

# Advanced Real-Time Situational Awareness Sourced from Synchrophasor Data

“Faster than the Eye, not faster than PI”

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# BPA Business Challenge

Leverage new Phasor Measurement Units (PMUs) deployment to provide wide-area situational awareness for grid stability.

Harden and build out the PI Data Historian beyond SCADA

Create a reusable infrastructure for analysis and alarming

# Technical Challenges

## PMUs are new devices

- newer interface protocol
- Expect 1.0 behavior

## Fast data means:

- Network constraints
- Computer processing and storage constraints

## Emerging science on new data set

- Calculations will change/evolve

# BPA Goals for Situational Awareness (SA) Applications

- Create a reusable architecture, that allow new SA applications (calculations) to be easily implemented



# SA Applications Developed

ODM

- Low Frequency (e.g. 0.25 Hz) Oscillation Detection of devices on Power Grid\*

MMM

- Detection of Poor Inner Area Oscillation Dampening (Mode Meter)\*

AAM

- Excessive Phase Angle Alarm +

IDM

- Power System Island Detection+

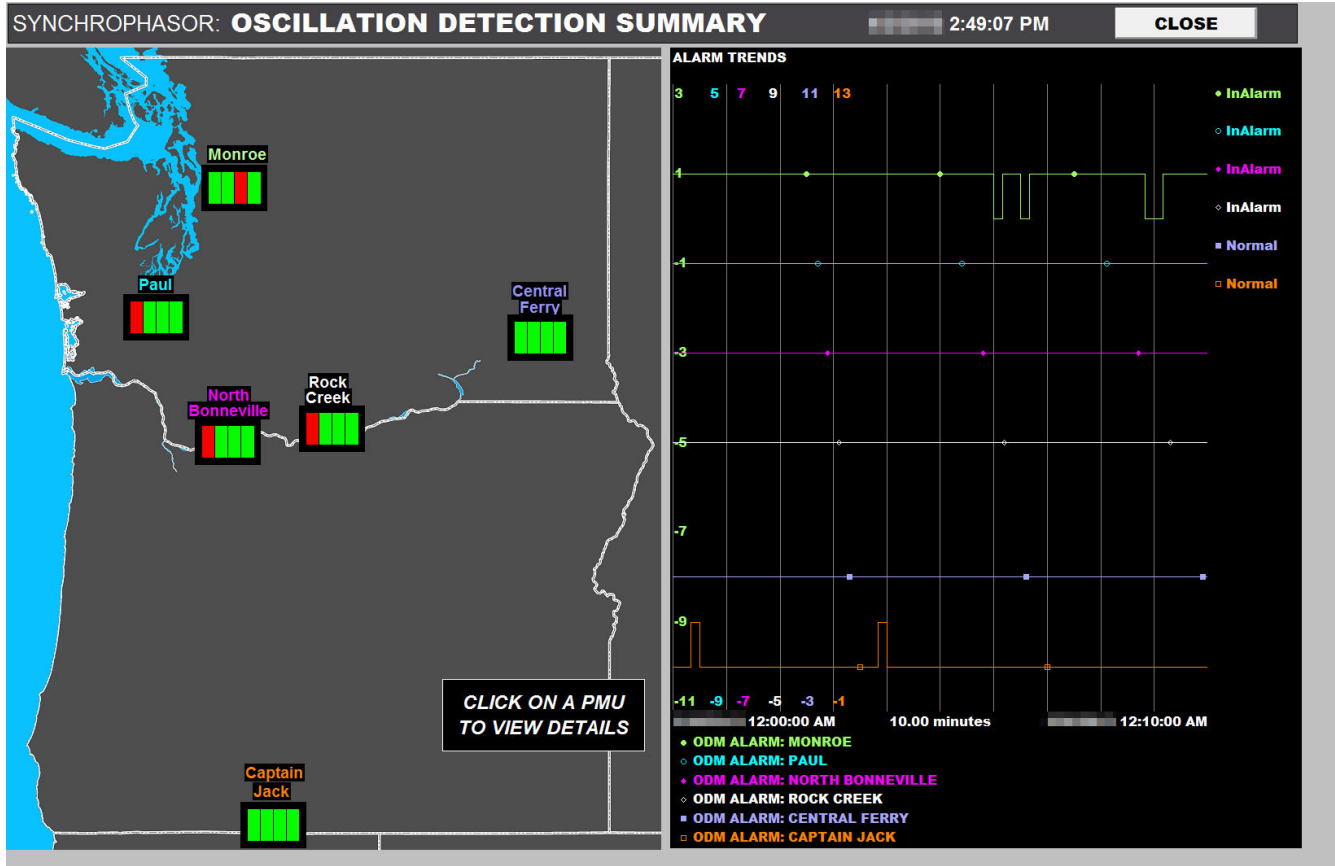
\* WECC/MontanaTech

+ BPA Developed

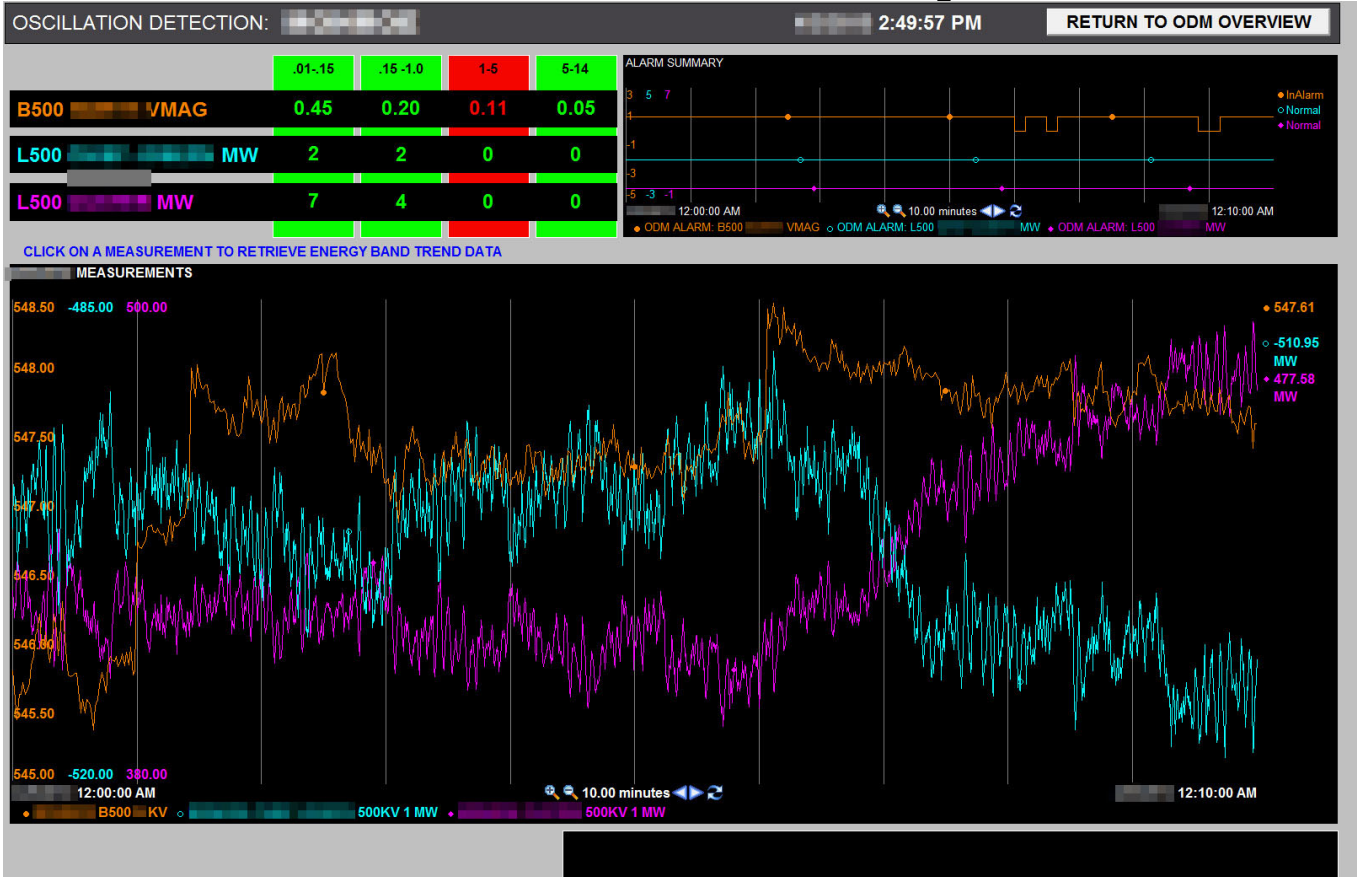


# Sample Displays

# Oscillation Detection (ODM)

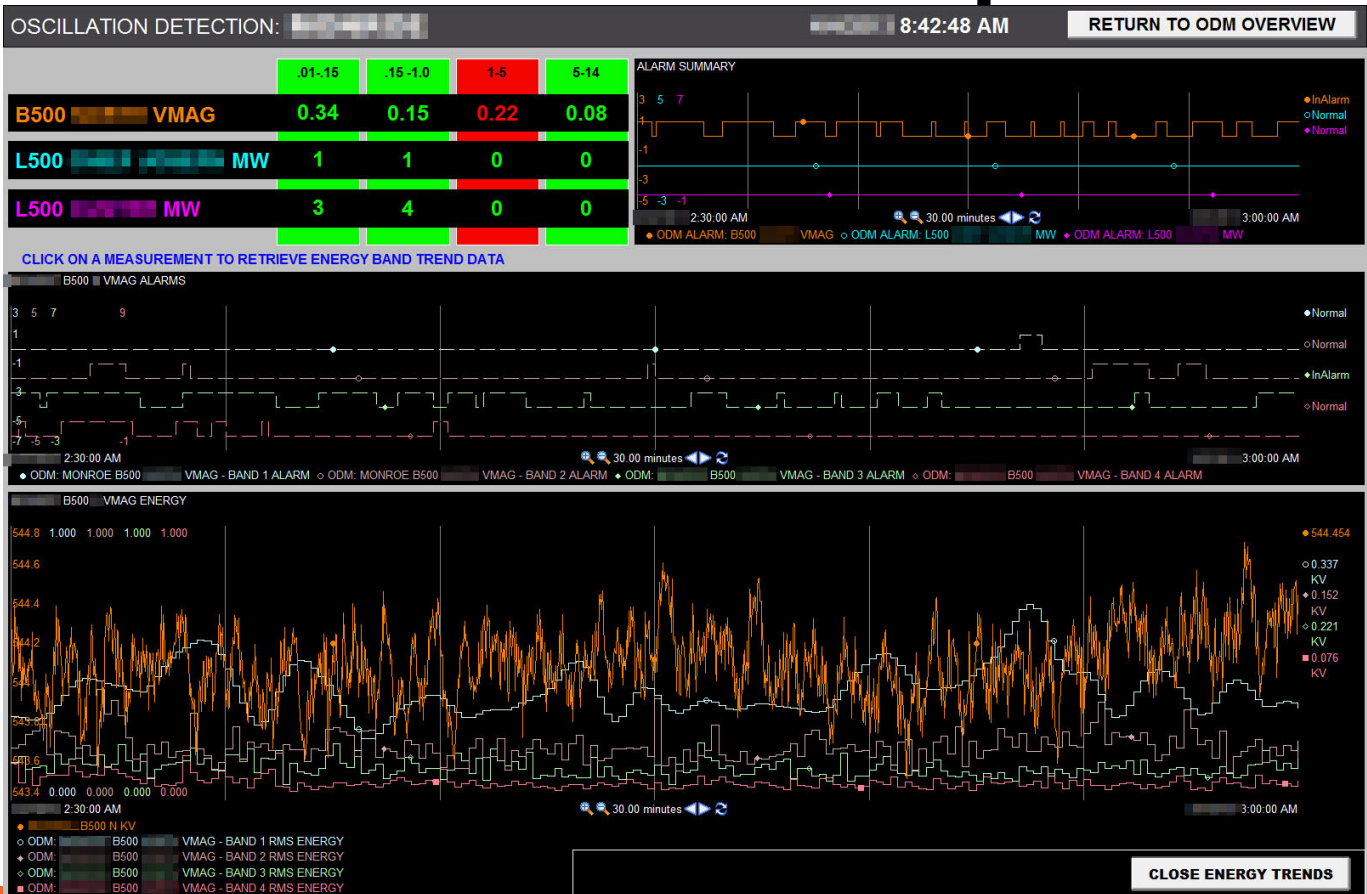


# ODM Detail-Inputs

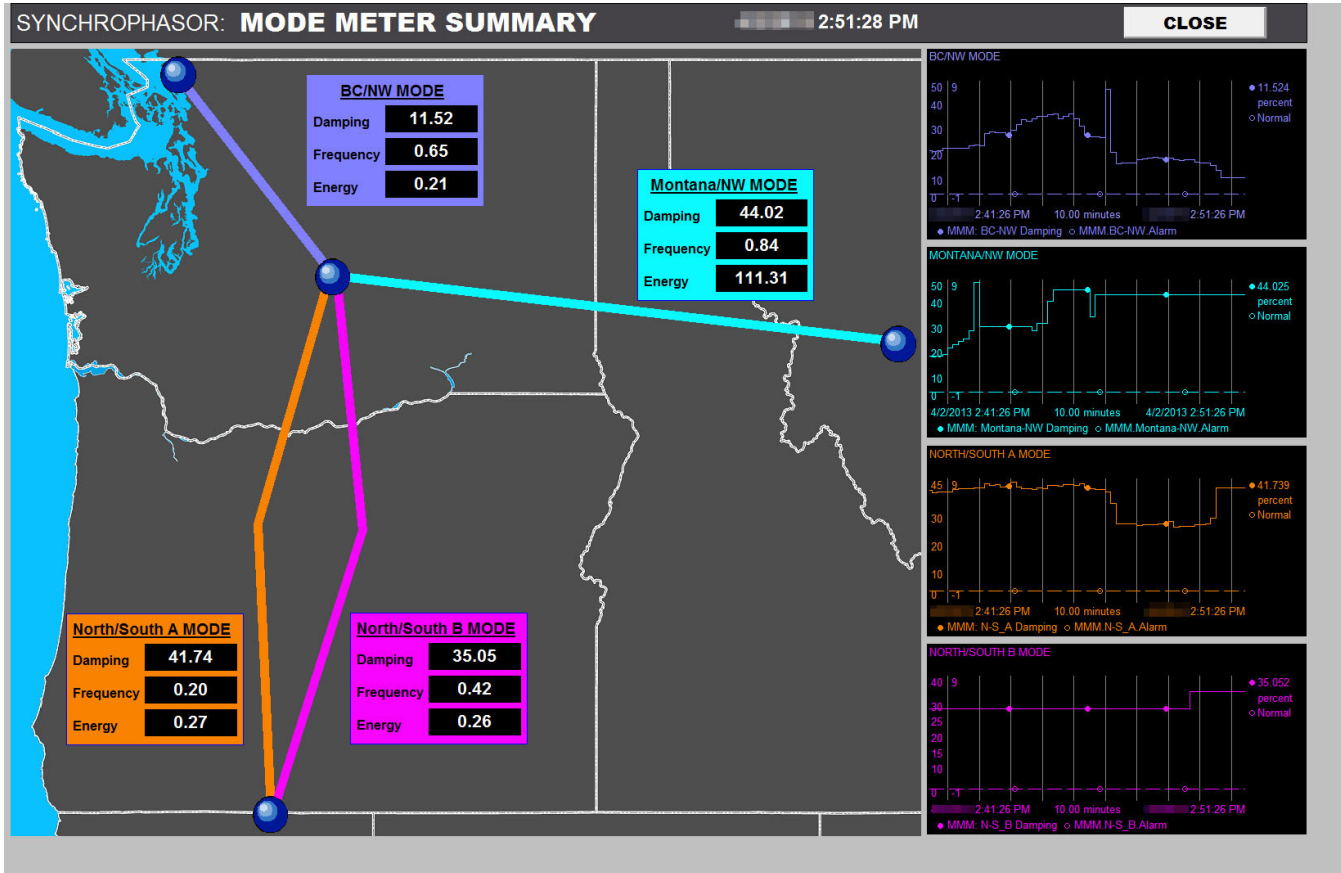




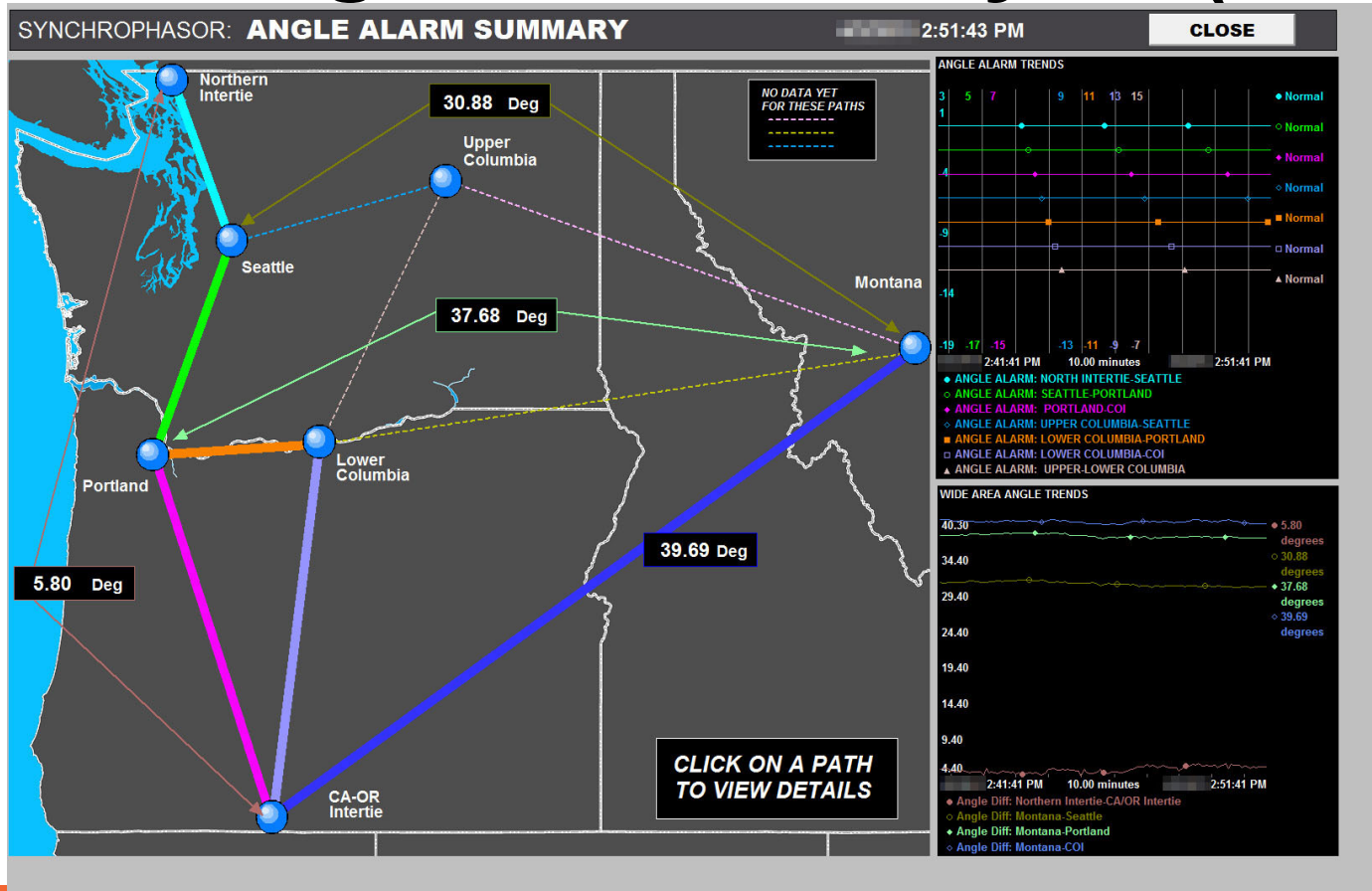
# ODM Detail-Outputs



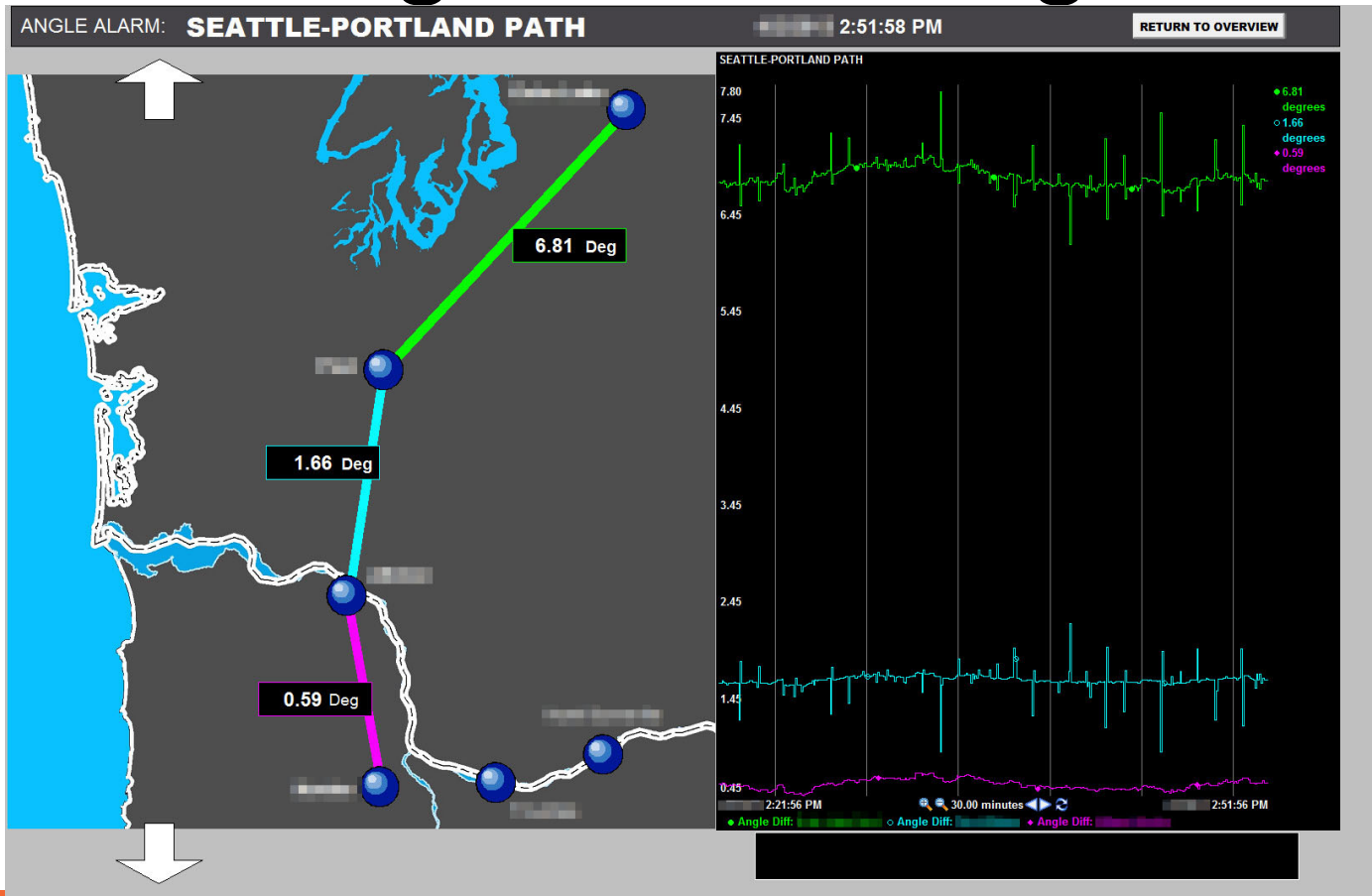
# Mode Meter (MMM)



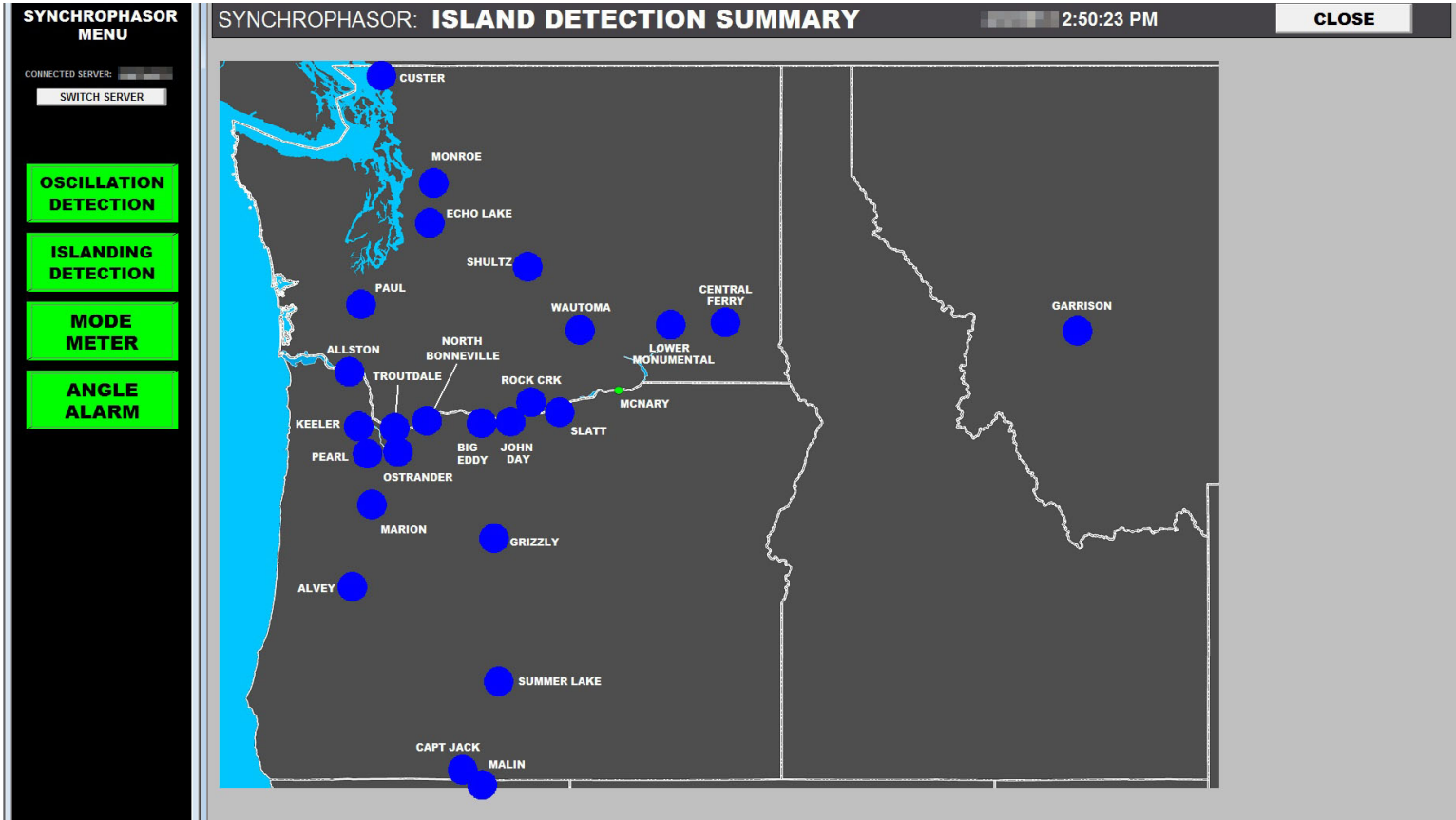
# Angle Alarm Analysis (AAM)



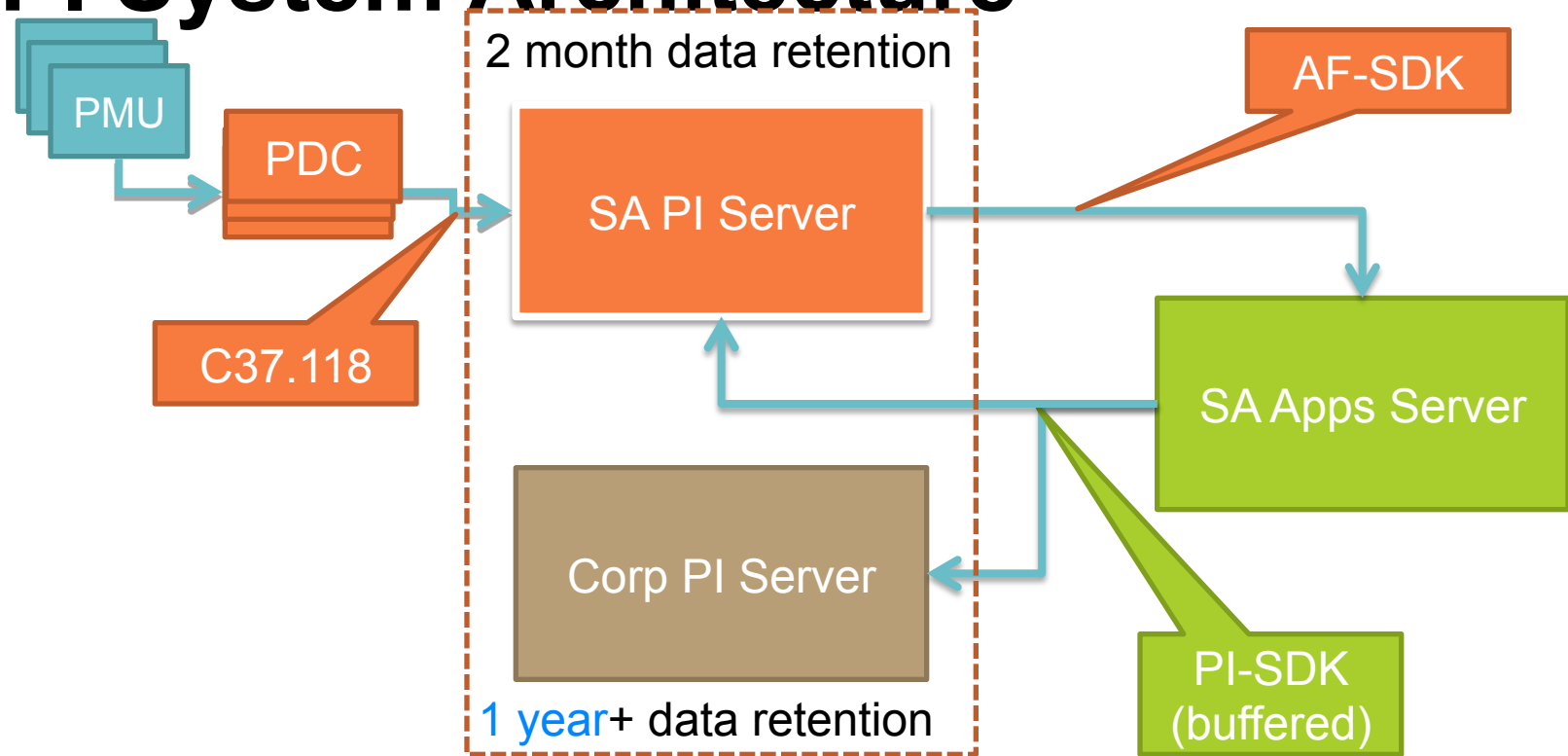
# Angle Alarm - Region



# Power Islanding Detection (IDM)



# PI System Architecture



# SA PI Server Details

SA PI Server

- 24 Core Windows server, 32G physical memory
- 1 GB Archive fills every hour
- 2 months of online data for Situational Awareness (SA) PI (2TB Storage)

# Historian PI Details

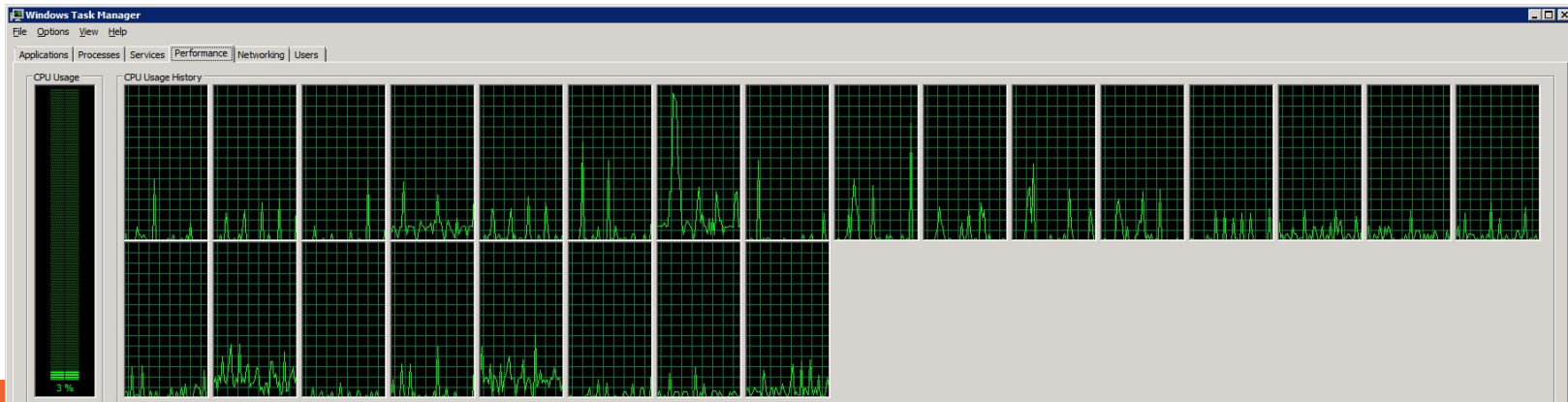
Corp PI Server

- 24 Core Windows server, 32G physical memory
- 1 year of high resolution (60 sps) data online
- All event data online
- All low-speed data (outputs from calculations every 5 to 10 seconds) online



# SA Application servers

- 2 servers
  - 24 Core Server
  - 64 GB Physical Memory
  - Windows 2008 R2

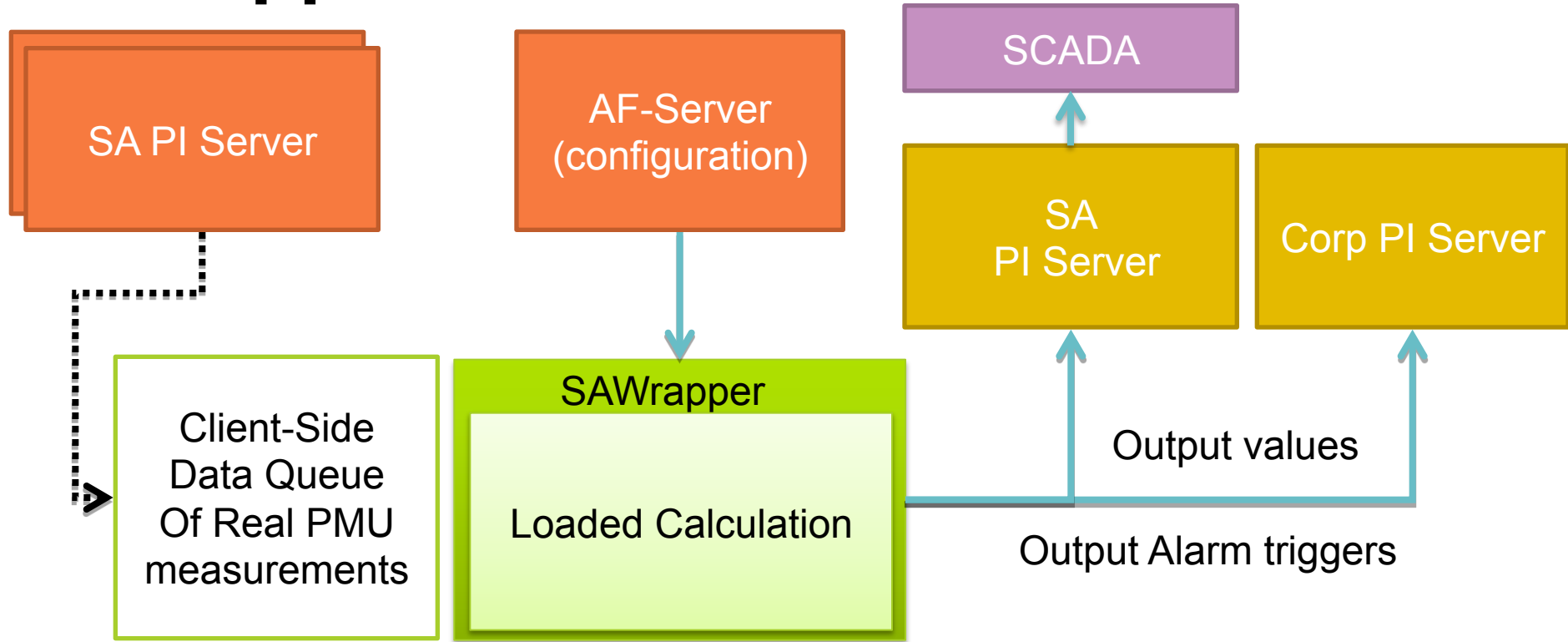


# Current Event Rates

C37118 Interface	Events/Min
From WISP PMUs stream 1	2,336,544
From WISP PMUs stream 2	2,590,145
From WISP PMUs stream 3	1,071,036
From WISP PMUs stream 4	809,655
From WISP Partner PMU steams	32,357

Current Event Rate: 113,966 Events/second

# SA Apps Architecture



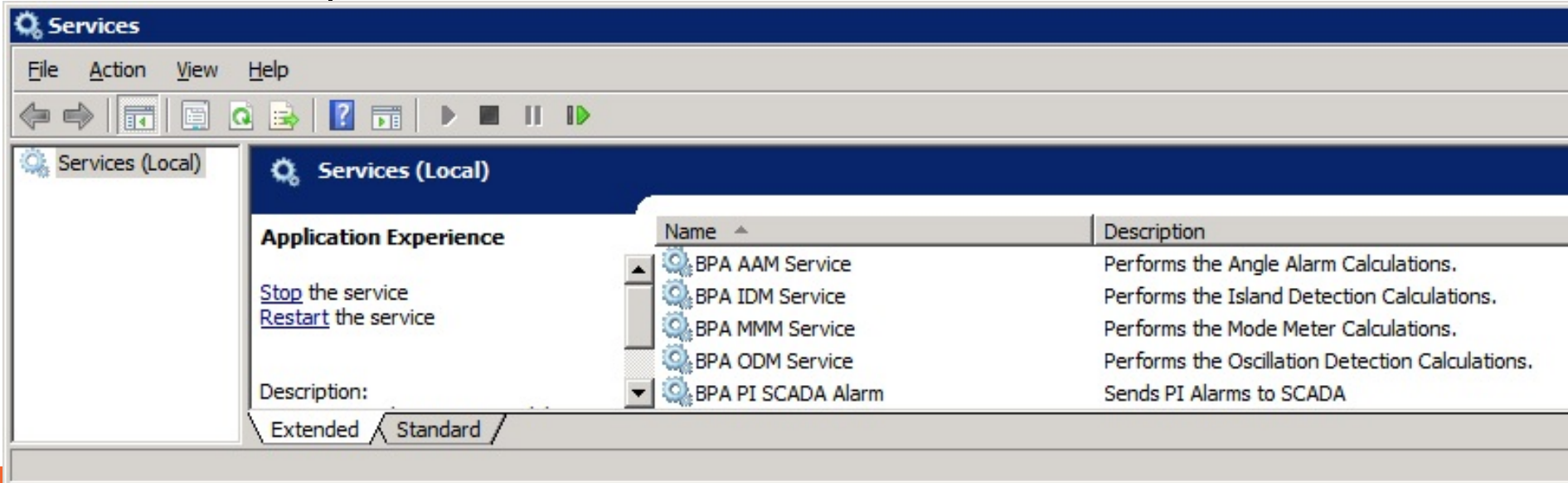
# Re-Assembling IEEE C37.118 (PMU Communications Protocol)

- Analyses require time aligned data



# Windows Services

- Each calculation runs as its own service (similar to ACE)



# AF Database

PI Data References

Meta Data for PMUs.

Calculation Definition

The screenshot shows the PI System Explorer application window. The title bar reads "BPA-PI-SVR01\FromSite-April-4-2013 - PI System Explorer". The menu bar includes File, Edit, View, Go, Tools, and Help. Below the menu bar is a toolbar with icons for Database, Query Date, Back, Check In, Refresh, New Element, and New Attribute. The main area is divided into two panes. The left pane, titled "Elements", shows a tree view of the system structure. The right pane, titled "Allston", shows the details for the selected element. The "Allston" element is expanded, showing two sub-elements: "W001ALLSTON\_\_01.A500FREQ\_\_1" and "W001ALLSTON\_\_01.B500NORTH\_\_1VP". The right pane also has tabs for General, Child Elements, Attributes, Ports, and Version. A filter box is present above a table with columns for Name and Value. The status bar at the bottom of the window displays "Allston Modified:4/2/2013 2:14:22 PM. Version: 1/1/1970 12:00:00 AM, Revision 1".

# AF Database – Calculation Definition

Extensible  
Calculations

Configurable  
Tuning and  
monitoring

The screenshot displays the PI System Explorer interface for the database 'BPA-PI-SVR01\FromSite-April-4-2013'. The left pane shows a tree view of 'Elements' with 'Oscillation Detection' selected under 'Applications'. The right pane shows the configuration for 'Oscillation Detection' with tabs for 'General', 'Child Elements', 'Attributes', 'Ports', and 'Version'. The 'General' tab is active, showing a table of parameters and their values.

Name	Value
Category: <None>	
AFFParameterCategory	LiveConfig
AngleJumpThreshold	0
CalculationDLL	Gov.Bpa.Synchrophasors.Applications.ODMInterface.dll
CalculationWrapper	Gov.Bpa.Synchrophasors.Applications.ODMInterface.ODMWrapper
InputSignalsToIgnore	0
LiveUpdateCheck	5 s
MaxPIDataQueueLength	3500 s
PIInputCategory	PIInput
PIDOutputCategory	ODMOutput
RunTime	True
Category: CalculationSchedule	
CalculationFrequency	5 s
Category: IncomingBuffer	
BufferSize	10 s
PeriodSize	5 s
Category: ODMOutput	
HeartBeat	The requested server was not found in the known servers table. Un
Category: OperationParameters	
InputBlockSize	5

# Re-Assembly Rules

- Per block time: count of events must match rule

Data Rate \* Block Time

60 events \* 5 seconds

- Any block not matching the rule is counted as bad.



# BPA Synchronphasor SA Deployment



# Kudos and Cautions!

PI Server 2012 is  
rock solid!

Fast Interface patch  
turnaround

PI-SDK... Watch  
threading!

AF-SDK 2012 –  
looking good!

# SA Wrapper Requirements

- IData – sends and retrieves data from the calculation
- ILog – enables logging out of the calculation

# Looking Ahead: PMU Deployment Goals

Currently deployed PMUs -- 82 (42 stations)

Target deployment 2014 – 104

Partner data integration – 41

# Looking Ahead: Analysis

## Increase geographic data models

- + CA
- + Montana
- + Alberta
- + Nevada

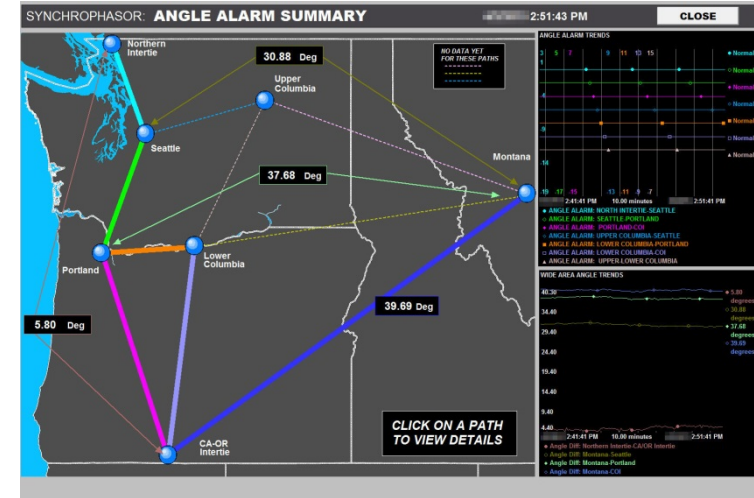
## Add Analyses

- Geospatial Frequency Analysis
- Generation Insertion Efficiency

# BPA Situational Awareness

Advanced Real-Time Situational Awareness using Synchrophasor data.

BONNEVILLE  
POWER ADMINISTRATION



## Business Challenge

Turn Real-Time PMU data into Operator Awareness

Leverage latest in high speed Phasor Measurement Analysis

Prepare for future calculations

## Solution

PI AF based analysis plugin architecture

PI Server 2012 using PI-AF 2012 data access


## Results and Benefits

Online displays show abnormal system behavior.

Replay of real event data shows event identification, ready and waiting!

Potential of early warning for system instability

# Forum Developing!



BPA working with Casne and MontanaTech to maintain analysis and solution code.

Expand functions, unify event definitions

Share data, ideas, test cases

Contact [Jeff.Hopper@casne.com](mailto:Jeff.Hopper@casne.com)

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