# The Entergy Phasor System

## Pushing PI to New Heights

Floyd Galvan, PE

2007 OSIsoft Users Conference

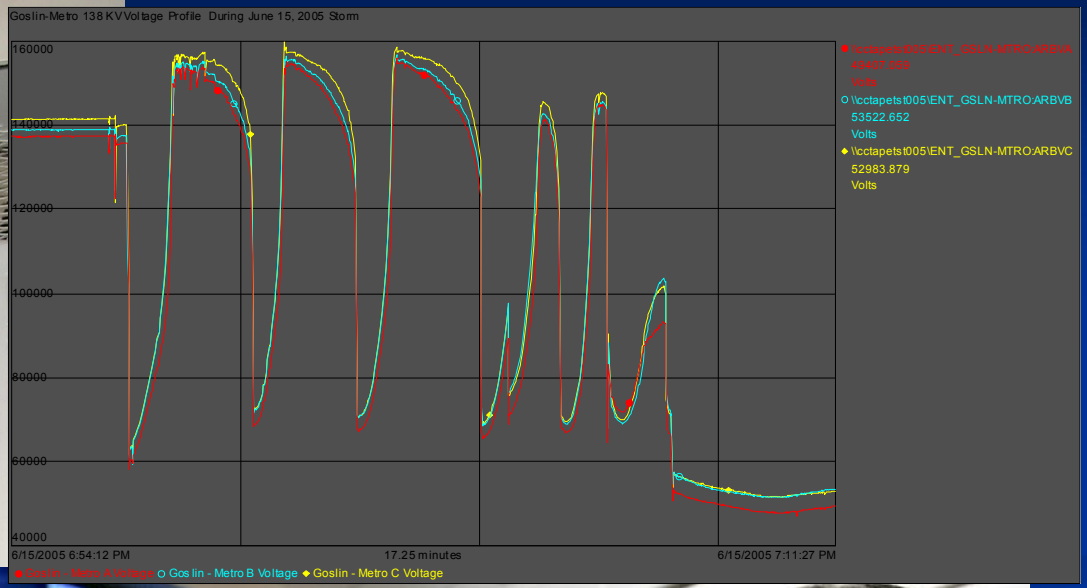
Monterey, CA

- Entergy Owns and Operates approximately 30,000 MW of capacity
- Entergy delivers electricity to approximately 2.6 million utility customers across 4 states
- Entergy is the second-largest nuclear operator in the nation, operating 12 units
- Entergy is a Fortune 500 company with revenues of more than $10 billion in 2006
- Entergy is the second cleanest utility generator among the top 10 generators and was the first U.S. utility to voluntarily stabilize greenhouse gas emissions

Entergy®

THE POWER OF PEOPLE™

# The Entergy Phasor System


# It started with….


August 14, 2003

# Largest Blackout in US History

"Caused in part by deficiencies by the system that monitors the electric grid, and a lack of awareness of deteriorating conditions by the operators who monitor the system." Joint DOE & FERC Report to Congress – Feb 2006

## August 14th 2003 Blackout

***By-The-Numbers***

**1 Canadian Province**

**3 deaths**

**8 U.S. states**

**12 airports closed**

**23 cases of looting in Ottawa**

**250+ power plants**

**9,266 square miles**

**61,800 MW of power lost**

**1.5 mill Cleveland residents without water**

**50 million people**

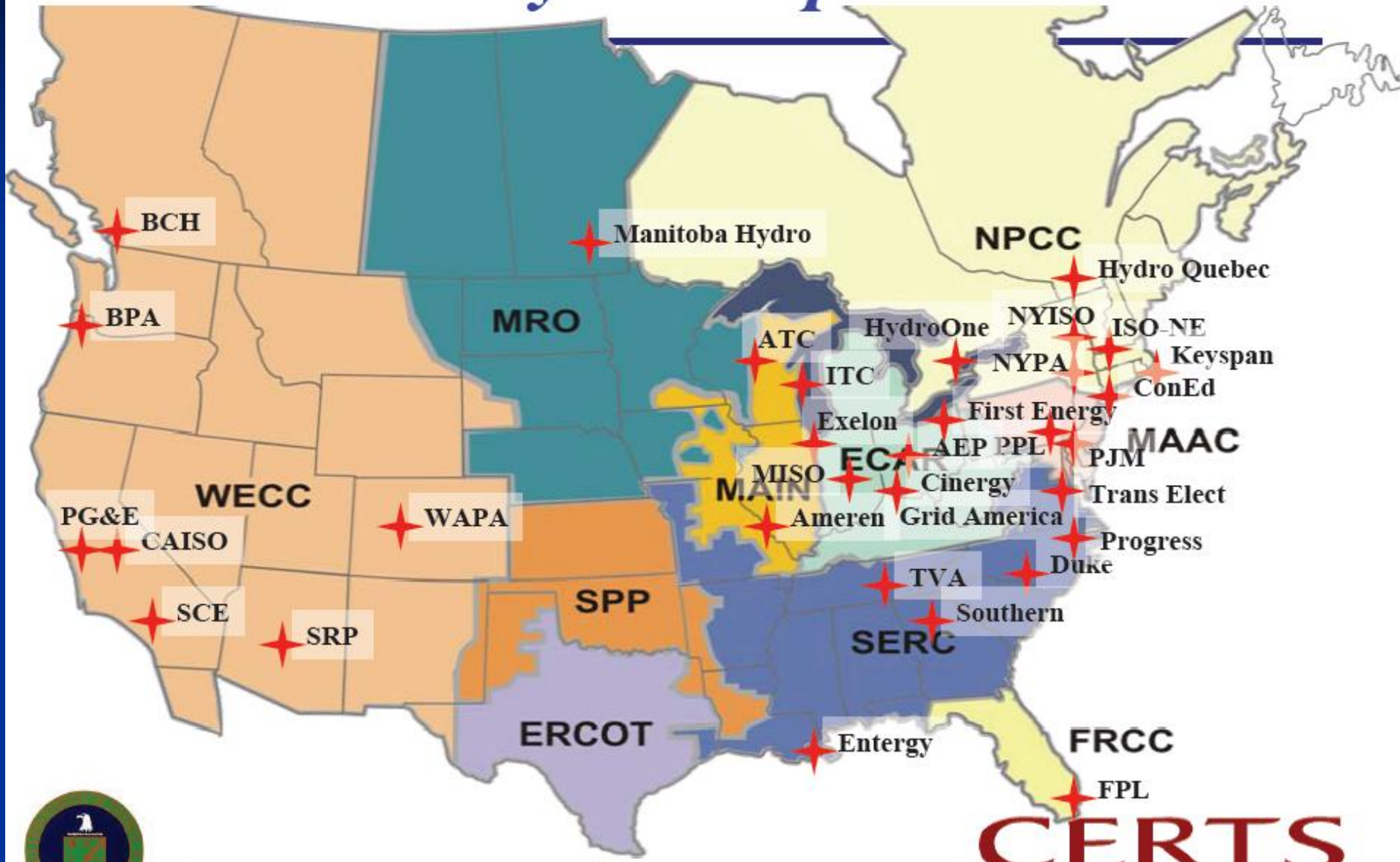
**$4.5-10 billion in economic activity lost**

# North American Synchro-Phasor Initiative (NASPI)

***Lead by DOE and NERC***

- ***Vision – improve power system reliability through wide-area measurement, monitoring and control (throughout the North American grid)***
  - ***www.phasors.pnl.gov***
  - ***Montreal Canada 9/6-7***

# Utility Participants*




CERTS

Consortium for Electric Reliability Technology Solutions

# Entergy Phasor Time-Line


August 2003

Nov 2004

# Building the Beta System

- Design Communication Infrastructure
  - Within Entergy
  - Between Companies in the Eastern Interconnect
- Determine location of PMU on Entergy System
- Vendor Selection for PMU & PDC
- NDA to share Phasor Data
- Get Approvals and Money
- Build a team
- Get Iron in the Ground
  - Dec 2004 1st PMU sends data to TVA Super PDC
  - May 2005 Ten PMUs operational

# Entergy Phasor Time-Line


August 2003

Aug 2005

Nov 2004

# Unprecedented Natural Disaster

Two Hurricanes: Katrina and Rita

Flooding from Breeched Levees lasting many weeks

All Generation in SE La was lost

# Double Trouble

| Summary | Katrina | Rita |
|---|---|---|
| Cat., Landfall, Rest. | C4–Aug 29- 42 days | C3–Sept 24-21 days |
| Areas Impacted | Ms, La, NO | Ar, Ms, La, NO, Tx |
| Customers Out | 1,091 K, 41 % base | 800 K, 30% |
| Tran Line Out | 181 | 341 |
| Subs Out | 263 | 443 |
| Fossil Units Impact | 15 | 14 |
| Nuc Units Impact | Waterford 3 | |
| Dist Pole Destroyed | 17,400 | 11,500 |
| Resource Deployed | 10,200Workers<br>3,500 Support | 13,000 Workers<br>4.500 Support |

- Staff scattered across the US and Canada
- Working from hotels, friends homes, and eventually an apartment and a temporary office in Houston
- Dealing with home repair, losses-personal, spiritual, and financial,
- Eventually we began to rebuild


# Entergy Phasor Time-Line


August 2003

Nov 2004

Dec 2006

Aug 2005

# Entergy
# PMU Locations

- 20 Sites are installed
- PMU – ARBITER 1133A, Power Sentinal; SEL 421
- PDC – OSIsoft PI

# Entergy PMU Locations

- 500 KV – 10
- 345 KV – 1
- 230 KV – 4
- 138/115 KV – 3
- Distribution – 2
- Arkansas – 9
- Louisiana – 5
- Mississippi – 2
- Texas (NON-ERCOT) – 4

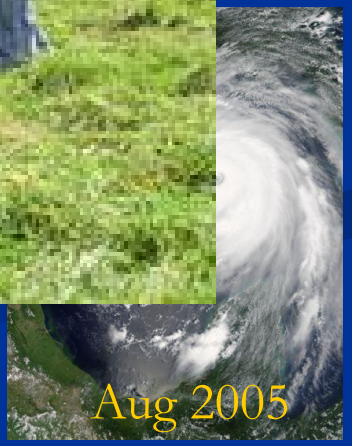
# Entergy Phasor Time-Line


August 2

Dec 2006

Nov 2004

Aug 2007



Aug 2005

# Fixing Problems-C37.118

- New Synchro-Phasor Standard C37.118
  - Firmware upgrade on PMU – for SEL the relay must be taken out of service
  - Pi Interface for C37.118:
    - The process of getting a C37.118 interface to market has taken too long
    - Still issues with bringing data in from TVA
    - Works only w/ Arbiter & SEL PMU
  - It's time - C37.118 Server

# Fixing Problems-PMU

- Arbiter 1133 Power Sentinel PMU
  - 37.118 Firmware Unstable
  - Remote Re-boot (needed)
  - Remote Firmware upgrades (needed)
  - Remote Calibration (needed)
  - Don't stop Firmware upgrades are in progress

# Fixing Problems- Infrastructure

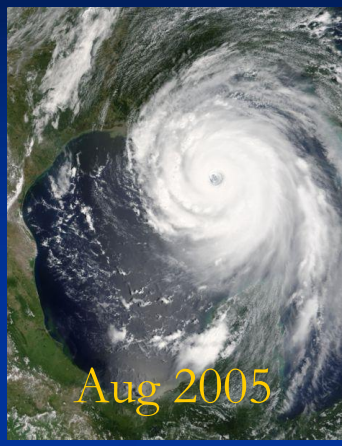
- Migrate from Corporate network to private internal network for critical data
- New Server Infrastructure: 5 days of history to 5 years

# Entergy Phasor Time-Line

August 2003


Dec 2006


Aug 2007


Aug 2005

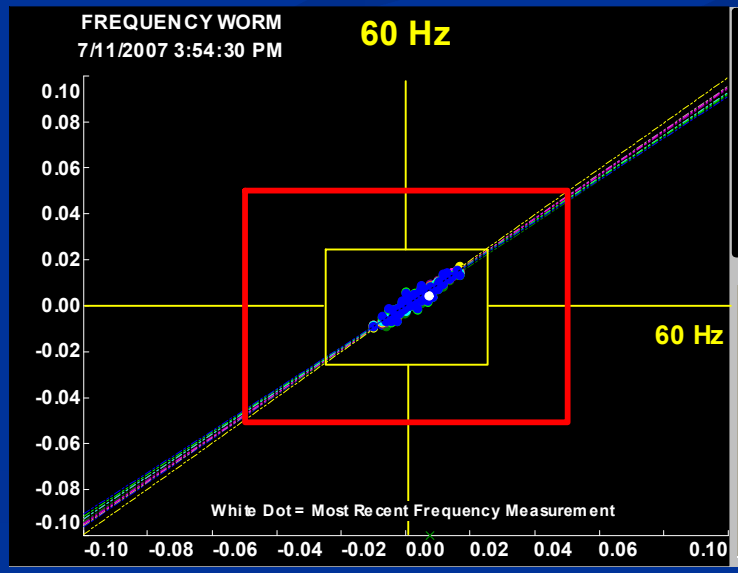

Nov 2004

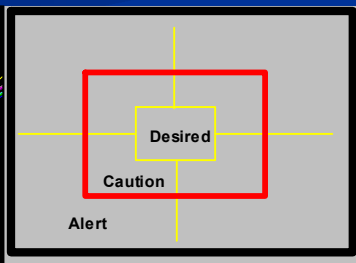
# Entergy Wide-Area Initiatives

- **Detection, Prevention and Mitigation of Cascading Events – Prototype Implementations**
- ***Joint project Incorporating Phasor Measurements into State Estimation (Phase 2)***

# Entergy Wide-Area Initiatives

- *PMU Meter Placement Study for Monitoring and Control*
- *Event Location Triangulation*
- System Security Using Phase Angle Differences



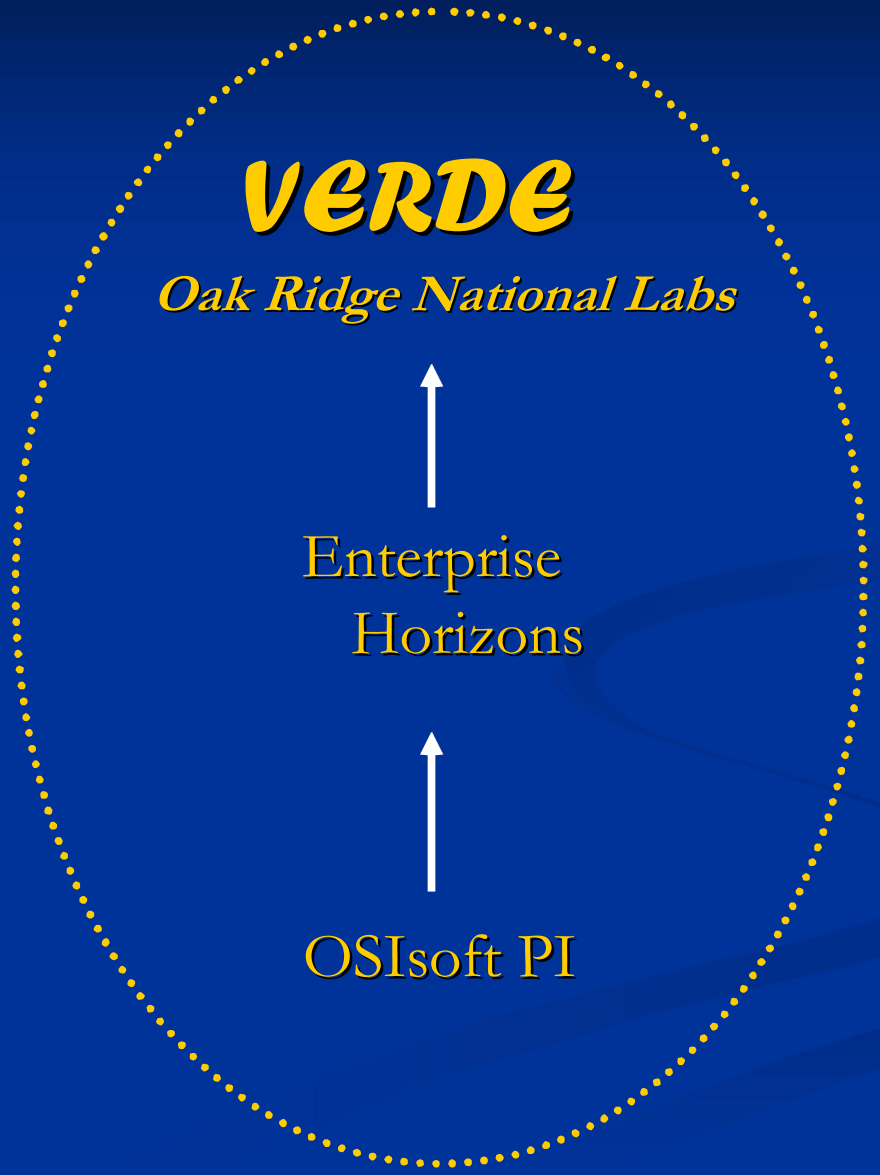

This chart represents your operating frequency domain. Frequency here is represented as a difference from 60 Hz.

The system should be operated within the desired range (the yellow dashed box). Caution should be noted when frequencies begin to migrate outside of the yellow dashed box.

Frequencies falling in the alert region (outside of the red box) should be closely monitered.

If the frequency worm begins to scatter, this represents potential islanding.

# Regional Visualization




ProcessBook Display

ProcessBook Display

ProcessBook Display

ProcessBook Display

# Electric Grid & Energy Infrastructure Situational Awareness

**Major power outages over the past decade have occurred due to a lack of wide-area situational understanding**

**ORNL, in partnership with TVA, is developing a resource for the U.S. DOE's Office of Electricity Delivery & Energy Reliability that will enable real-time status of the electric grid and assess inter-dependencies with critical energy sectors**

**Assist in coordination of federal response to natural disasters or major events**

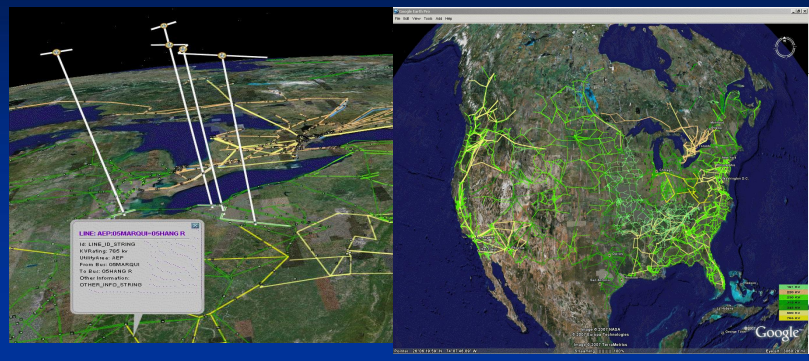
# Electric Grid & Energy Infrastructure Situational Awareness

- U.S. DOE Office of Electricity Delivery and Energy Reliability sponsored effort
- Coordinate federal response to natural disasters or major events
- ORNL, in partnership with TVA, developing real-time visualization tool
- Initially assess status of transmission lines in the Southeast

# VERDE Capabilities

## Visualizing Energy Resources Dynamically on Earth

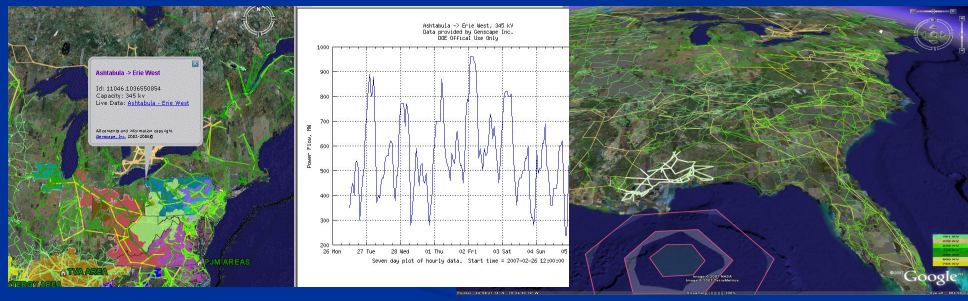
- Platform provides wide area visualization capability
  - Flexible system
- Real-time status of transmission lines
- Real-time weather overlays
- Predictive impact models & Animated replay
- Data analysis
- Energy infrastructure interdependencies:
  - Coal delivery and rail lines
  - Refinery and oil wells
  - Natural gas pipelines
  - Transportation and evacuation routes
  - Population impacts - LandScan

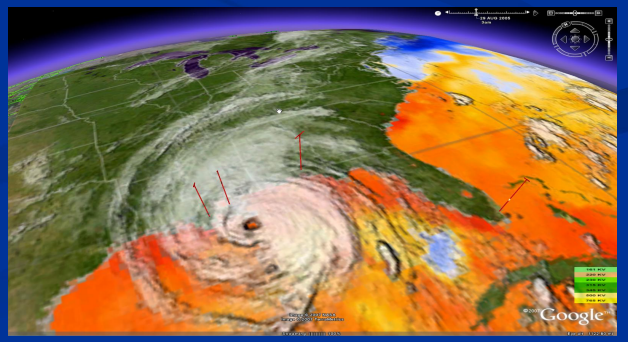


Wide-Area Power Grid Situational Awareness

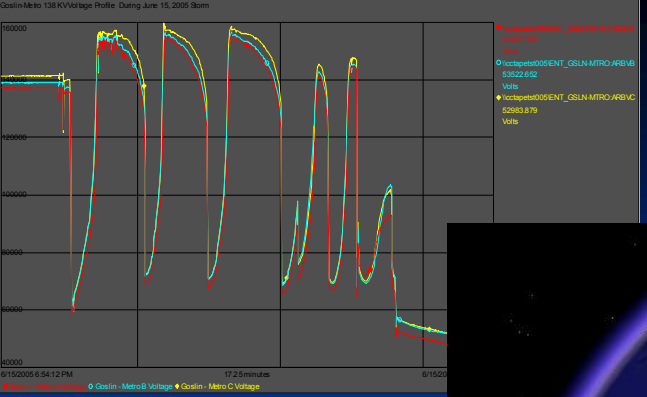
Streaming Analysis

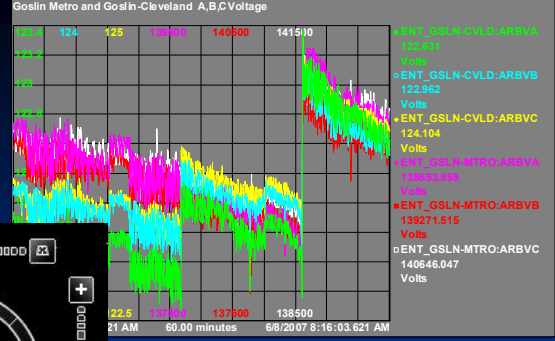
Impact Models

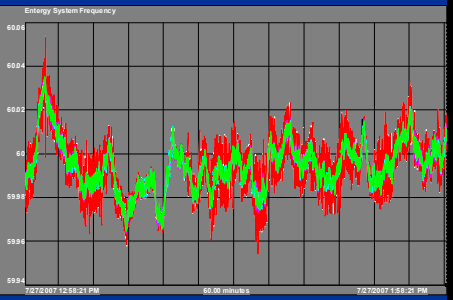




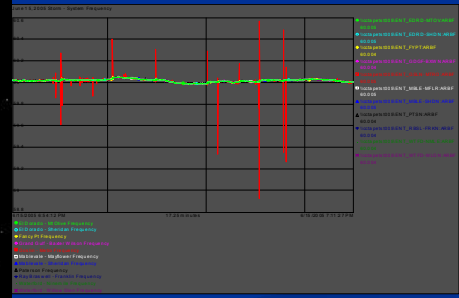
Real-time Weather Overlays



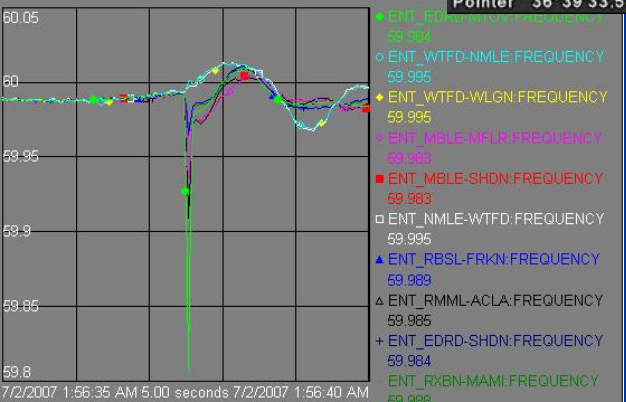



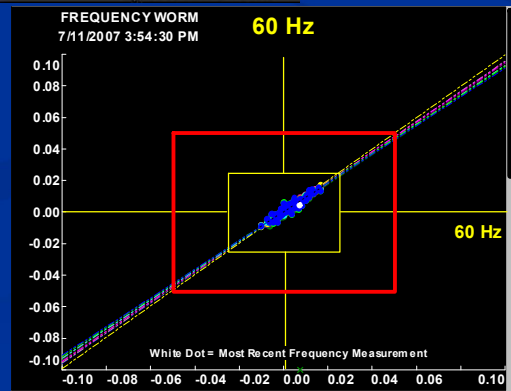



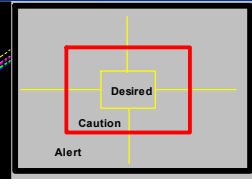




Mt Olive - Hartburg 500 kV Trip (5 Second View)

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