Synchrophasors

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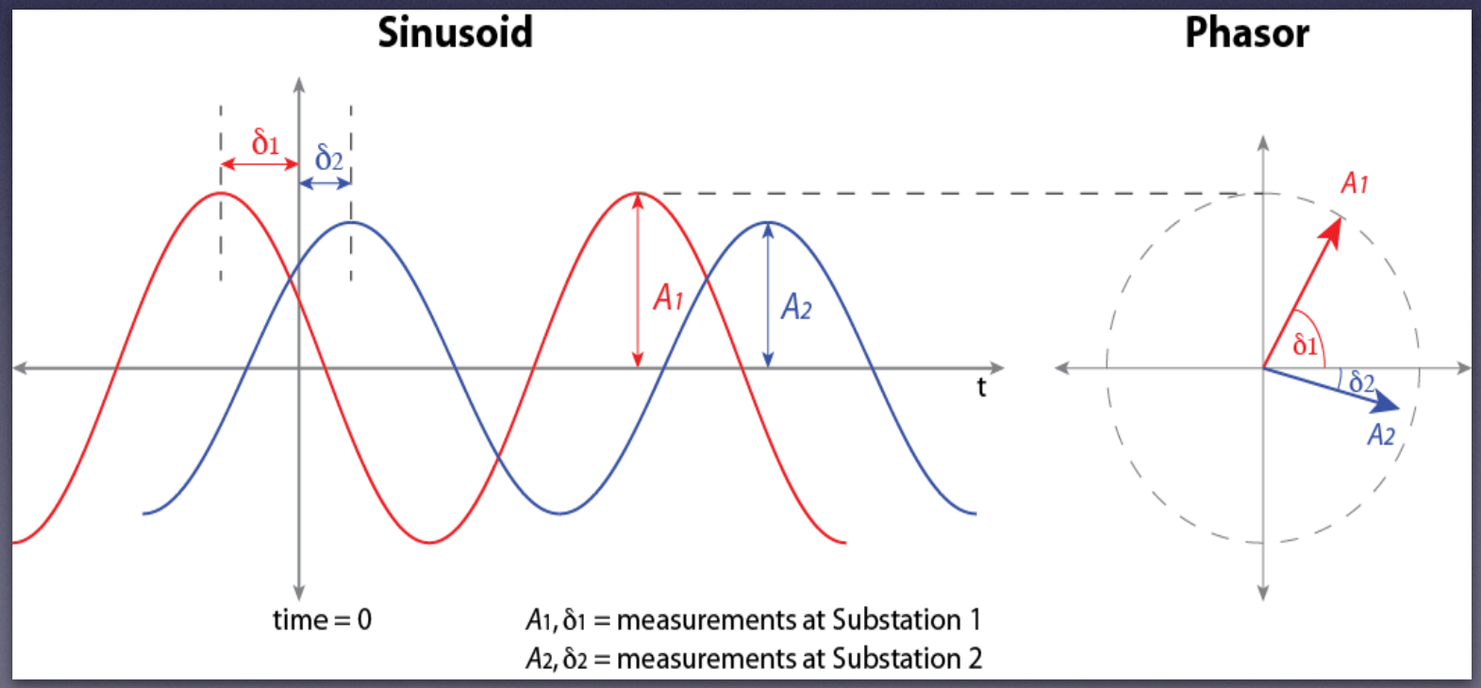
The Old Way

- Power system measurements have historically been voltage and current magnitudes and instantaneous power
- These measurements are sampled by the SCADA system whenever SCADA gets around to it
  - The time between samples is often measured in seconds
    - Status changes are handled by exception
  - The data may or may not have time stamps
- “Stuck” data can be minutes or hours old

What are Synchrophasors?

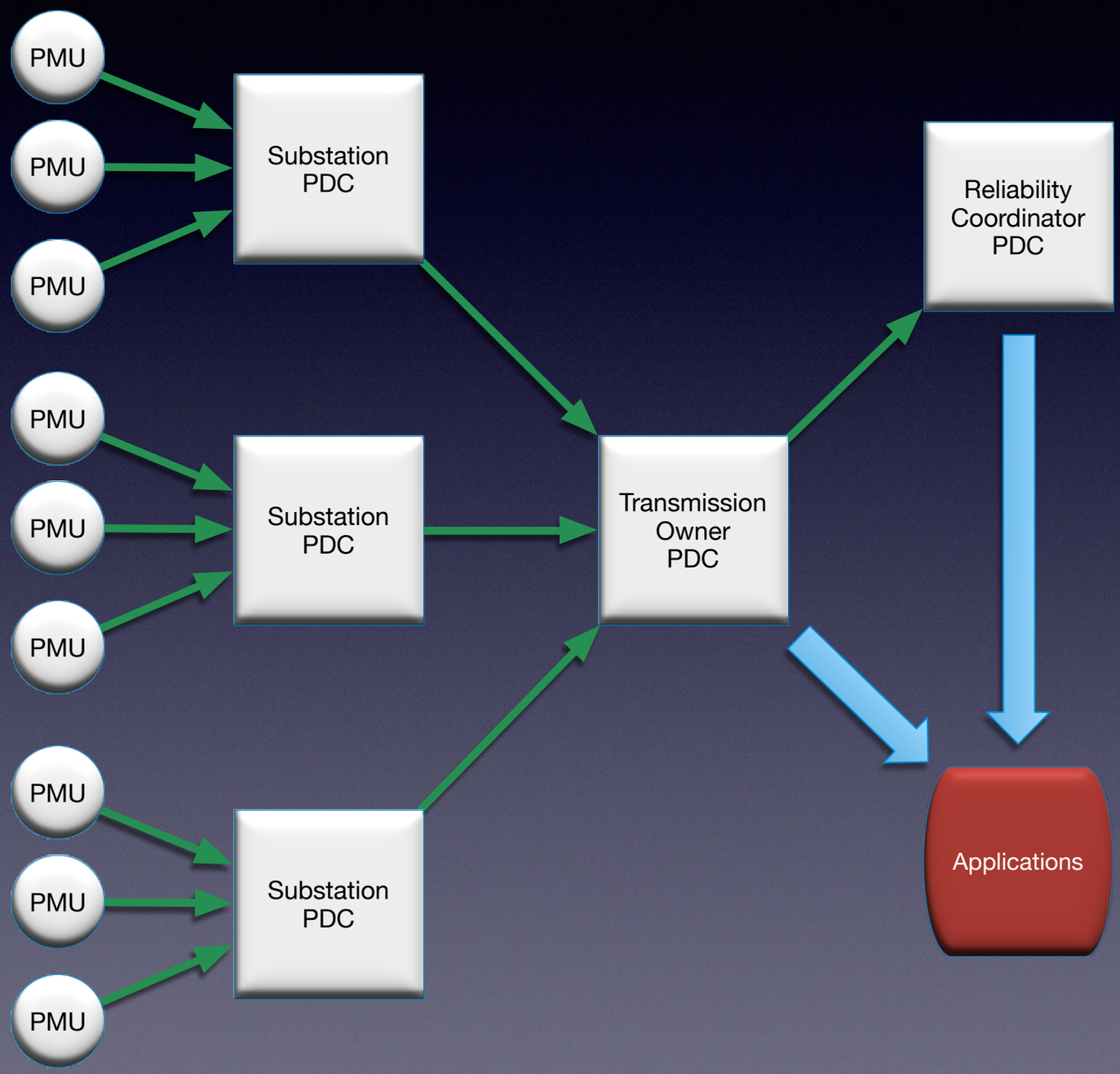
- What is a Synchrophasor?
  - Time-synchronized measurements of voltages and currents that include phase angles



PMUs

- Phasor Measurement Units (PMUs)
  - PMUs generate and transmit synchrophasor measurements
    - 30 to 120 samples per second
      - At 30 samples per second, a single PMU produces 2,592,000 records per day
- Most modern relays and DFRs can be configured to have PMU capability

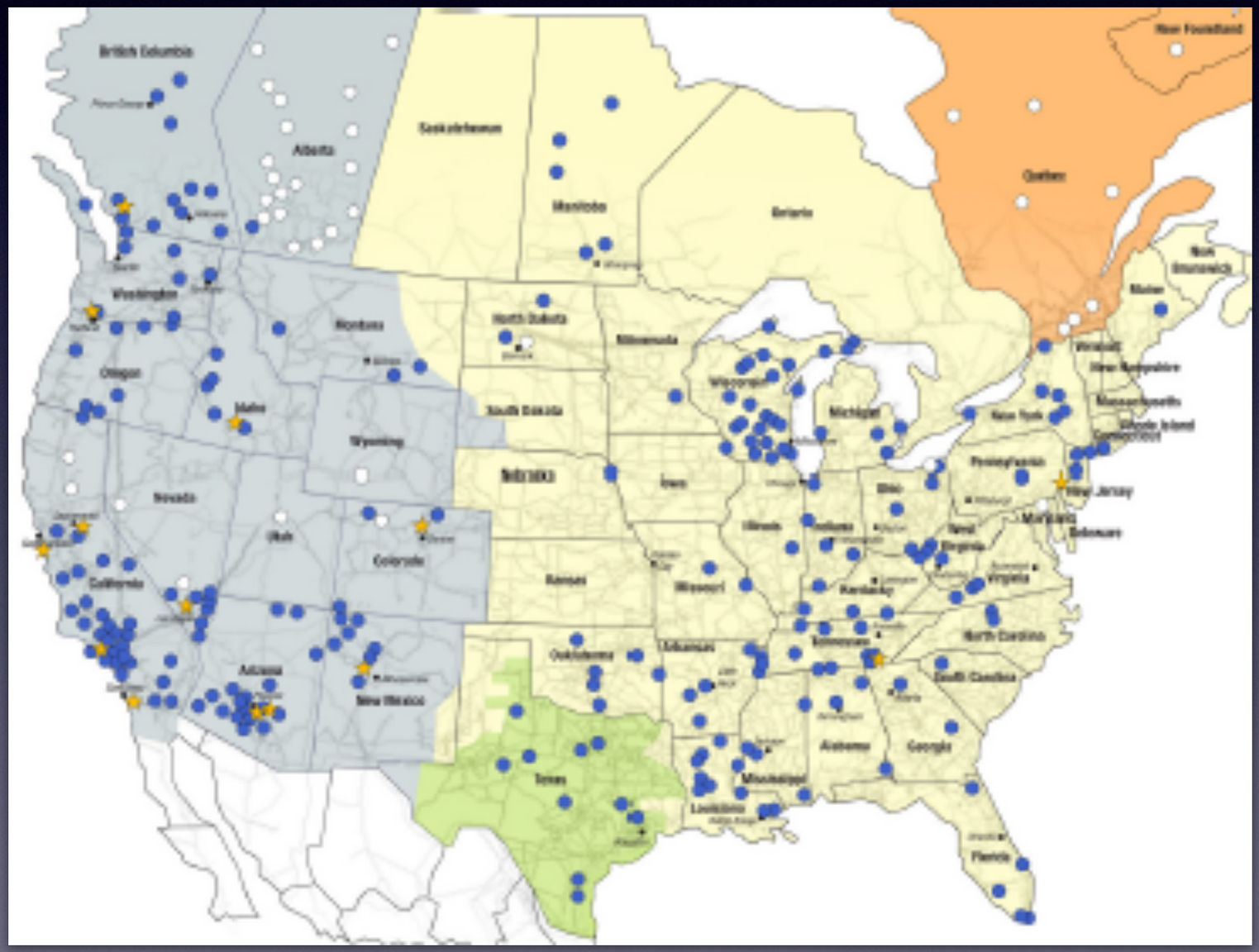
PMU Data Transfer



Note: Substation PDCs are not always present

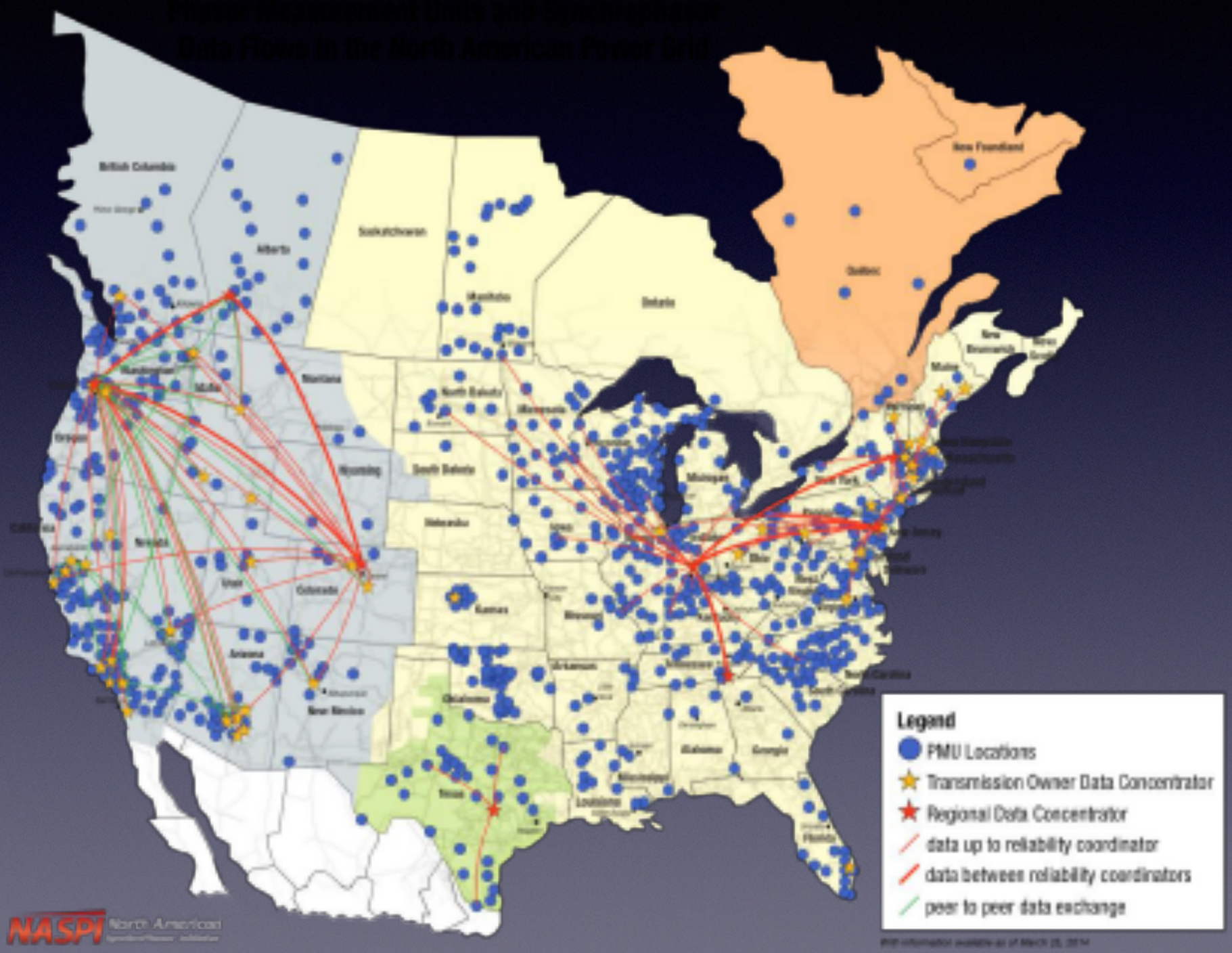
PMU Locations - 2011

2011… Not bad, but just wait!



Source: “Summary of the North American SynchroPhasor Initiative (NASPI) Activity Area”, U.S. Department of Energy, June 2012

PMU Locations - 2014



Source: North American SynchroPhasor Initiative (NASPI) Synchrophasor Technology Fact Sheet October, 2014

ComEd Installations

- 6 substations
  - Dresden, Goodings Grove, LaSalle, Nelson, Taylor, Zion
  - 11 PMUs
- More planned and in progress…
- Locations selected according to geography and convenience
  - It is relatively inexpensive to install a PMU when substation equipment is already being upgraded

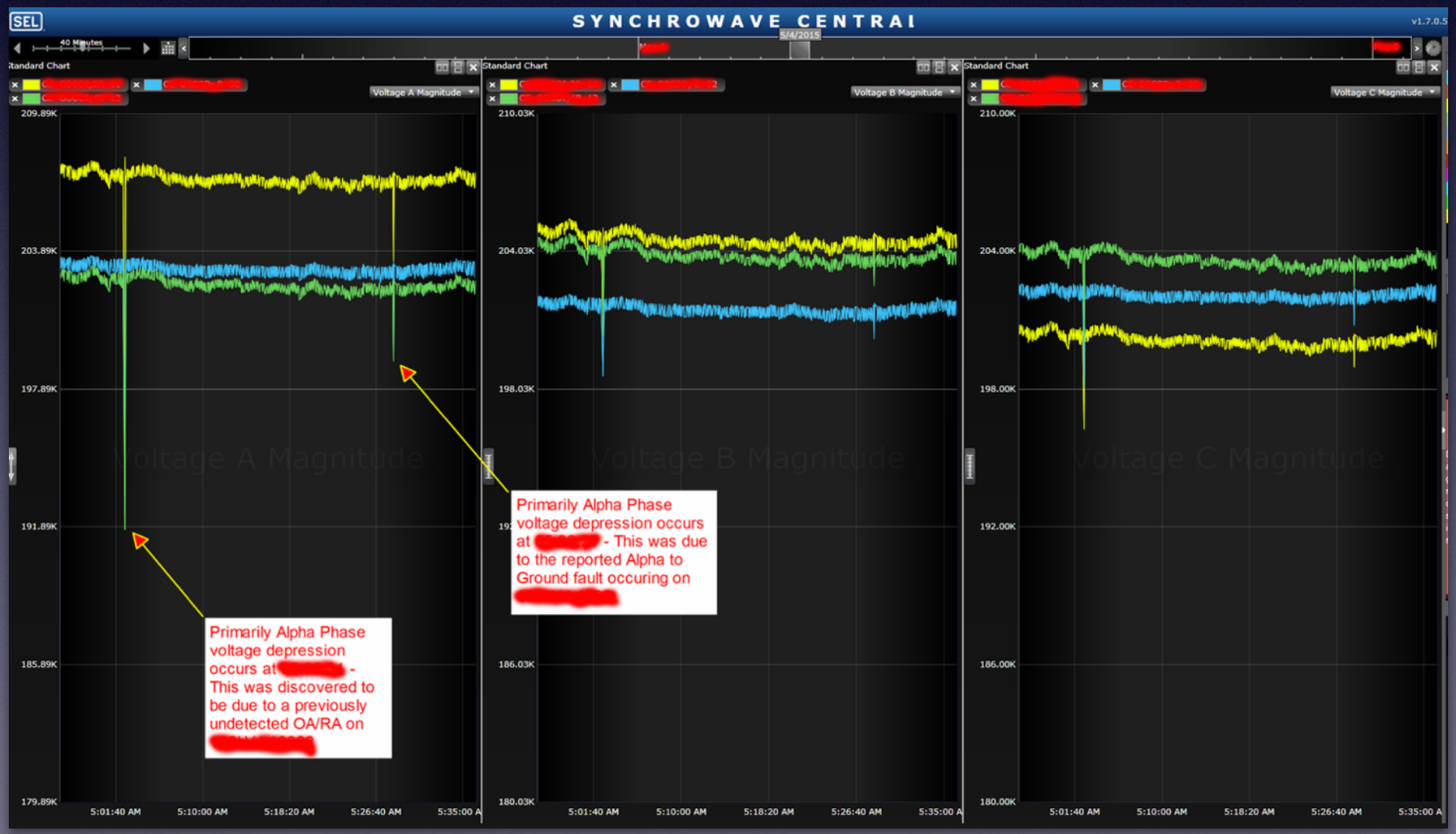
PMU Applications

- "If you build it, they will come." [1]
  - Until recently, application development has been limited by the lack of data, but the situation is improving rapidly
  - As more applications are developed and deployed, it becomes easier to justify installing more PMUs

[1] Field of Dreams (paraphrased)

Easy Application

- Digital Fault Recorder with Continuous Storage
  - Do not underestimate how useful this is!



Other Applications

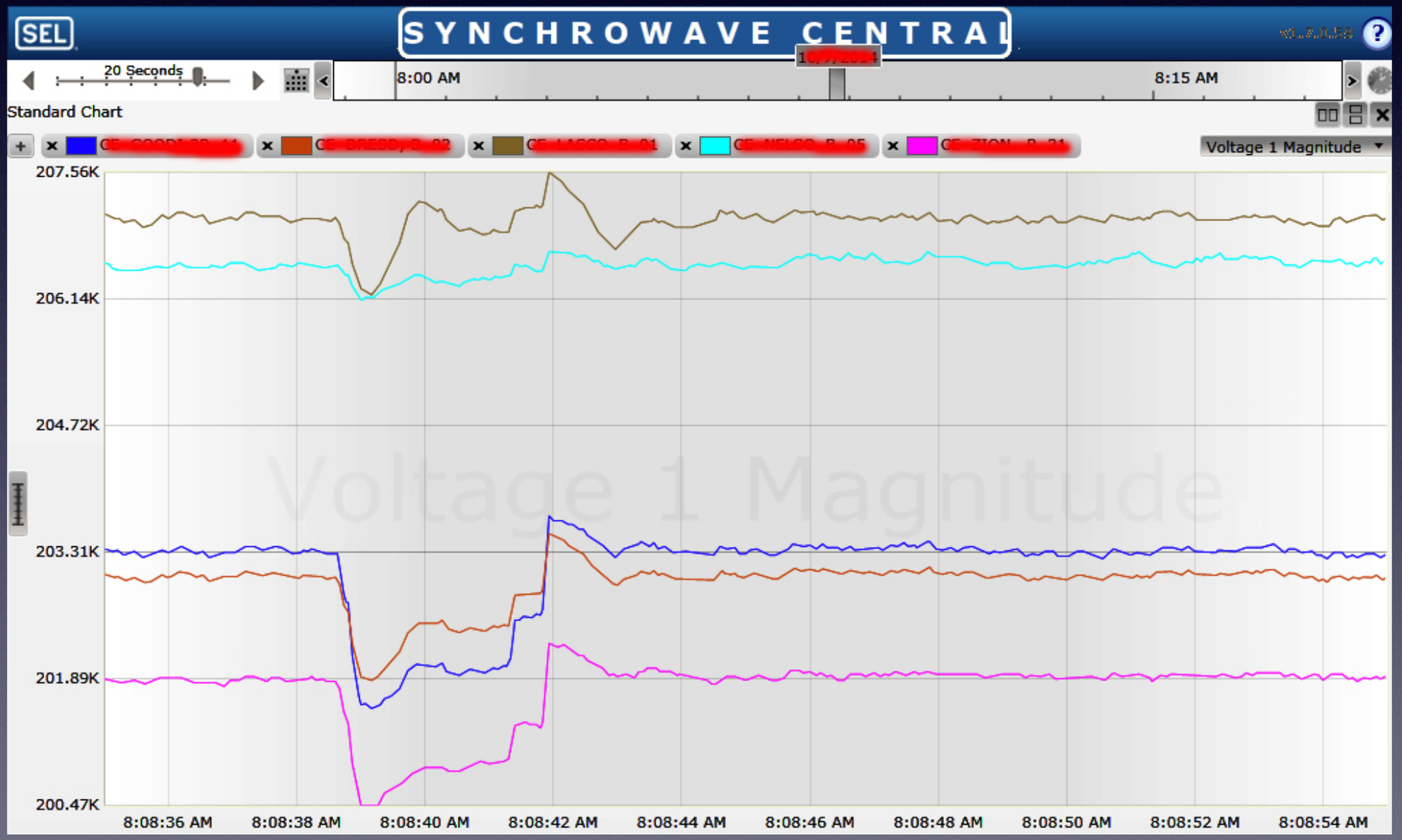
- Improved State Estimation
  - Incorporate PMU measurements into existing state estimators
  - Linear state estimators
    - Equations are linear, so system is solved directly without iterating a solution
- Model Validation
  - High sample rates allow model and system response to be compared
- Oscillation detection and identification
- Event classification

The Squirrel

- A squirrel got onto a 12kV bus where it didn't belong…

What We Learned

- The squirrel caused a transient seen on the transmission system



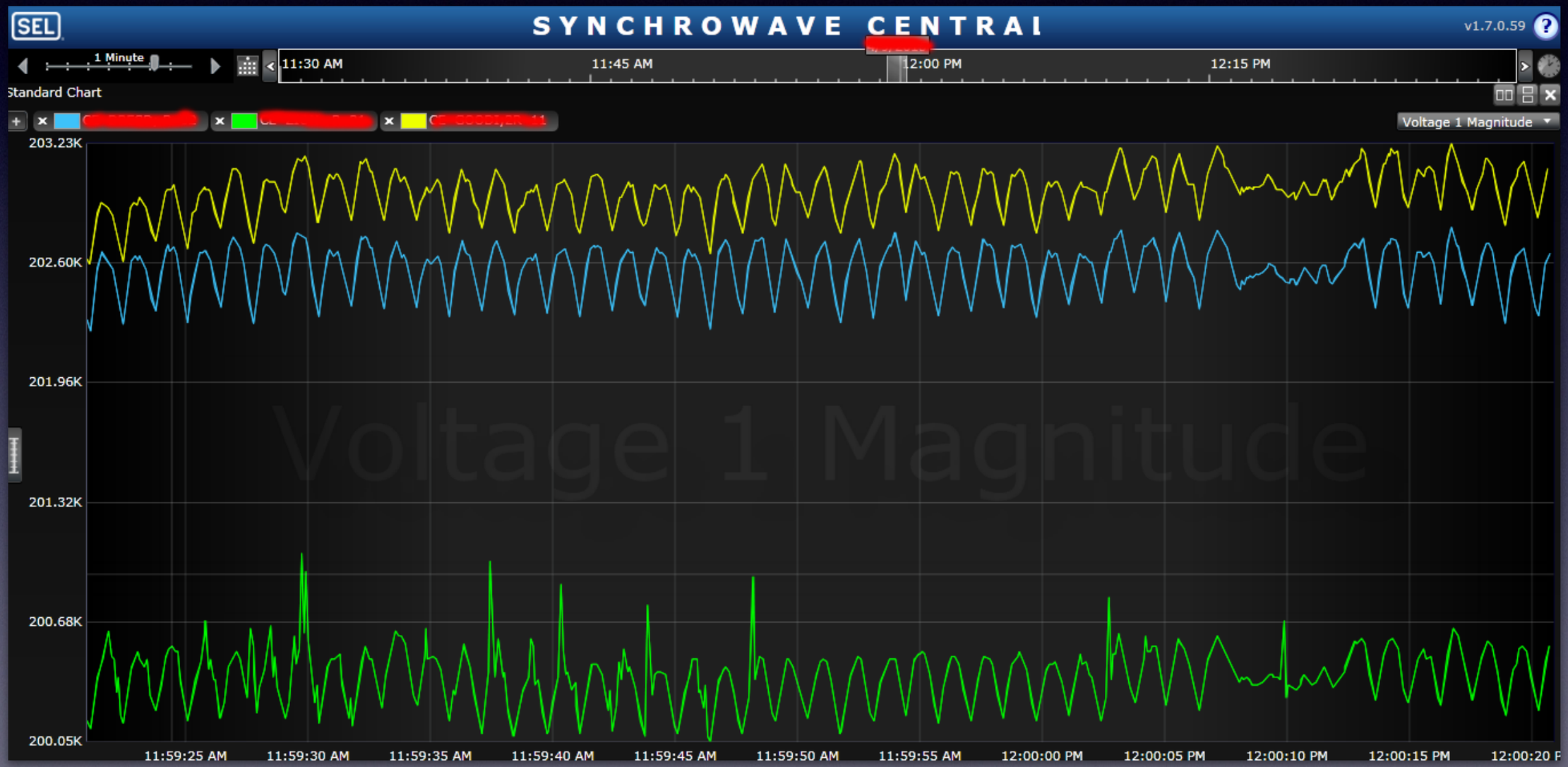
Remaining Challenges

- Existing system was implemented as a pilot/science project
    - We now have to build it so that it can handle large numbers of PMUs
        - Communications and storage capacity
- Control-room implementation
    - We have figured out how to do post-event analysis, now we have to turn it into a tool for real-time operators

ComEd/Argonne Effort

- Event Detection
- Spectral Analysis
- Improved State Estimation
- Improved Dynamic Models

Oscillations



The End