SCHWEITZER ENGINEERING LABORATORIES

Wide-Area Distribution Synchrophasor System

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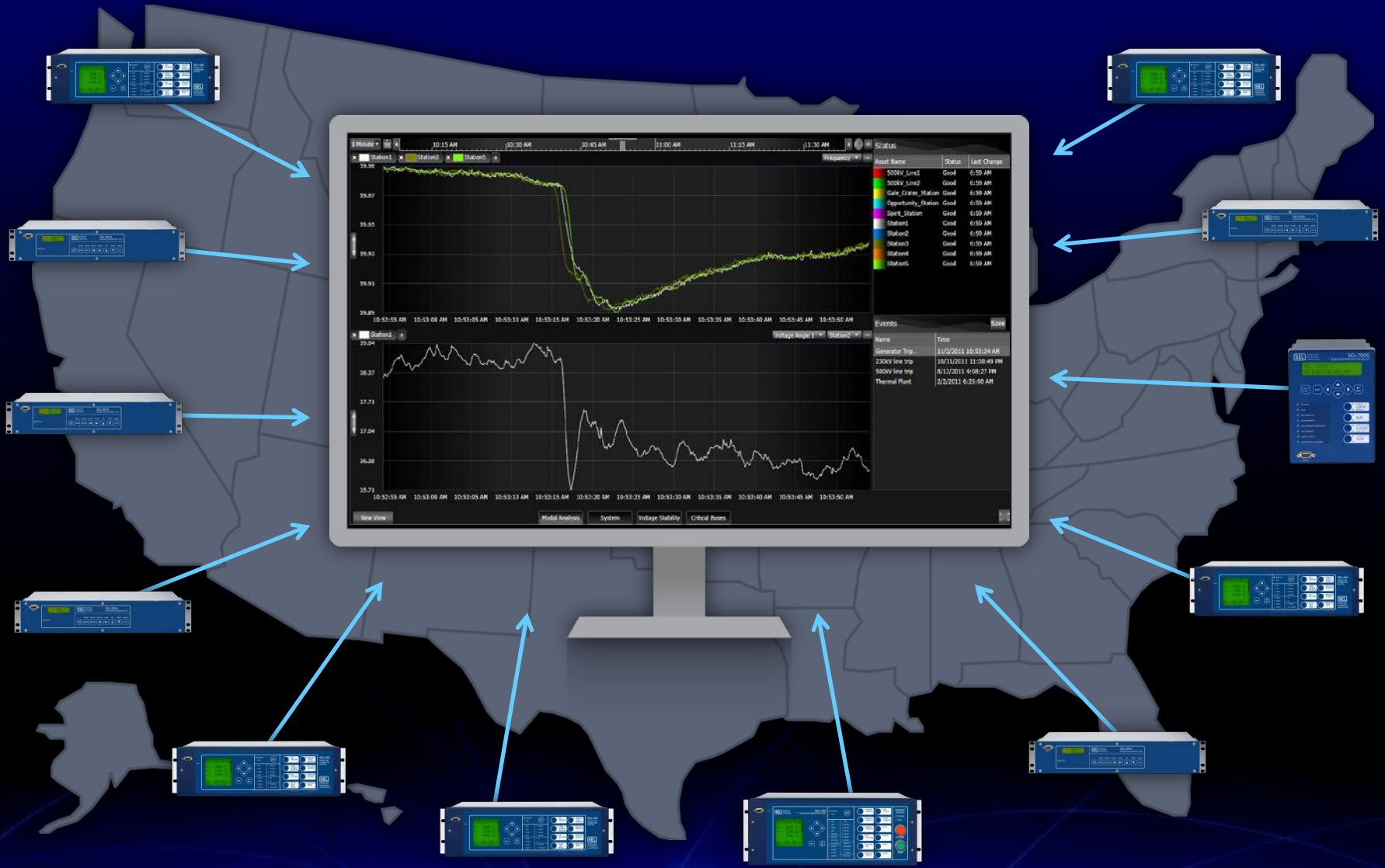
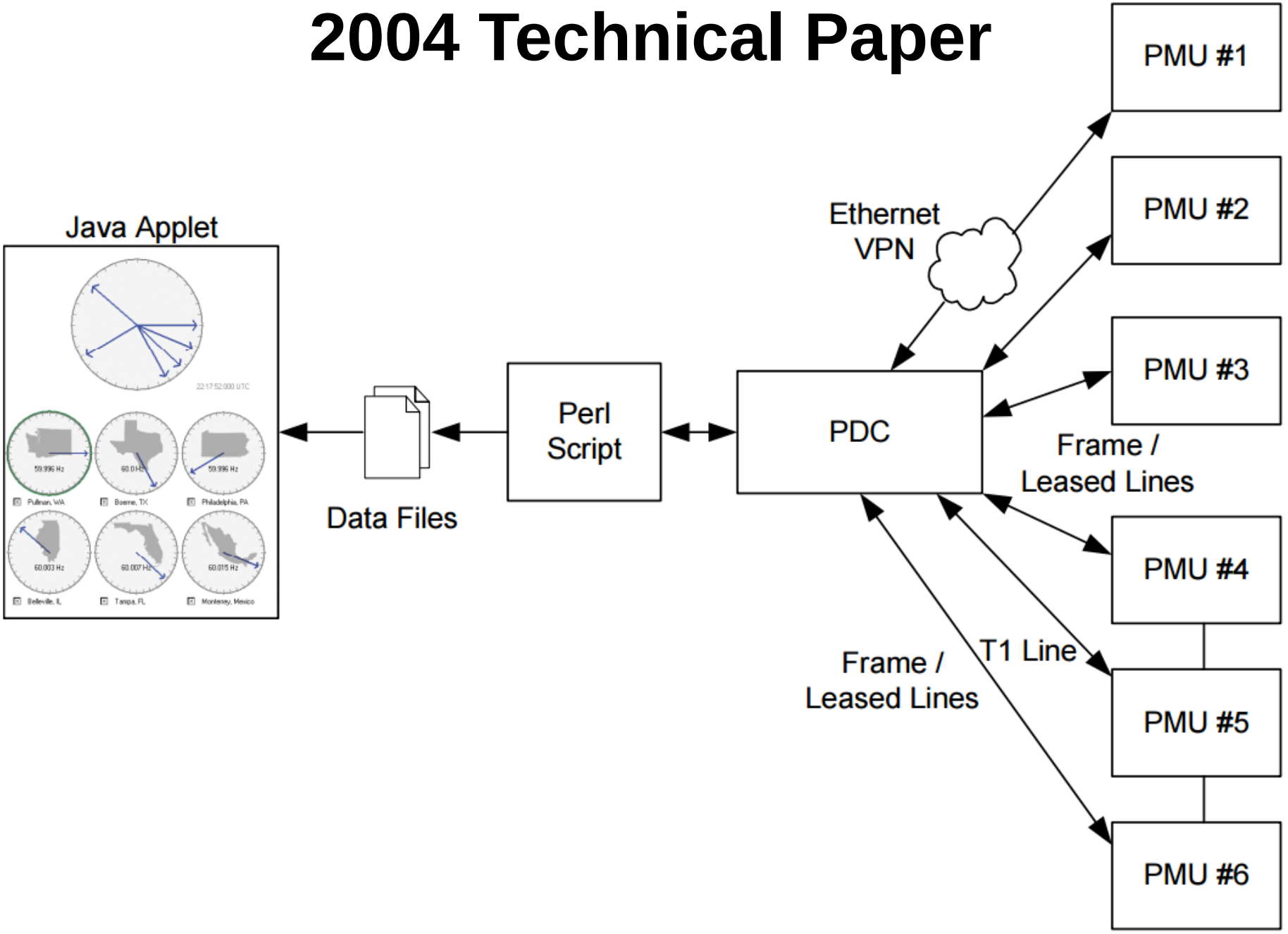
Making Electric Power Safer, More Reliable, and More Economical®

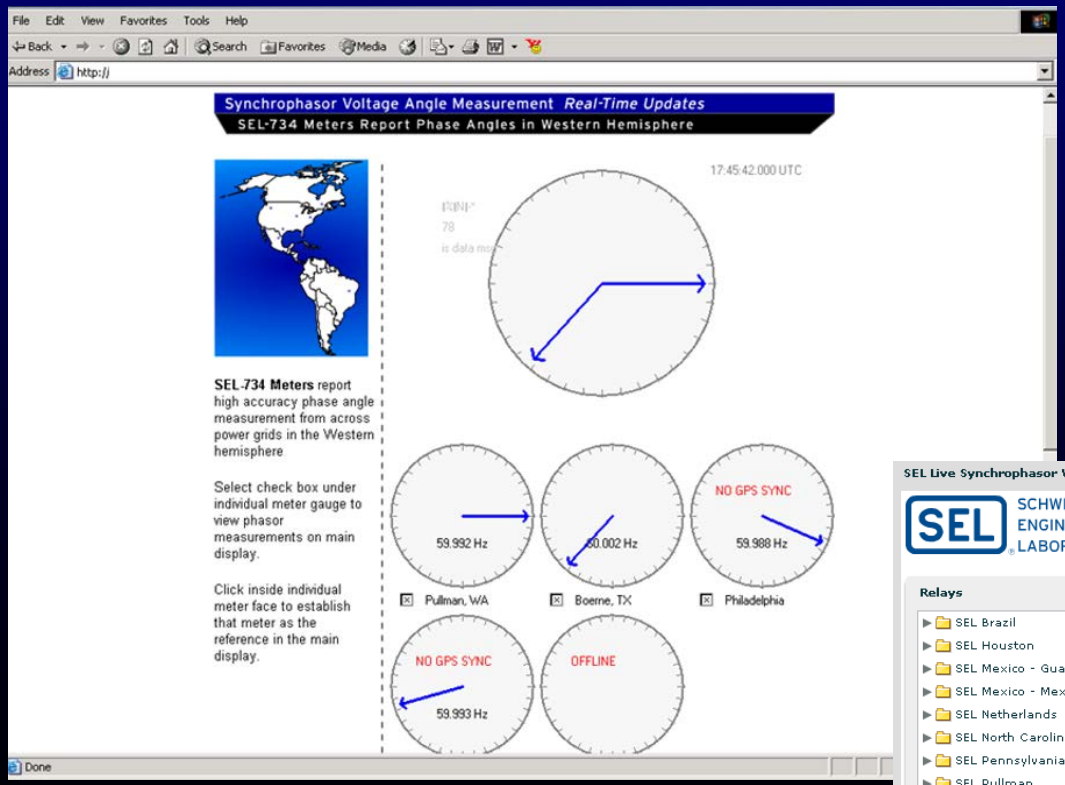
Wall-Outlet Connected PMUs & Web-Based Visualization



2004 Technical Paper

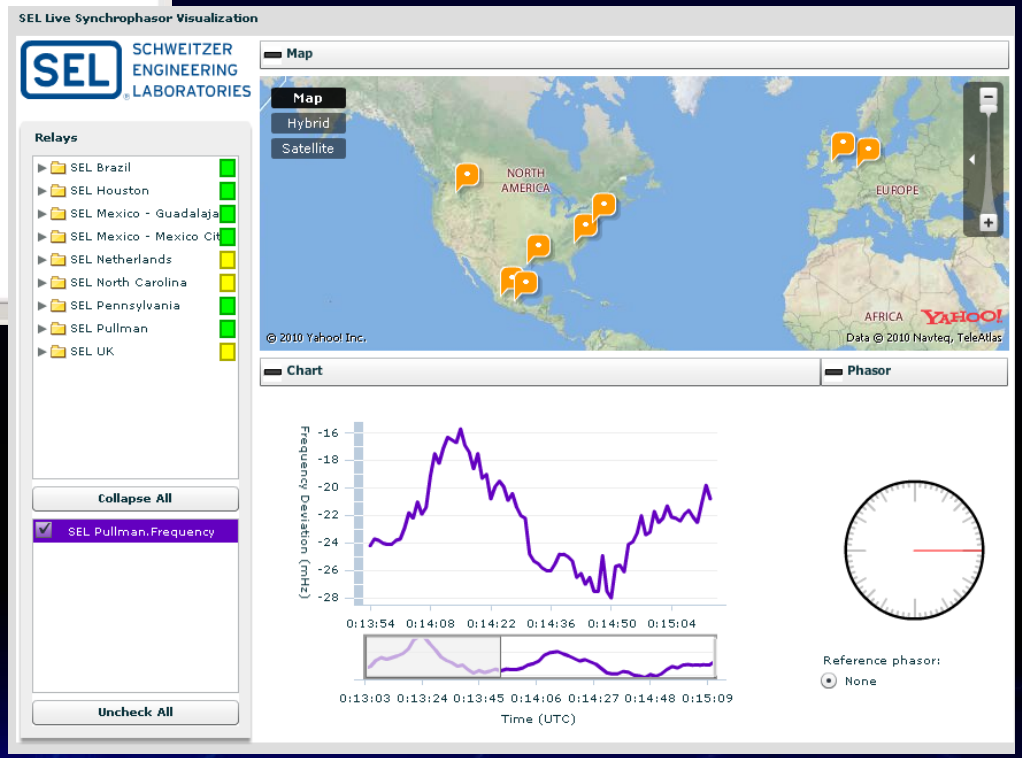


13 Years of Internet Synchrophasors

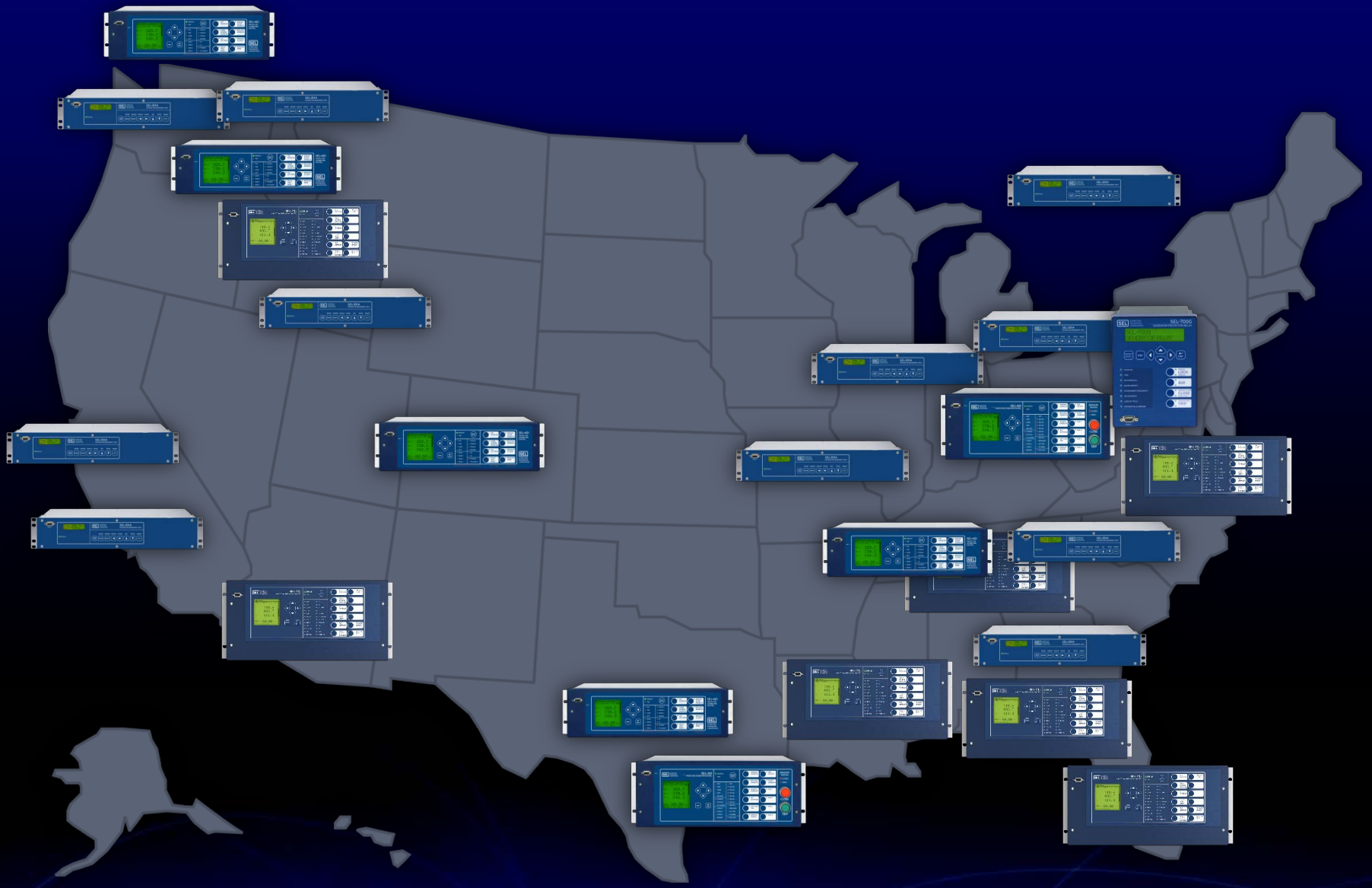


2003

2007



Present System: 2011 - today



Measurements (full production PMUs)

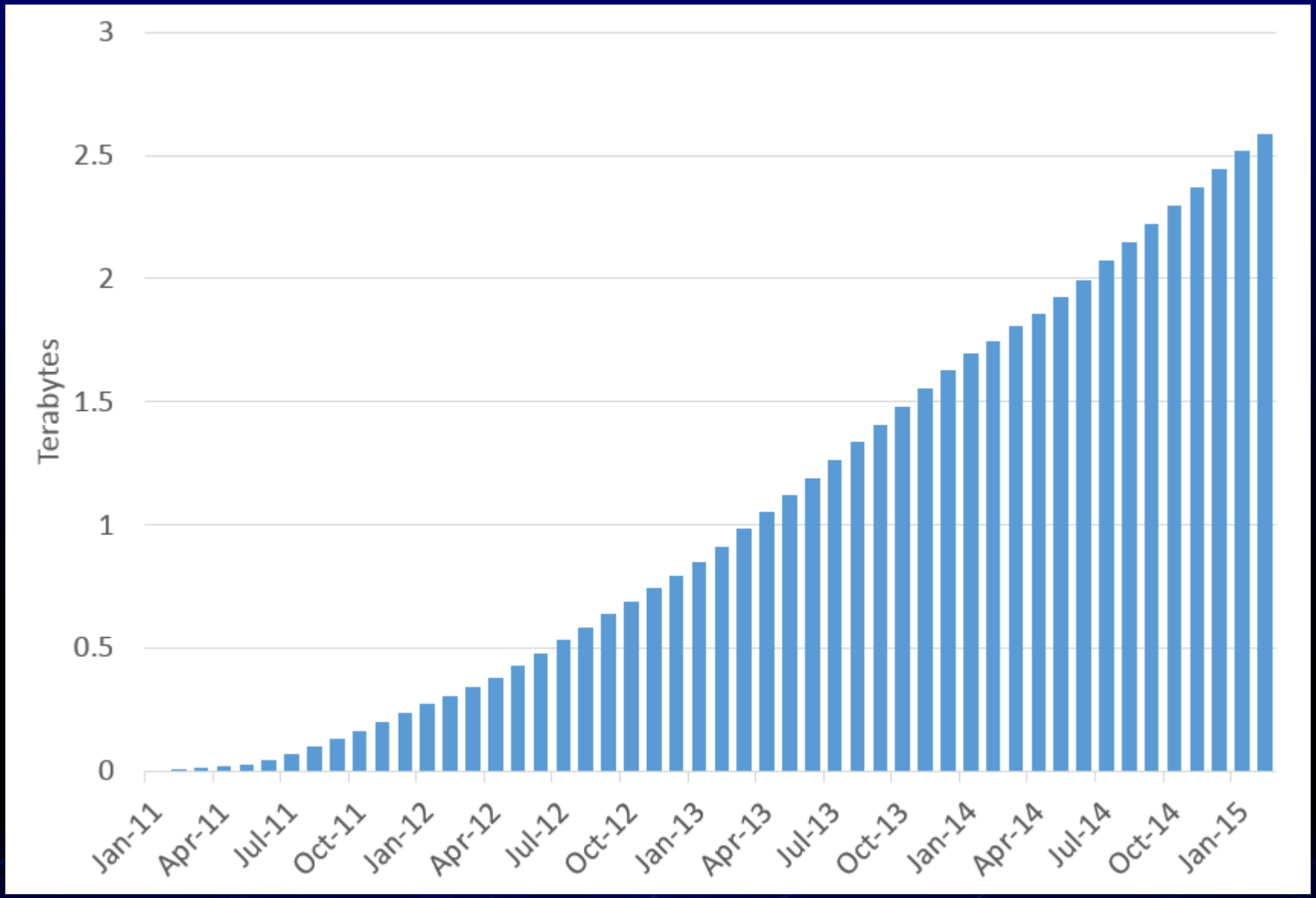
- Voltage magnitude
- Voltage angle
- Frequency
- df/dt
- Three phase (some locations)
- IEEE C37.118 accurate

Why?

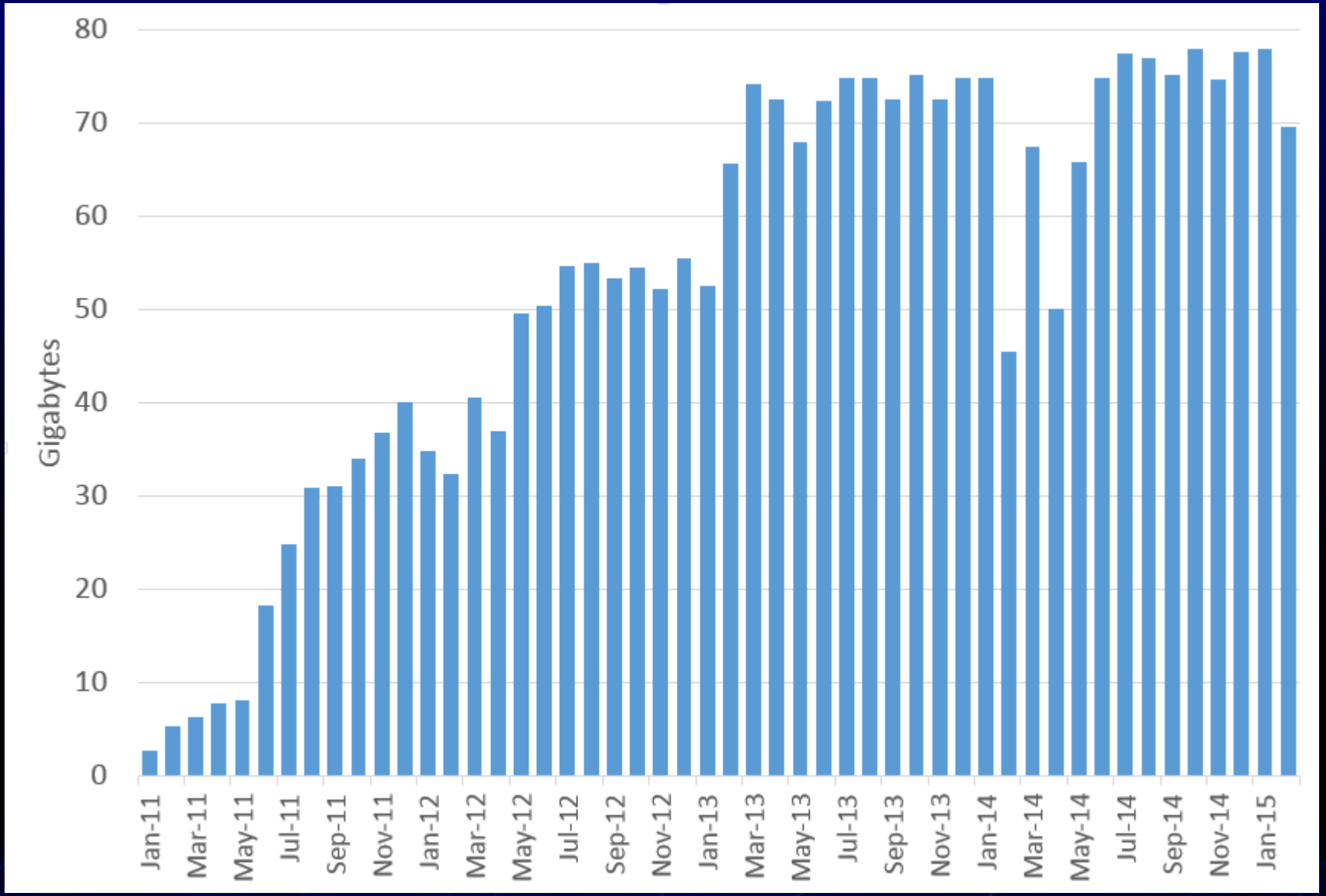
- System level testing
  - 24x7 365
  - Clocks, PMUs, PDCs, RTACs, network, software, visualization, analysis
- Research
  - Needs data!
  - Algorithm development
- http://www.synchrophasors.com

What Have We Learned and Seen?

(0) It Takes Lots Of Storage

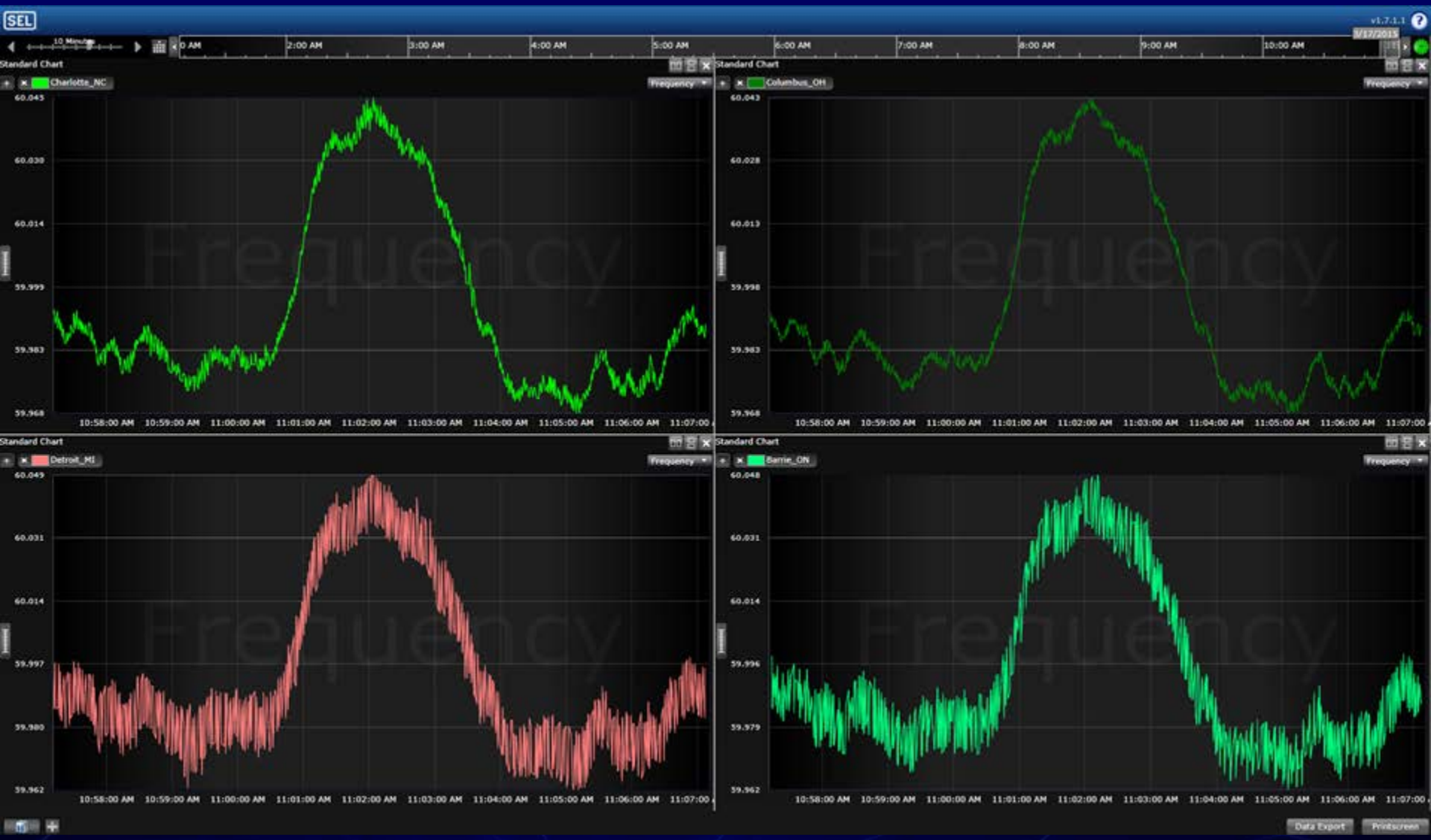


Gigabytes Per Month



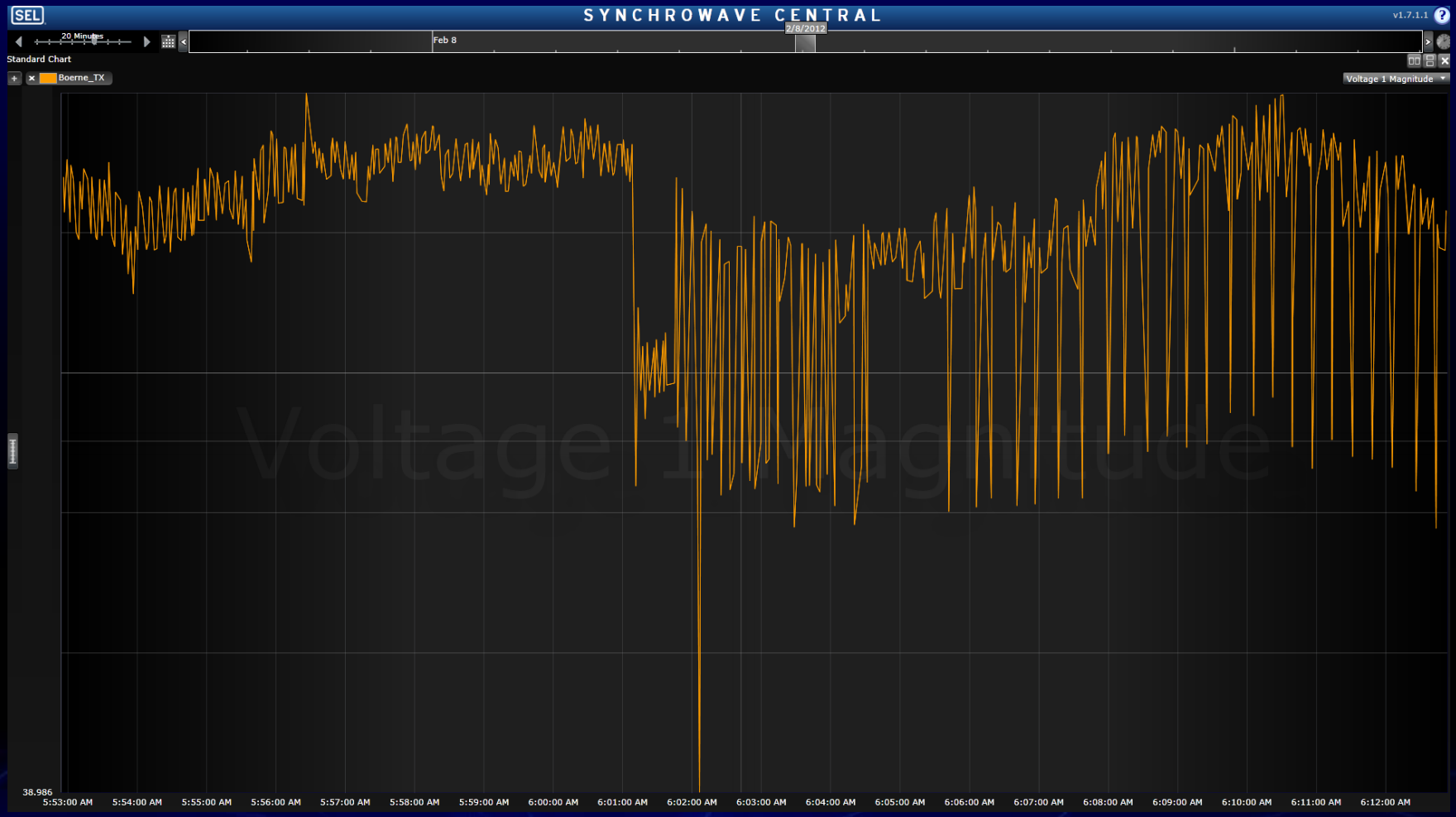
(1) Local Conditions Can Be Noisy

Better and Less-Better Locations…



Non-Random Noise Happens Too

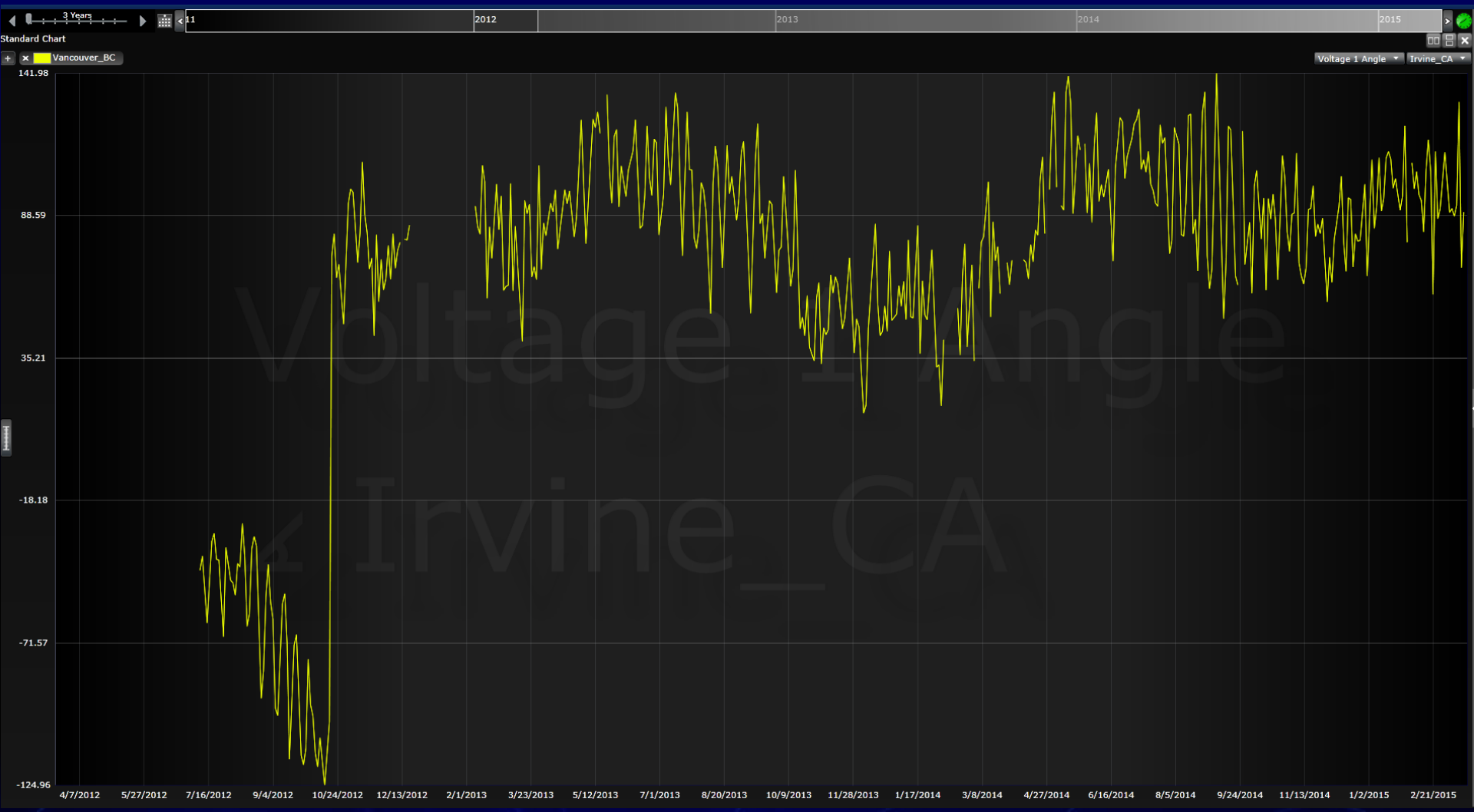
"Sure enough, you press the power save button on the fax and the pulses go away. You wake it back up, and they come back. Looks like we can turn the problem on and off! I should be on CSI :)



(2) Unknown Absolute Angle But Can Measure Angle Variation

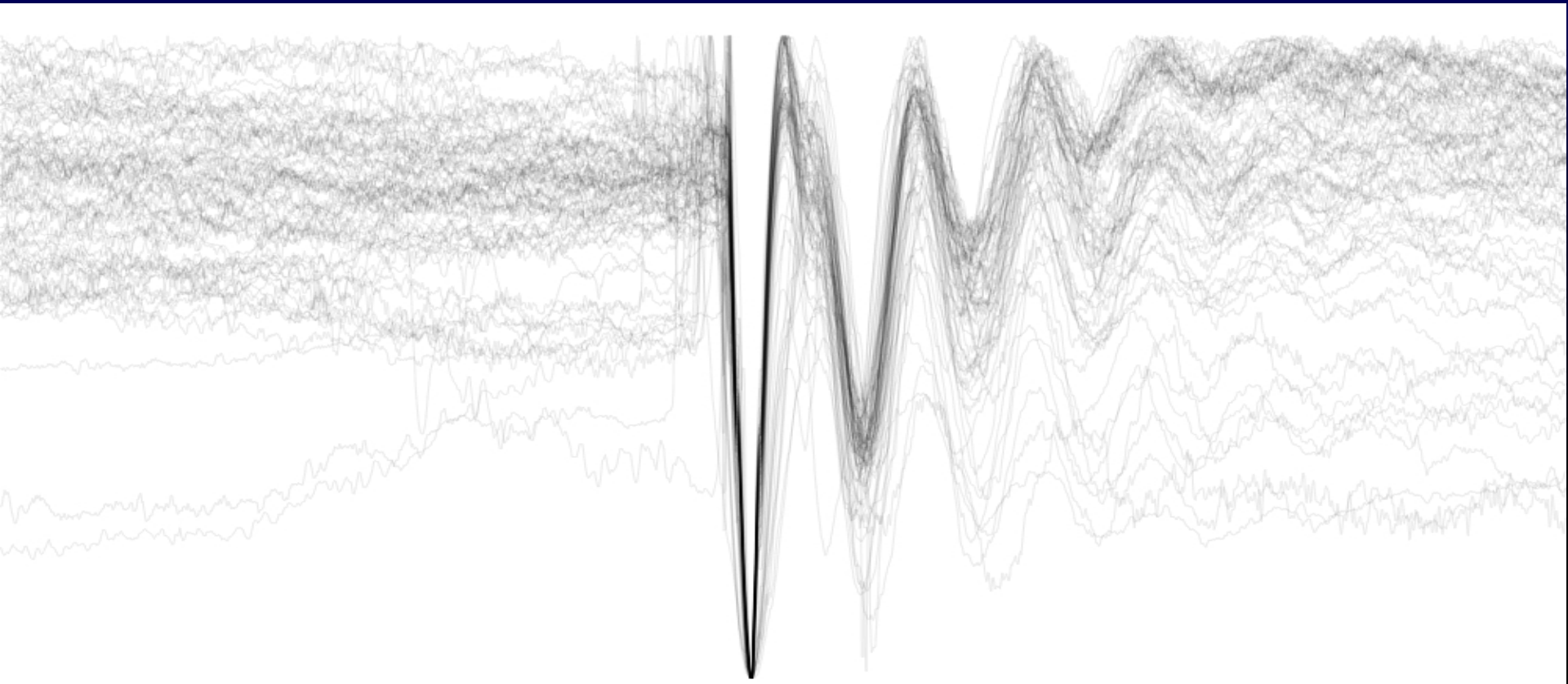
(3) Daily Summer Angle Variation

(4) Our Angle Can Get Moved Too



(5) We See Many Oscillations

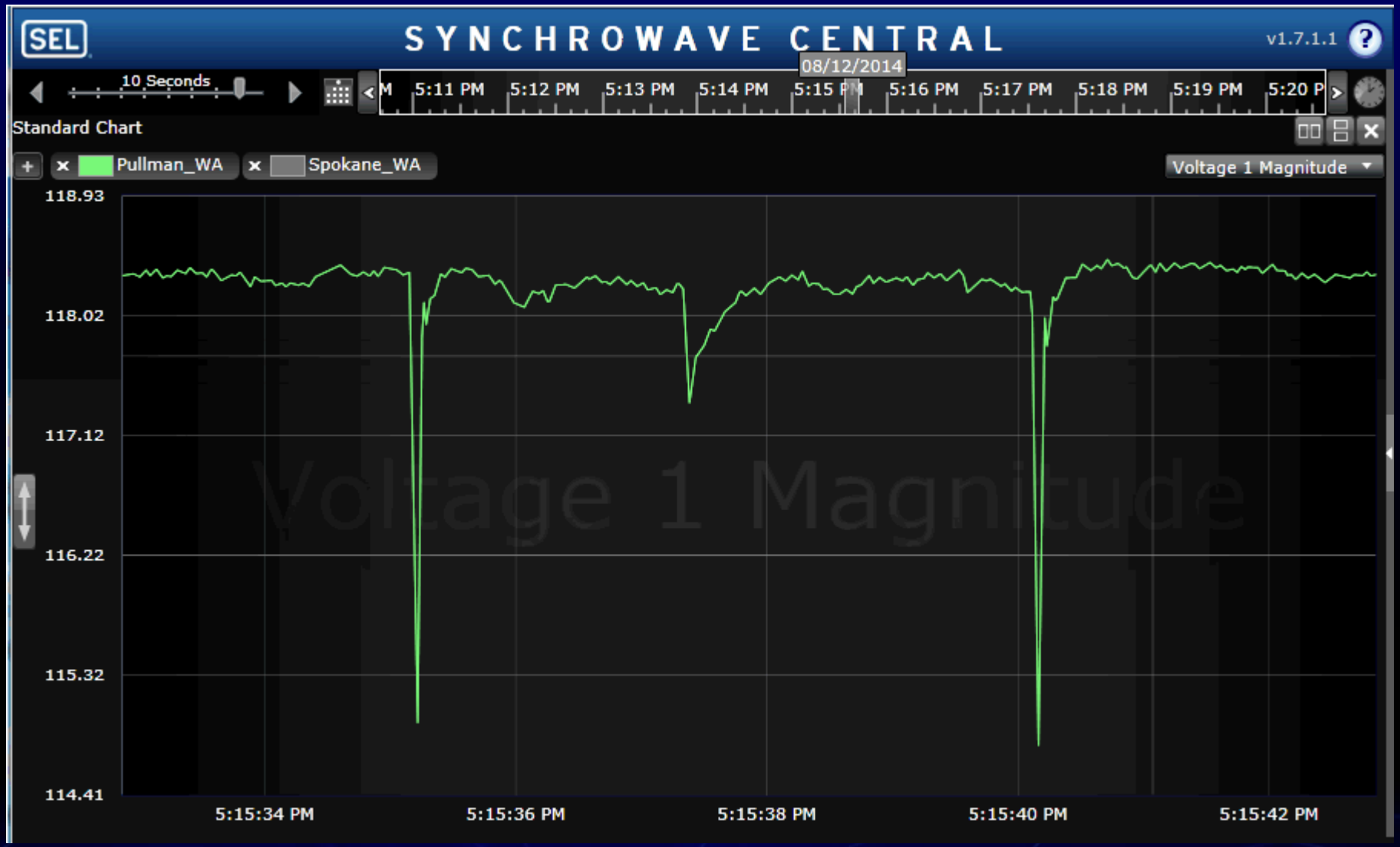
Many Oscillations



Can Correlate Some Oscillations To Public Data

Grand Coulee-Schultz
500 kV
5/21/2012 9:07AM

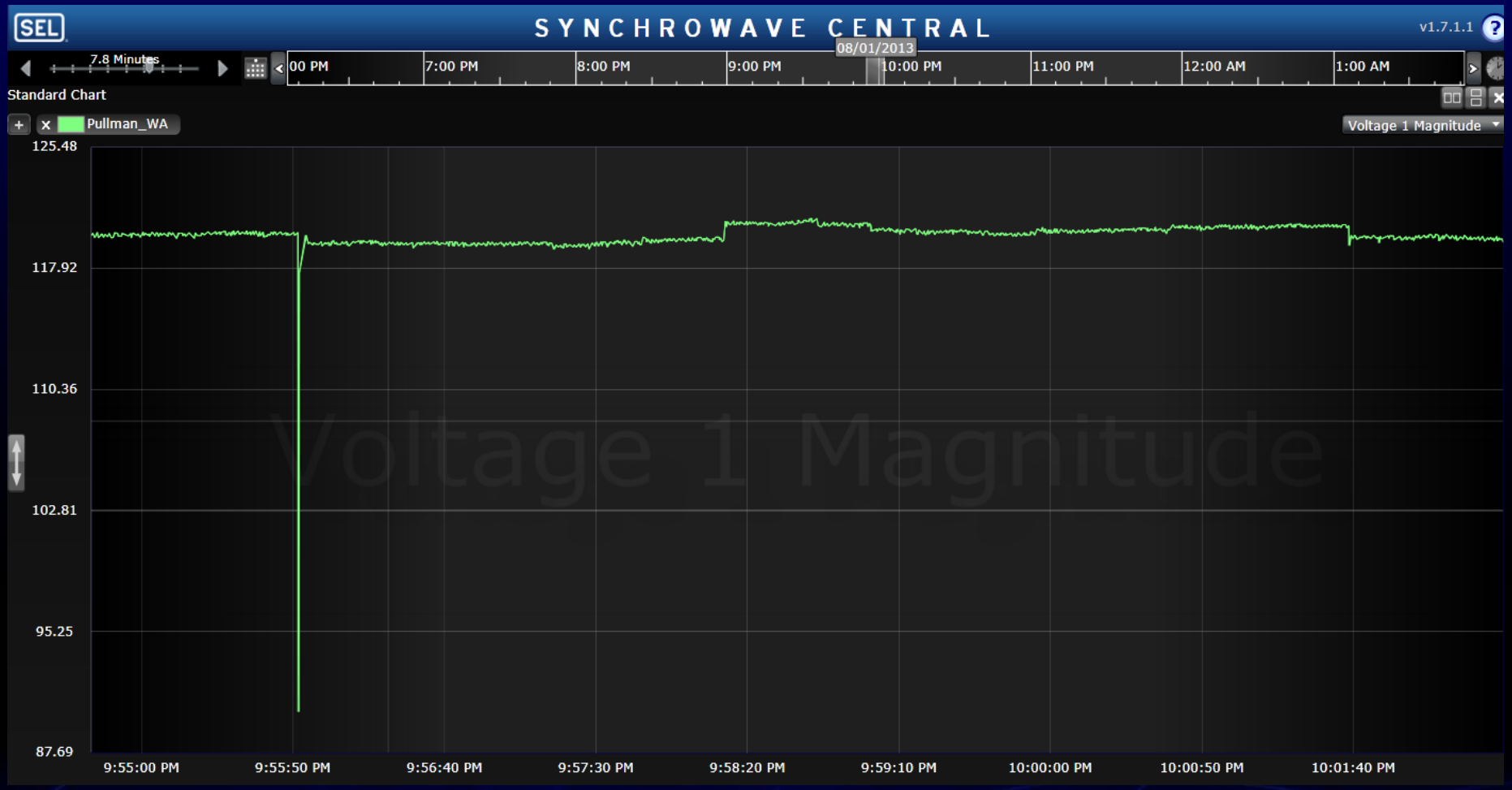
(6) Weather Induced Local Outages



(7) Outages Local To Our Buildings

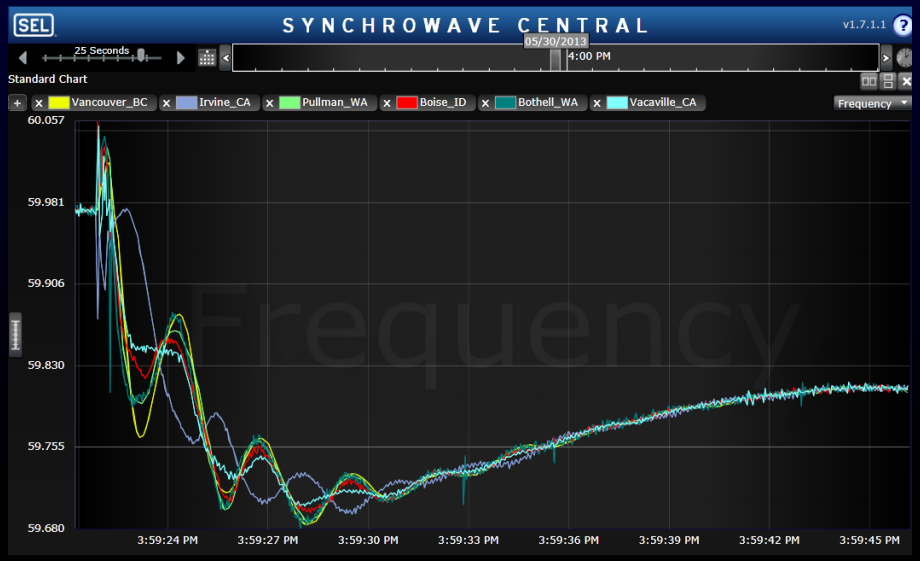
We're measuring the computer network's tolerance to low voltage?

(8) Voltage & Step Changes

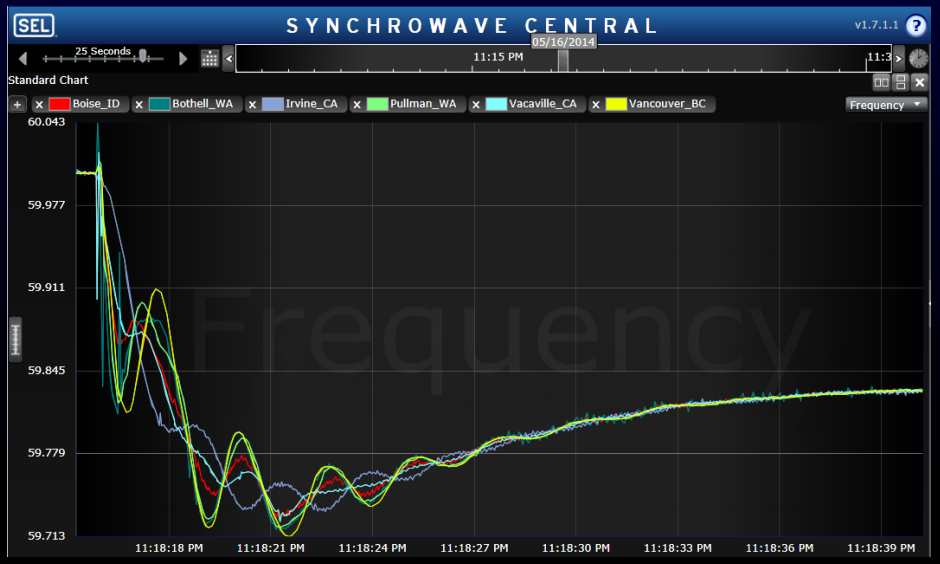


(9) Analysis of System Wide Events

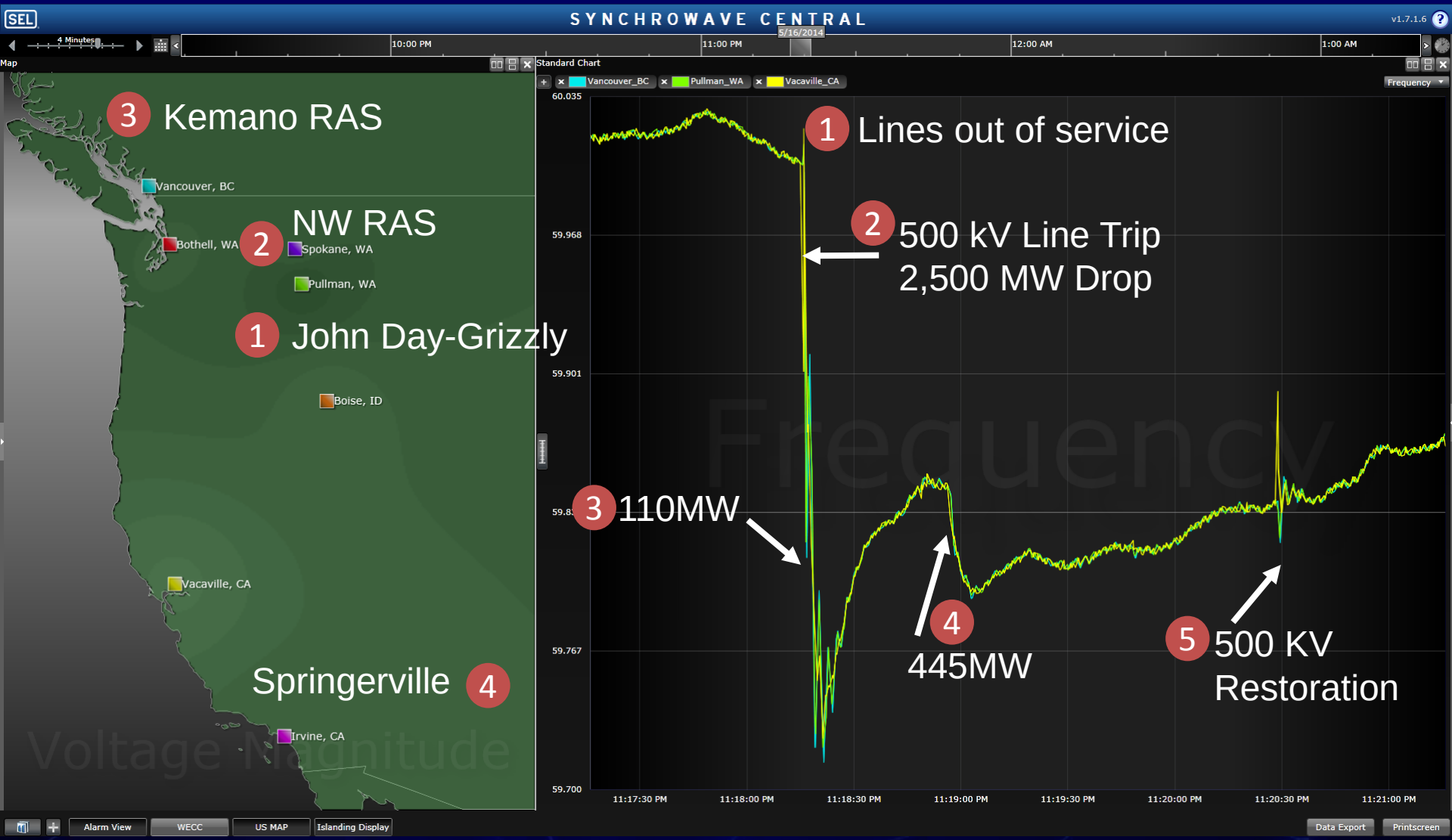
May 2013 – 2500 MW loss

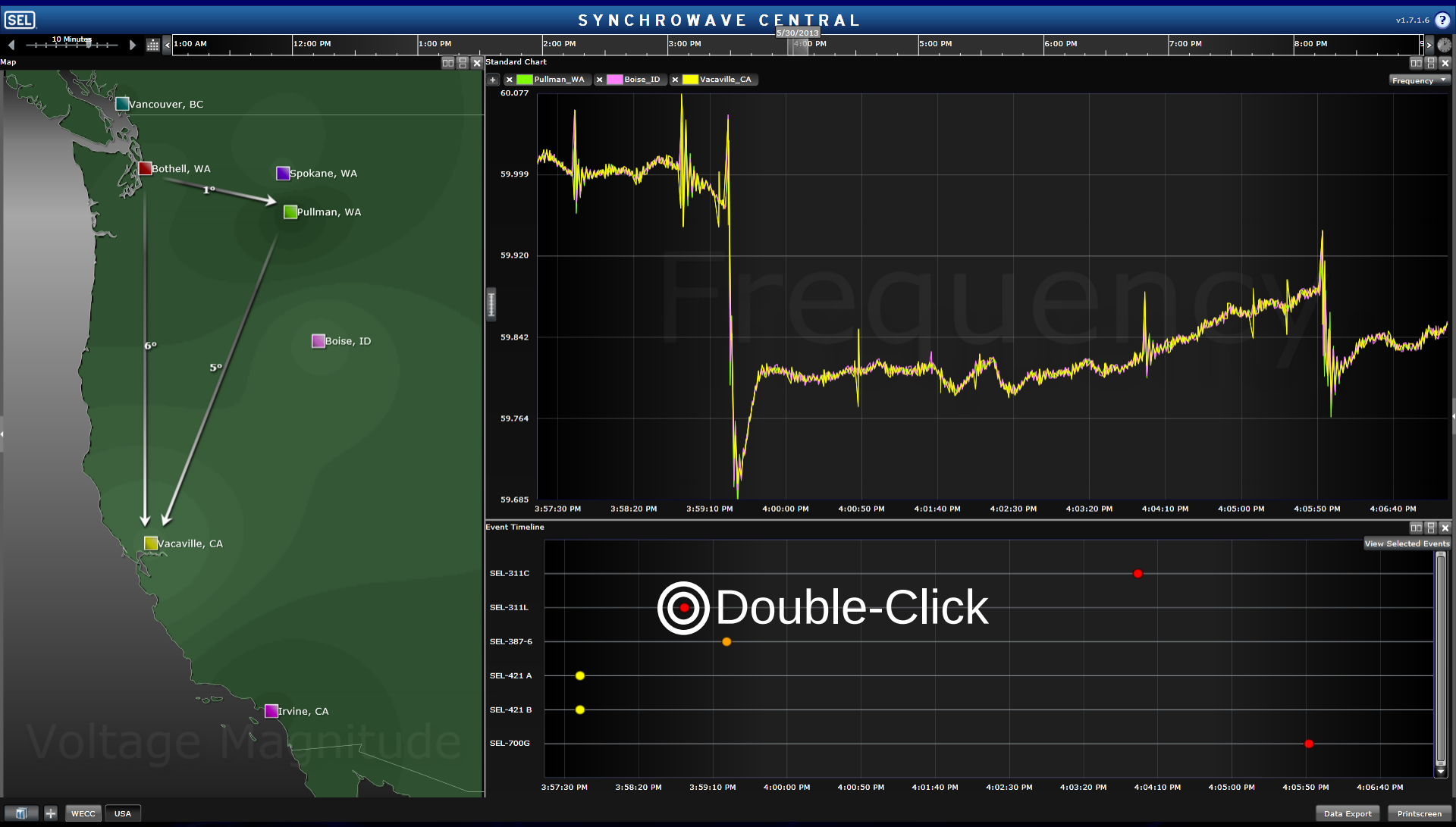


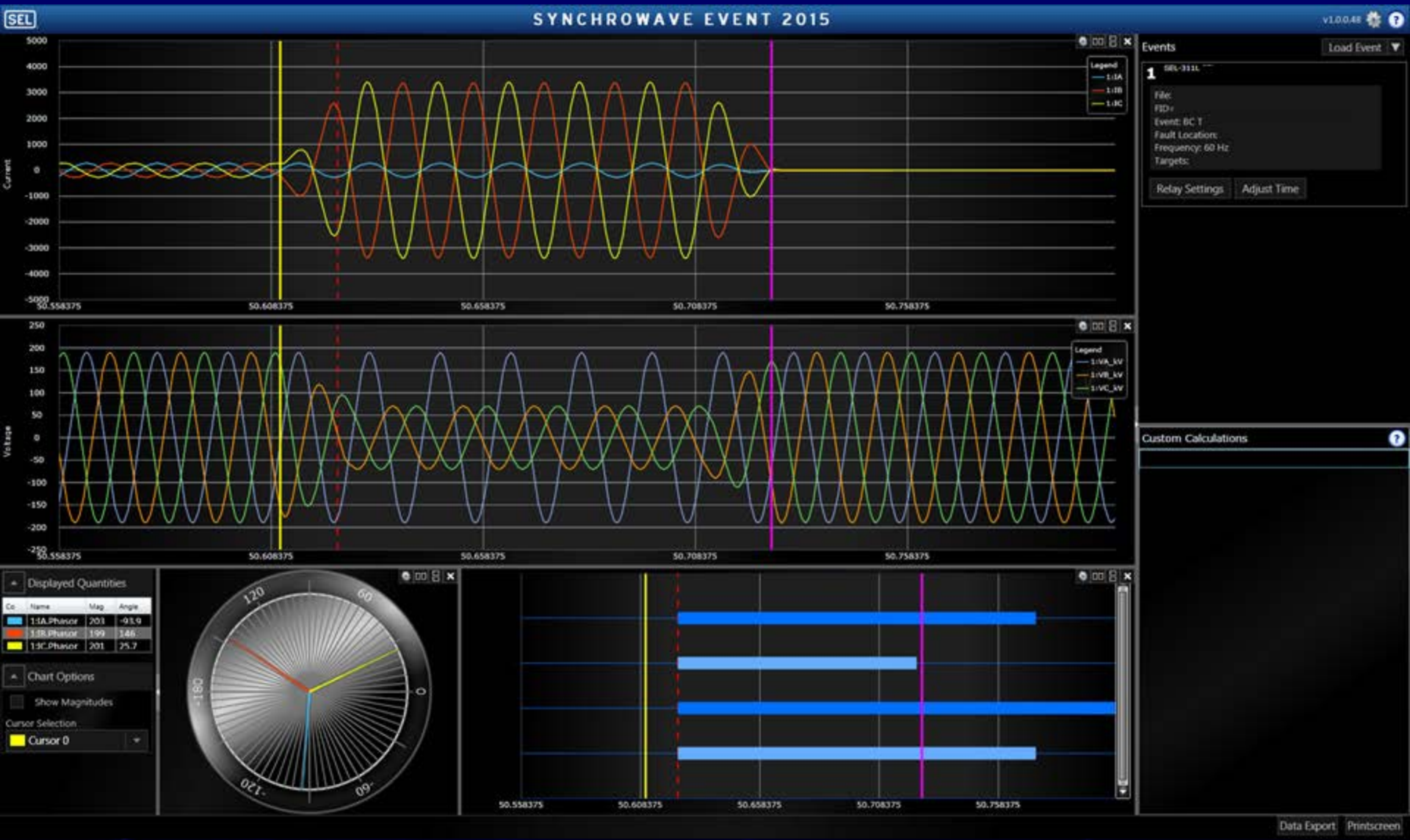
May 2014 – 2900 MW loss



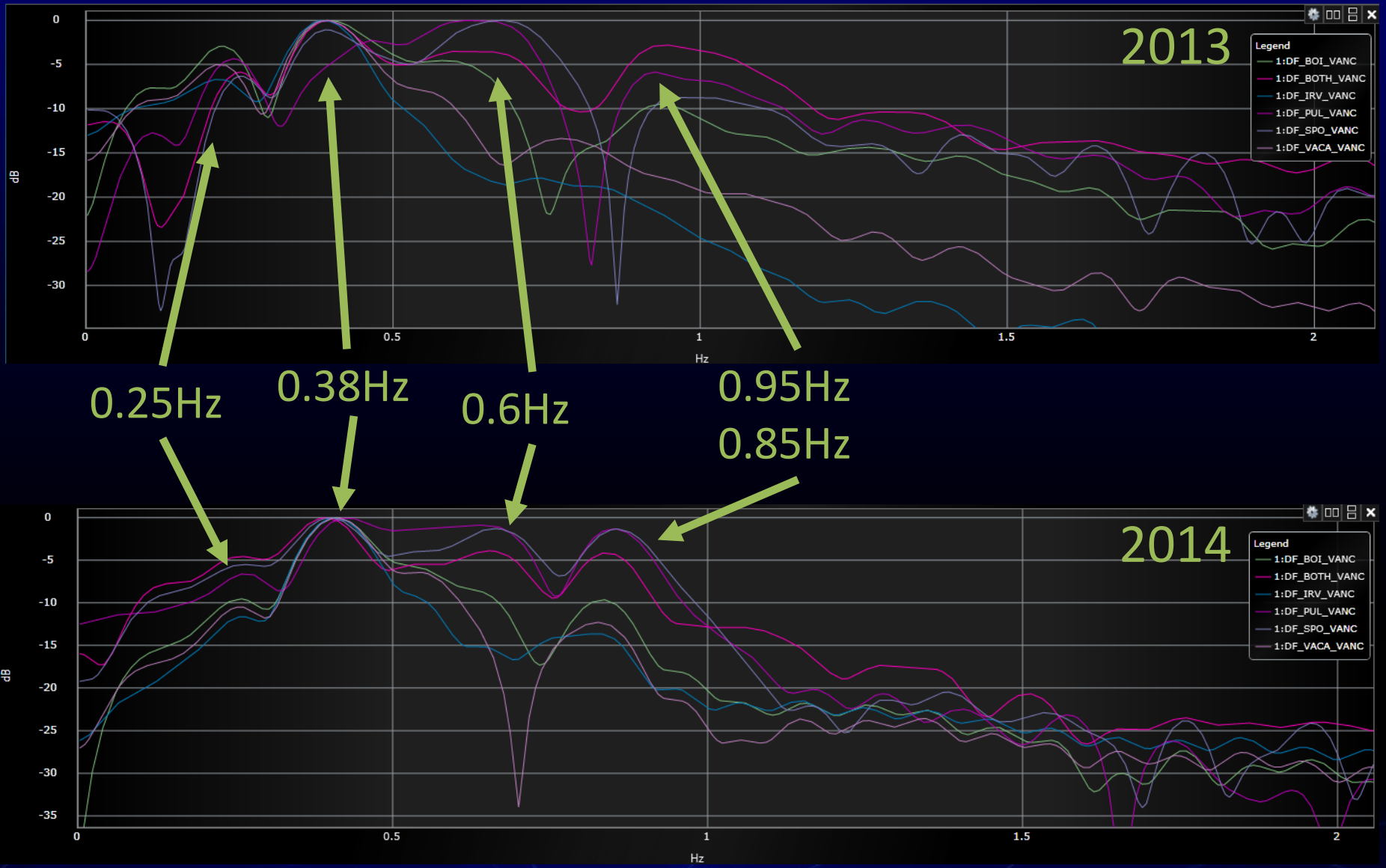
May 16, 2014



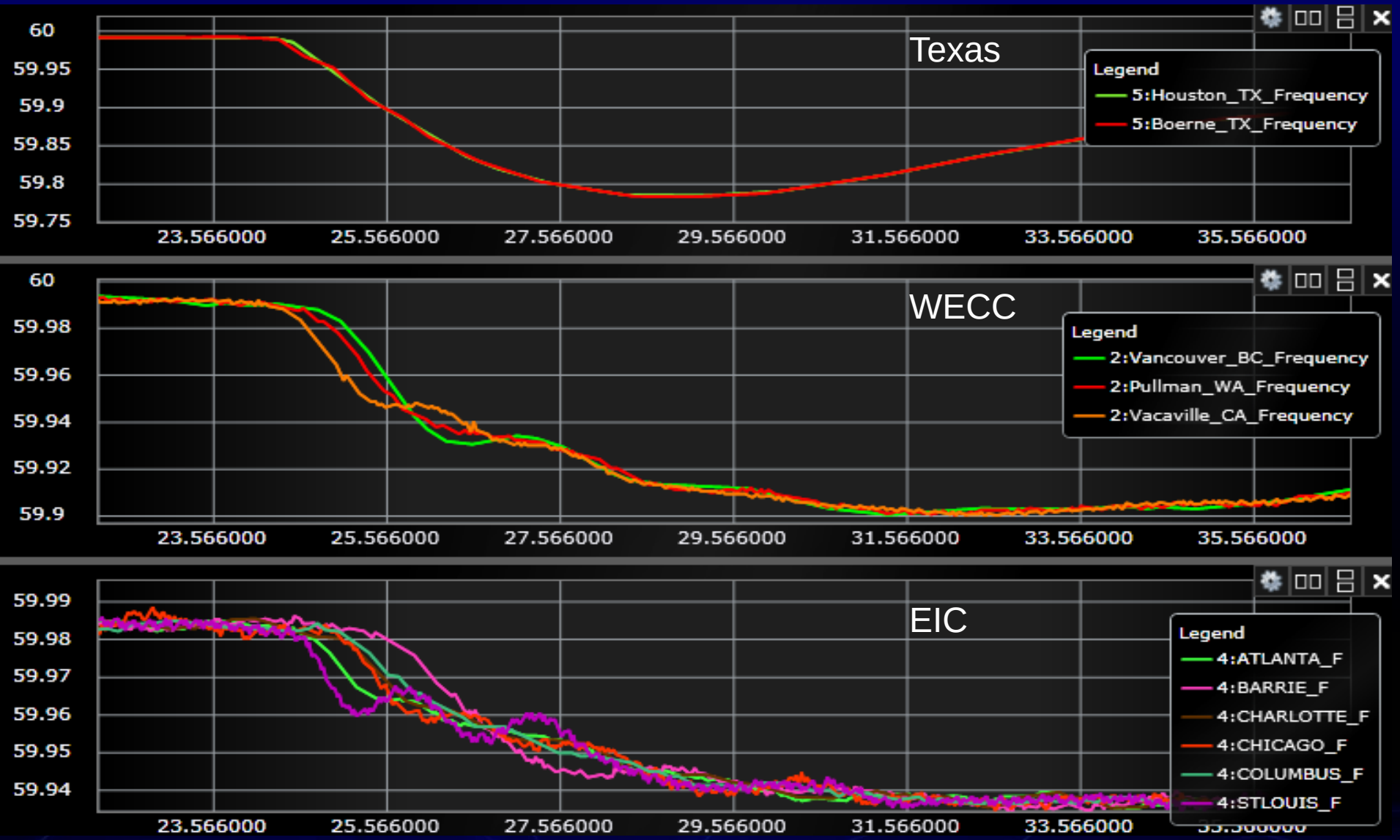




(10) FFT Event Comparison



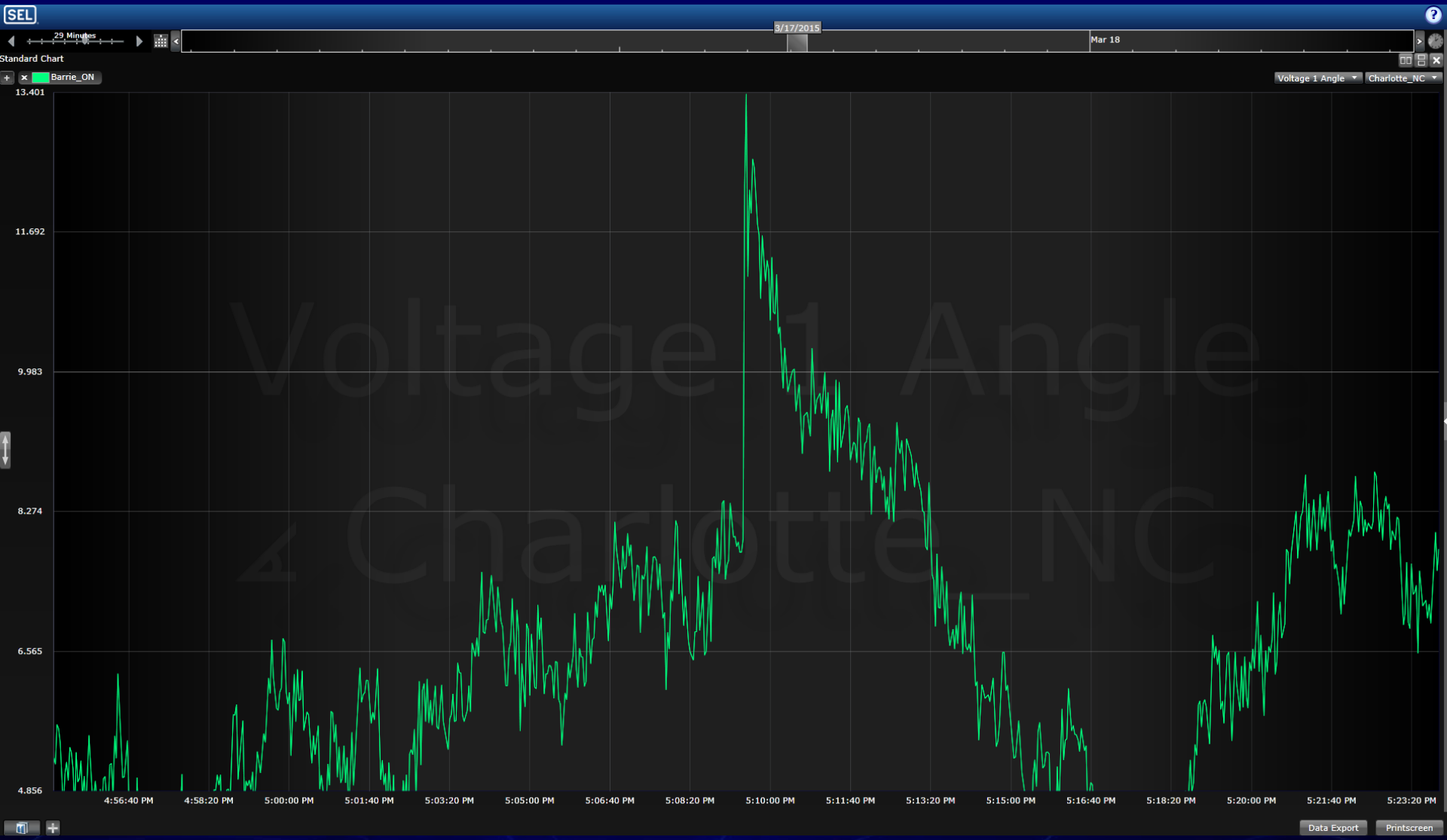
(11) Comparing Across The U.S.A



Normal Frequency Variations

(12) Phase Jumps

St. Patrick's Day Event?



(13) Field Engineers “Borrow” Our PMUs

“Hi Greg,
Sorry, we were doing some IRIG testing and needed the PMU.
It should be back now.”