

# **Operations Implementation Task Team Report**

## **NASPI Workgroup Meeting**

**September 6-7, 2007**

**Terry Bilke, Midwest ISO  
David Hawkins, California ISO**

# *Agenda*

- **Team's Scope (Mission) Goals and Activities**
- **Key Deliverables & Accomplishments for 2007**
- **Top Items for Next Year**
- **Complementary WECC Activities & Accomplishments**
- **Areas where WG Support is Needed**

# *Team's Scope, Goals and Activities*

## **Scope**

- ❑ Deployment of and training and tools enabling operators, reliability coordinators and others engaged in operational aspects of grid reliability to effectively monitor and assess the real-time operations of the bulk power grid on a wide area basis.
- ❑ Tools include applications that utilize PMU data for state estimation and other real-time applications.

## **Goals & Activities**

- Expand and improve suite of tools
- Provide Operator (and Engineer) education and training on phasor technology and use of tools
- Expand and promote NASPI participation and infrastructure
- Display development and management

# *Key 2007 Deliverables & Accomplishments*

- ❑ Develop prototype wide-area visualization tool
  - New RTDMS version released to NASPI community – *supports improved real time performance and enhanced visualization, alarming and navigation capabilities*
  - Successfully integrated FNET information with RTDMS – *demonstrates capability to send alarms/alerts from other applications to central RTDMS data hub*
  - Tool supports c37.118 standard to streamline integration of new devices into displays
  - Calibrated phasor measurements against MISO state estimator for data & info accuracy
- ❑ Obtain user feedback from operations staff on visualization displays
  - Functional specification document on visualization enhancements shared with team members & NASPI WG for review and comments in Jan,' 07 – *Posted on EIPP/NASPI website*
  - Visualization client in field trial & testing for 4 weeks to gather feedback prior to release
  - Small-signal stability application is currently undergoing field trial
  - Preparing Operator Training Package for CEH accredit operator training on phasor technology and use of tools – *encourages operator involvement and promotes participation*
- ❑ Develop functional requirements/guidelines/specifications for visualization
  - Posted on EIPP/NASPI website for WG review and comments
- ❑ Other accomplishments (supports the PI team deliverables)
  - Automated 'Daily Reports' on alarms, trends & statistics – *assists in baselining efforts*
  - Established web services and interfaces for accessing: (1) long-term historical data, (2) event file archive (3) PMU performance statistics, and (4) alarm logs.

# *NASPI-OITT Proposals for 2008*

- Improve application dependability - Goal to make displays robust (problem with a single PMU in a zone will not defeat functionality)
- Establish realistic alarming limits and automated email notifications on threshold violations and associated root cause information
- Apply statistical concepts to identify abnormalities and soft limits that complement the hard thresholds
- Expand integration with other applications to accept alarms, alerts and information from companion technologies (e.g. FNet, Powerworld Genscape)
- Work with appropriate committees to begin the process for establishing guidelines and procedures for desired reliability coordinator action when approaching or reaching alarm limits - Note: Terry/Dave, we placed this in here for your consideration – not sure how achievable this may be but we should start thinking about this
- User based extraction and presentation on long-term statistics
- Develop event archive for engineers and researchers
- Monitoring power – angle sensitivities and power-voltage sensitivities in

# *Complementary WECC Phasor Activities & Accomplishments*

- ❑ **WECC *Wide Area Measurement Task Force (WAMS TF)*** formed in 2007

- *Dave Hawkins, WAMS TF Chair*

**Mission:** create a robust, widely available and secure synchronized data measurement exchange network for the western interconnection with associated analysis and monitoring tools for better planning, operation, and improved reliability of the interconnection.

**Scope:** – Create vision for WECC WAMS

– Identify Gaps in data

– Serve as WECC focal point for interaction with DOE, NASPI & NERC on policy & standards issues

– Coordinate WAMS with other WECC groups

- ❑ WECC Phasor Network currently integrates 56 PMUs across 4 Organizations (BPA, WAPA, PG&E, and SCE) and is streaming data in real time to CAISO

– Network comprises of ***WECC Operations Network*** (WON) & few leased T1 circuits

- ❑ CAISO is the process of migrating the phasor data platform and applications onto production grade hardware and into real time operations.

– Draft white paper on associated IT challenges is in progress

# WECC PMU Installations

## PMU Inventory:

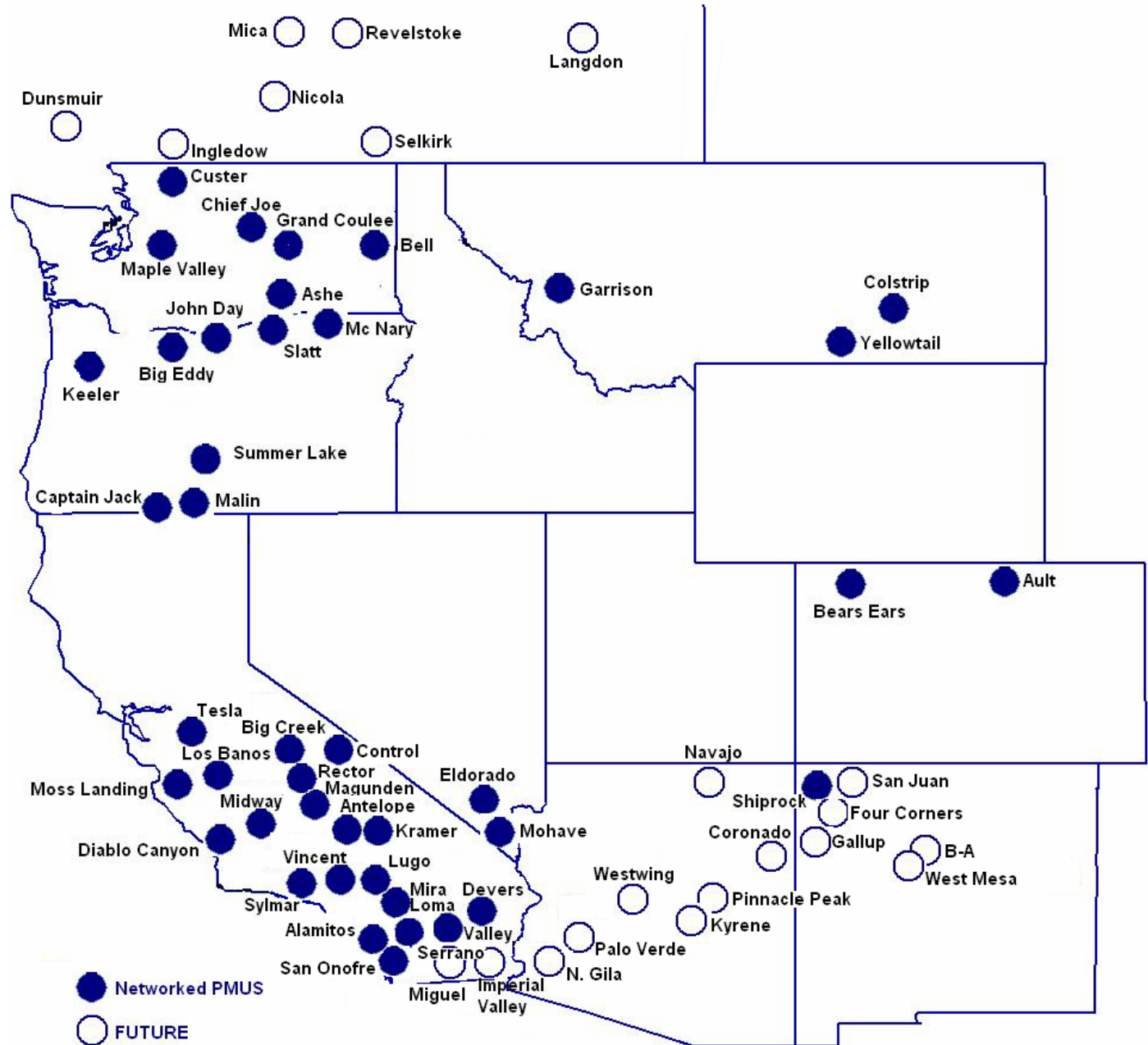
- BPA – 24 (Networked)
- WAPA – 5 (Networked)
- SCE – 18 (Networked)
- PG&E – 6 (Networked)
- APS/SRP – 9
- BC Hydro – 11
- Public Service New Mexico – 4
- San Diego Gas & Electric – 5

## WECC TOTALS:

– 82 PMUs (540 Phasors)

## NETWORKED to CA ISO:

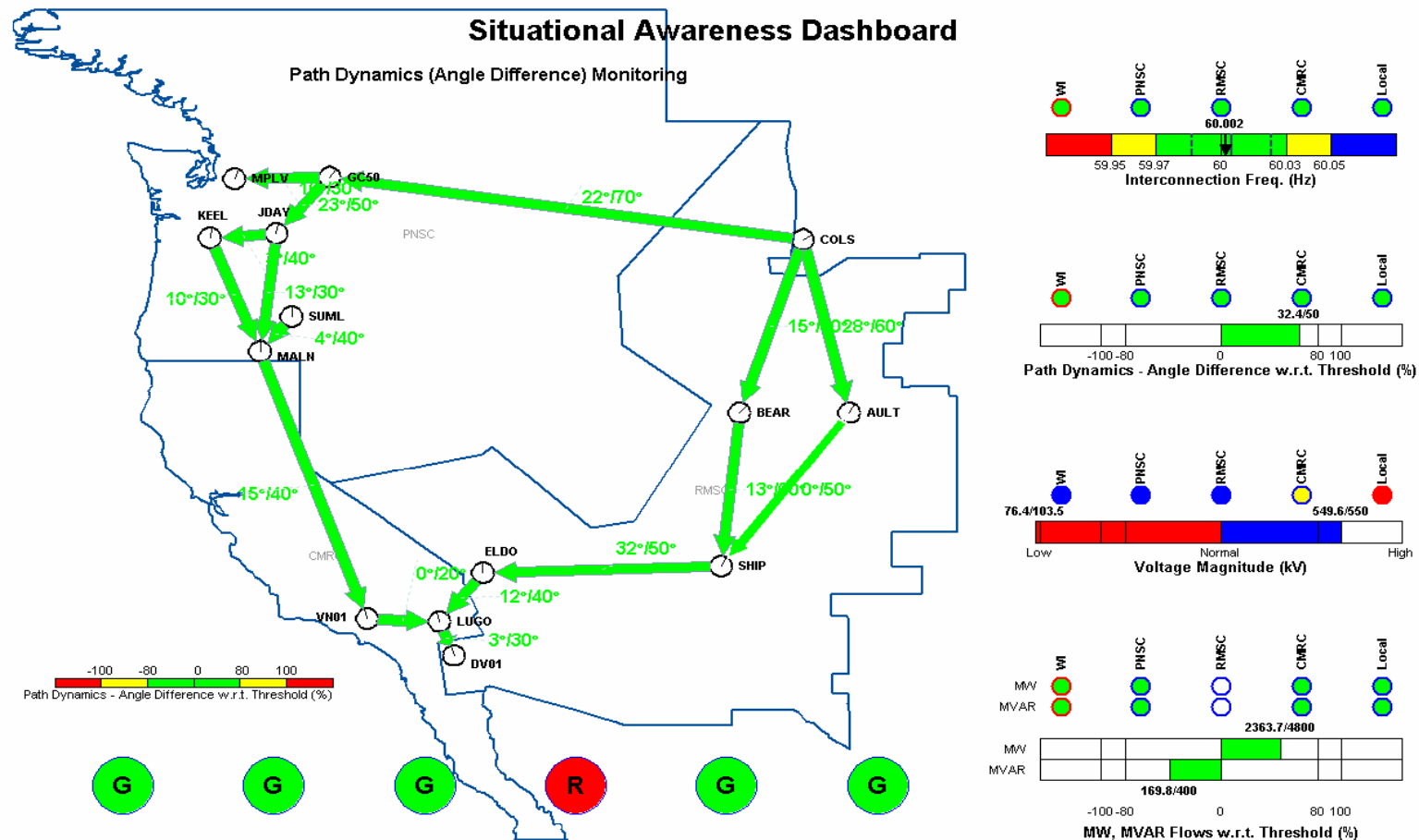
– 53 PMUs (350 Phasors)



# Application Highlights

- CA Independent System Operator (CAISO)

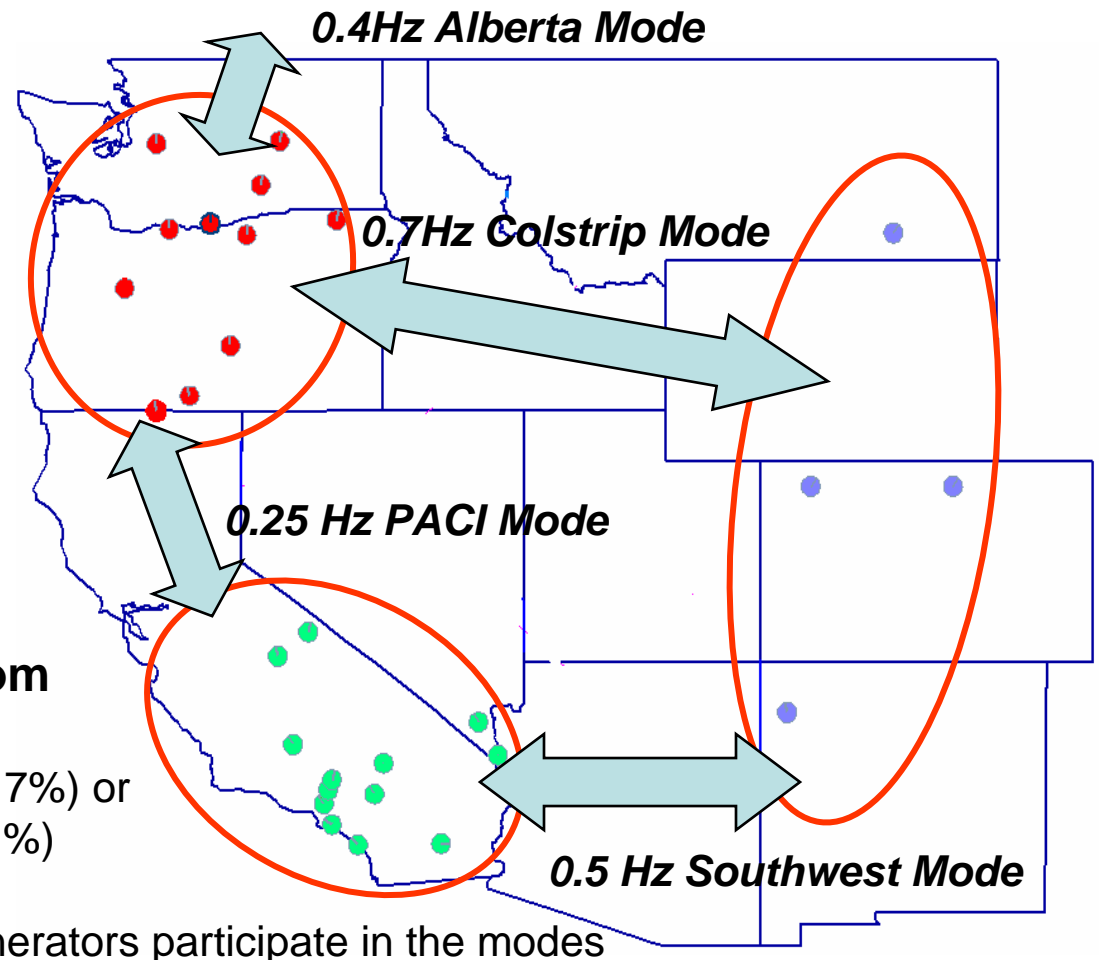
## Real Time Dynamics Monitoring System (RTDMS)





# *Small-Signal Stability is an Emerging Focus*

- **Low frequency oscillations constantly exist in the power system**
- **These are electro-mechanical interactions between:**
  - groups of generators swinging against each other (inter-area mode)
  - generator swinging against the rest of the system (local mode)
- **PMUs have the high resolution/wide-area visibility to analyze these modes**



**Goal: Real-time identification of undesirable oscillatory modes from ambient data**

mode damping - well damped (e.g. 7%) or poorly damped (e.g. 1%)

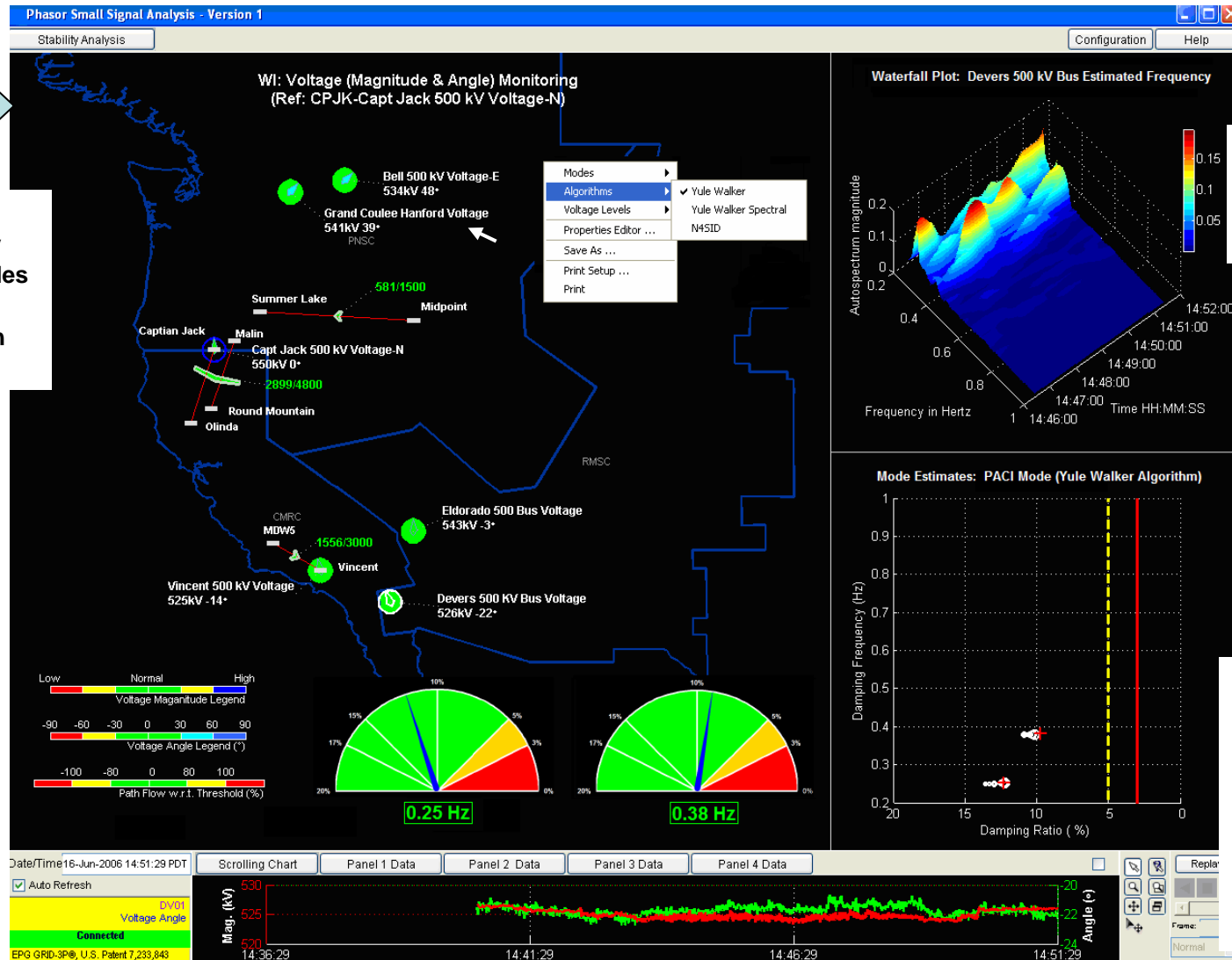
mode frequency (typically 0.1-1Hz)

mode shape - which clusters of generators participate in the modes

# Small-Signal Stability Monitoring Application

- A prototype small signal stability monitoring application has been developed and installed at the CA ISO and BPA to evaluate algorithms in a real time environment
- The prototype is currently being adapted for the Eastern Interconnection

Monitor :  
Low Frequency  
oscillatory modes  
across the  
interconnection



Waterfall to identify  
oscillation freq.  
and it's trend over  
time

Frequency-damping  
plots to track %  
damping of different  
oscillatory modes in  
real time  
(3% and 5% alerting  
and alarming  
thresholds shown)

# *CAISO Goals for Future Research & Analytical Capability*

- Pattern recognition capability to detect abnormal operating conditions
- Ability to identify good or poor damping for all dominant modes of oscillation of the power grid.
- Detect poorly tuned power system stabilizers
- Automatic system for segmentation of the grid – predetermine emergency control actions.
- Analysis of the response of loads to voltage and frequency variations.
- Measure the safe reactive power margins and voltage stability limits on specific transmission lines to avoid voltage collapse.
- Research and develop a real time dynamics nomogram monitoring, alerts and control prototype.
- Assess impact of renewables integration.

# *Areas Where We Need WG Support*

- Grow the infrastructure
- Provide input on taxonomy (new ideas on future capability)
  - Tools and Displays
  - Priorities
  - Business Case Summary (Need)
  - Detailed Descriptions
- Complete vendor / researcher template
- Develop tools to provide information messages to RTDMS data hub
- Training information
  - Cues and suggested actions
  - Events
- Participants from other Interconnections

# *Backup Slides*

# *Key NASPI 2007 Deliverables*

## **OI Team**

- Develop prototype wide-area visualization tool
- Obtain user feedback from operations staff on visualization displays
- Develop functional requirements/guidelines/specifications for visualization

## **PI Team (where OI team can provide support)**

- baselining measurements of phase angles and small signal stability performance
- Gather statistics on phase angle separations across system
- Get familiarized with the tools & techniques to perform small signal stability analysis using PMU data. Identify dominant frequency modes and associated damping for system ambient conditions.
- Report on normality of phase angle separations and dominant frequency modes.

# *Top OI Team Items (This Year)*

- Deploy c37.118 standard to streamline addition of new PMUs into the EIPP phasor network and the integrating other applications
- Catalog and grow visualization and monitoring capabilities
- Improve displays for RTDMS, establish framework for meaningful alert and alarm thresholds
- Provide interface specification for importing information into RTDMS from vendors and researchers
- Automate reports for PMU/PDC/grid performance and identify clusters for more robust displays
- Operator Education, input and involvement – Deploy CEH-accredited operator training
- Develop small-signal stability application to detect and analyze poorly damped oscillations
- Develop event archive for engineers and researchers
- Grow “catalog” (taxonomy)

# *Display and Tool Objectives*

- Provide integrated information and alerts (Red, Yellow, Green) in a common centralized display – ‘*Dashboard Summary*’ display
- Maintain consistent wide area user displays throughout the Eastern Interconnection
  - Some ability to customize RTDMS
  - Users can still tap into data stream for local applications
- Identify a group or individuals to have ownership for creating and/or modifying displays (change management)



# *Visualization Display Concepts*

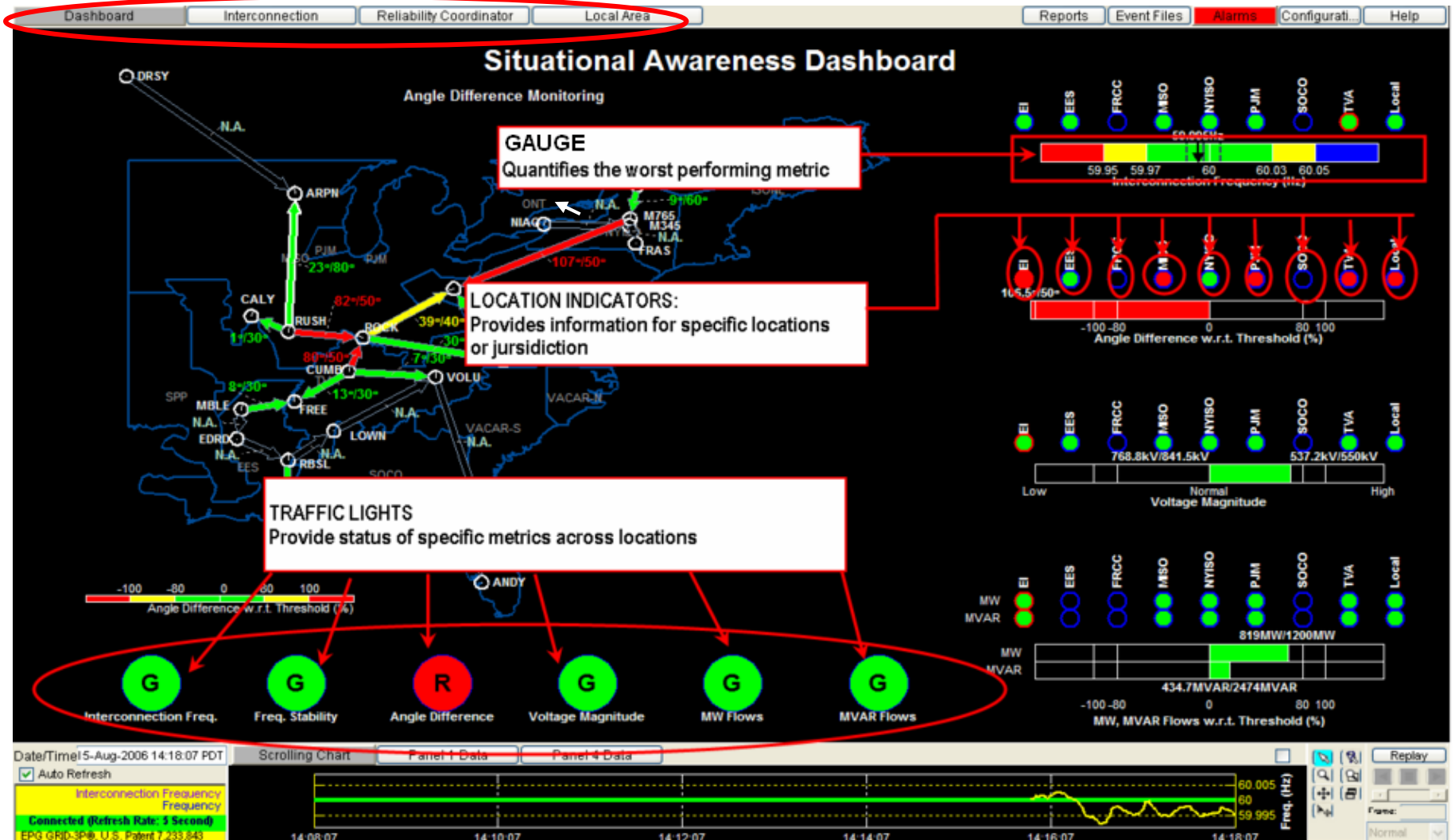
- Based on User Needs
- Provide an information hub for operators
- There may be 20 or more parameters that can be monitored with phasor data
- Display *Real Estate* limited - It is likely only one window will be made available for EIPP applications
- Bring operators' attention to situations where something is beyond a hard limit or has changed significantly
- E-mail alerts to bring more eyes in the control room for significant problems
- Obtain Human Factors input

## *Visualization Display Concepts (Continued)*

- Common wide-area displays with one layer of local configurability
- Additional information can be found within 2-3 mouse-clicks
- Provide a backup layer of local visibility
- Goal to make displays robust (problem with a single PMU in a zone will not defeat functionality)
- Open architecture to accept alarms, alerts and information from companion technologies and vendors and researchers that tap into data stream

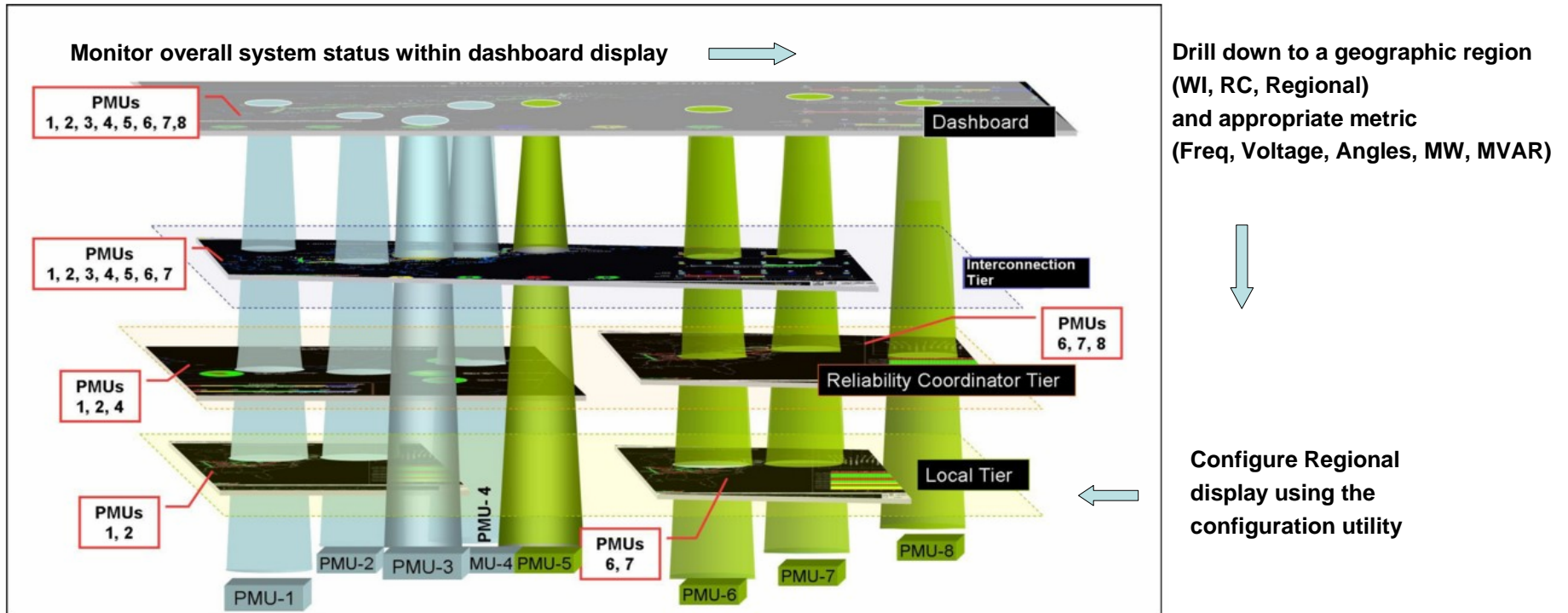
# Interconnection Dashboard Display

Visualization Tiers – Dashboard Summary, Interconnection, Reliability Coordinator, Local Area



# Tiered Visualization Architecture

Develop set of displays that allow the user to monitor the entire Interconnection, Reliability Coordinator regions and local systems



- **Display Tier 1: Dashboard Summary Display (Default)**
- **Display Tier 2: Interconnection Displays**
- **Display Tier 3: Reliability Coordinator Displays**
- **Display Tier 4: Local Displays (User to configure this set of displays)**

# Example: Navigation to Identify Problem Area

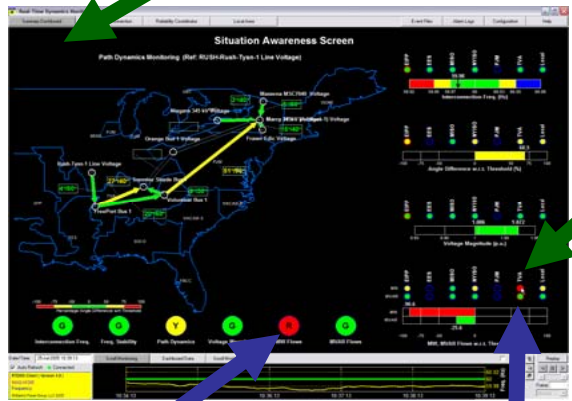
**Situation:** MW Flows within TVA's Reliability Coordinator region is approaching predefined alarming limits (i.e., Localized "MW Flows" violation)

**STEP 3**

**Question:** How severe is the problem?  
**Action:** Analyze the other metrics – Frequency, Voltages, Angle Differences, etc.

**STEP 1**

**Question:** Is there a Problem?  
 Where is the Problem?  
**Action:** Click on the "Dashboard Display" tab



**Result:** "MW Flows" problem identified.  
 Problem confined within TVA's Reliability Coordinator region

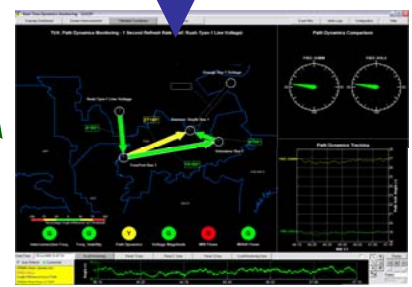
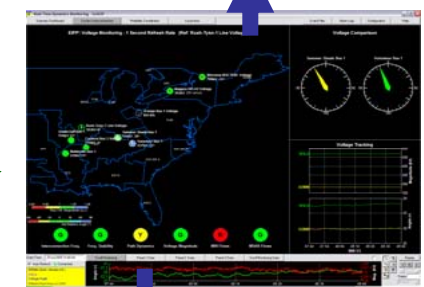
**STEP 2**

**Question:** Which monitored MW Path within TVA's region is associated with the problem?  
**Action:** Double-click on the highlighted red "bubble".



**Result:** TVA's "MW Flows" 1-Panel display shown. The MW flows between Summer Shade and Paddys Run is close to limits.

**Result:** Time history and comparative analysis capability.



# *Display Management Process*

- TVA to coordinate integration of new PMUs into the SuperPDC.
- CERTS provide assist to TVA in calibrating the new devices through comparisons with State Estimator snapshots and monitor data quality performance for these new devices.
- Reliability Coordinators and Transmission Owner representatives to suggest critical paths for monitoring and threshold limits.
- EPG develop draft displays incorporating information from new PMUs.
- NASPI Operations Implementation Task Team to review and validate selected paths, and threshold limits.
- EPG and TVA to implement new displays at the central RTDMS Server.

# RTDMS Data Hub

## - Current System Architecture

### Streaming Data Acquisition Formats

- PDCStream Format
- C37.118 Format

### Central Data Management & RT Alarming

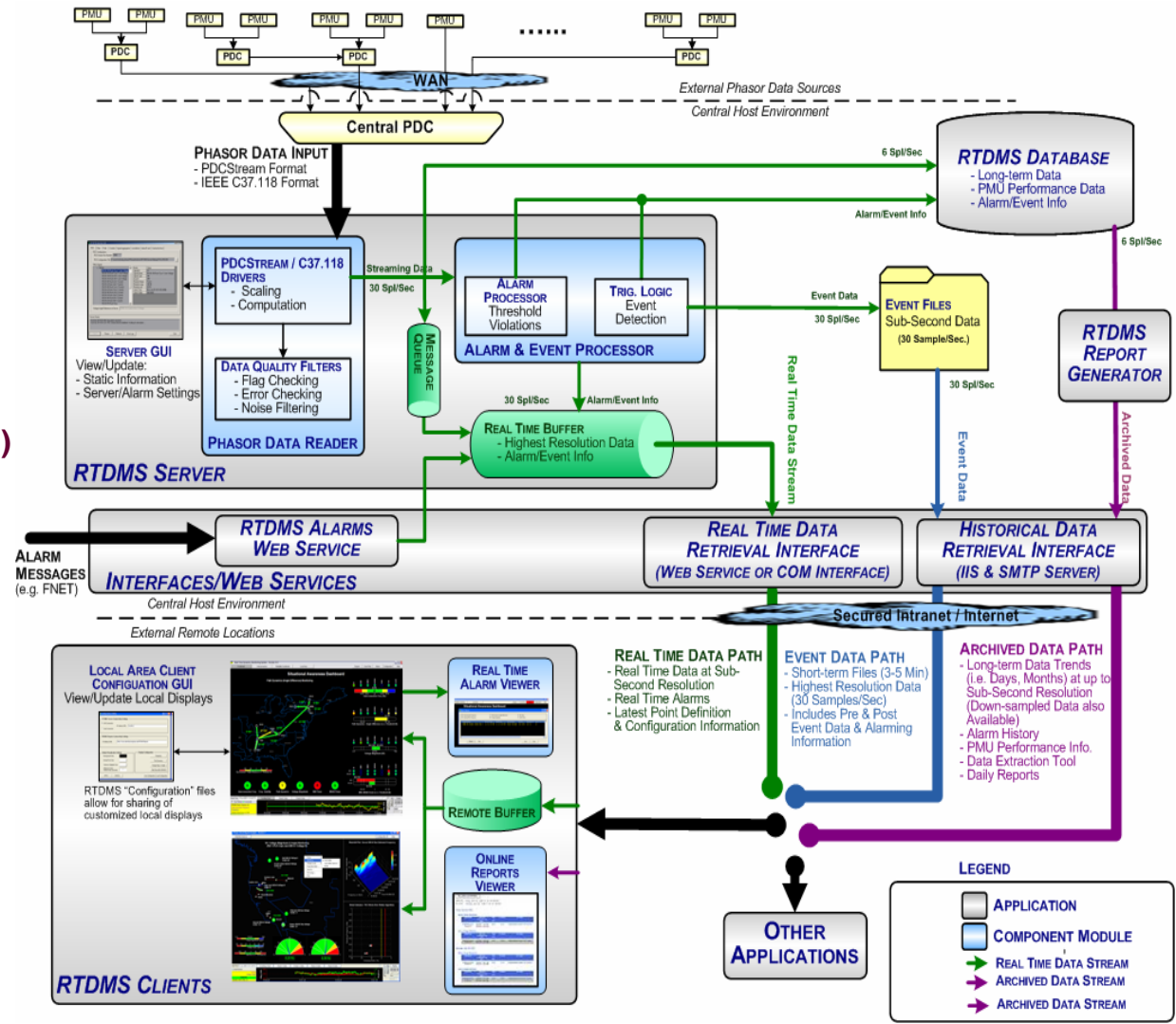
- Real time data quality filters
- Short term data in memory Buffer (1 Hour)
- Long term data in database (30 Days)
- Event Files with pre/post event data (3 min)

### Data Interfaces & Integration

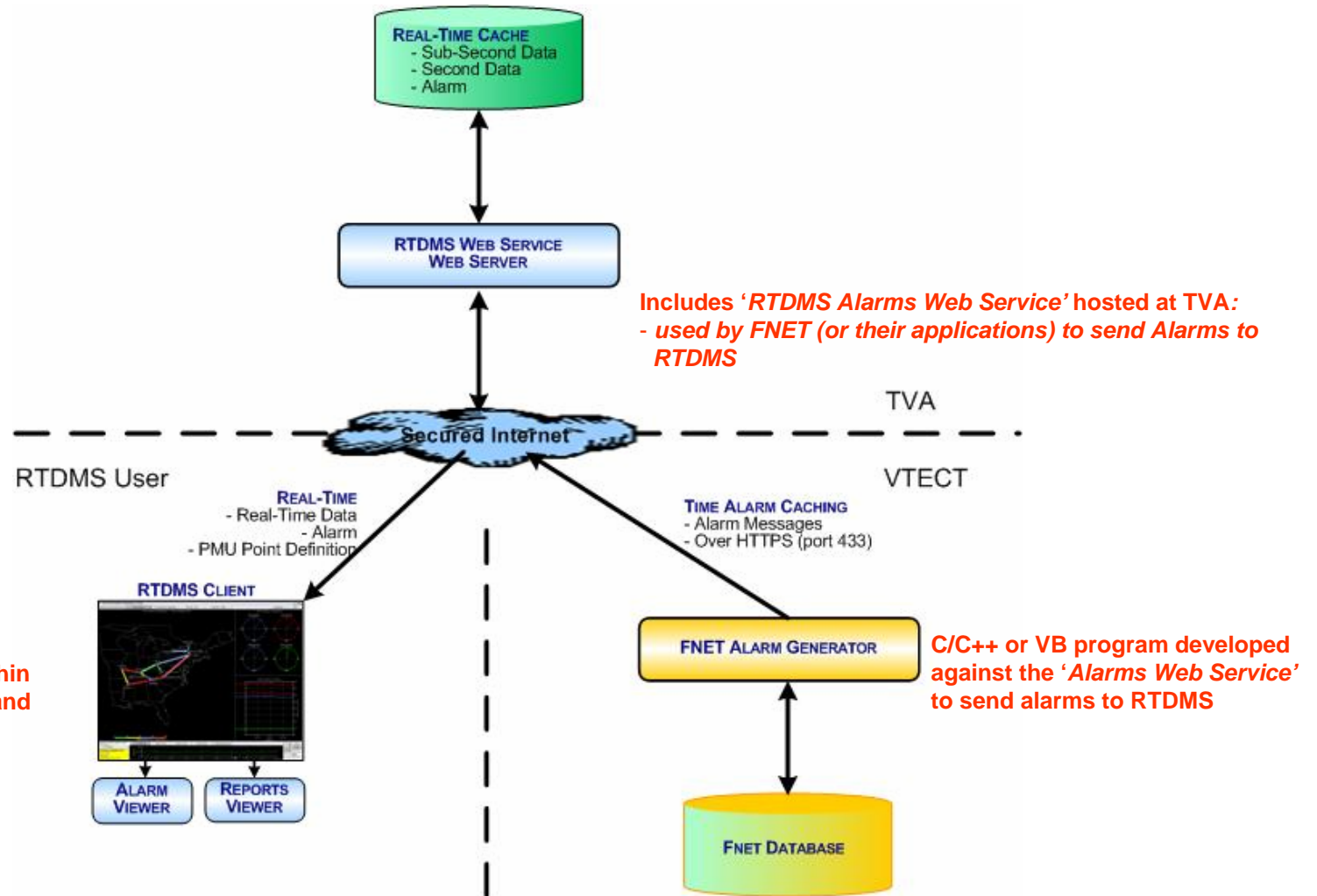
- NASPI (EIPP): FNET Integration
- CAISO: PI Integration
- Real Time /Historical Data Extraction

### Applications / Algorithms

- Wide Area Visualization (Dashboards, Tiered Display Architecture)
- Small Signal Stability Monitoring
- Event Analysis
- Reporting Services

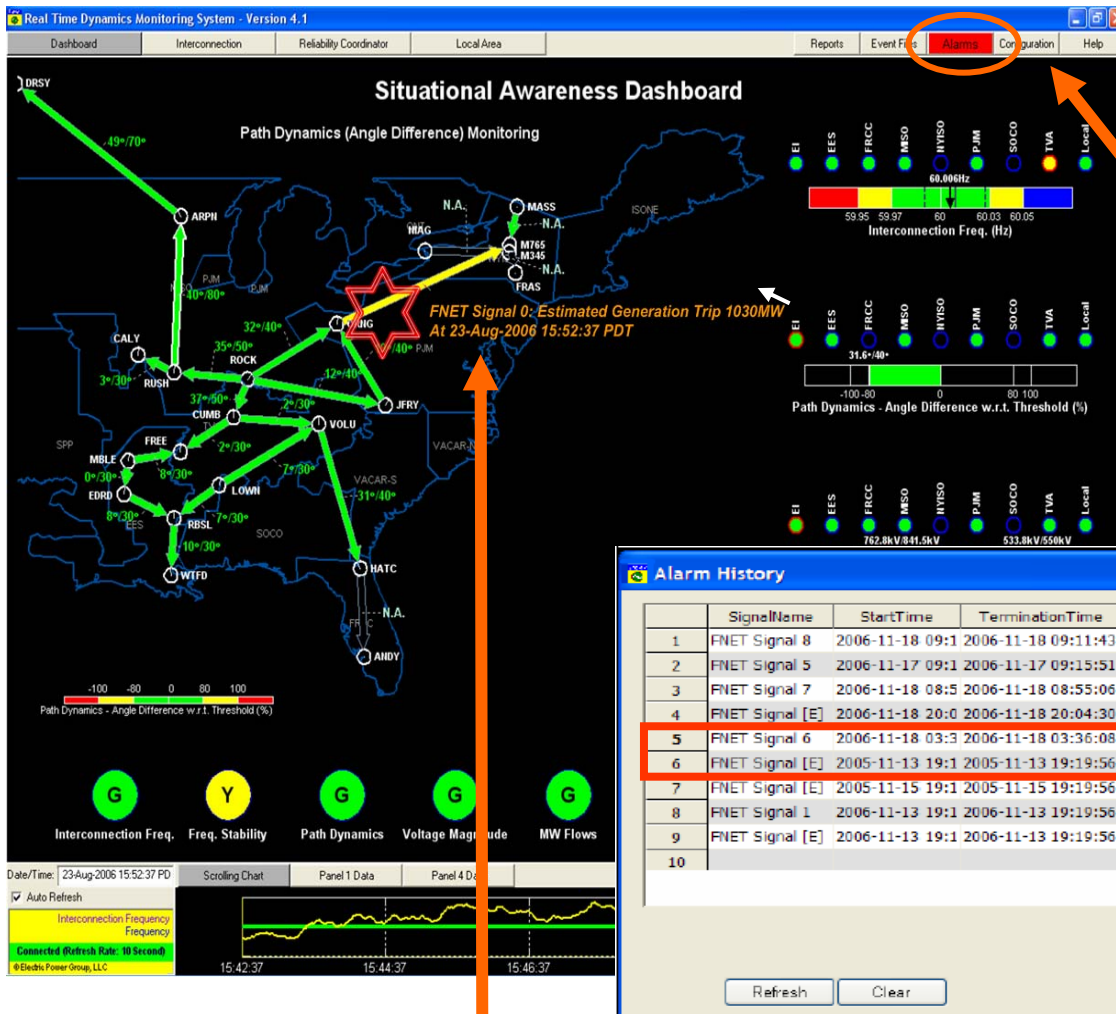


# *FNET Integration with RTDMS*





# Real Time Alarming (FNET Integration)



## Supported Alarm Types:

- High Frequency
- Low Frequency
- High Voltage
- Low Voltage
- High Angle Difference
- High MW Flow
- High MVAR Flow
- Frequency Transient
- Voltage Transient
- Angle Difference Transient
- Load Drop
- Generation Trip

New alarm is generated indicated by the "Alarms" tab turning **RED**.

Clicking on the **RED** "Alarms" tab pulls up the Alarm History box containing the most recent Alarm(s).

	SignalName	StartTime	TerminationTime	AlarmType	CurrentValue	Threshold	Unit	TimeWindow (s)	Description
1	FNET Signal 8	2006-11-18 09:1	2006-11-18 09:11:43	Load Drop	172	0.007	MW	----	[Longitude, Latitu
2	FNET Signal 5	2006-11-17 09:1	2006-11-17 09:15:51	Load Drop	322	0.007	MW	----	[Longitude, Latitu
3	FNET Signal 7	2006-11-18 08:5	2006-11-18 08:55:06	Load Drop	671	0.0045	MW	----	[Longitude, Latitu
4	FNET Signal [E]	2006-11-18 20:0	2006-11-18 20:04:30	Generation Trip	718	0.0045	MW	----	[Latitude, Longitu
5	FNET Signal 6	2006-11-18 03:3	2006-11-18 03:36:08	Generation Trip	920	0.0045	MW	----	[Longitude, Latitu
6	FNET Signal [E]	2005-11-13 19:1	2005-11-13 19:19:56	Generabon Trip	1896	0.005	MW	----	[Latitude, Longitu
7	FNET Signal [E]	2005-11-15 19:1	2005-11-15 19:19:56	Generabon Trip	1896	0.005	MW	----	[Latitude, Longitu
8	FNET Signal 1	2006-11-13 19:1	2006-11-13 19:19:56	Generabon Trip	1896	0.005	MW	----	[Latitude, Longitu
9	FNET Signal [E]	2006-11-13 19:1	2006-11-13 19:19:56	Generabon Trip	1896	0.005	MW	----	[Latitude, Longitu
10									

FNET Alarms (i.e. **Generation Trip** or **Load Drop**), the event location as estimated via FNET's triangulation Algorithms, and the associated MW amount geographically shown within the RTDMS *Situational Awareness Dashboard* display.

# Long-Term Data Extraction & Trends

The screenshot shows a web-based interface for generating a Data Trend Report. The interface includes a left sidebar with navigation options like 'PMU Performance', 'Data Trends', and 'Alarm Log'. The main area contains a 'DATA TREND REPORT' form with the following steps:

- 1. Select Report:** The 'DATA TREND REPORT' is selected.
- 2. Select Date:** The 'Start Date/Time' is set to '05/07/2006 12:54'.
- 3. Select Duration:** The 'Daily' radio button is selected.
- 4. Select Signal Type:** The 'Signal Type' dropdown is set to 'Frequency'.
- 5. Select Signals:** Signals are moved from the 'Unselect Signals' list to the 'Selected Signals' list. The selected signals include 'BC50.FR Big Eddy 500 Freq' and 'ELDO.FR Eldorado'.

At the bottom, there are options for 'Chart' and 'Export Data', and a 'Data Extraction Information' section showing 'Time Duration' as '< 1 Hour', 'Signal Selection' as 'Data Resolution', and 'Data Resolution' as '> 24 Hours'. A red arrow points from this section to a 'File Download' dialog box.

The 'File Download' dialog box shows the following information:

- Do you want to open or save this file?**
- Name: RTDMS\_PMU\_Signal\_Data.csv
- Type: Microsoft Office Excel Comma Separated Values Fil...
- From: localhost
- Buttons: Open, Save, Cancel
- Warning: While files from the Internet can be useful, some files can potentially harm your computer. If you do not trust the source, do not open or save this file. [What's the risk?](#)

The chart, titled 'Relative Voltage Angles - July 4<sup>th</sup>, 2005', displays 'Angle - Degrees' on the y-axis (ranging from -100 to 100) against time on the x-axis (00:00 to 02:00). The chart shows several data series with their respective mean and standard deviation values:

Signal	Mean (Degrees)	Std. Dev. (Degrees)
Rush-Stfr-1 Line	42	3
Marcy 345kV	-35	10
Marcy 765kV	-34	10
Cordova Bus 2	0	0
Freeport Bus 2	-2	1
Shelby Bus 2	2	1
Summer Shade	14	8
Volunteer Bus 1	12	7

# Generating Alarm Summary Reports

Select Alarm Types & Date/Time:

Select Report Type:

- PMU Performance
- Data Trends
- Alarm Log**
- Event Files

Print -->

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Data Availability:

From:  
02/09/2007 00:08  
Pacific Standard Time

Until:  
02/09/2007 01:48

**ALARM LOG REPORT**

Start Date/Time:

(based on your PC's time zone settings)

**1. Select Report**

**2. Select Date/Time**

Time Duration:

- 1 Hour
- 24 Hours
- Customized

**3. Select Duration**

Select Alarm Types:

- High Frequency
- Low Frequency
- High Voltage
- Low Voltage
- High Angle Difference
- High MW Flow
- High MVAR Flow
- Frequency Transient
- Voltage Transient
- Angle Difference Transient
- Load Drop
- Generation Trip
- Other Event

**4. Select Alarm Type**

Start Date/Time: 03/09/2007 12:15  
(based on your PC's time zone settings)

March, 2007

Sun	Mon	Tue	Wed	Thu	Fri	Sat
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31
Time: 12:15						
Select date						

**5. Submit**

**ALARM LOG REPORT**

Start Time: Friday, April 28, 2006 11:55:00 PM PDT  
End Time: Saturday, April 29, 2006 12:05:00 AM PDT

Friday, April 28, 2006

Higher Voltage Magnitude

Signal Name	Start Time	Termination Time (PDT)	Value (kV)	Threshold	Description
SUMM.VM Summer Shade Bus 1	4/28/2006 11:36:02PM	4/29/2006 12:04:06AM	248.75	185.15	Voltage Magnitude Higher Than Threshold

Lower Voltage Magnitude

Signal Name	Start Time	Termination Time (PDT)	Value (kV)	Threshold	Description
SUMM.VM Summer Shade Bus 2	4/28/2006 11:36:02PM	4/29/2006 12:04:06AM	44.23	144.90	Voltage Magnitude Lower Than Threshold

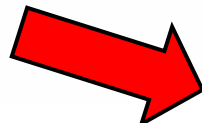
Saturday, April 29, 2006

Higher Voltage Magnitude

Signal Name	Start Time	Termination Time (PDT)	Value (kV)	Threshold	Description
SUMM.VM Summer Shade Bus 1	4/29/2006 12:04:17AM	4/29/2006 12:05:00AM	248.84	185.15	Voltage Magnitude Higher Than Threshold

Lower Voltage Magnitude

Signal Name	Start Time	Termination Time (PDT)	Value (kV)	Threshold	Description
SUMM.VM Summer Shade Bus 2	4/29/2006 12:04:17AM	4/29/2006 12:05:00AM	44.24	144.90	Voltage Magnitude Lower Than Threshold



# Event Archive & Downloading Mechanism

Select Date:

The interface is titled "EVENT FILES DOWNLOAD". It features a "Select Date:" field with the date "02/09/2007" and a "Search" button. A red arrow points from the "Search" button to the "EVENT FILES DOWNLOAD" title. Below the search field, the steps "1. Select Date" and "2. Press Search" are listed. A large red arrow points from the search area to the event list.

Click an event in the list to download

Event List:	Date Created:	Type:
<a href="#">070826.014111000.0t,Matt Funk,Matt Funk,PJM,Frequency Transient,54mHz,50mHz</a>	08/25/2007 9:41:26 PM EDT	Frequency Transient at Matt Funk with value 54.0009mHz and threshold 50.000mHz
<a href="#">070826.030819000.0t,Shelby,Shelby,TVA,Frequency Transient,51mHz,50mHz</a>	08/25/2007 11:08:32 PM EDT	Frequency Transient at Shelby with value 51.0025mHz and threshold 50.000mHz

Click on an Event to download

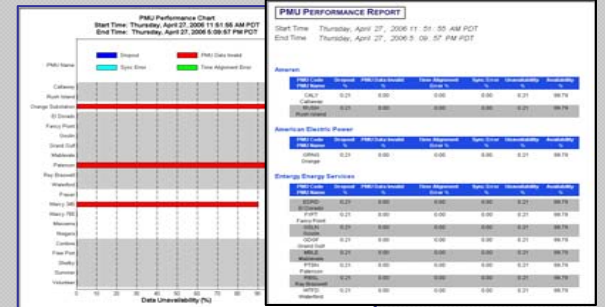
The "File Download" dialog box asks "Do you want to open or save this file?". It displays the file name "...Funk,PJM,Frequency\_Transient,54mHz,50mHz.zip", the type "WinZip File, 4.68MB", and the source "From: eipp.tva.com". There are "Open", "Save", and "Cancel" buttons. A warning icon is present at the bottom left, with the text: "While files from the Internet can be useful, some files can potentially harm your computer. If you do not trust the source, do not open or save this file. [What's the risk?](#)"

# Data Extraction & Reporting Services (Summary)

## PMU Performance

- Benchmark performance; Identify problem PMUs and errors with causes;

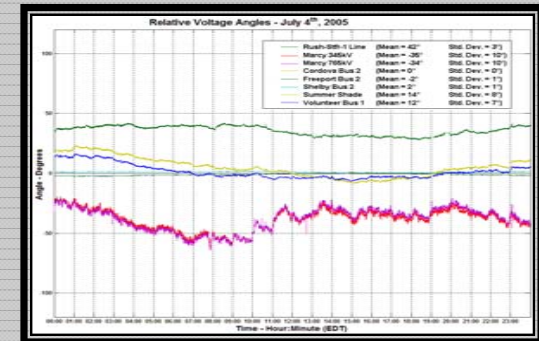
- Charts and Tables;
- Selectable Data Resolution; Time Period; Signals (PMUs)



## Data Trends

- Create Trends around various parameters- time; peak load; outages
- Useful for developing monitoring guidelines alarming thresholds etc.

- Charts and Tables;
- Selectable Data Resolution; Signals/Signal Types;
- Portable Data Files



## Event Files

- Triggered by event detection logic; Automatically records/archives event data before and after trigger
- Provides valuable ability for off-line analysis and forensics

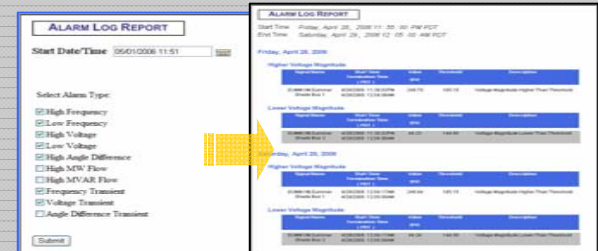
- Searchable and selectable
- Portable Event Files
- Streaming playback for visualization of event in system



## Alarm Logs

- Alarm History Logs; Alarm Details; Types of violations etc.

- Selectable Data Resolution; Alarm Types;
- Portable Data Files



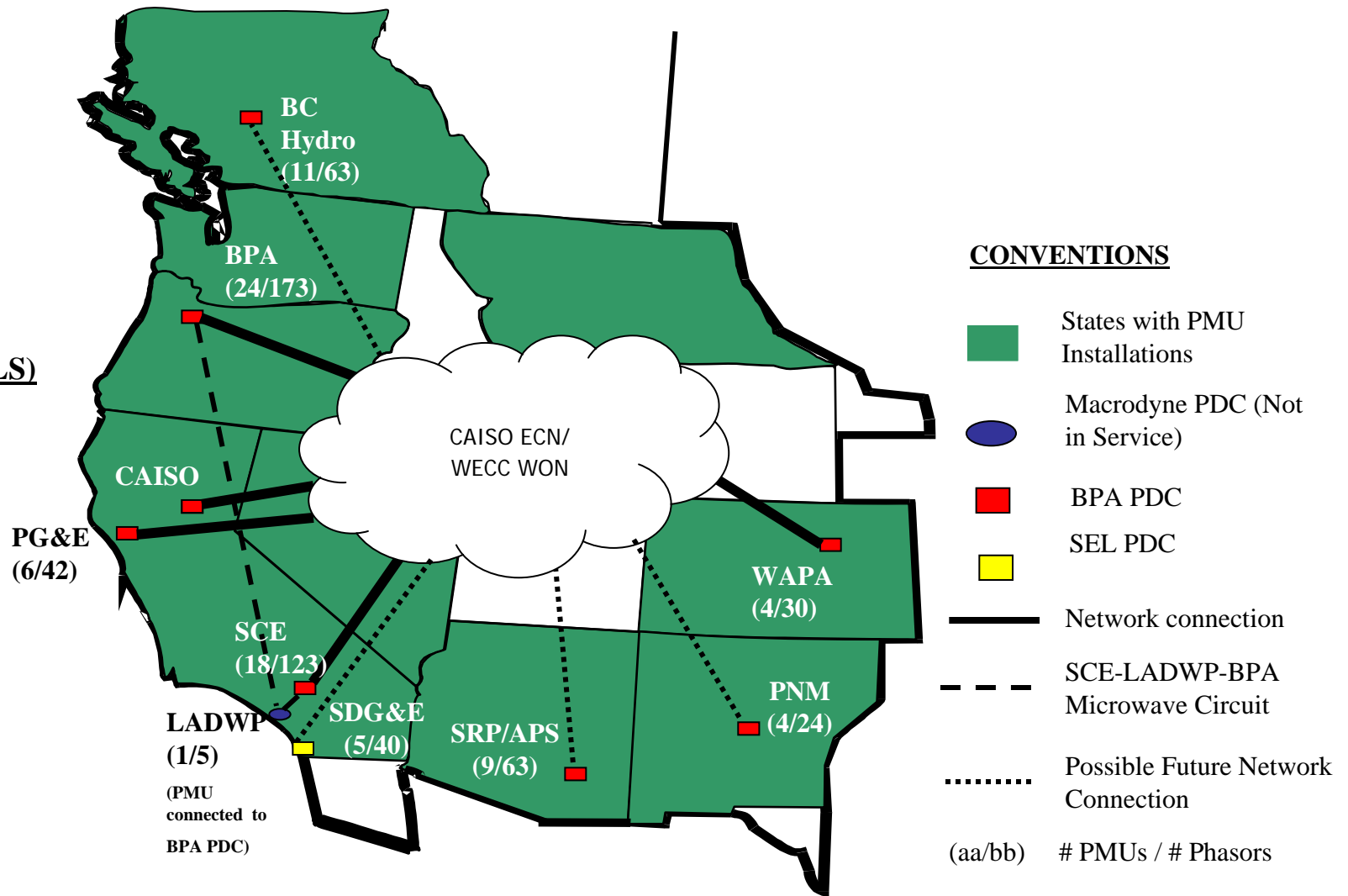
# WECC Synchronized Phasor Network

## WECC TOTALS

82 PMUs  
540 Phasors

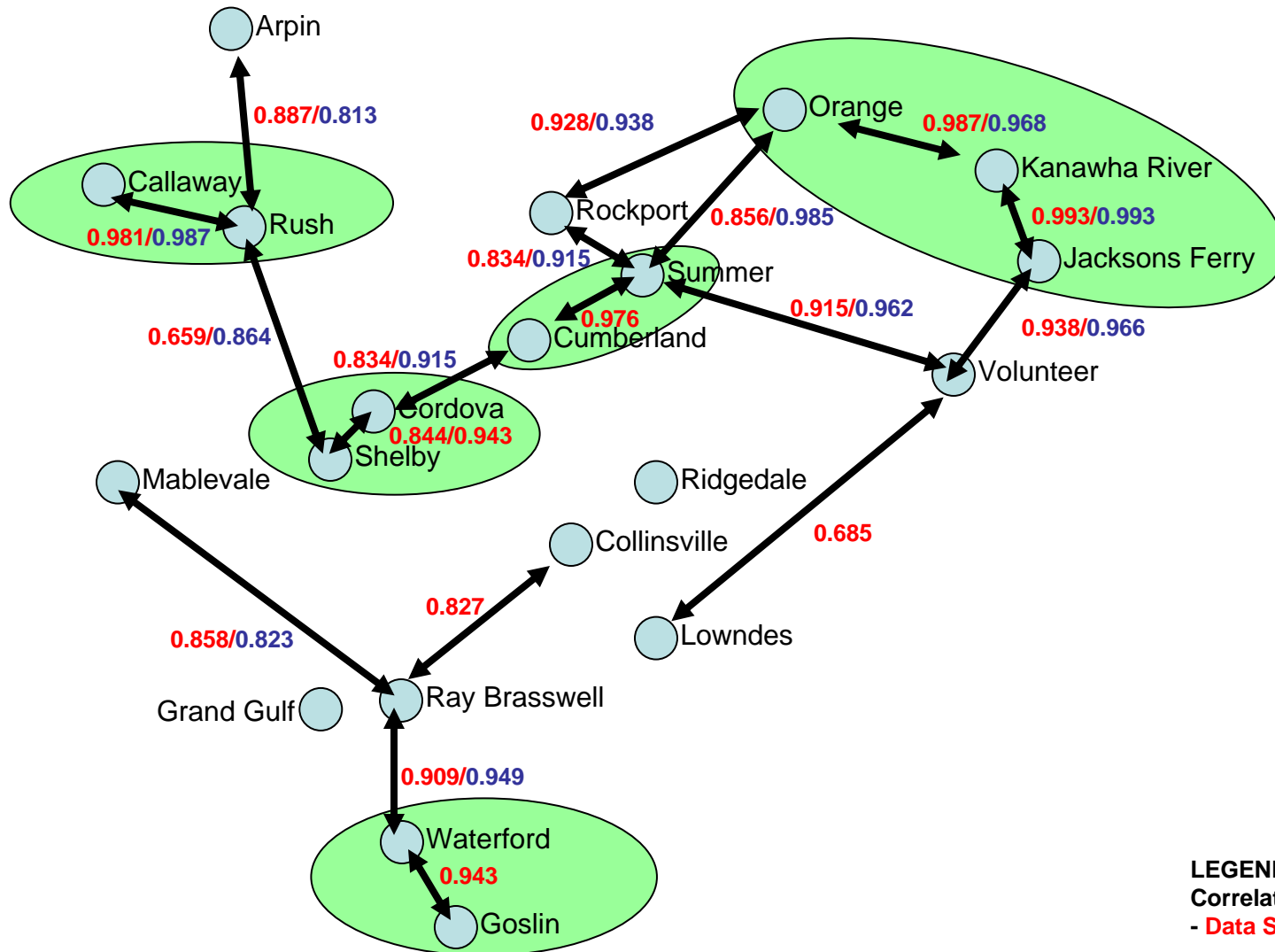
## NETWORKED (CAISO TOTALS)

53 PMUs  
350 Phasors



# Correlation Analysis

Correlation Analysis is used in identifying cohesive groups across the Interconnection to define angle difference monitoring points



# *Midwest ISO Observations*

- Normal “bottom up” TO budget approval, engineering process takes 2+ years unless executives provide support
- Primary interest is in “dual use” devices (meters, DMEs, relays with PMU capability)
  - Vendors need to be encouraged by louder voice to provide upgrade packages to their devices
  - “Cookbooks” to simplify the process
- Encourage PMU capability on station upgrades (small incremental \$)
- Need to support initial “value added” tools and capabilities and then sell them
  - Alerts on significant events
  - Event archive
  - Tools developed by vendors and researchers and the open architecture and processes to share the value



# *Priorities (Transition to NASPI)*

- Leverage and Merge Efforts (post disturbance analysis and model validation-West, Operating tools under development-East)
- PMUs and Network
  - Basic network up so entities can "test drive" the technology
  - Sufficient coverage for situational awareness across the interconnections and to begin identifying system issues such as oscillatory modes etc.
  - work to get applications to deliver value to operators
- Fact-based data quality plan
  - Work out process and infrastructure problems
  - Robust tools that work with realistic quality
- NDAs (NERC for reliability entities, researcher/vendor)
- Some infrastructure support
  - Central event repository
  - Knowledge base and collaboration
- Long term architecture and data retention strategy

# RTDMS Daily Summary Reports

## *Daily Summary Reports*

- Intended to provide operators, engineers and NASPI teams daily summaries of infrastructure and grid performance
- Following slides are examples of what is planned for deployment in 2007

# Daily Report

## Daily Report

January 3, 2007

### SUMMARY SECTION

#### ALARMS

<b>TOTAL ALARMS:</b>	<b>10</b>												
<b>FREQUENCY ALARMS</b>	<b>3</b>	<b>FNET ALARMS</b>	<b>1</b>	<b>VOLTAGE ALARMS</b>	<b>3</b>	<b>ANGLE ALARMS</b>	<b>3</b>						
LOW FREQUENCY	1	Generation Trip	1	LOW VOLTAGE	2	HIGH ANGLE DIFFERENCE	3						
HIGH FREQUENCY	1	Load Drop	0	HIGH VOLTAGE	0	ANGLE TRANSIENT	0						
TRANSIENT	1			TRANSIENT	1								

Frequency Alarms	TVA	MISO	PJM	FRCC	SPC	ISNE	NYIS	IMO	HQT	EES	SOCO	VACS
High Frequency	-	-	-	1	-	-	-	-	-	-	-	-
Low Frequency	-	-	-	-	-	-	1	-	-	-	-	-
Frequency Transient	-	-	-	1	-	-	-	-	-	-	-	-

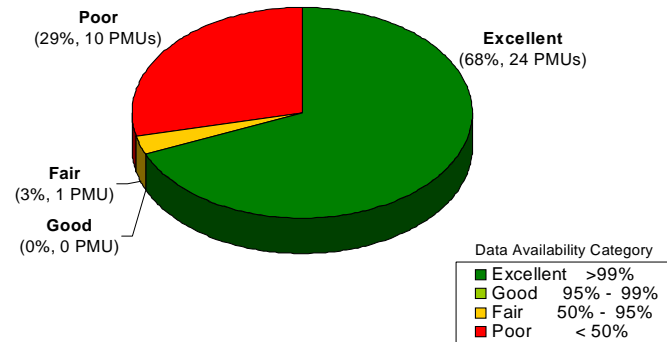
FNET Alarms	TVA	MISO	PJM	FRCC	SPC	ISNE	NYIS	IMO	HQT	EES	SOCO	VACS
Generation Trip	-	-	-	-	1	-	-	-	-	-	-	-
Load Drop	-	-	-	-	-	-	-	-	-	-	-	-

Angle Alarms	TVA	MISO	PJM	FRCC	SPC	ISNE	NYIS	IMO	HQT	EES	SOCO	VACS
High Angle Difference	-	-	2	-	-	-	-	-	-	1	-	-
Angle Transient	-	-	-	-	-	-	-	-	-	-	-	-

Voltage Alarms	TVA	MISO	PJM	FRCC	SPC	ISNE	NYIS	IMO	HQT	EES	SOCO	VACS
Low Voltage Alarms	1	-	-	-	-	-	1	-	-	-	-	-
High Voltage Alarms	1	-	-	-	-	-	-	-	-	1	-	-
Transient Voltage Alarms	-	-	-	1	-	-	-	-	-	-	-	-

#### DATA AVAILABILITY

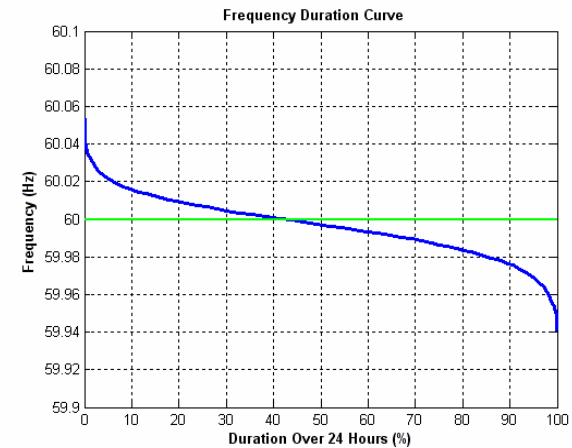
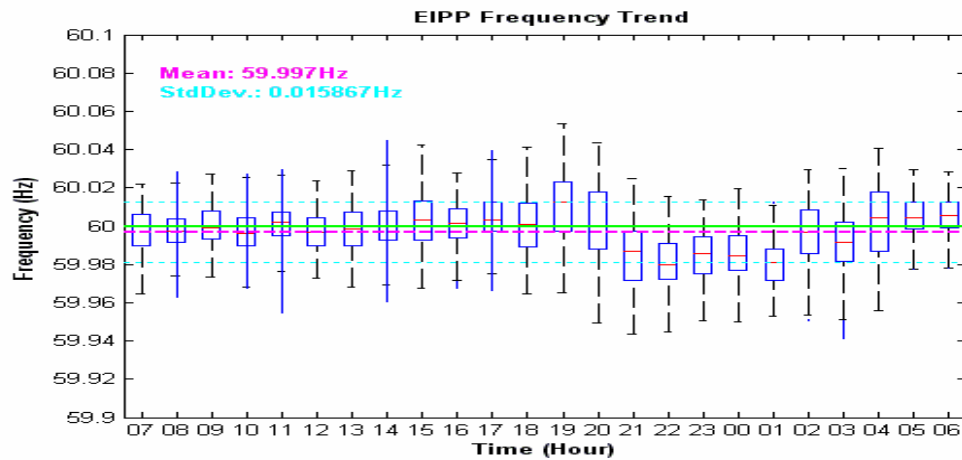
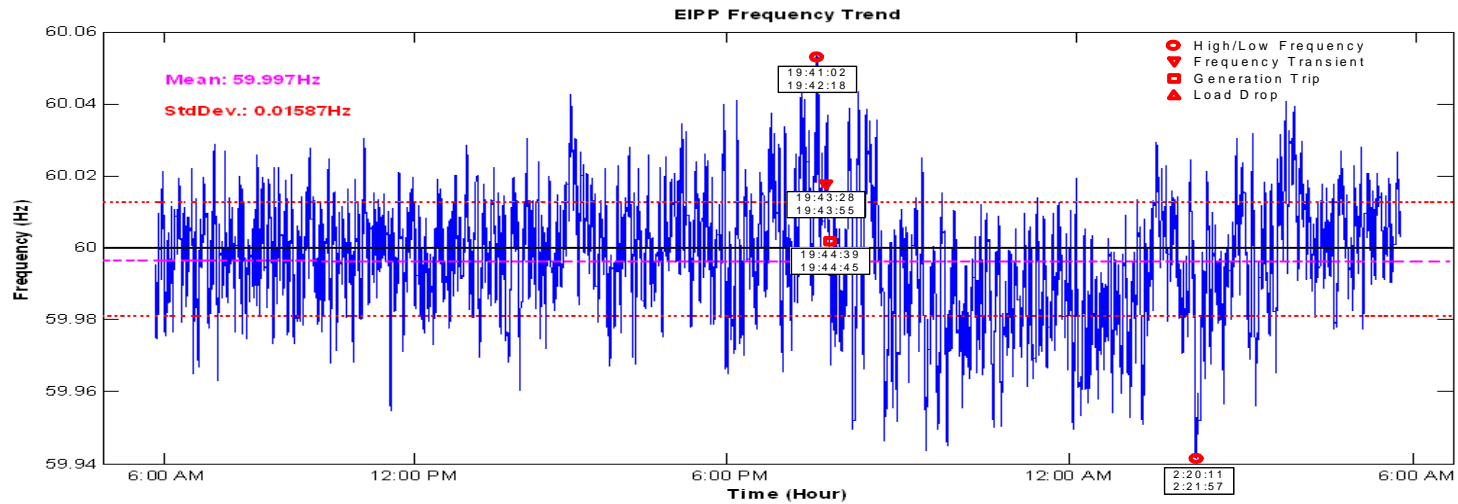
##### Overall PMUs' Performance



# Daily Report (continued)

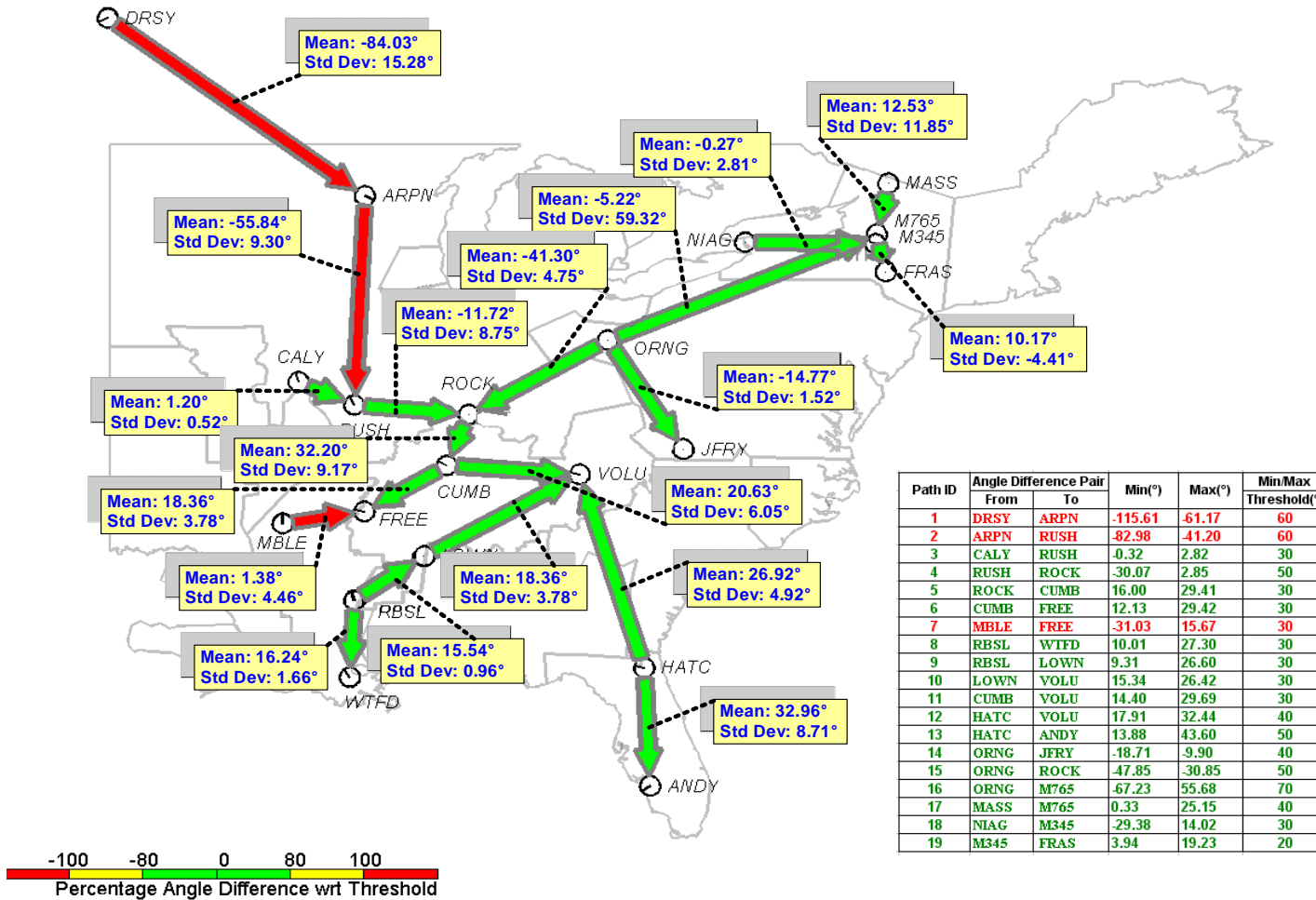
## TRENDS & STATISTICS

### Frequency Trends & Statistics



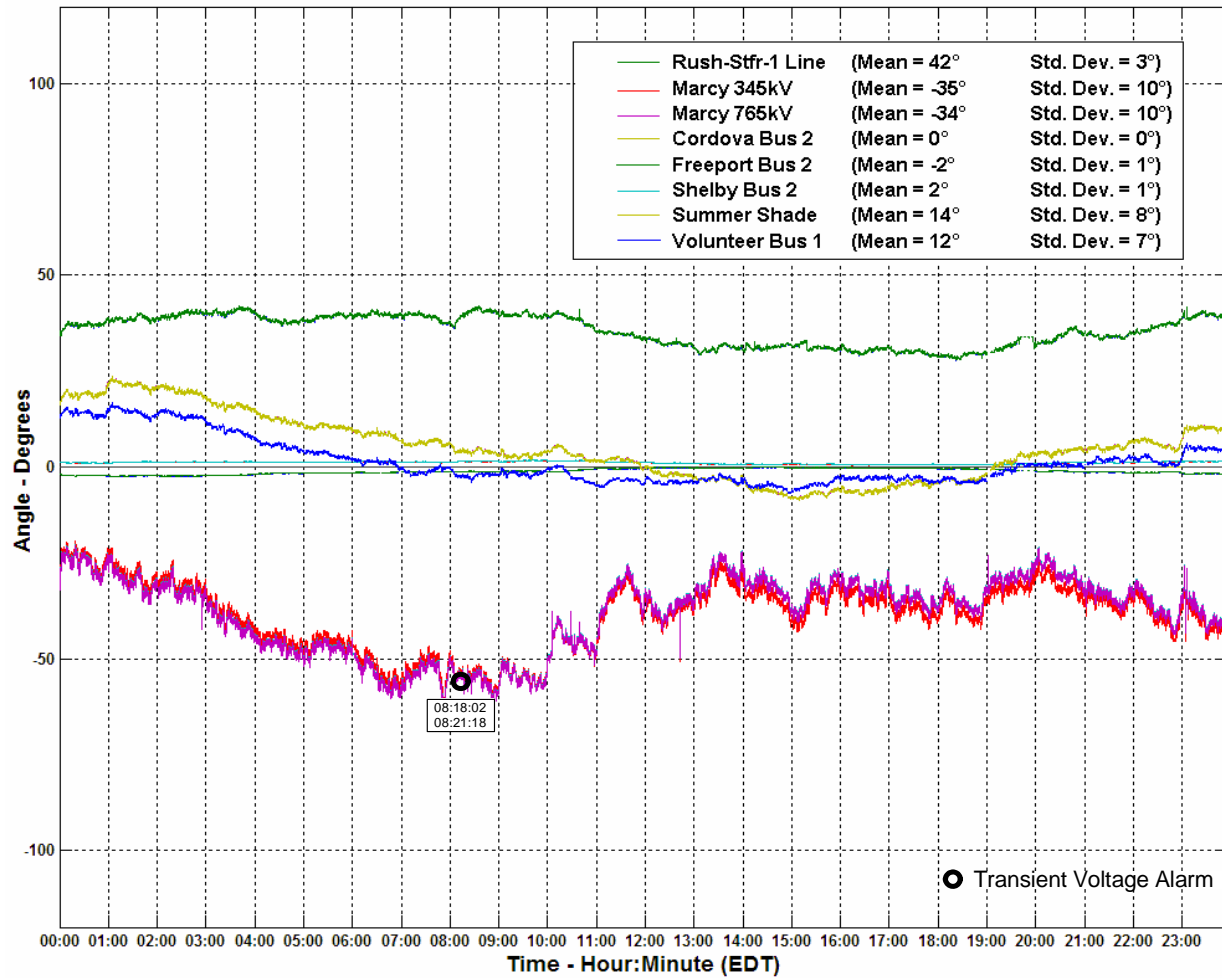
# Daily Report (continued)

## Voltage Angle Difference Statistics – On Peak



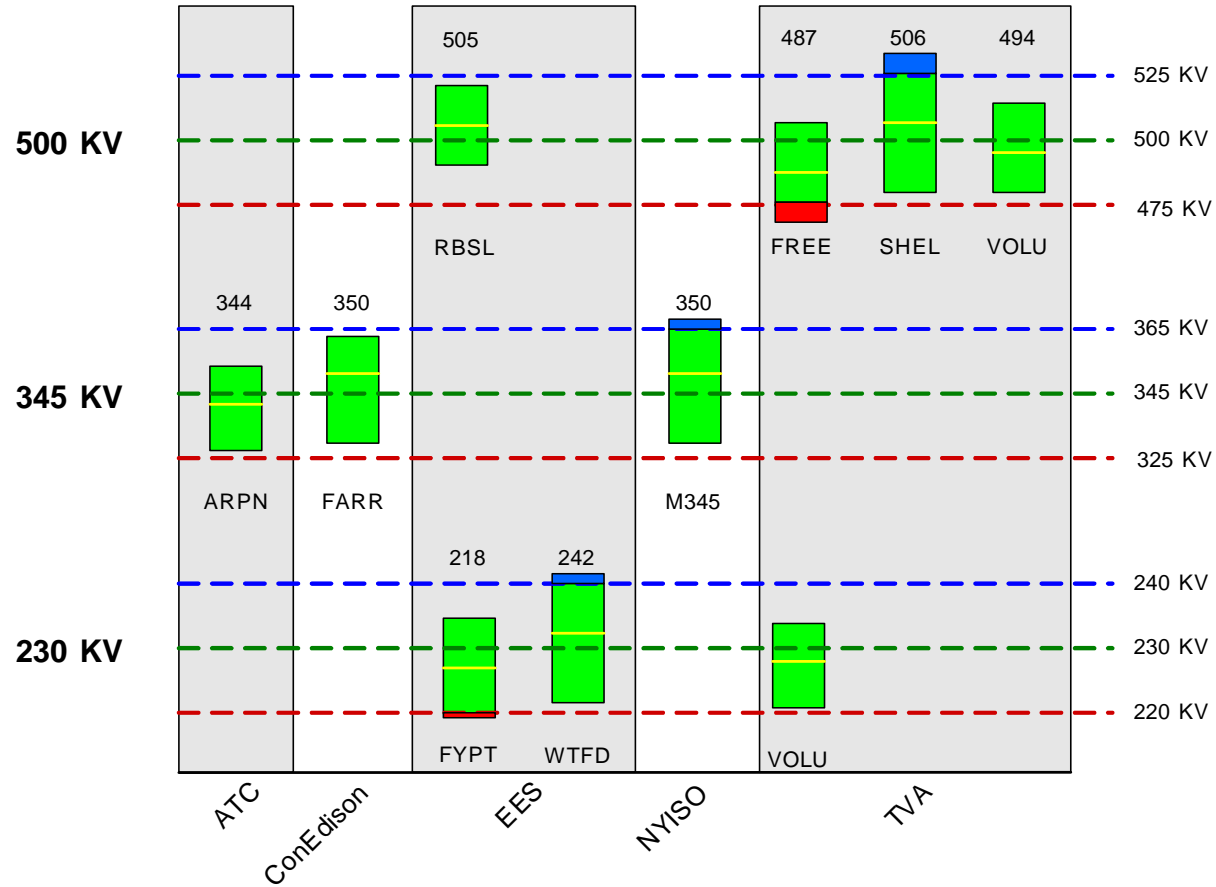
# Daily Report (continued)

## Relative Voltage Angle Trends & Statistics



# Daily Report (continued)

## Voltage Profiles





# Daily Report (continued)

## PMU DATA AVAILABILITY

