Peak Reliability Synchrophasor Technology Implementation Roadmap and Current Progress

October 19, 2016, NASPI Meeting, Seattle

Hongming Zhang, Brett Wangen

PEAKRELIABILITY
assuring the wide area view

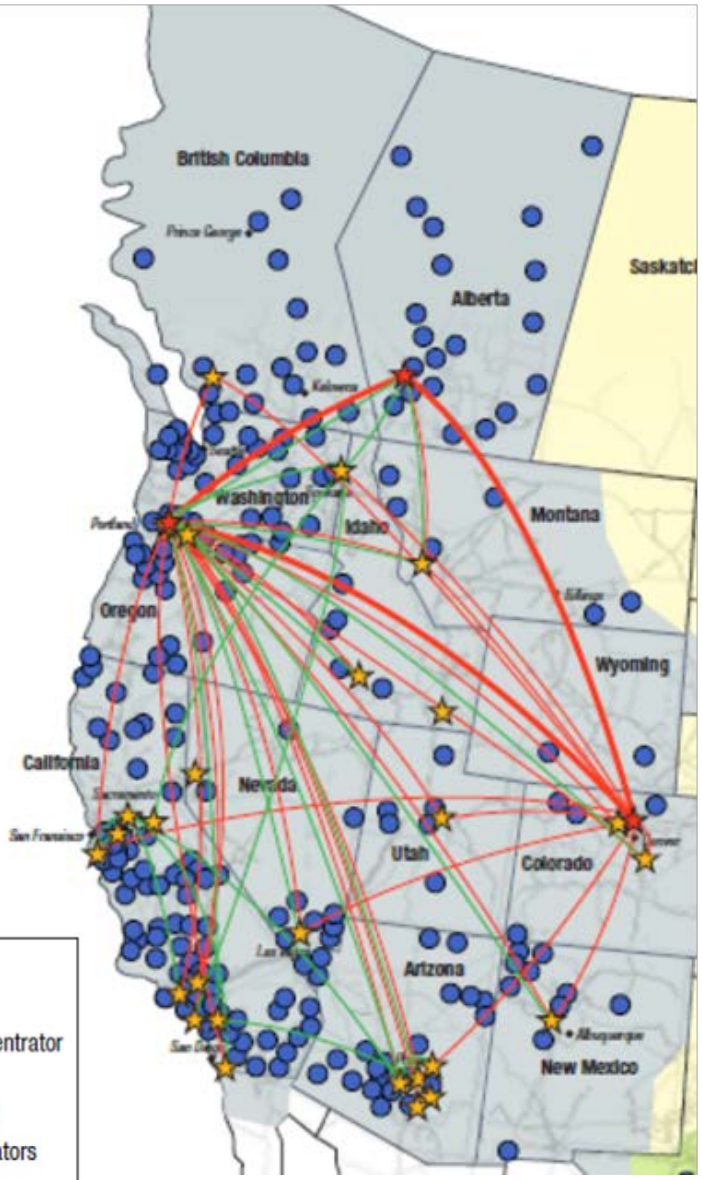
Outline

- Where we are at Synchrophasor Implementation
  - A short review of WISP and PRSP projects
- Roadmap of Synchrophasor Technology Implementation towards Control Room Solution (CRS) Use Cases Development
- Conclusion

WISP - A little history

WISP Accomplishments:

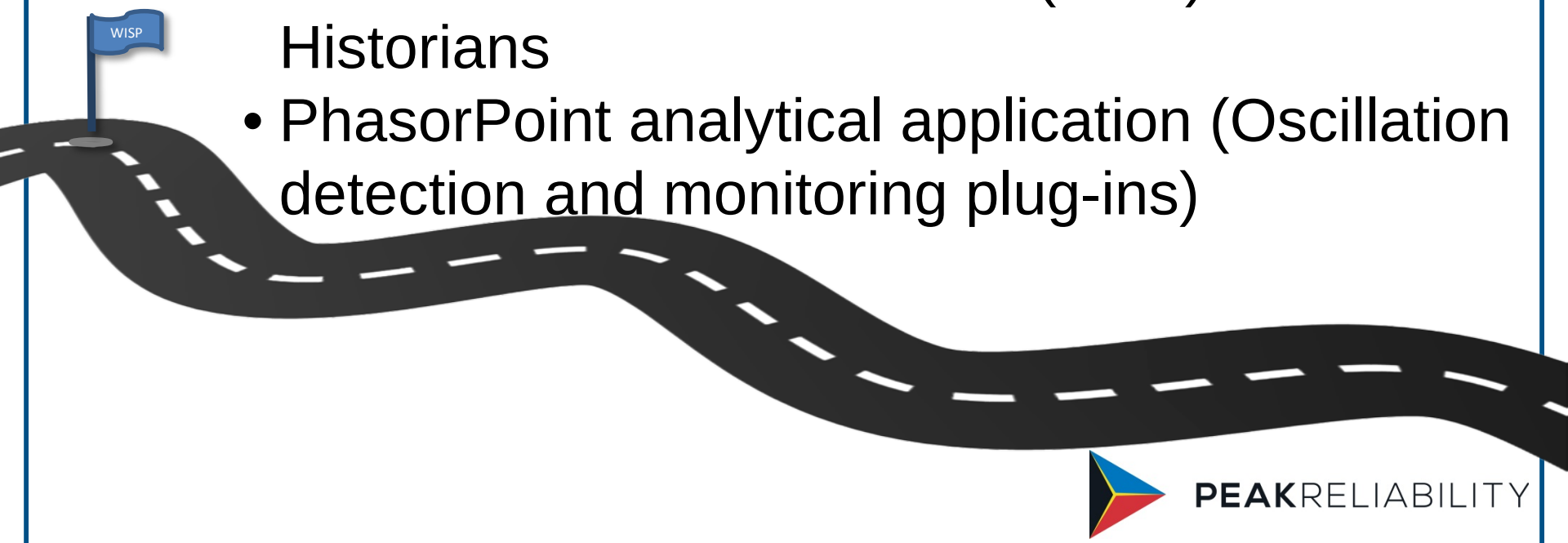
- 585 Phasor Measurement Units
- 69 Phasor Data Concentrators
- WAN Communication Infrastructure
- Data Center(s) and Information Technology Infrastructure
- Advanced Transmission Software Applications
- Control Room Remodel & Expansion



PEAKRELIABILITY

WISP Infrastructure

- WISP WAN for PMU data transport
- SharePoint infrastructure to externalize applications
- Phasor Measurement devices (PMU)
- Phasor Data Concentrators (PDC) and Historians
- PhasorPoint analytical application (Oscillation detection and monitoring plug-ins)



PEAKRELIABILITY

Data Management & Quality

- 80,000 data points stored at primary and backup sites every second
- 2GB data per hour

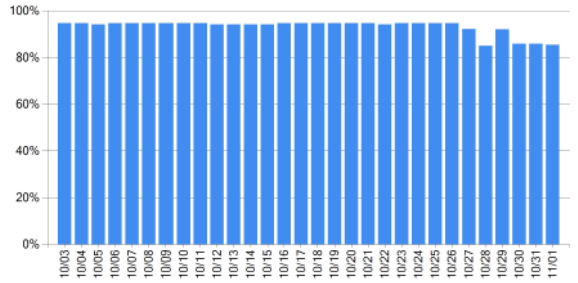
openPDC Data Quality Report
Peak Reliability

Sunday, November 01, 2015

5-day Device Data Quality

	10/28	10/29	10/30	10/31	11/01
L4: Good	150	154	155	154	154
L3: Fair	11	20	18	19	18
L2: Poor	21	9	26	26	27
L1: Offline	6	5	1	1	1
L0: Failed	1	1	1	1	1
Total	189	189	201	201	201

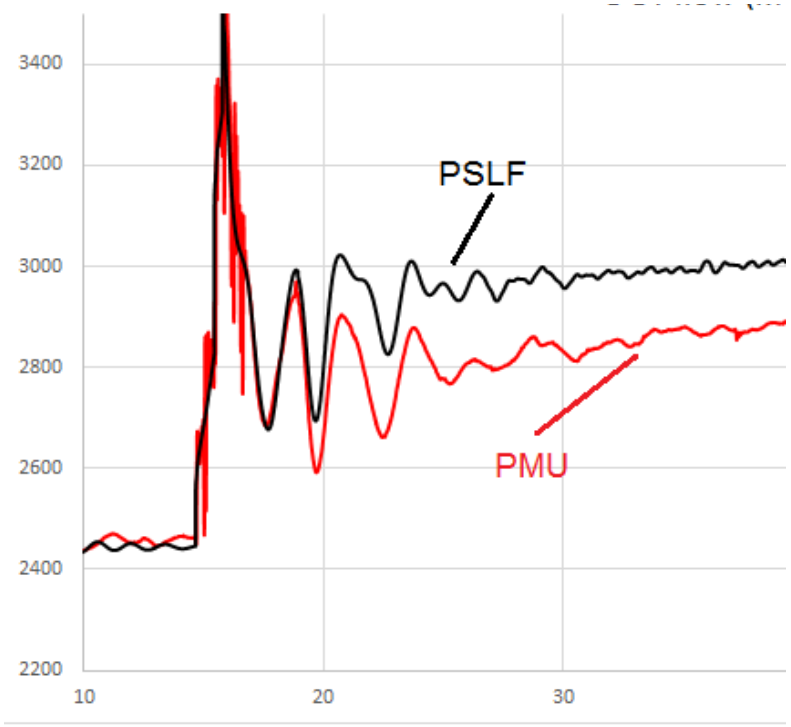
Percent of Devices with Acceptable Quality (30 days)

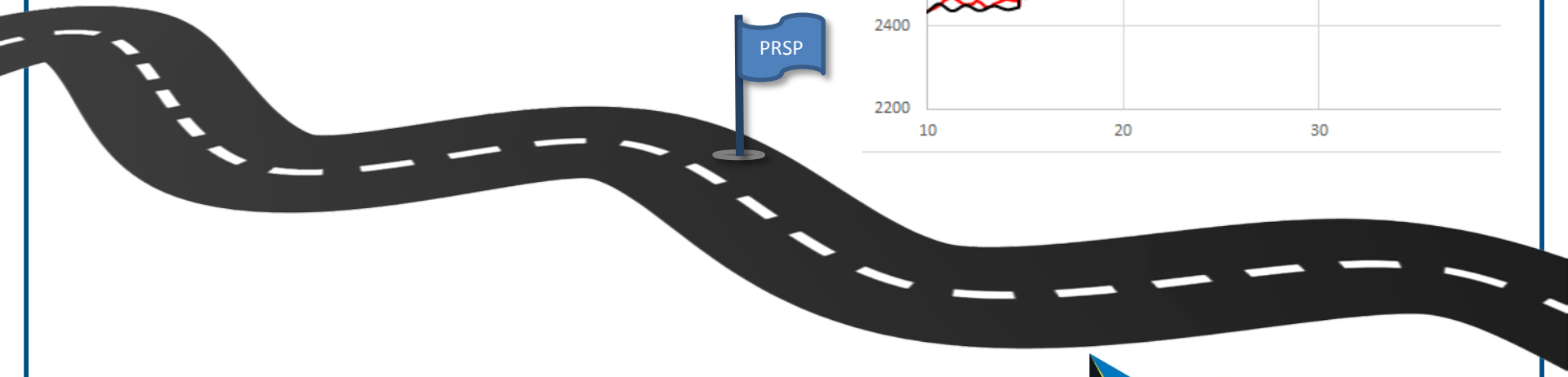


PEAKRELIABILITY

PRSP – Delivering Value

- Data Quality Tools
- Model Validation
- Angle Integration into State Estimation
- Baselining, oscillation detection, LSE

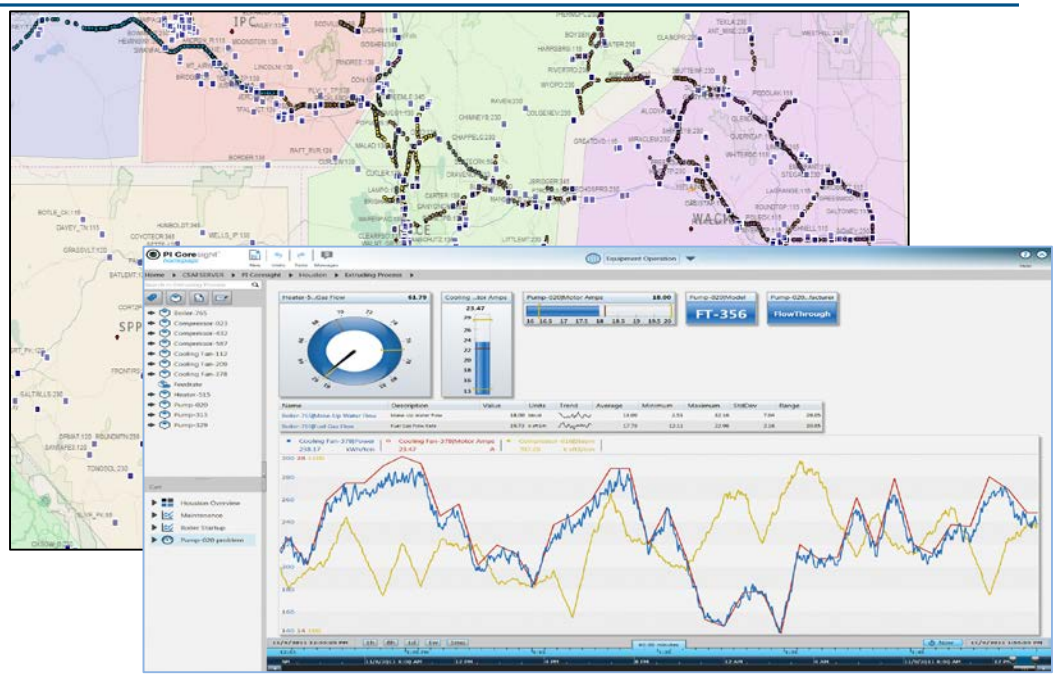


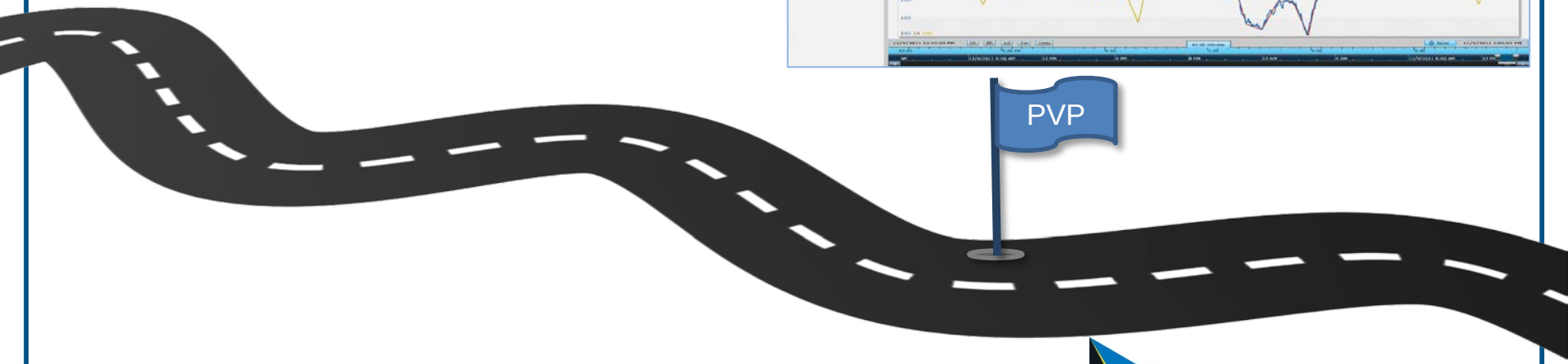


PEAKRELIABILITY

Bringing it all together – Peak Visualization Platform (PVP)

- Geo Spatial data organization and visualization
- Organize data from multiple sources



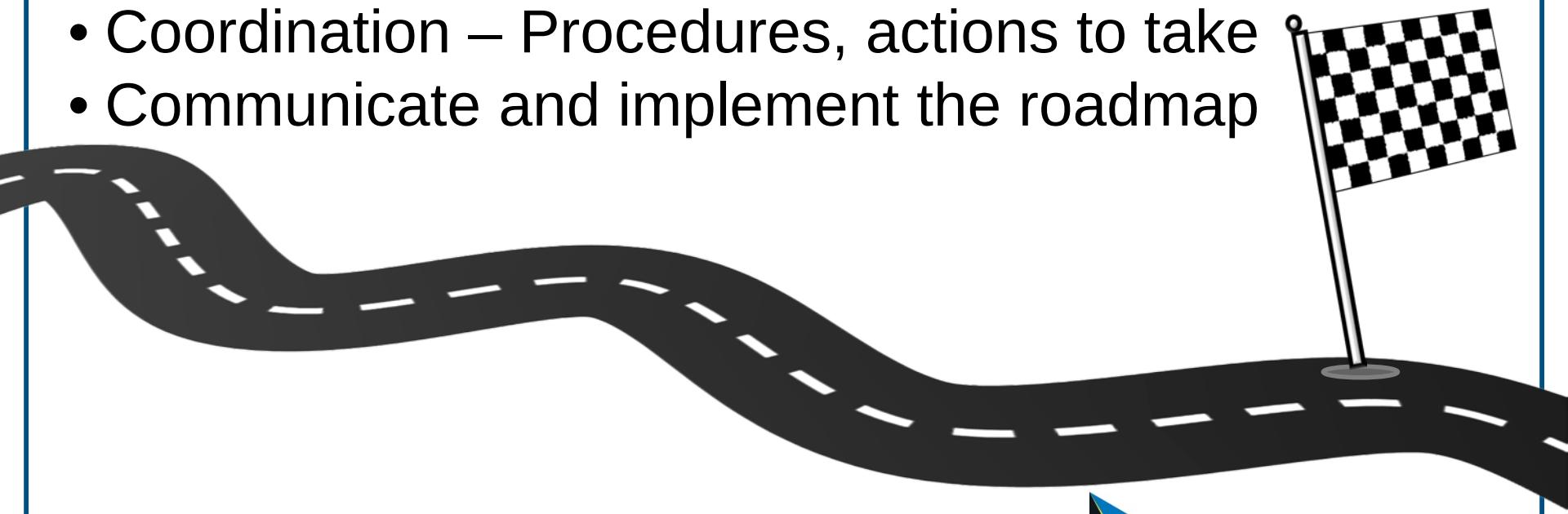


PEAKRELIABILITY

Control Room of the Future

Getting this technology operational requires:

- Data quality
- Visualization and alarming
- Training
- Coordination – Procedures, actions to take
- Communicate and implement the roadmap



PEAKRELIABILITY

Roadmap of Synchrophasor and CRS Use Cases Development

PEAKRELIABILITY
assuring the wide area view

Peak Initiative, Strategy and Tactic

- Drive Operational and Technological Excellence
  - Promote data accuracy and bring data, models and tools to maturity
    - Increase synchrophasor tool value to system operations
      - Perform system model validation (MOD-033) by PMU data
      - Implement linear state estimation to support PMU data validation and conditioning
      - Provide PMU data driven backup visualization for operational awareness in case of ICCP or EMS failure
      - Perform phase angle separation, islanding and frequency excursions monitoring
      - Monitor system oscillatory modes and forced oscillations

PEAKRELIABILITY

System Event Validation Framework

- Peak staff leads WECC/MOD-033 task to validate system models with PMU data
  - We made a few achievements till date:
    - Map up 96% generating unit capacity in our EMS model with WECC planning *.dyd files
    - Enable online TSAT run in ‘Monitor’ mode for transient stability assessment for every 15 minutes.
    - Validate TSAT event simulation output with recorded PMU data
    - Create a pre-disturbance basecase from two ways
      1) Production EMS SE snapshot cases (5 minutes auto archived)
      2) DTS event replay SE case (10-20 seconds prior to the event)

      The basecases were exported/shared in GE/PLSF and PowerWorld

Creating a Pre-Disturbance Case from DTS Replay

- Our EMS records all SCADA values in Historical Data Record (HDR) files in real time
- Our DTS tool has the capability of replaying these HDR files while having SE and RTCA up running
- Peak team developed a quick process to enable creating desired SE solution cases from replay
- The function allows us to create a SE snapshot 10-20s prior to the event roughly
- **By DTS Replay Peak could build a system event simulation and validate it by TSAT in hours now**

PEAKRELIABILITY

Grid Operation Situational Awareness

- Ensure high quality down sampled (DS) PMU available for Situational Awareness
  - Supplemental to ICCP measurements
    - **238 PMU data received and 250+ PMU will come in**
  - Calculate line flows (P/Q) and Path flows from PMU Voltage and Current signals (in progress)
  - Enable LSE solution for PMU data conditioning
  - Make DS PMU data (frequency, voltage and resultant line/path flows) available for RC situational awareness in case of ICCP link failure

PEAKRELIABILITY

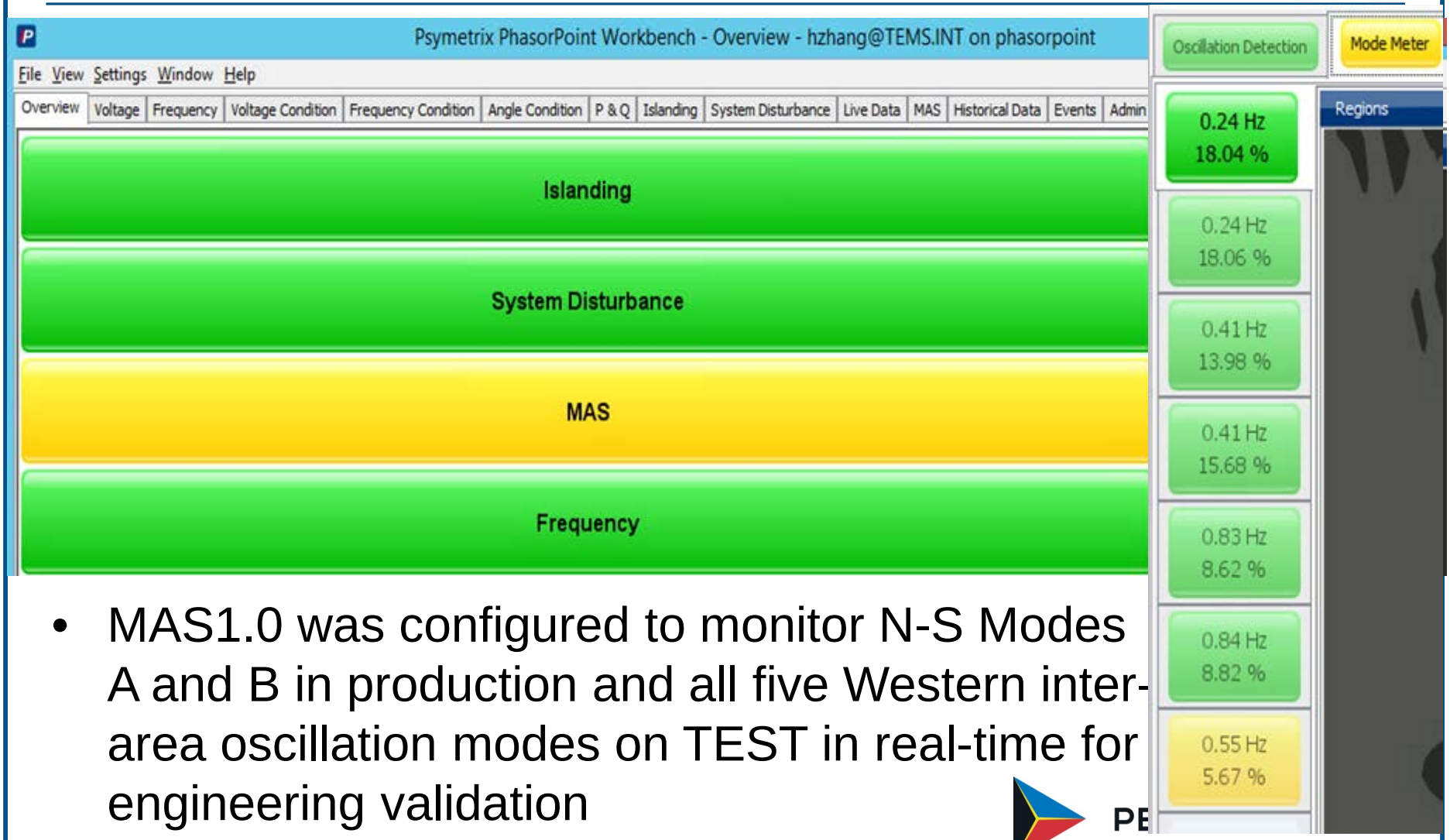
Enable Angle Separation Monitoring

- Monitor phase angle difference (PAD) for selected Paths/IROLs or wide area bus pair
  - Enable SE solved phase angles available for PAD monitoring due to limited PMU coverage
    - New approach-Virtual Bus Angle was developed to monitor angular stress on specific Path or IROL
    - Enhanced TSAT software to calculate PAD limits for every 15 minutes on selected paths/IROLs
    - Integrate DS PMU or SE solved voltage angles, TSAT output PAD limits to the CRS for awareness of a stressed condition or operation pattern change

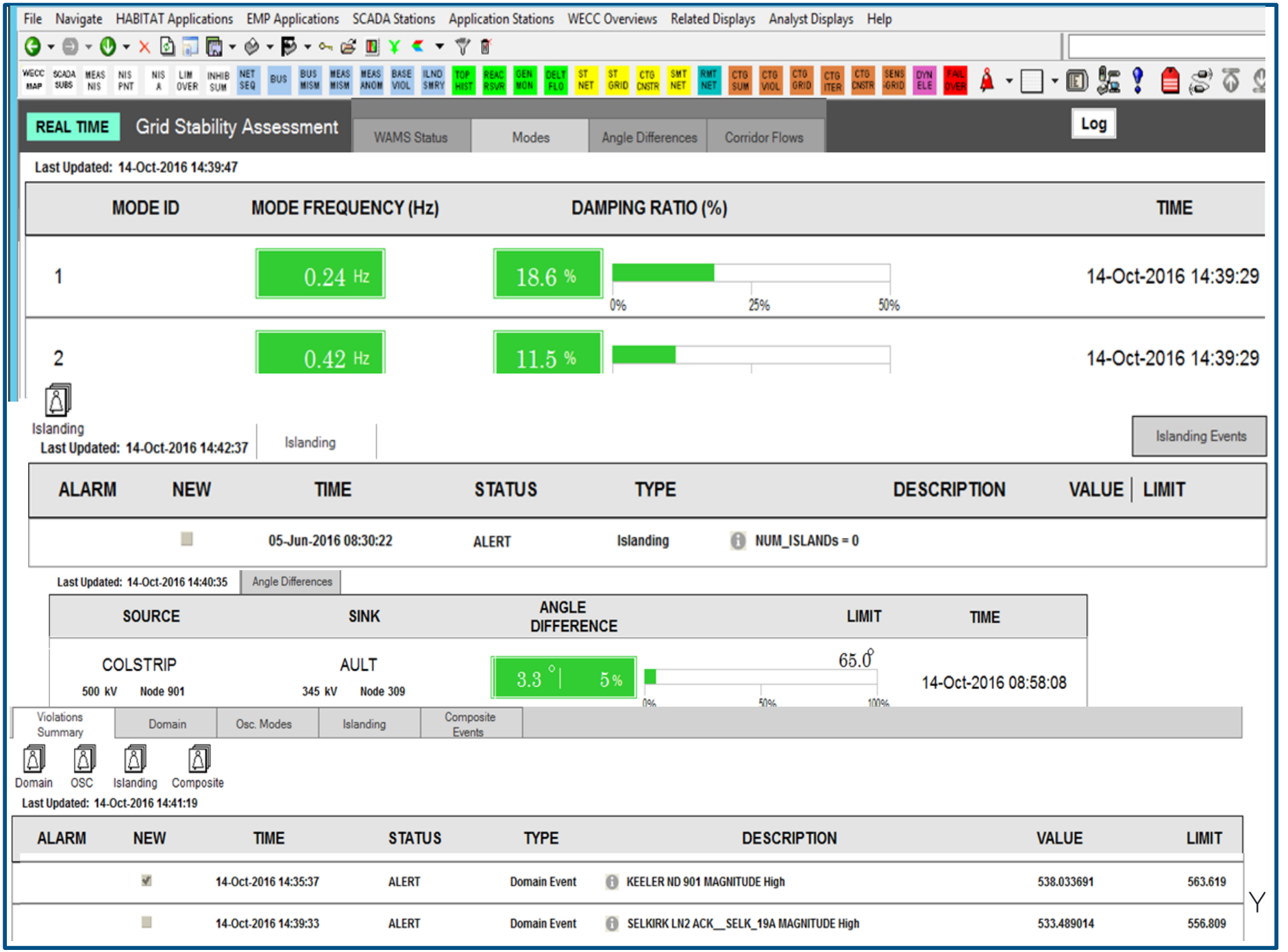
Enabling Mode Meters for CRS Use

- Integrate MontanaTech MAS into the CRS enviroment
  - MAS 1.0 output results transfer to EMS via GSA that has been functional since May 2016
    - Work on new GSA enhancement to modify OSCMOM data tables to enable the data to be stored in OSI PI
      - **Mode Meter/Oscillation Detection alarm baselining**
  - MAS2.0 offline mode acceptance test completed Real-time mode upgrade will be considered
  - Visualize and alarm MAS results in CRS use

GE-Alstom PhasorPoint Built in MAS 1.0



- MAS1.0 was configured to monitor N-S Modes A and B in production and all five Western inter-area oscillation modes on TEST in real-time for engineering validation


File Navigate HABITAT Applications EMP Applications SCADA Stations Application Stations WECC Overviews Related Displays Analyst Displays Help
REAL TIME
Grid Stability Assessment
WAMS Status
Modes
Angle Differences
Corridor Flows
Log
Last Updated: 14-Oct-2016 14:39:47
MODE ID
MODE FREQUENCY (Hz)
DAMPING RATIO (%)
TIME
1
0.24 Hz
18.6 %
0%
25%
50%
14-Oct-2016 14:39:29
2
0.42 Hz
11.5 %
14-Oct-2016 14:39:29
Islanding
Last Updated: 14-Oct-2016 14:42:37
Islanding
Islanding Events
ALARM
NEW
TIME
STATUS
TYPE
DESCRIPTION
VALUE
LIMIT
05-Jun-2016 08:30:22
ALERT
Islanding
NUM_ISLANDs = 0
Last Updated: 14-Oct-2016 14:40:35
Angle Differences
SOURCE
SINK
ANGLE DIFFERENCE
LIMIT
TIME
COLSTRIP
500 kV Node 901
AULT
345 kV Node 309
3.3 °
5 %
65.0°
0%
50%
100%
14-Oct-2016 08:58:08
Violations Summary
Domain
Osc. Modes
Islanding
Composite Events
Domain
OSC
Islanding
Composite
Last Updated: 14-Oct-2016 14:41:19
ALARM
NEW
TIME
STATUS
TYPE
DESCRIPTION
VALUE
LIMIT
14-Oct-2016 14:35:37
ALERT
Domain Event
KEELER ND 901 MAGNITUDE High
538.033691
563.619
14-Oct-2016 14:39:33
ALERT
Domain Event
SELKIRK LN2 ACK__SELK_19A MAGNITUDE High
533.489014
556.809

Forced Oscillation Detection and Online Source Locating

- Integrate WSU OMS online results into the CRS for actionable alarms and visualization
  - Through the CERTS project Peak deployed WSU OMS online tool into our Lab at 06/2016
    - Work closely with the project team to validate the tool and review oscillation results bi-weekly
    - Two source location algorithms using both PMU and SCADA data were developed and validated offline
    - Prototype of integrating WSU OMS tool with source location algorithms into PI Processbook for actionable alarms and user friendly visualization

PEAKRELIABILITY

Forced Oscillation Source Identification

- Not all generators are covered by PMU. It results in difficulty of finding the source from mode shapes
- SCADA data is much more readily available
  - ~10 second sample rate in Peak EMS/SCADA
- Peak collaborated with WSU to develop a new Pattern Mining Algorithm-PMA to process the SCADA data to find the likely cause of oscillations
  - The key is recognizing the pattern caused by the oscillations to SCADA data and ruling out Noise effects
  - PMA was used to identify six oscillation events correctly from 3-5 minutes of oscillation data

PEAKRELIABILITY

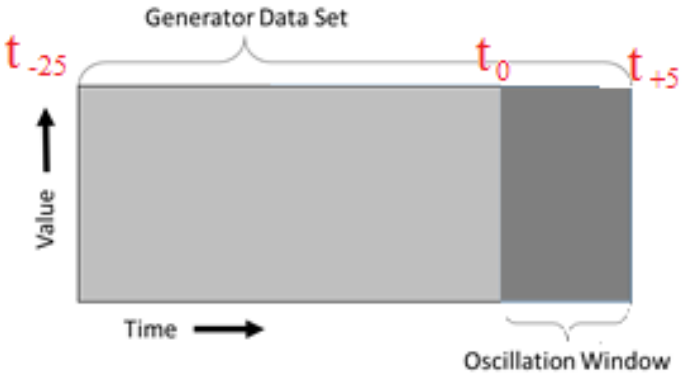
Operationalizing the Tool (In Progress)

Online Oscillation Detection Tool

Retrieve SCADA Data from PI Historian

PMA

Flag Potential Generators likely causing oscillation



RC will contact the generator owner to report/confirm the issue and develop a resolution if the oscillation causes any reliability issue.

What if no reliability incurred?

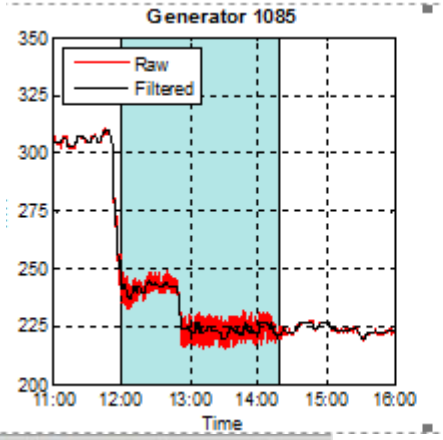
PEAKRELIABILITY

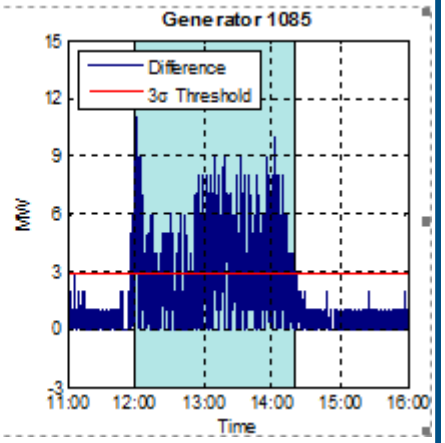
CRS: Visualize MAS and OMS Solutions Results in a Centralized Geographic View

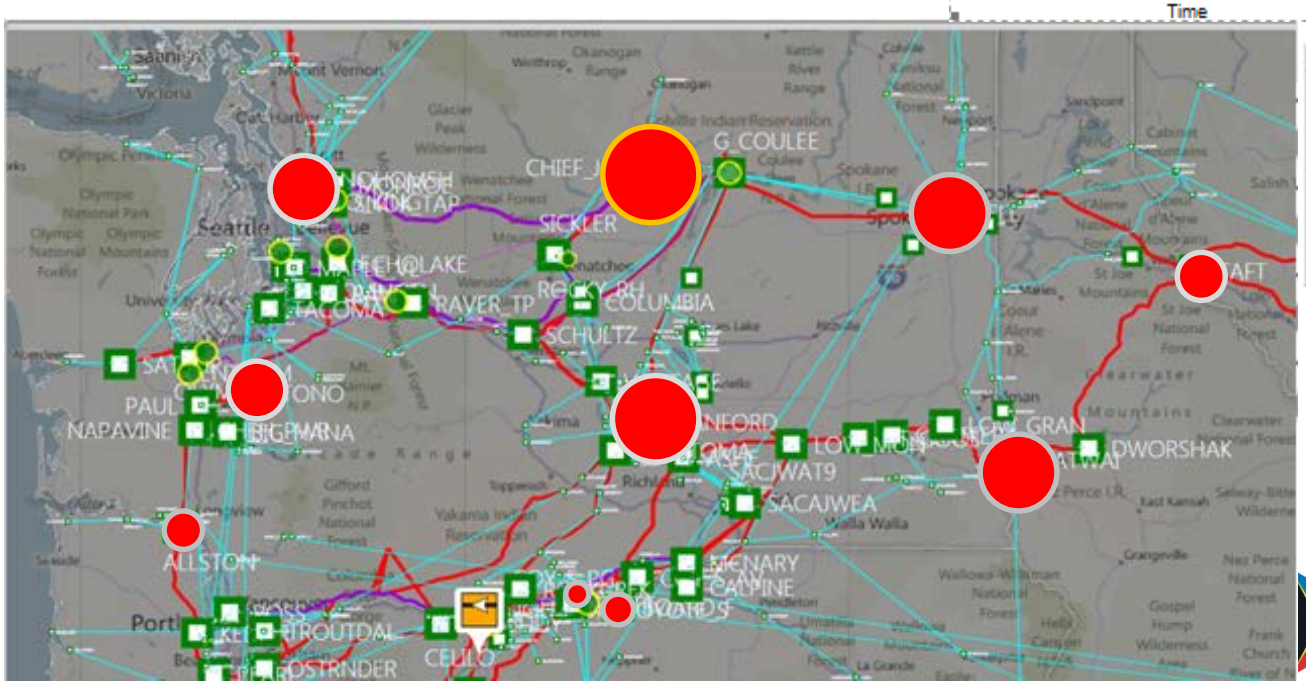
Possible sources identified using PMA

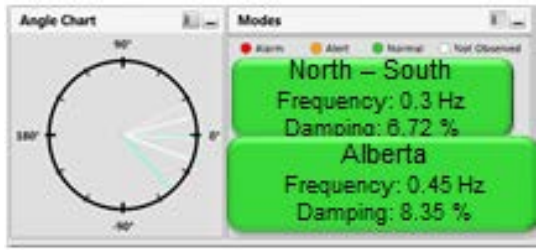
$Length_{osc} = 841$, $Length_{amb} = 960$.

Ranking	Channel Name	Ranking Index K_{PMA}	NUM_{osc}	NUM_{amb}
1	Generator 1085	0.1888	164	6
2	Generator 1088	0.1082	112	24
3	Generator 1087	0.0619	74	25









MAS and OMS results store in PI to visualize in a centralized geo-graphic platform

PEAKRELIABILITY

Conclusion

- Peak (formerly WECC RC) made a long way to implement synchrophasor applications in a control room setting
- The synchrophasor implementation roadmap and CRS use cases were defined to increase value of synchrophasor applications to system operations
- Target to roll out identified use cases in the control room in 2 years

PEAKRELIABILITY

Hongming Zhang, hzhang@peakrc.com
Manager, Network Applications
Brett Wangen, bwangen@peakrc.com
Director, Engineering