# Overcoming Technical Challenges of SynchroPhasors
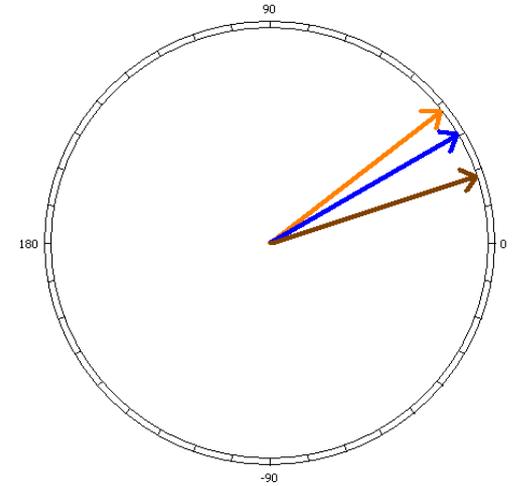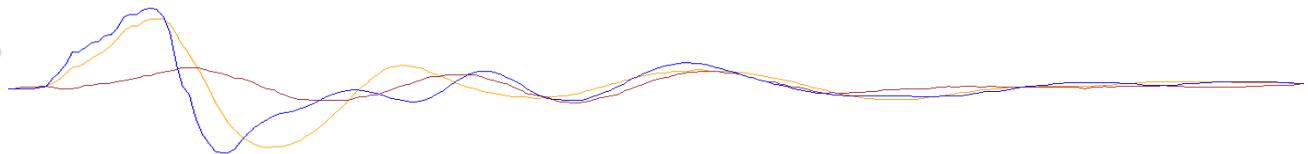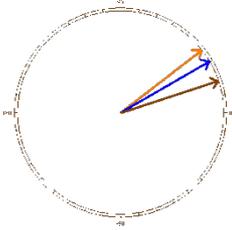
Austin D. White P.E.

Steven E. Chisholm
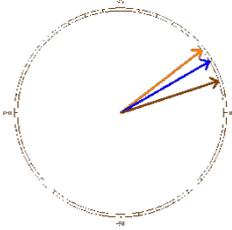
Oklahoma Gas & Electric

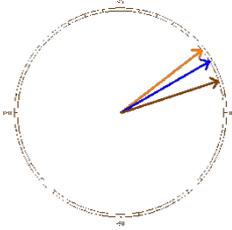# Inspirational Quote

*"The best way to predict the future is to create it."*

-Peter Drucker

# Outline

- Architecture Changes
  - Current
  - Planned
- Data Storage
  - Constraints
    - Historian Responsiveness
    - Data Retention
- Data Integrity/Analysis Problems

# Hardware & Software (Current)



**PMUs** — SEL-421 (8 PMUs) → **Data Concentration & Storage** — SEL-3306 → TVA SPDC → **Clients** — RTDMS

SEL-421, Ametek TR-2000 → openPDC GRID PROTECTION ALLIANCE → OSI OpenPMU, Microsoft SQL Database → OG&E PhasorView

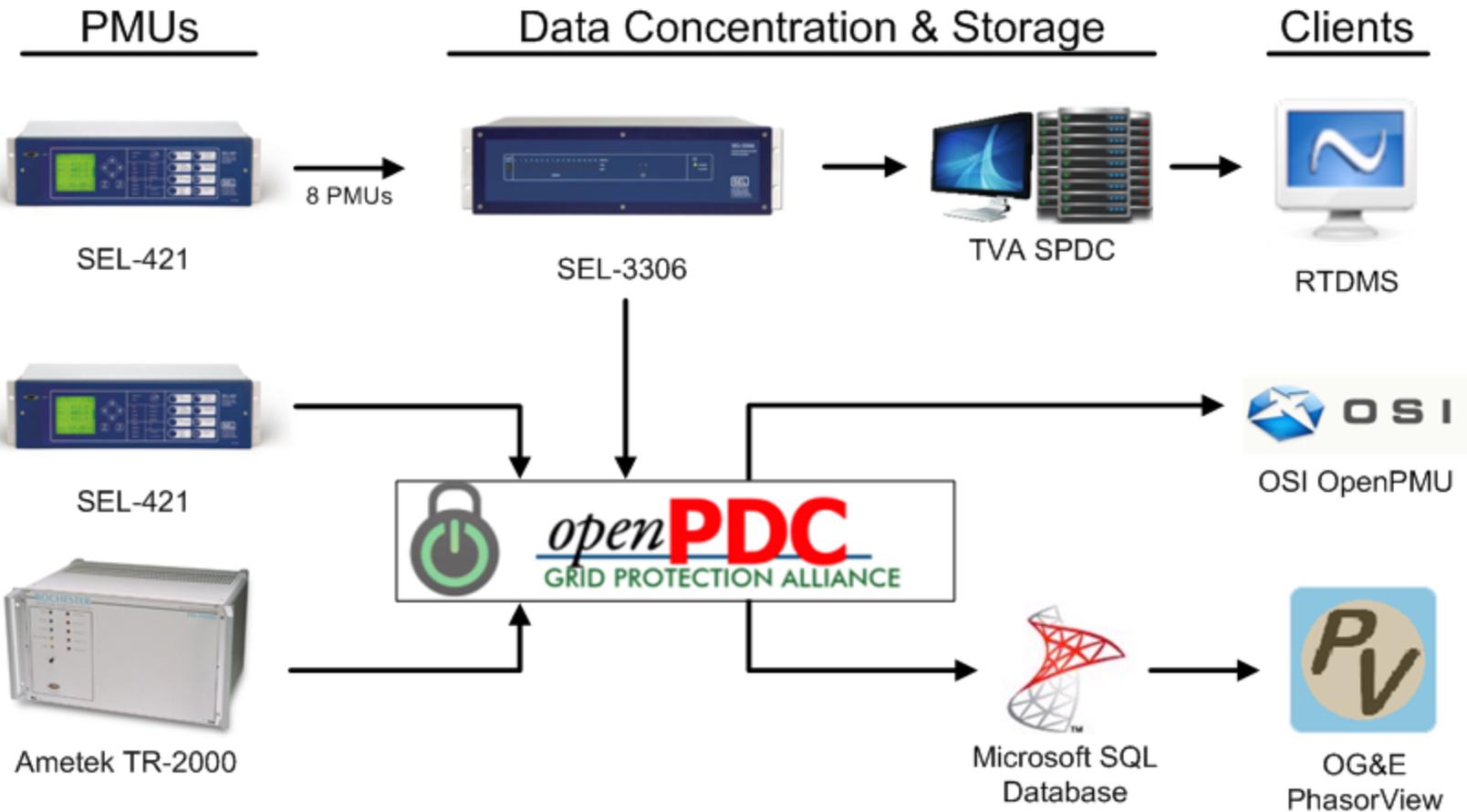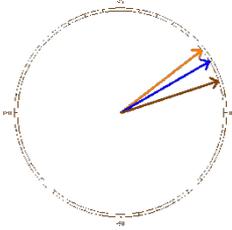# Hardware & Software (Planned)

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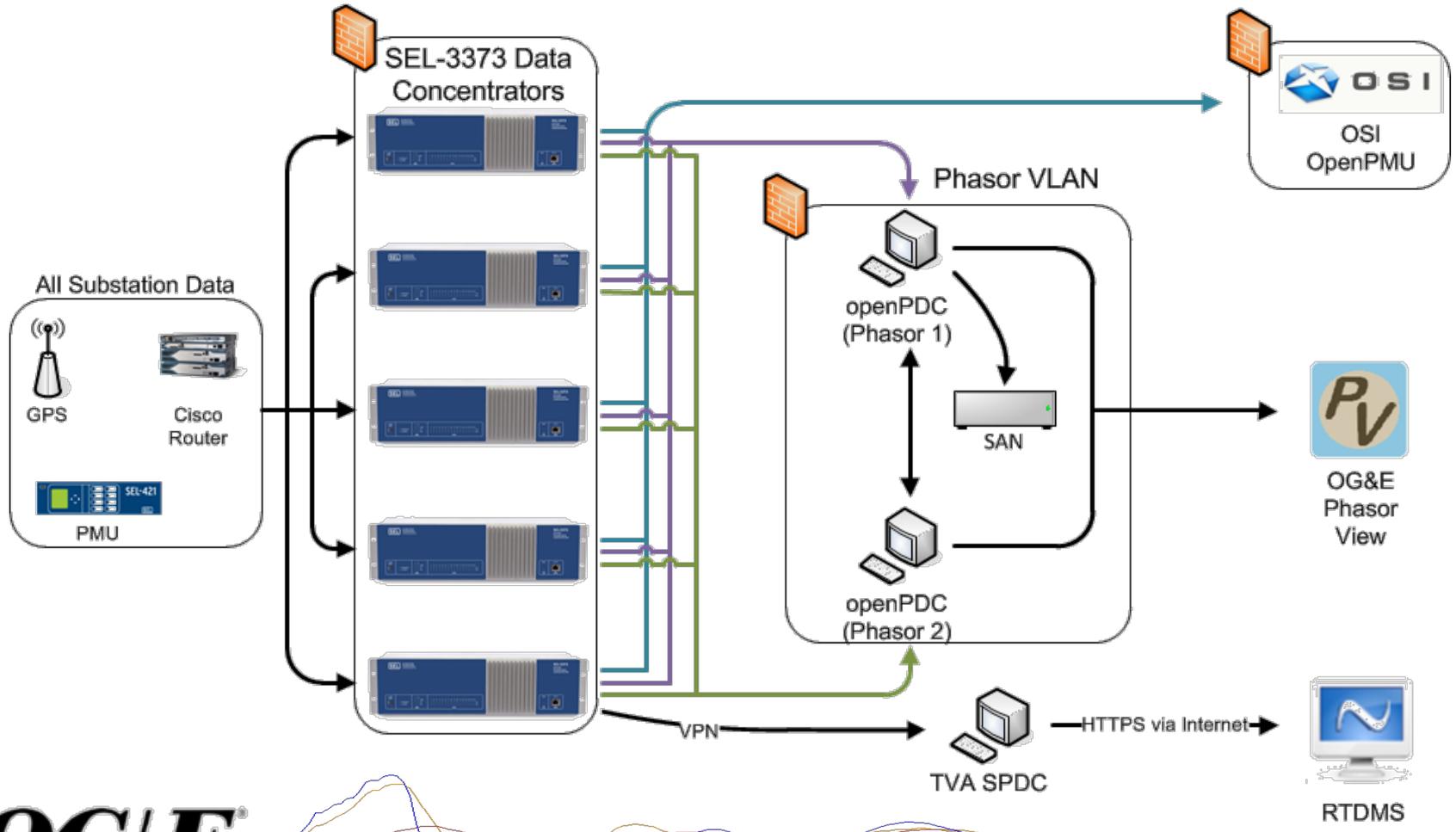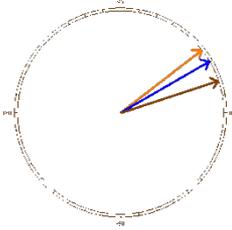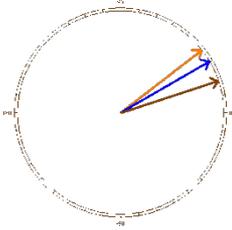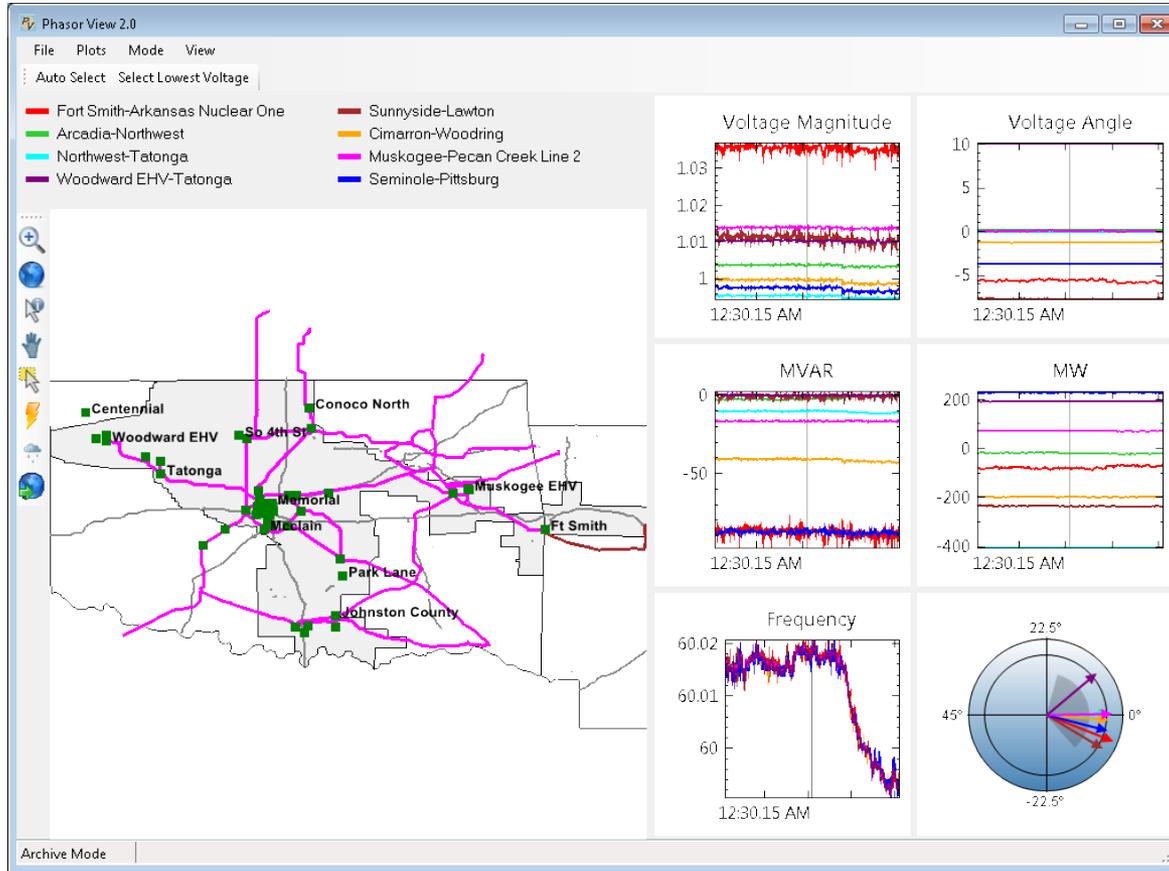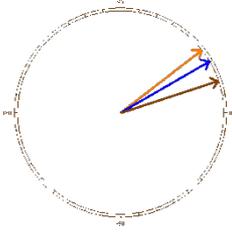- Data Integrity/Analysis Problems

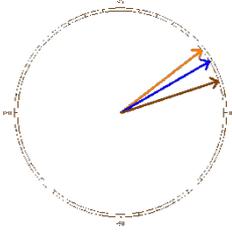# Constraint #1
# Historian Responsiveness

# Constraint #2
# Data Retention Policy

- ☐ Problem
  - ■ Hard to tell what is important
- ☐ Some Considerations
  - ■ Fixed Duration
  - ■ Multi-tier Storage
- ☐ Solution
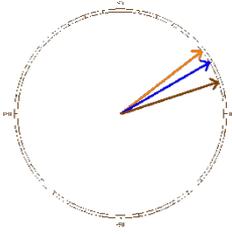  - ■ Keep all data, indefinitely

# Why?

- The rate of storage growth will soon outpace the rate of SynchroPhasor growth

- The challenge is not long term, the challenge is the next 3 years

- Based on these projections, we feel there is not a good reason to discard data

**Storage Density vs SynchroPhasor Requirements**
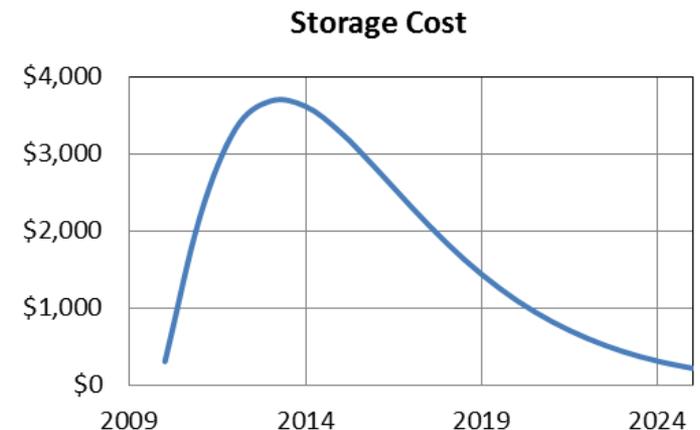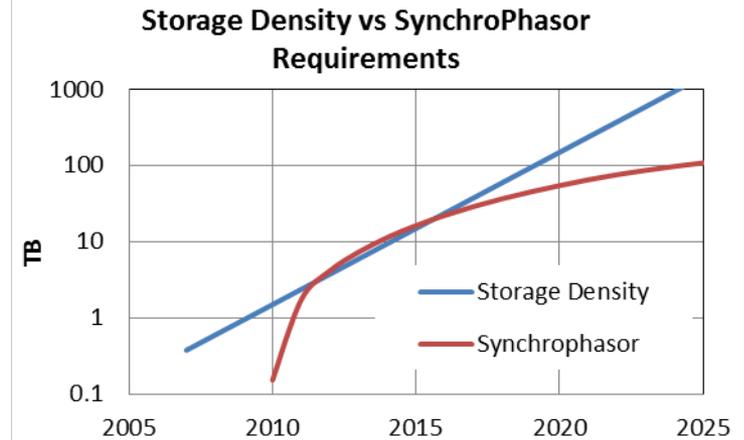
**Storage Cost**

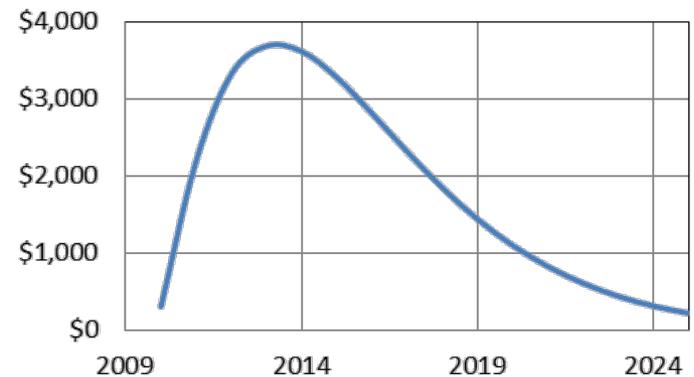# Getting over the hump (Lossless Compression)

- ☐ Problem:
  - ■ Growing at 9 TB/Year
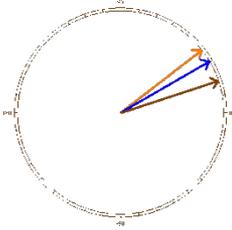  - ■ Up to 2.01 Trillion Data Samples
- ☐ Solution:
  - ■ Developed Custom High Speed Compression
  - ■ Reduced data storage requirement from 24.7GB/day to 7.4GB/day
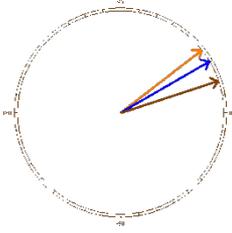
**Storage Cost**



| Method | Compress Rate | Decompress Rate |
|---|---|---|
| QuickLZ | 6.5MB/sec | 56.7MB/sec |
| LZMA | 184KB/sec | 5.76MB/sec |
| OGE's | 644MB/sec | 792MB/sec |

# Varying Data Requirements

| Historian Method | 2 Trillion Points |
|---|---|
| Raw Data | 32 TB |
| OGE's Uncompressed | 18 TB |
| OGE's Compressed | 5.4 TB |
| openHistorian 1.0 | 19 TB |
| openHistorian 2.0 Lossless | ~5.2 TB |
| Expected Minimum Lossless | ~3.6 TB |

# Recap – Storage Growth

- Data is more valuable than storage cost - Keep indefinitely

- Implemented Lossless Compression in August 2011

- Historian is Faster

- Reduced data storage requirement by 70%
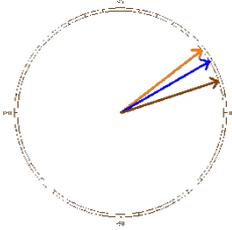
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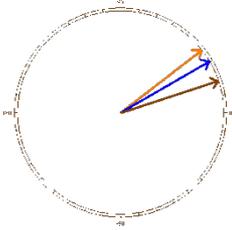
# Data Analysis

- Use of automated analysis routines to support advanced synchrophasor applications:
  - Oscillation detection (FFT emailer)
  - Failing equipment detection
  - Event detection
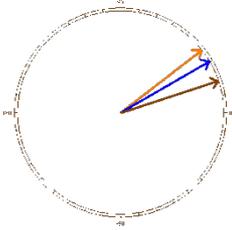- These routines need to work around known data problems
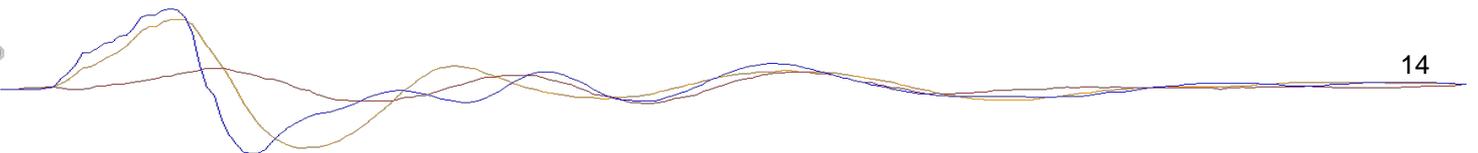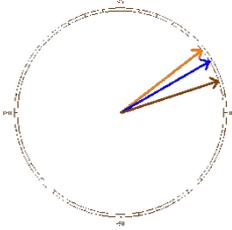
# CT/PT Measurement Error

- Five PMUs on the same ring bus don't agree
- CCVT Accuracy is typically 0.6% for the relaying class
- Calibration needed



Voltage Magnitude

(4 hours)

Voltage Angle
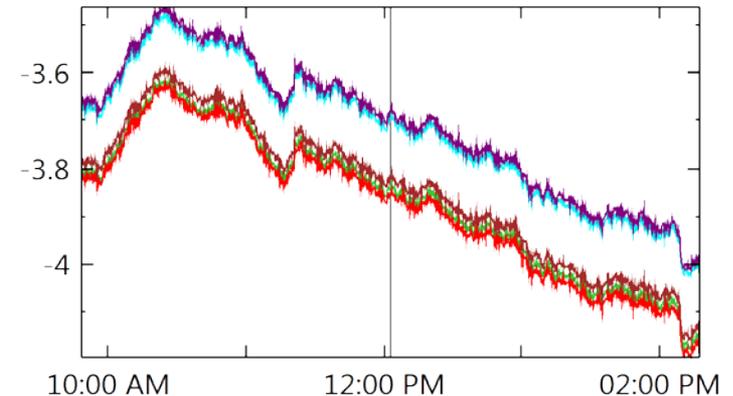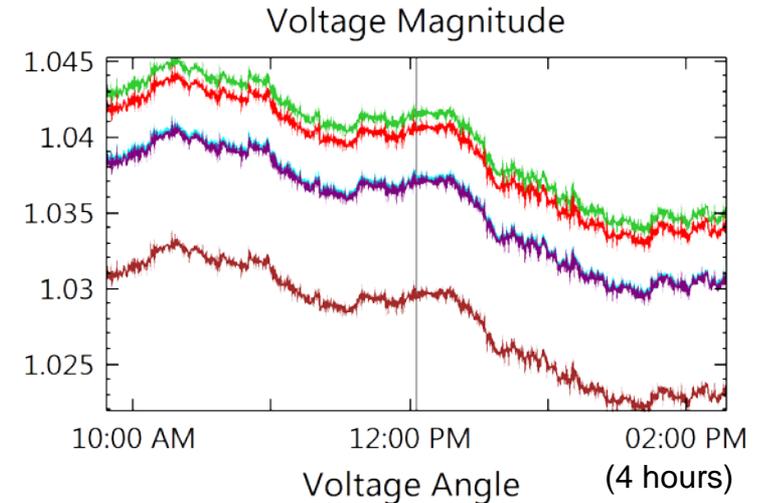
# Discovery of Failing Equipment

- Discovered many loose connections in the potential circuits at fuses or terminal blocks

- This has caused misoperations in the past (relays get confused)

- Proactively finding these helps prevent future outages and misoperations

### Voltage Magnitude



(35 minutes)

### Voltage Magnitude



(4 seconds)
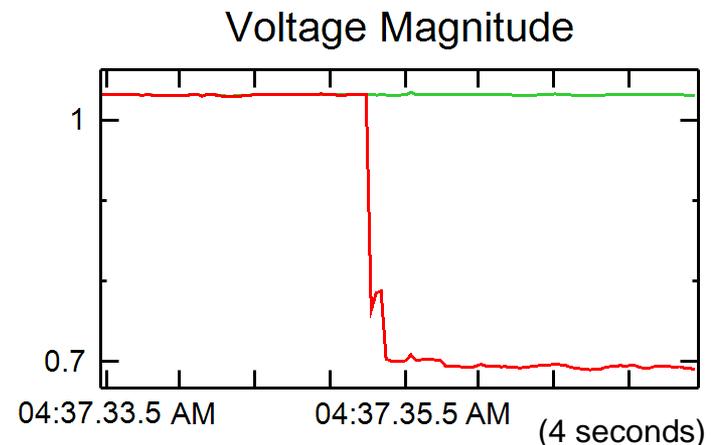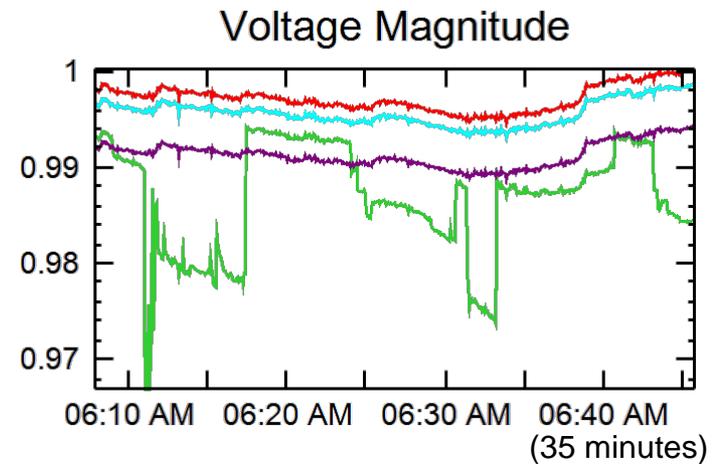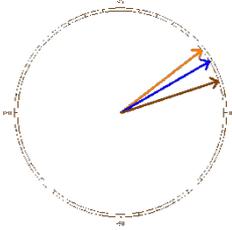
# PT Problem Report

- □ Our daily PT Problem report performs a dV/dT to help identify abnormal voltage fluctuations

**PT Problem Report**

☐ PhasorServer@oge.com

ⓘ This message may contain extra line breaks.

Sent:    Thu 11/17/2011 7:05 AM

To:

　　　5 - Cimarron Transformer 2 (345-138kV)
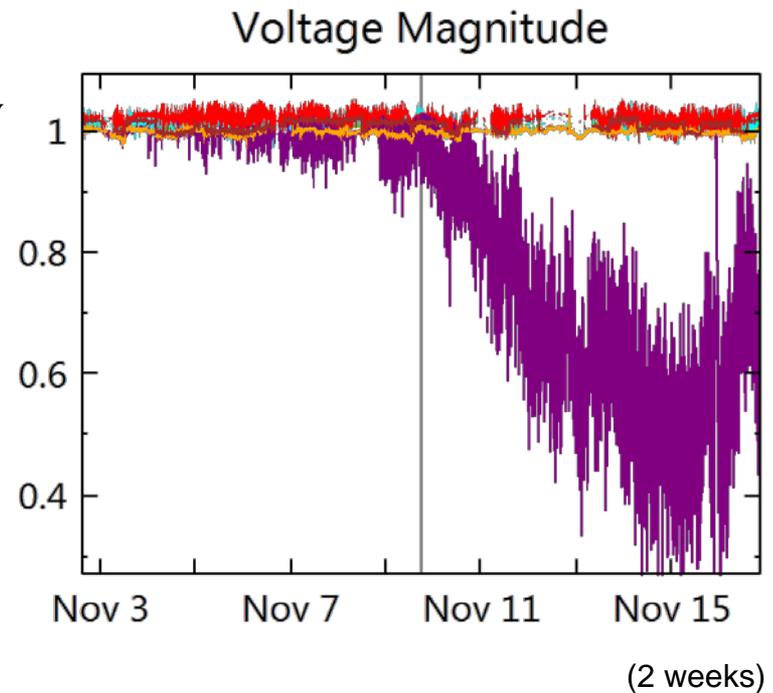　　6 - Cimarron-Draper
　　5 - Cimarron-Minco
　　5 - Cimarron-Northwest
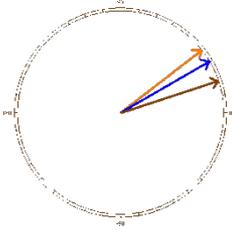181093 - Cimarron-Woodring
　　1 - Cimarron-Cornville
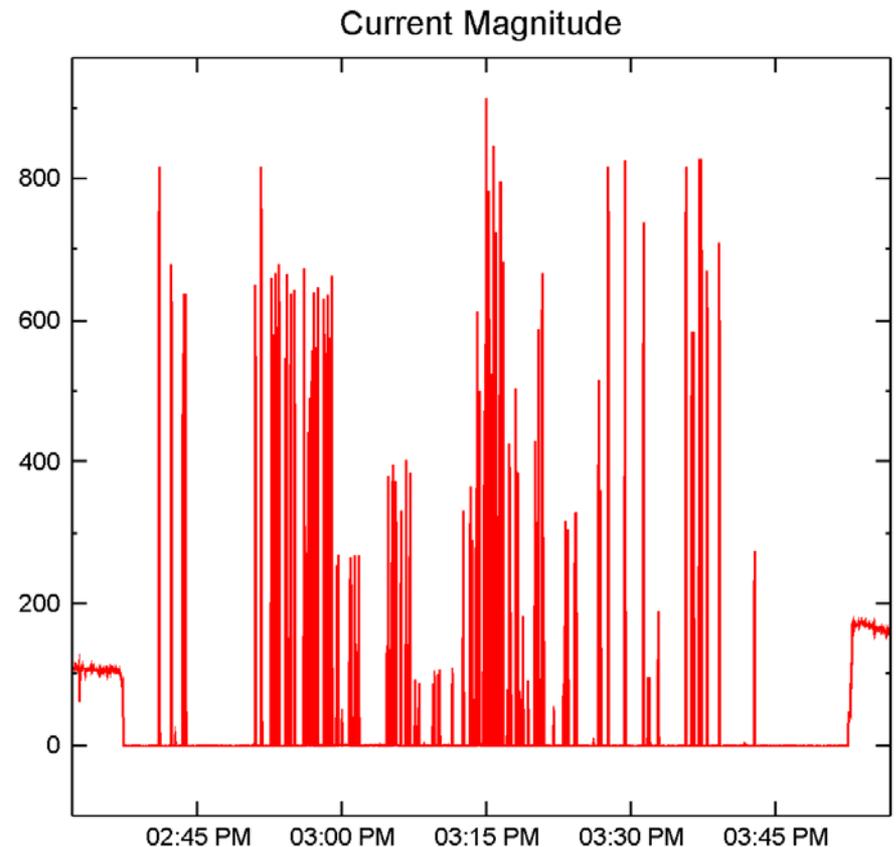　　1 - Cimarron-Division
　　1 - Cimarron-El Reno

### Voltage Magnitude



(2 weeks)
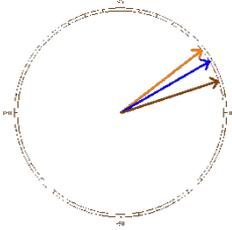
Failing analog input

17

# Beware of Relay Testing

- 8/18/2011 – 345kV line from Sunnyside to Lawton went dead

- 260 high current event were experienced

- Detection algorithms need to know how to handle relay testing
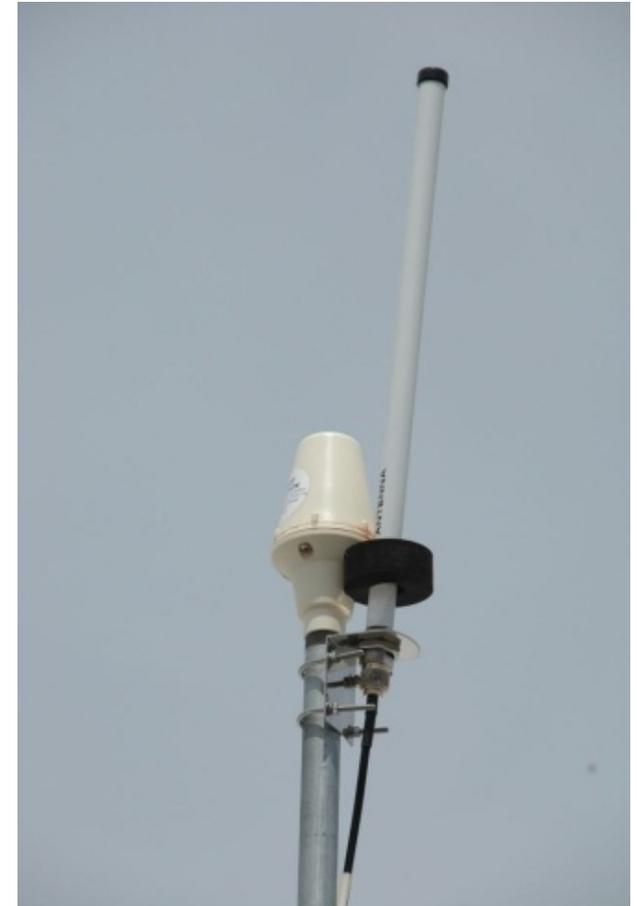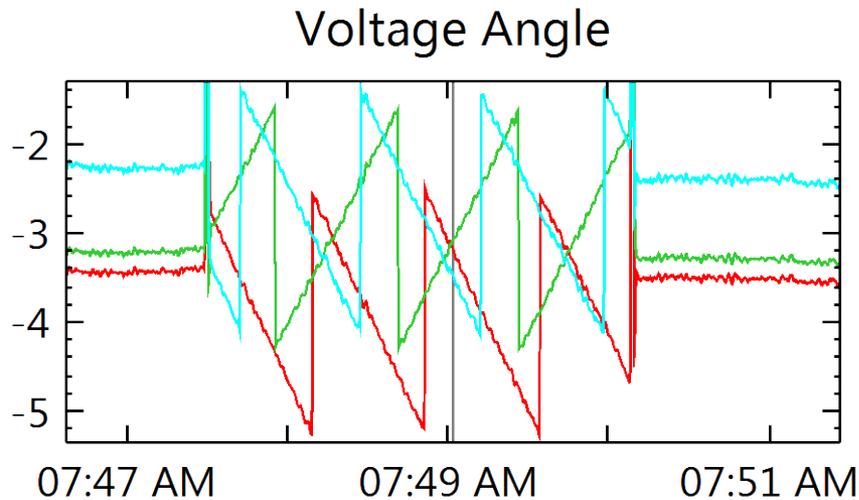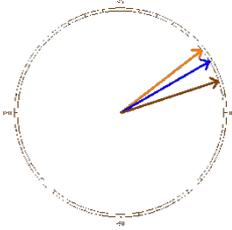
**Current Magnitude**

(75 Minutes)

# Identifying GPS Problems

☐ A 3G data radio antenna mounted adjacent to the GPS antenna will very effectively jam the GPS signal!

### Voltage Angle

# Wrap Up

- Security: Preconcentrated PMUs with SEL appliances to ease security requirements

- Storage: Implemented custom compression to be available in GPA's openHistorian 2.0 in order to maintain all of our data until 1TB floppies are released in 2020

- Data Analysis: Developed tools to automatically detect oscillations, failing equipment and system disturbances
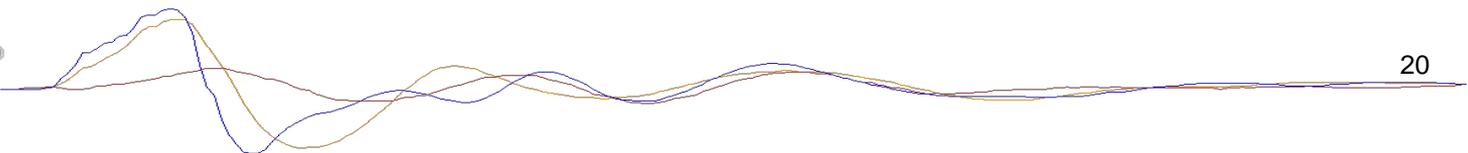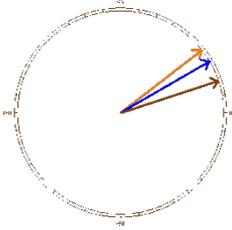
# Questions?

- Thanks! Feel free to contact us if you have any questions.
  - Austin White
    - whitead@oge.com (405-553-5996)
  - Steven Chisholm
    - chishose@oge.com (405-553-3764)