI Server 2012, C37.118 Interface with PIBufss
  - 2-node PI Collective, 9 PI Interface nodes
  - Simulation tools for reading/writing PMU data
- Dell PowerEdge Server
  - 4 x R720 Servers, 2 x Intel Xeon 2.90GHz, 192GB RDIMM
  - 2 x 300GB SAS SCSI, 4 x 350GB PCIe Flash Drives
  - Intel 10Gb NIC, QLogic 8Gb Optical Fibre Channel
- Dell Compellent SAN
  - 24x200GB SSD, 24x15K 300GB SAS, 12x7.2K 2TB SAS

OSIsoft/Dell Benchmark Conclusions

- Write Throughput
  - Distributed across PI Interface nodes for performance
  - C37.118 + PIBufss = 57K EPS sustained data rate
  - Archiving rate = 500K EPS with all server-grade storage
- Read Throughput
  - Sustained = 15M EPS on Flash drives with 31K IOPS
  - Cached data = 20M EPS exhausting 16 CPU cores
- Overall Scalability
  - Additional CPU/RAM would increase read throughput
  - Linear scale out of read workload across PI HA nodes
- Technical Whitepaper
  - PI Server 2012: *Smart Grid High-Speed Data Management on Dell Reference Architecture*
  - *Available at OSIsoft.com → Resources → White Papers*

6.

Conclusion

Ann Moore-OSIsoft

PI System-based WAMS Advantages

- Production Grade Solution
- Performance and Scalability
- Security via a defense in depth architecture
- High availability with interface and PI HA collectives
- Maintainability using model-based PMU/signal registry
- Standards based interoperability
- Model driven data access environment

OSIsoft WAMS Technical Consultation

- Team:
  - Industry: Ann Moore (Main Contact)
  - CoE (Center of Excellence): Matt Heere
  - Advisor: Chuck Wells
  - Field Service: Danilo Ribeiro and Bruno Bachiega

- Consideration:
  - How many PMUs
  - How many times/scans per second
  - How many measurements per PMUs
  - FFT (Fast Fourier Transform) requirements
  - Compression and Exception requirements
  - Architecture requirements
  - Analytics, notifications and visualization requirements
  - Hardware/storage/network bandwidth, etc.

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7.

Q&A

Thank you

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