American Transmission Company

Smart Grid Investment Grant Update

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ARRA disclaimer

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Project participants

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- University of Illinois (Champaign-Urbana)
  - PMU Data Quality Study
    - Karl Reinhard
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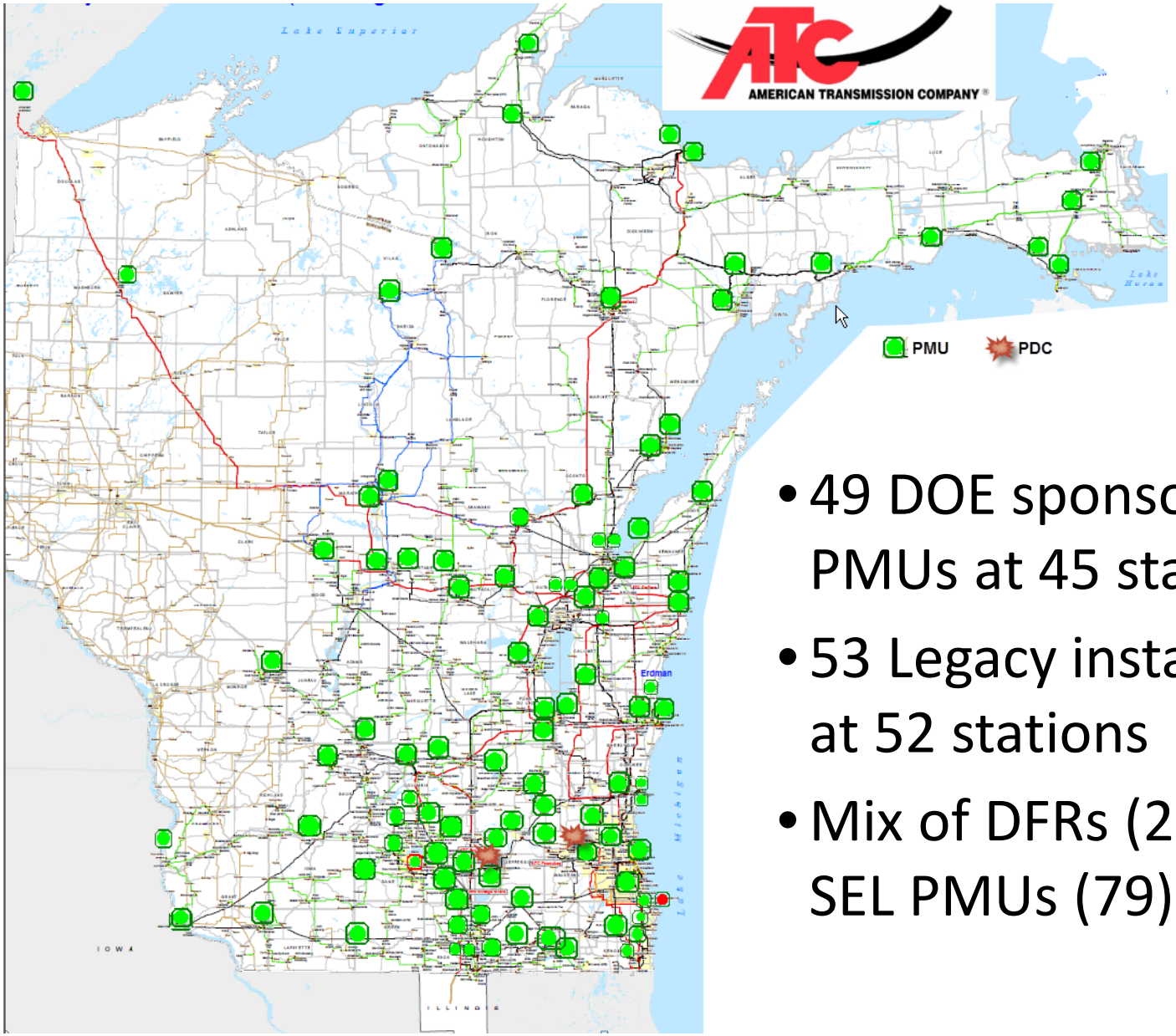
Project Map (As Of 10/17/2013)



- 49 DOE sponsored PMUs at 45 stations
- 53 Legacy installations at 52 stations
- Mix of DFRs (23) and SEL PMUs (79)

BIG PICTURE

Project Priorities From Here?

- What are the most important tasks and applications ahead for your project?
  - ✓ Transition the applications we already have (PhasorPoint, ETV, etc…) from our development system to our production environment.
  - ✓ Work to increase buy in from Operations and other departments (Planning, System Protection, etc..)
  - ✓ Develop and implement tools to mine the data to identify abnormalities versus using system events to trigger the use of the data. (We'll never catch events before they happen if we don't have tools looking for the needles in the haystack)

Project Priorities From Here? (cont'd)

- How are phasor data applications being used (or will be used) in your control room?
  - ✓Data is available to operations via PI ProcessBook displays. Some use by operations engineering group but not the real time desk.
  - ✓Working to integrate alarms and data flows from PhasorPoint to EMS to identify when there is value using the tool.
  - ✓Considering the use of Alstom eterraVision as a single source for wide area visualization.

Project Priorities From Here? (cont'd)

- How are phasor data applications being used (or will be used) by your planners?
  - ✓Data from "odd" events being routed to planning personnel to determine if observed system behavior is expected based on existing models.
  - ✓No formal process in place to initiate a model review for system events at this time.
  - ✓Looking at ways to get plant specific data to the generator owners to help improve our unit model information.

Project Priorities From Here? (cont'd)

- What outcomes will mean success for this project by the end of 2015?
  - ✓Synchrophasor data based displays and applications will be routinely used by real time operations personnel to operate the system. (One more tool in their toolset and not a replacement for existing tools.)
  - ✓Planning and operational models being routinely reviewed (and updated when needed) based on the data.
  - ✓Other departments noticeably agitated when data is not available.

Project Priorities From Here? (cont'd)

- What key obstacles stand in the way or what problems need to be solved to achieve these outcomes?
  - ✓Applications need to be shown to provide real value to the operations group that they cannot derive from SCADA to get buy in
  - ✓"Easy Button" tools need to be implemented to make the comparison of dynamics model results and PMU event data.
  - ✓Ongoing education and training needed for those who can derive value from the data to increase usage

Success Stories So Far

Name and explain “three” significant accomplishments or benefits achieved to date from this synchrophasor technology project.

- ✓ We used the data to analyze in depth an islanding event on our system. The level of detail we were able to provide on the sequence of events was far beyond anything we could have done with SCADA data alone.
- ✓ We routinely use the data to respond to customer event questions. (voltage dips, etc..) We can now answer with certainty that there was or was not anything happening on the transmission system at the time they were affected.
- ✓ We are identifying normal and odd behavior on our system and are working to explain the odd data (effects of arc furnace loads, generator oscillations, system oscillations after line trips, etc…)
- ✓ Being used as a quick check on system protection device operation. Do faults clear in a reasonable amount of time? Do all three phases open at the same time?

Challenges and Lessons Learned

- What have been your biggest technical challenges?
  - ✓Configuring the data flow was the easy part. Now we need to get better at sorting through the massive amounts of data and deriving information that can help our Operations, Planning, System Protection, … groups do their jobs better.
  - ✓Managing the maintenance side of this new technology has been an issue. Limited number of field support people have a good working knowledge of how the systems function together.

Challenges and Lessons Learned (cont'd)

- What have been your biggest programmatic or execution challenges?
  - ✓Moving the technology from development to production hasn't been as easy as we had hoped. What works in development may not be what's desired in production.
  - ✓Buy in. Buy in. Buy in. As with all new technology we need to "sell" the value. Slowly making headway but work left to do.

Challenges and Lessons Learned (cont'd)

- Research needs – what do we need to figure out next?
  - ✓ It's all about the data now. We have the post event analysis piece down for specific identified events. How do we dig through the mountain of information and find the other events we should know about that may not be obvious?
  - ✓ We need to better understand the different failure modes within our systems to make sure our downstream applications handle things properly.

Synchrophasor Training

- ✓ We have provided training to all system operations personnel at a high level on the technology through our normal cycle training process.
- ✓ Specific application training will be provided to system operations personnel once we have those applications ready for production.
- ✓ All training materials are being developed in house at this time and the training is being delivered by in house personnel.

Project Timeline

- ✓ All hardware installations related to our project are complete. Our last PMU checkout which required a plant outage was completed the week of 10/14/2013.
- ✓ We are adding redundant PDCs and several PMUs under MISO's project and we will have those in service by year end 2013
- ✓ Our PI applications and tools for post event analysis and visualization have been in production for some time. Our PhasorPoint application has been functioning in a development environment for months. We will continue to develop and enhance that system with plans to move to production in 2014.

Phasor Data-sharing

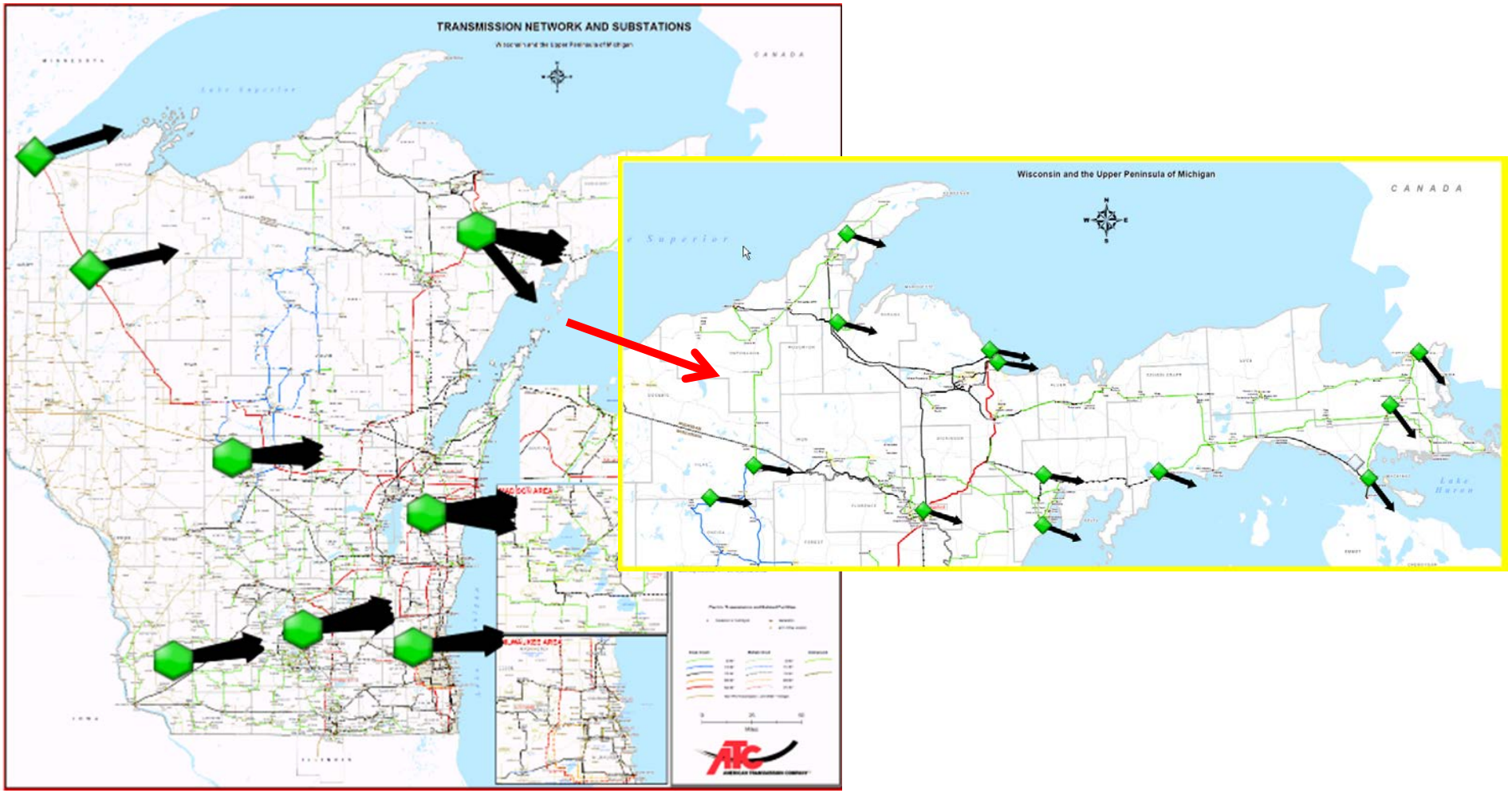
- ✓ We are sharing data from all our PMUs with MISO in real time.
- ✓ We are working with MISO to request data from PMUs that will help us better understand what's happening outside our footprint
- ✓ We do not envision connections to other TOs and RCs at this time under the assumption that we will be able to use MISO as our "data hub"

Phasor Data-sharing (cont'd)

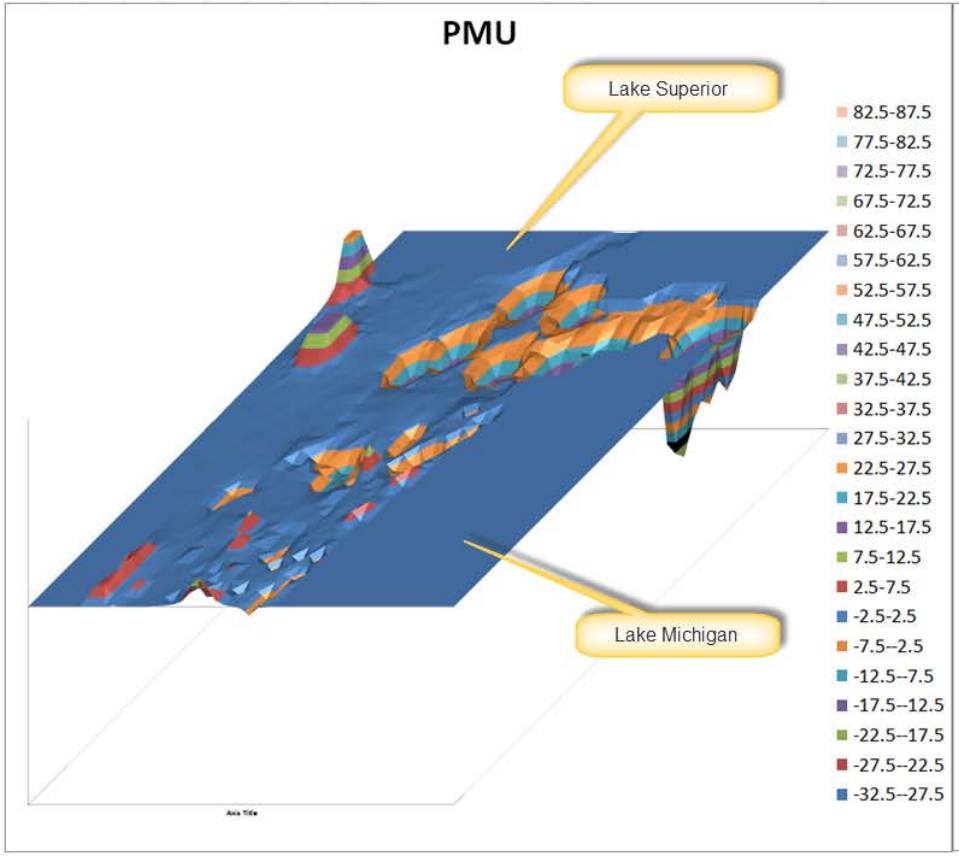
- ✓ We do not share applications output data at this time as we have not identified a need

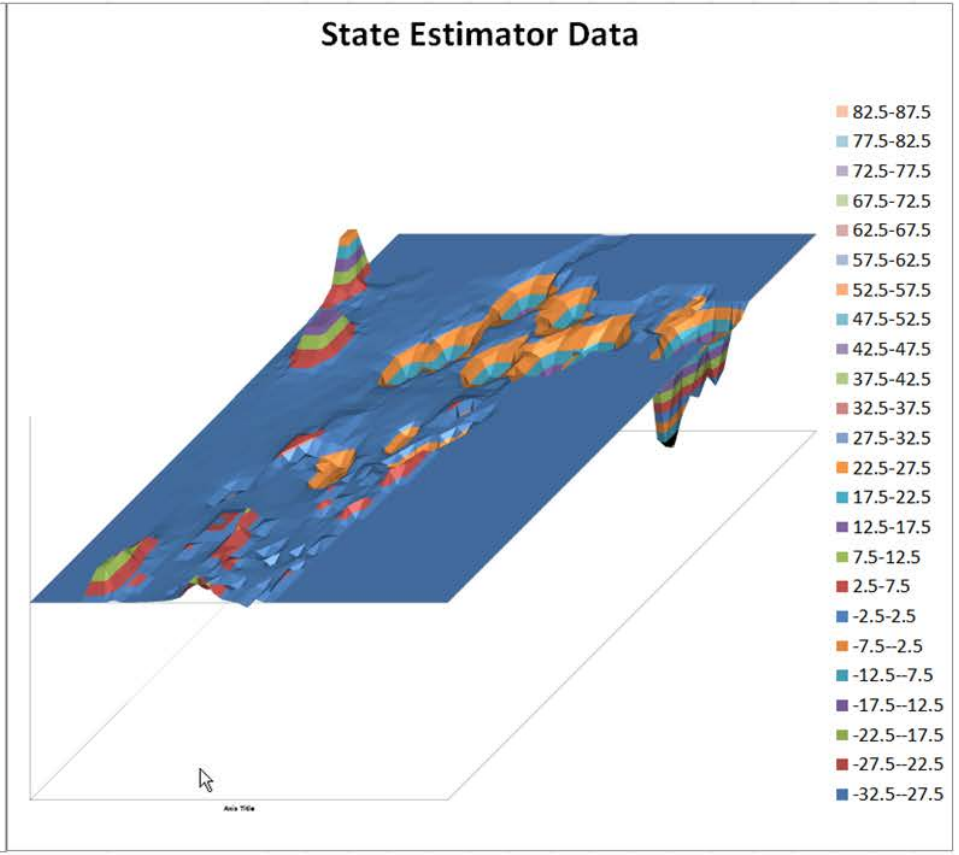
- ✓ Research Projects
  - ✓ University of Illinois [Karl Reinhard]
    - ❑ Synchrophasor data quality study
  - ✓ Michigan Tech
    - ❑ Line parameter estimation

Visualization Displays PhasorPoint



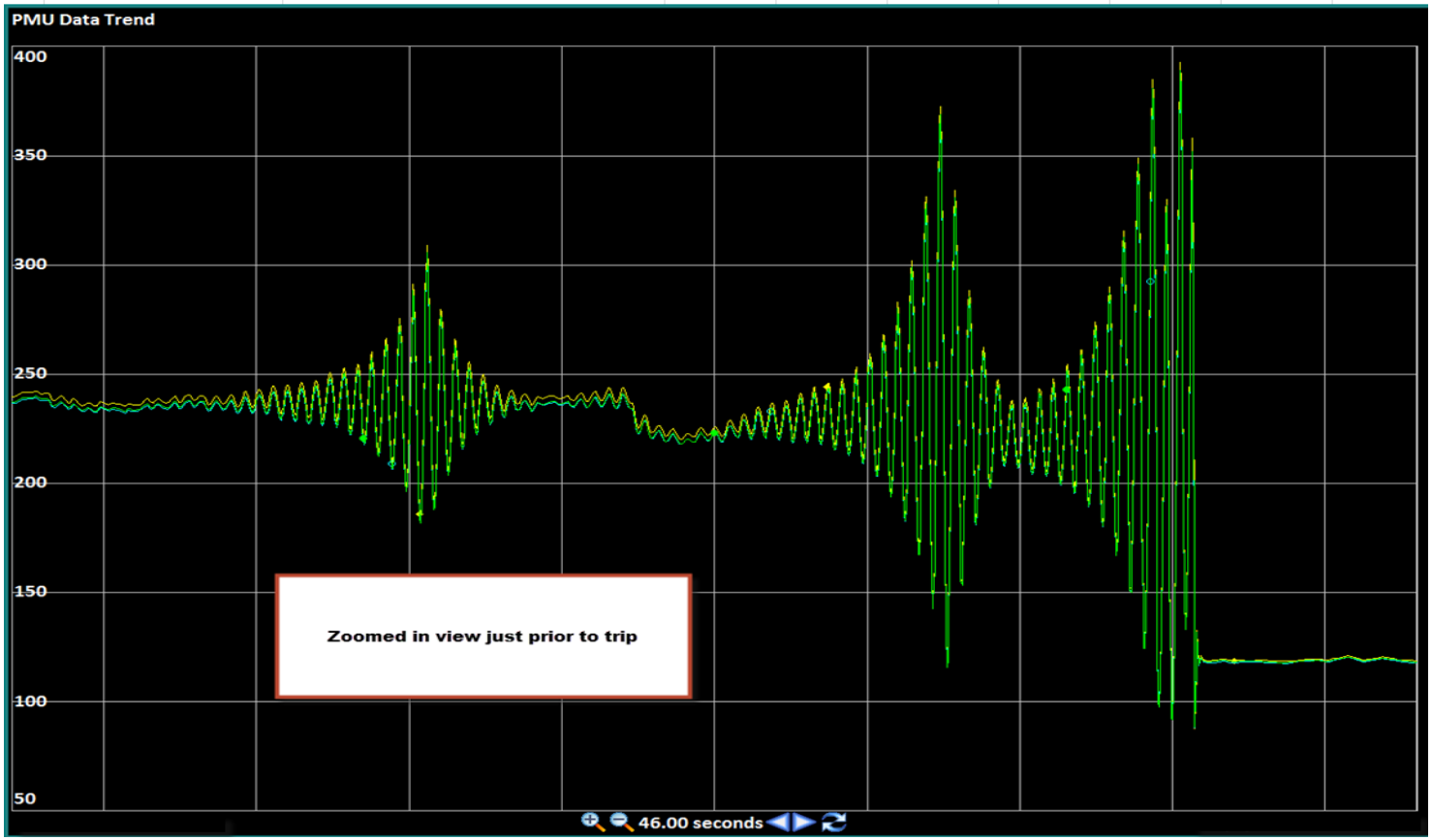
State Estimator Validation





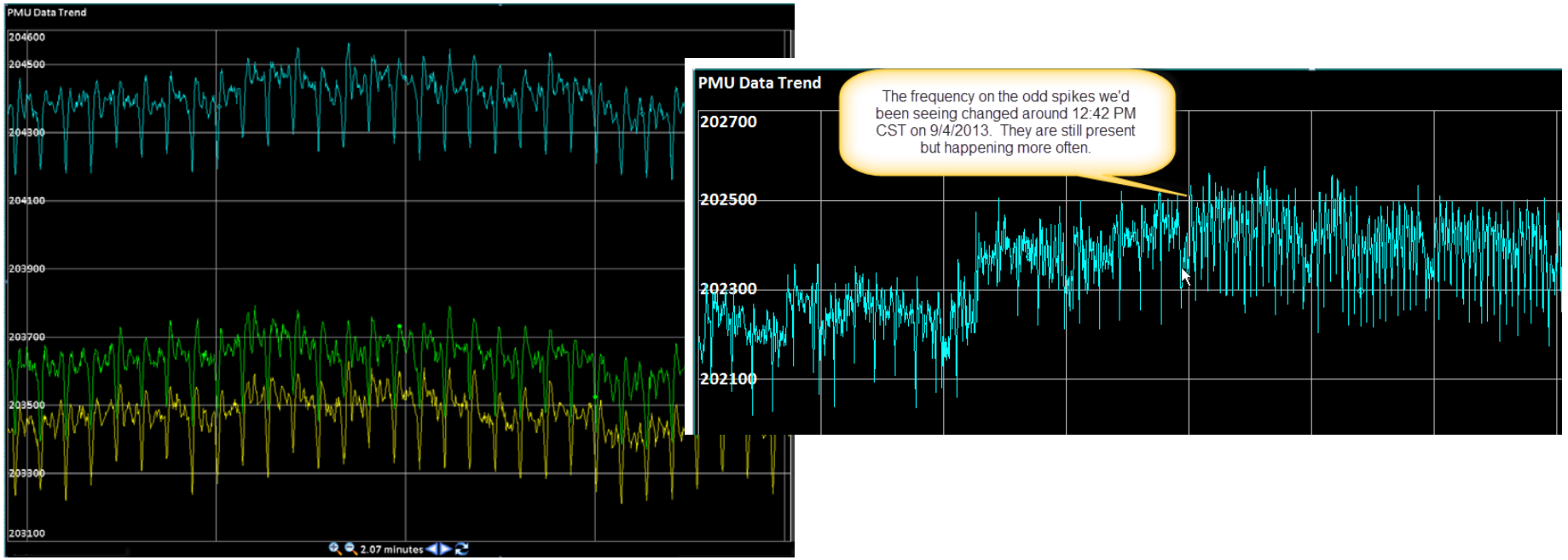
Data Uses – Supporting Customers

- Able to provide information to generation operator related to control issues at an interconnection substation with a line PMU.

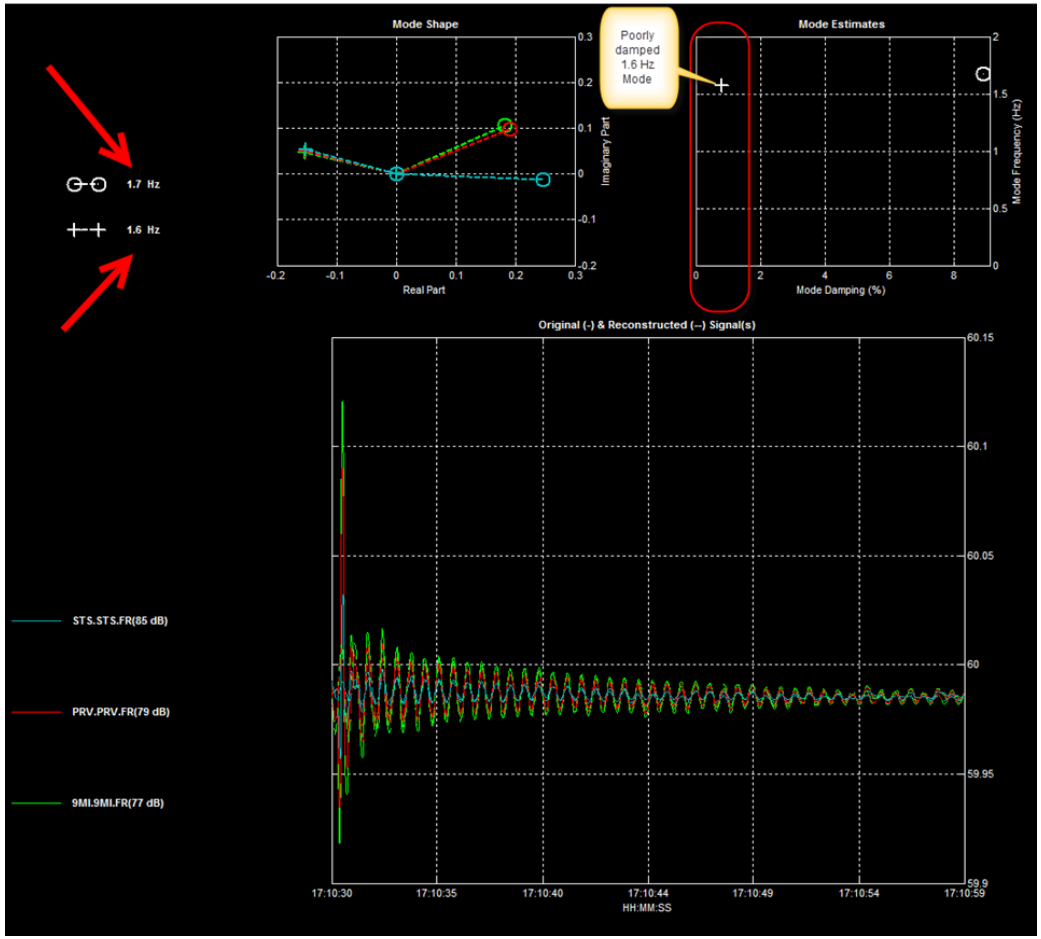


Data Uses – Identifying Odd System Behavior

- Odd voltage behavior observed periodically in data from our Southern Wisconsin PMUs.
- Sharing data with MISO and PJM to identify source (not causing problems – just curious)



Data Uses – Identifying Odd System Behavior and Comparing To Models



- Post event oscillations in weak part of our transmission system.
- Confirmed this is expected behavior with planning.
- Using PGDA tools made available by MISO

DETAILS

PMUs

[Total (completed) project data]

- 1 transmission owner in project
- Transmission elements monitored by PMUs
  - 0 elements >345 kV
  - ~80 elements >230 kV – 345 kV
  - ~80 elements <230 kV
- 19% of regional [ATC] footprint monitored by PMUs
- 97 substations with PMUs
- PMU installation rate
  - 102 PMUs installed
  - 45 stations in 2 years for our DOE project
  - 52 stations over 4 years for legacy project

PDCs and Communications

[data below for completed project]

- PDCs
  - 2 TO control centers with PDCs
  - 45 field “PDCs” (Provide concentration but limited data storage)
  - PDC availability rate impacted solely by upgrade and database issues. No issues with hardware or software significantly affecting availability to date.
- Communications system
  - Synchrophasor data communication link to MISO only
  - Scan PMUs via mix of company owner fiber, leased fiber, and leased frame relay
  - Communications system availability rate 100% (some isolated circuits less but overall system had no issues)

Data

- Data storage -- Archive/database status – what's stored in the field and what's archived in central facilities
  - Storage size (12 TerraByte disk)
  - Age/duration of data to be readily accessible
    - PI system data stored indefinitely with some compression applied
    - PhasorPoint 30 days online full scan rate data which shifts to long term storage with max/min/avg storage. Also have snapshot capability to keep full scan rate data for events
  - Is data access query process mature and workable? Yes
  - Total volume of data being generated by your phasor data system?
    - PMU sampling rate – 30 samples/second on all PMUs
    - Number of PMUs (102)
      - » number of current phases monitored/PMU (4.7)
      - » number of voltage phases monitored/PMU (4.1)
      - » number of data points measured per sample
        - 160 current triplets
        - 140 voltage triplets
        - 102 frequency values
        - 102 config_changed status bits
        - 102 config_version analogs
        - ~1200 values
    - Total volume data sent up by minute (15 Mbytes)
    - Total volume data being generated and stored per year? (8 TerraBytes)

Data Quality and Availability

- 92% of PMUs delivering good or better quality data (good implies we're receiving >= 99.9% of the data and that it has >= 99.9% good data quality.)
- 98% of PMUs delivering timely data. "Timely" implies no clock issues at sub and data arriving within 2 seconds at PDC as we do not have any real time applications requiring faster arrival times.
- Data issues primarily due to clock problems, especially at legacy sites. These problems can be with the interface from the clock to the PMU or clock hardware problems. (We use Arbiter model 1093B clocks at version 8.8.11 at all DOE sites)

Major Operational Applications Using Phasor Data

- Wide-area situational awareness
  - Alstom PhasorPoint
    - Planned integration into EMS (alarming, data flow) in 2014
    - In service already in our development environment with communication to all PMUs. Still working to configure tools within the application.
  - OSI Soft PI Historian
    - Used for post event analysis via ProcessBook displays
    - Used to generate communications warnings when PMU data lost
- State estimation
  - Alstom EMS / EMP 2.6
    - We have been feeding angle data to our EMS for several months but we are not using it as an input to the state estimator at this time.
    - Plans to do testing late 2013 to determine impacts on state estimator results using this data. This will require tuning of our accuracy class / weighting model in EMS.
    - Developed contour map of angle to compare scanned real time versus solved state estimator to highlight model/data issues