NASPI North American SynchroPhasor Initiative

Welcome to the NASPI Spring 2020 Working Group

April 15 & 16, 2020

U.S. DEPARTMENT OF ENERGY | Pacific Northwest NATIONAL LABORATORY | EPRI ELECTRIC POWER RESEARCH INSTITUTE

NASPI North American SynchroPhasor Initiative

Welcome to the NASPI Spring 2020 Working Group

Host: Eric Andersen

Pacific Northwest National Laboratory

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NASPI North American SynchroPhasor Initiative

Sign up for NASPI's Email

naspi@pnnl.gov

Presentations will be posted on the NASPI website

https://www.naspi.org

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NASPI North American SynchroPhasor Initiative

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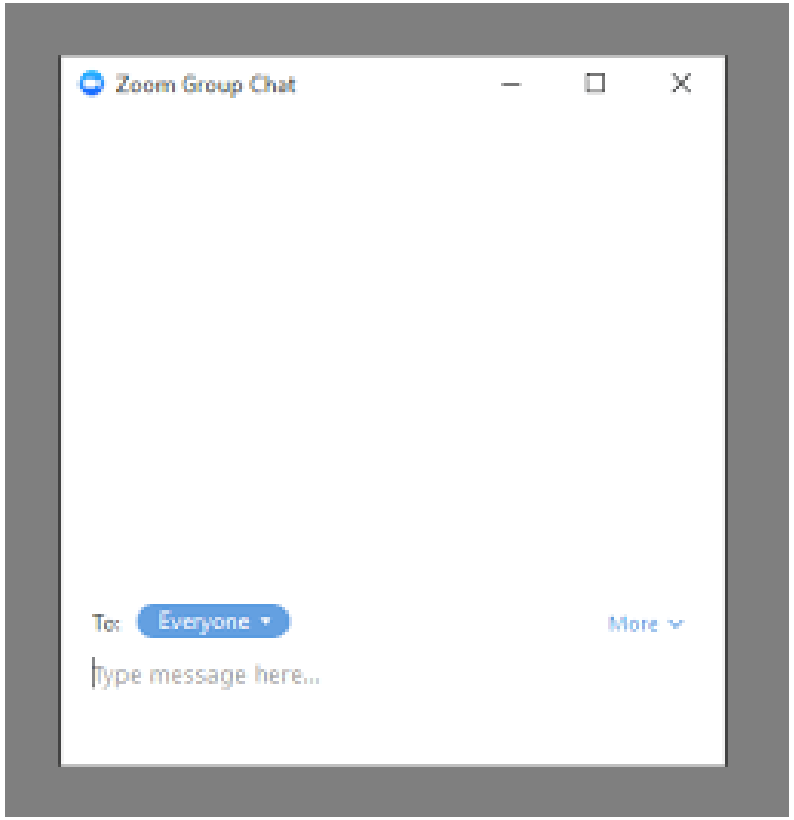
Q&A – The Zoom interface and how to post a comment or to ask a question



NASPI North American SynchroPhasor Initiative

Moderator:
Jeff Dagle
Pacific Northwest
National Laboratory

Program Updates

Description: Overview of the use of synchrophasor technologies, tools, and applications to operate a more resilient and efficient electric grid continue to evolve. Listen to what the leaders have to say about what they are doing to continue the advancement of time-synchronized telemetry. Expected updates from DOE, EPRI, FERC, NERC, EIDSN, and the NASPI technical task team leaders.

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NASPI North American SynchroPhasor Initiative

Today's Webinar Agenda

- Ali Ghassemian, U.S. Department of Energy
- Paul Myrda, Electric Power Research Institute
- Ken Simendinger, Eastern Interconnection Data Sharing Network
- Bahram Barazesh, Federal Energy Regulatory Commission
- Ryan Quint, North American Electric Reliability Corporation
- Aftab Alam and Tim Fritch, NERC Synchronized Measurement Subcommittee

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NASPI North American SynchroPhasor Initiative

Today's Webinar Agenda (continued)

- Control Room Solutions Task Team
  - Mike Cassiadoro, Jim Kleitsch, and Sarma (NDR) Nuthalapati
- Data and Network Management Task Team
  - Dan Brancaccio and Matthew Rhodes
- Distribution Task Team
  - Sascha von Meier and Dan Dietmeyer
- Engineering Analysis Task Team
  - Evangelos Farantatos and Shaun Murphy
- Performance Requirements Standards & Verification Task Team
  - Jim O'Brien and Farnoosh Rahmatian

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U.S. DEPARTMENT OF ENERGY
Office of Electricity

Department of Energy
North American SynchroPhasor Initiative (NASPI)

Ali Ghassemian Ph.D., EE
Program Manager, Advanced Modeling Grid Research
Office of Electricity
Department of Energy

April, 2020

Office of Electricity (OE) Objectives

- Provide national leadership to ensure a secure resilient and reliable energy delivery system.
- Develop technologies to improve the infrastructure that brings electricity into our homes, offices, and factories.
- Support development of the federal and state electricity policies and programs that shape electricity system planning and market operations.
- Drive electric grid modernization and resiliency through research, partnerships, facilitations, and modeling and analytics.

OE's Synchrophasor FY19 Goals

- Completed 4 industry cost-shared pre-commercial synchrophasor-based demonstrations of advanced applications under NETL FOA 1492
  1. Real Time Applications Using Linear State Estimation Technology
  2. Substation Secondary Asset Health Monitoring and Management System
  3. Operationalizing Synchrophasors for Enhanced Electric Grid Reliability and Asset Utilization
  4. Advanced Synchrophasor Protocol (ASP) Development and Demonstration Project
- Made awards under FOA-1861 (Big Data Analysis of Synchrophasor Data)
  - The goal of this FOA is to explore the use of big data, artificial intelligence and machine learning technology to discover insights and tools for better grid operation and management. This work is focused on discovery of additional information that might reside in the existing PMU data that could precursors to abnormal events
- Completed Eastern Interconnection Situational Awareness Monitoring System (ESAMS) demonstration with PJM, ISO-NE, NYISO, and MISO
- Continued development of next generation PMUs
- Initiated development of new dynamic load modeling techniques, based in part on advanced grid monitoring technologies
- Conducted two meetings of NASPI

OE's Synchrophasor FY20 Plans

- Transfer ESAMS (Eastern Interconnection Situational Awareness Monitoring System) to EIDSN (Eastern Interconnection Data Sharing Network)
- Re-focus NASPI to support next generation advanced grid monitoring technology and system analysis needs
    - Emerging emphasis on high-speed point-on-wave measurements to characterize system-level impacts of inverter-based resources and other fast acting phenomena during off normal condition
- Support Development of combined Transmission/Distribution design and buildout.
- Continue improving data quality
- Data-sharing for real-time situational awareness and with researchers and transmission operators to do big data analysis for baselining, anomaly detection, mis-operations diagnosis and operator decision support tools
- Webinars on the NASPI functionalities
- Gap Analysis – What are the future needs/desires going forward

OE's Initiatives

Existing capabilities are not sufficient for understanding and mitigating the reliability and resiliency of the grid.

1. **North American Energy Resiliency Model (NAERM)**

   Working with the national labs and relevant stakeholders OE will develop an integrated model of multiple infrastructures to study, analyze, and address vulnerabilities in the North American Energy System. This models is intended to allow us for sequencing of events to understand risk across critical energy infrastructure sectors and identifying key energy infrastructure interdependencies as well as identify potential infrastructure investments to improve resiliency and mitigate risks associated with energy system interdependencies

2. **Revolutionize Sensing Technology Utilization**

   In order to get the understanding of what the next generation of sensors should be in order to support the reliability and resiliency of the system, in December 2018 the department has put coordinated roadmap of sensor technology and data analytics to get a better understanding of:

   - Infrastructures interdependency;
   - System resiliency;
   - Fault detection and failure identification;
   - Behind the meter DER impact.

NASPI's areas of activities

DOE is considering leveraging NASPI for additional programmatic linkages that supports OE's Initiatives:

- Processing of data into information (data analytics)
- Further developing data practices for collection, sharing, and management of data to make efficient use of data
- Advancement in sensors and its application applied to the protective relaying
- Reducing high Operation and Maintenance cost associated with PMUs data quality and outages
- Further utilization of Artificial Intelligence and Machine Learning techniques
- Wide-Area Oscillation Assessment and Trending Analysis and automated, autonomous system protection schemes, including wide-area damping.
- Incorporating the DOE's Sensing and Measurement Roadmap study recommendations into NASPI.
- Wide adoption of developed technologies under NASPI

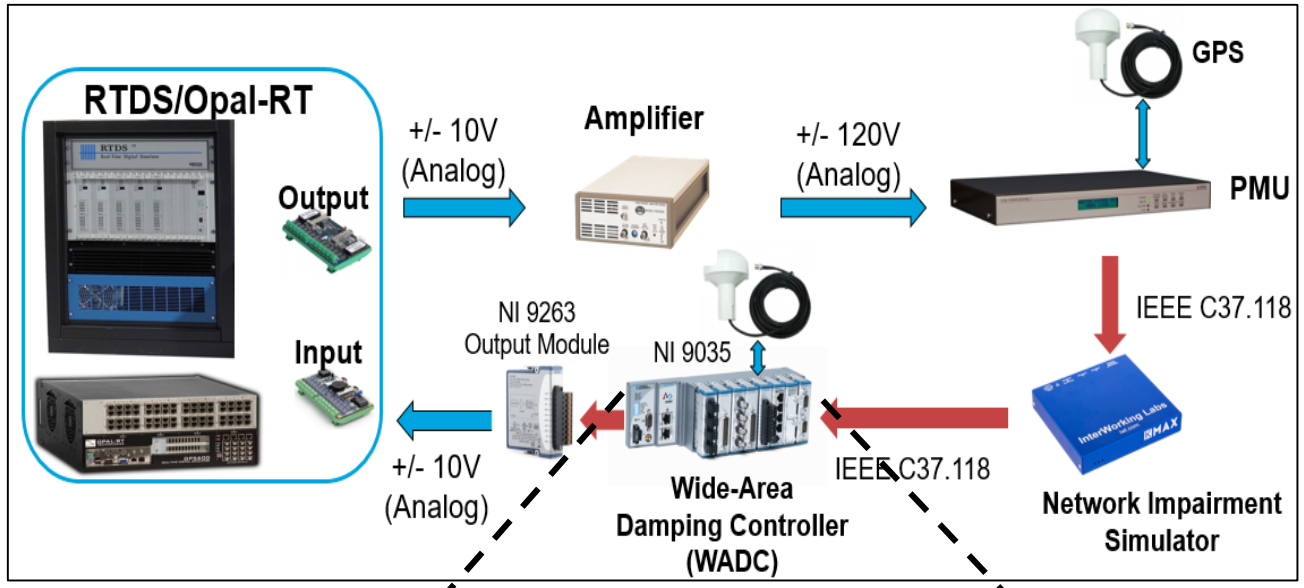
Summary of EPRI Synchrophasor Related Activities

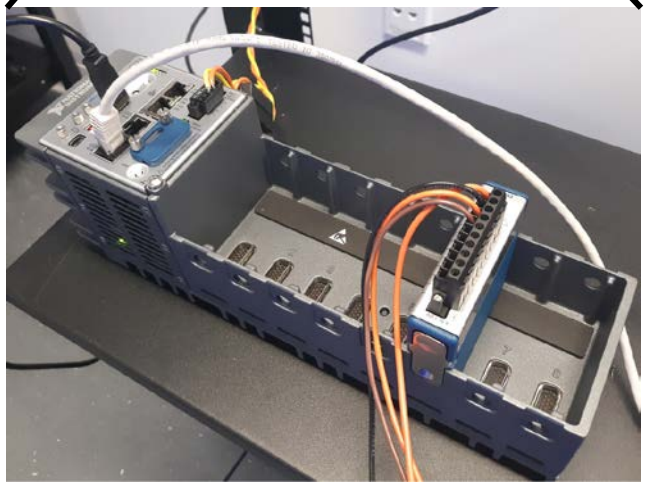
Paul Myrda
Evangelos Farantatos
Mahendra Patel
Hossein Hooshyar

NASPI Webinar – Organizational Updates
April 16, 2020

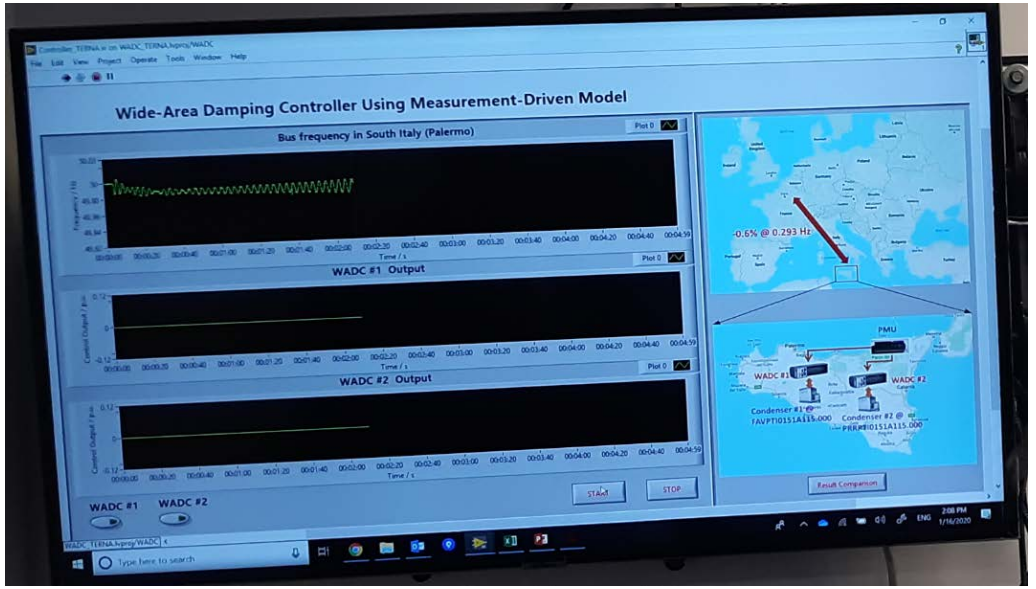
1. Synchrophasor-Based Wide Area Oscillations Damping Controller

In collaboration with University Tennessee Knoxville (UTK)



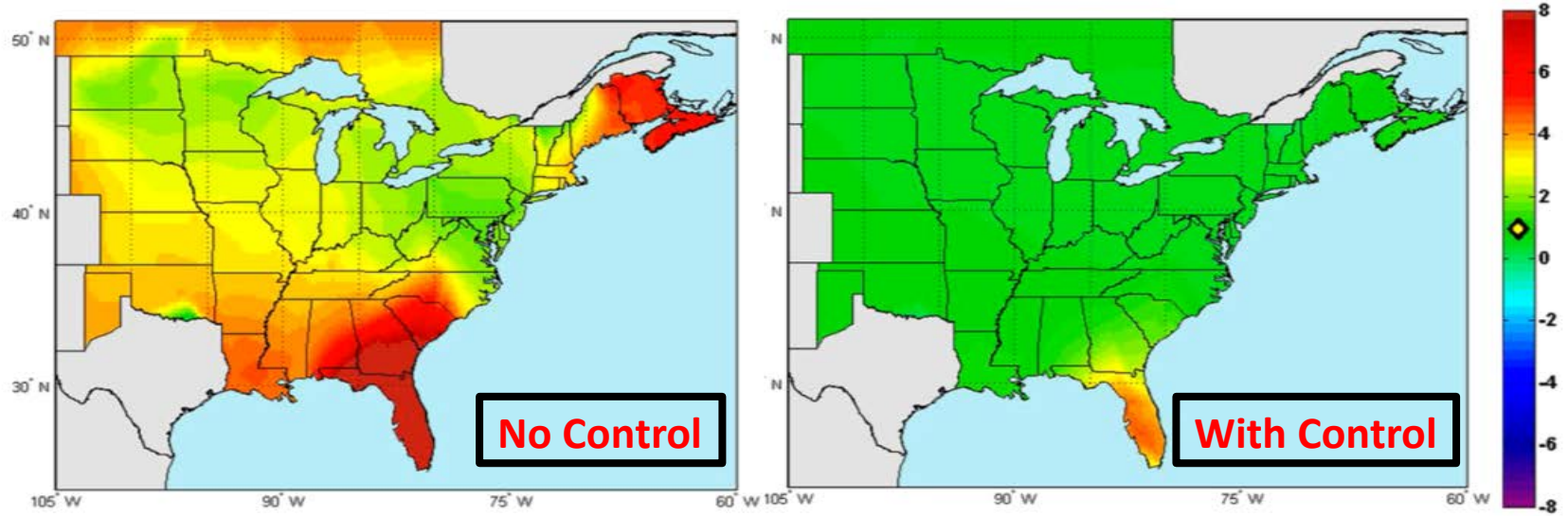


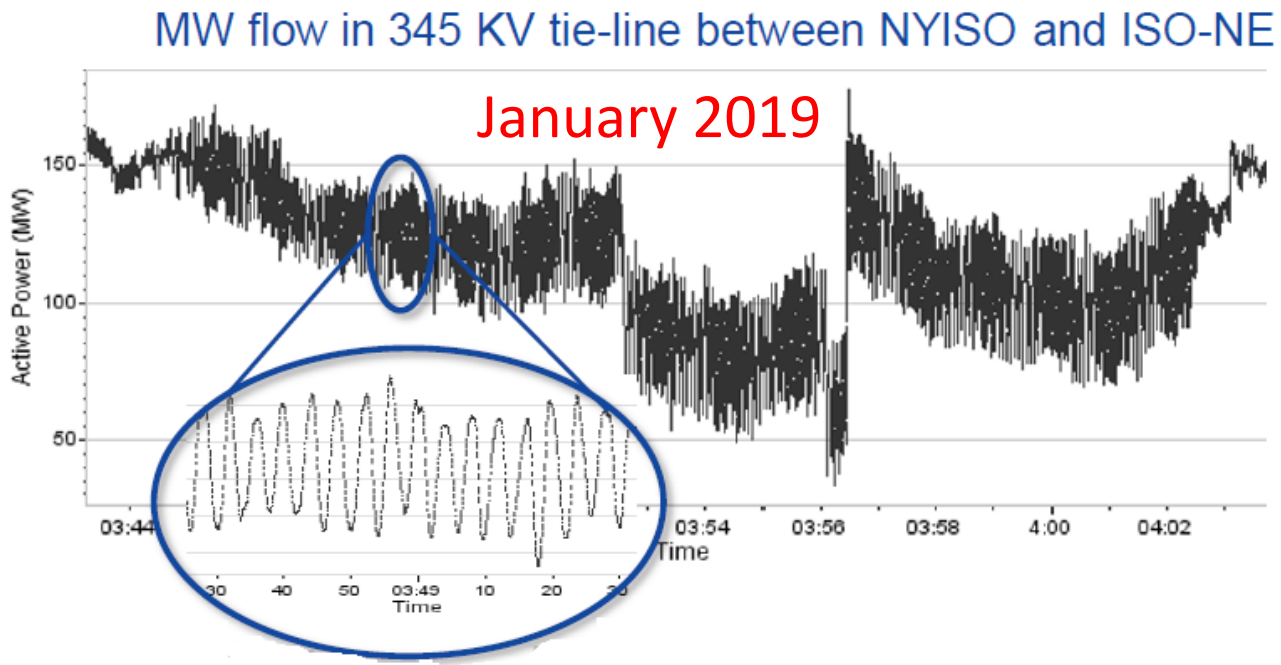
- WADC via generator excitation system or FACTS/HVDC controller
- Adaptive controller
- Hardware-In-the-Loop (RTDS/Opal-RT) implementation
- Ongoing case studies with NYPA, TERNA (Italy) & SEC (Saudi Arabia)
  - Jan. 2020 Demo at NYPA AGILe



2. Wide Area Forced Oscillations Control & Mitigation

- Use of Battery Energy Storage Systems (BESS) and Inverter Based Resources (IBRs) to suppress magnitude of forced oscillations



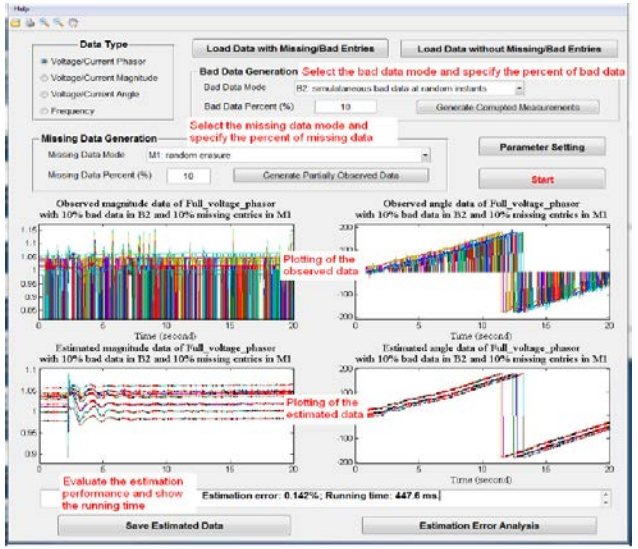


In collaboration with University Tennessee Knoxville (UTK)

3. Data Quality Conditioning of Streaming Synchrophasor Data

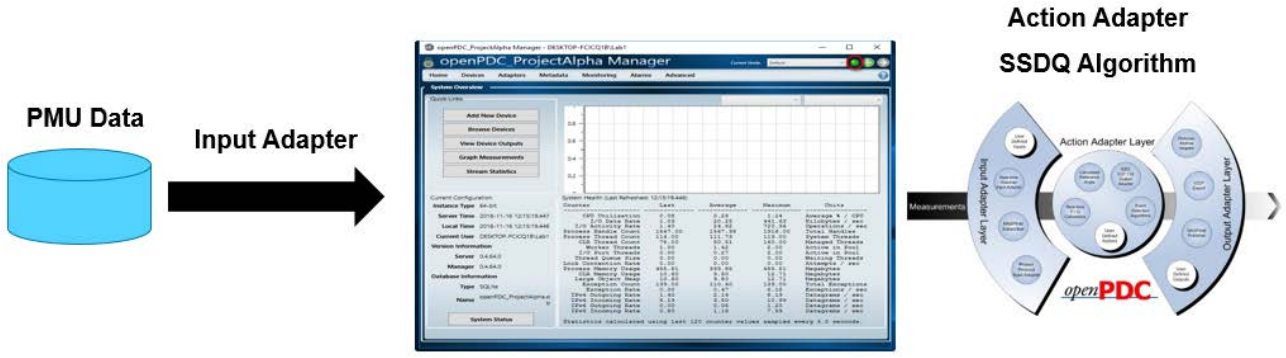
- Goal: Improve synchrophasor data quality by estimating missing data and replacing bad data in synchrophasor streams
- Model free technique, no need for topology information or system parameters
- Computationally efficient for real-time implementation
- Algorithms have been tested with recorded synchrophasor data provided by EPRI members
- Demos with streaming synchrophasor data hosted by utilities/ISOs
- Collaboration with vendors for implementation in commercial platforms

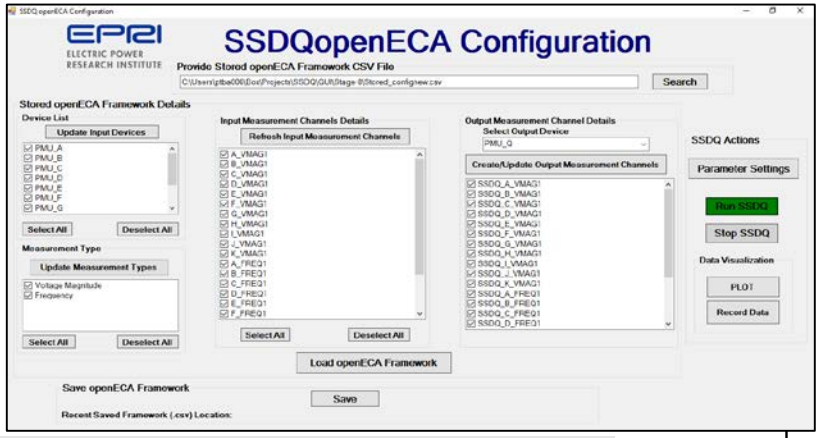
Offline SSDQ Tool



In collaboration with RPI

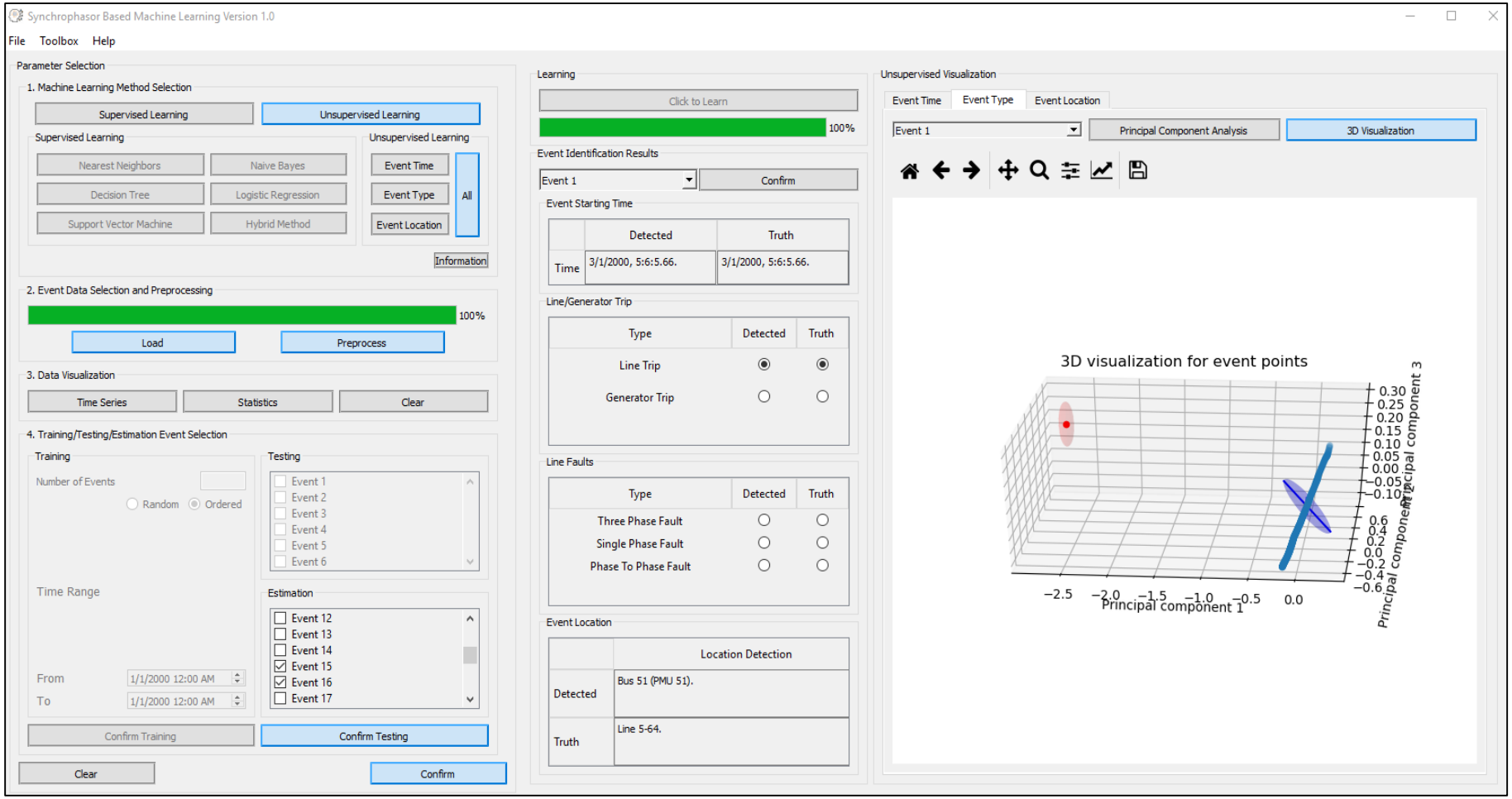
Online SSDQ Tool (OpenPDC & OpenECA)





4. Machine Learning Using Synchrophasor Data

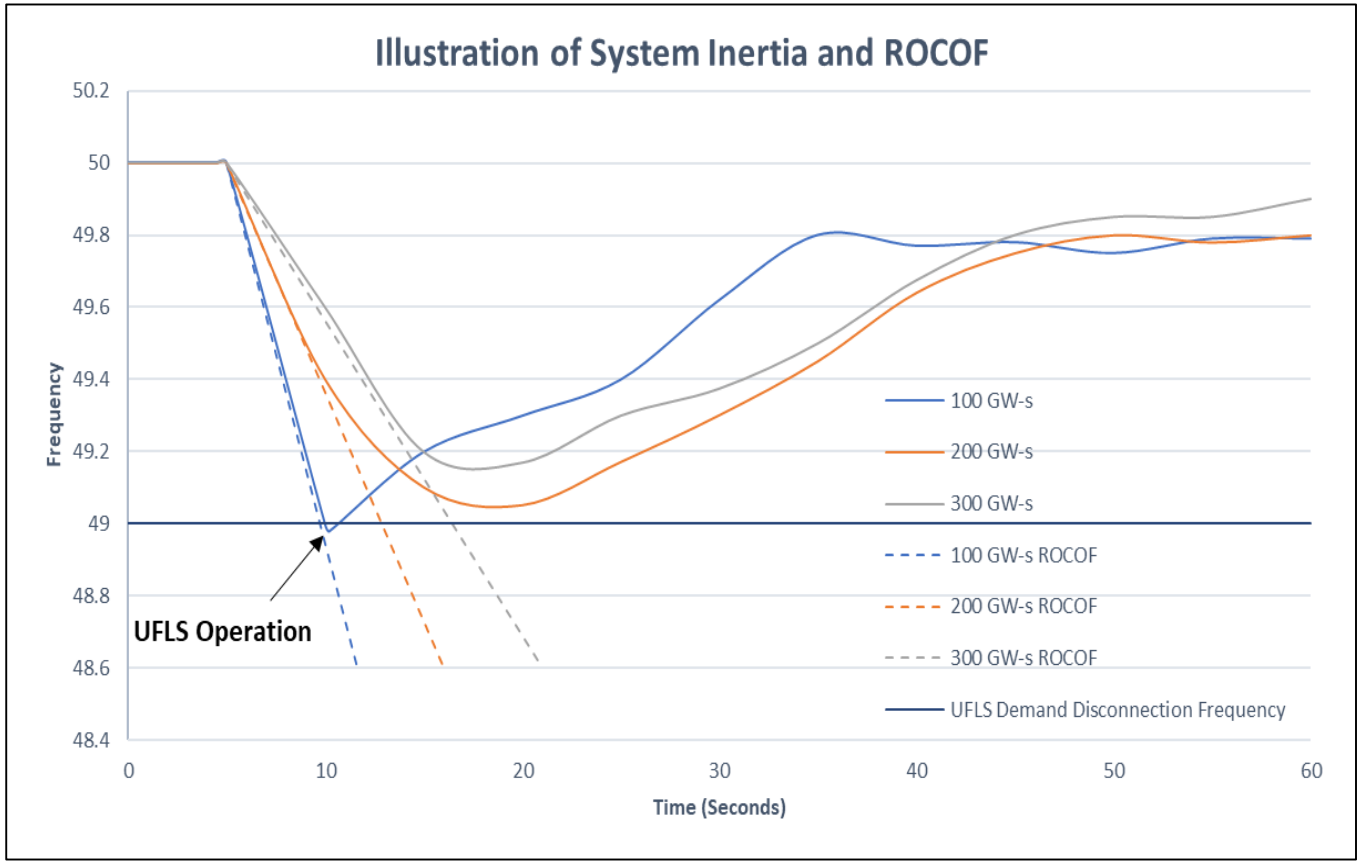
- Event Identification (time, type & location) through supervised & unsupervised machine learning
- Synchrophasor Based Machine Learning (SBML) software



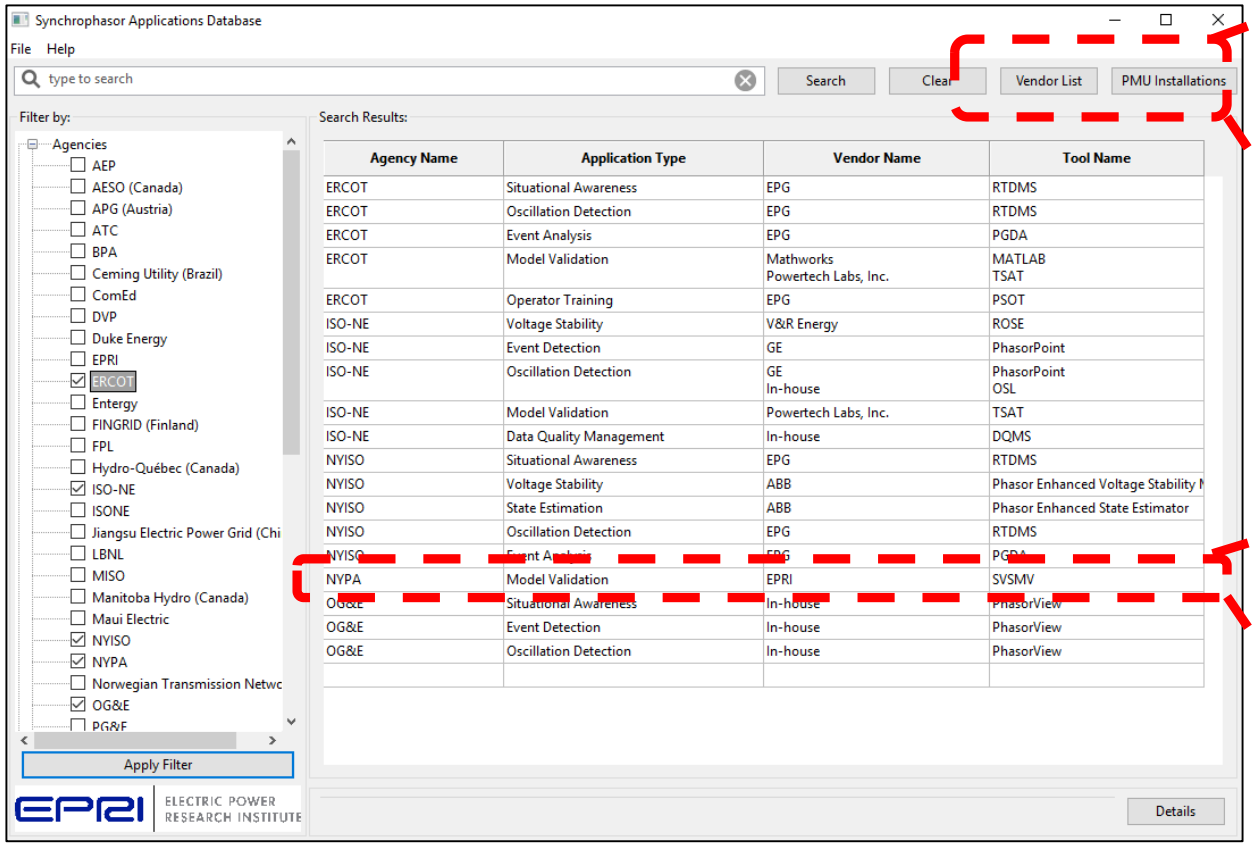
In collaboration with ASU

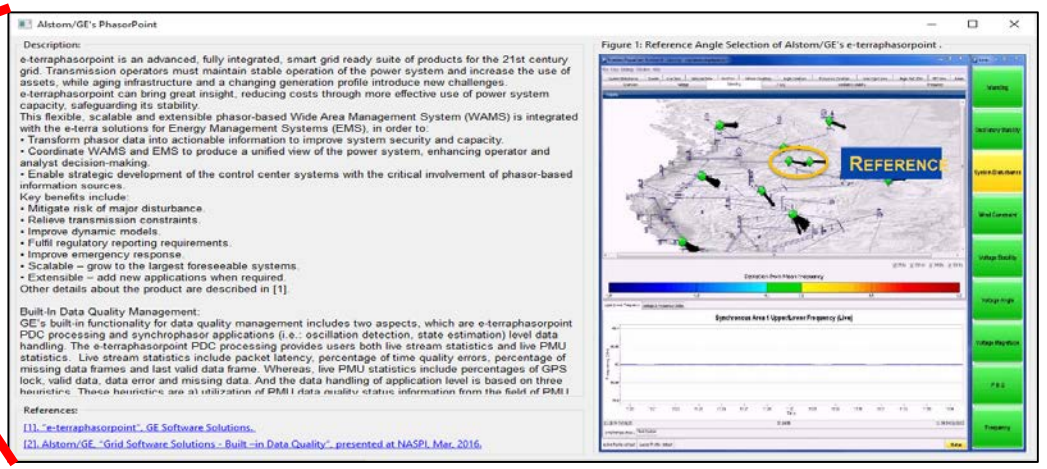
5. PMU Based Inertia Monitoring

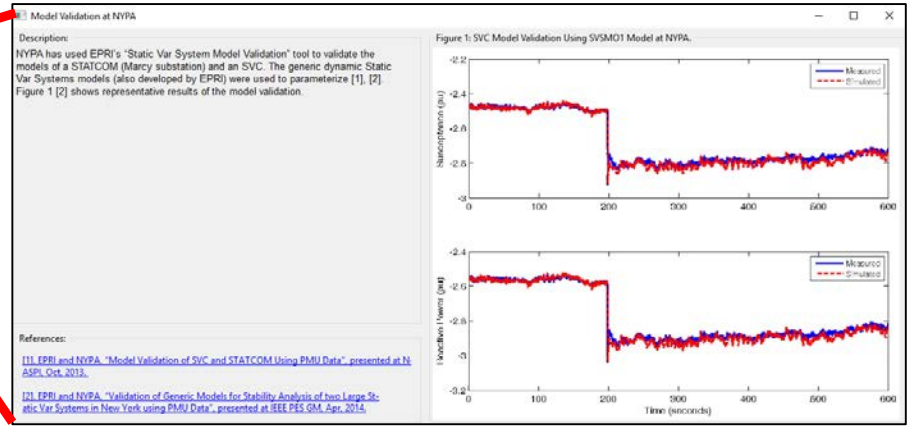
- With increasing levels of IBRs, system inertia is decreasing
- RoCoF increase, less time for PFR to respond
- Growing interest and need for online inertia monitoring using PMUs
  - Monitor against inertia floors
  - Estimate regional inertia
- EPRI white paper “Online Inertia Estimation & Monitoring - Industry Practices & Research Activities”
  1. Present Industry Practices
  2. Research Activities and Proposed Technologies



6. Synchrophasor Applications Database







- Entries based on publicly available documents
- For each entry, summary description of application and related references

Value: Inform utility/ISO engineers and executive management about uses cases and derived value of synchrophasor technology

Together…Shaping the Future of Electricity

EIDSN's Purposes

- Facilitate an efficient, effective and secure network for the sharing of operating reliability data within the Eastern and Quebec Interconnections among its members and participants.

- Promote the reliable and efficient operation of the Bulk Electric System (BES) through use of Electric Information Network (EInet).

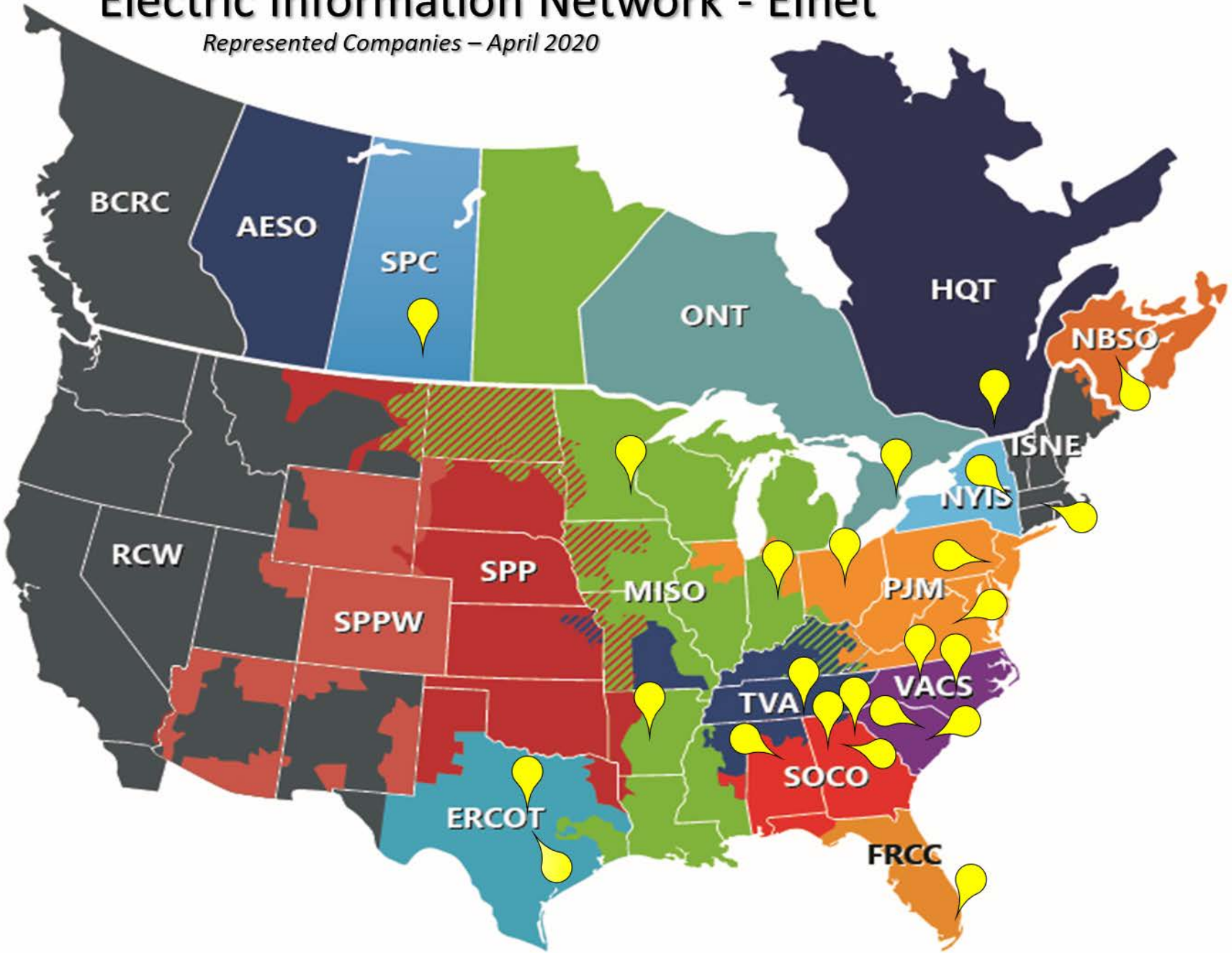
- Currently includes sharing both SCADA and synchrophasor data among appropriate entities.

- Facilitate the adoption, development and support for various software tools for members and participants that promotes the reliable and efficient operation of the Bulk Electric System.

EIDSN, Inc.

Electric Information Network - EInet

Represented Companies – April 2020



Joining EIDSN, Inc.

- Nonstock, nonprofit corporation - 501(c)(6)

- In early 2018, EIDSN's Board of Directors approved the removal of the geographic restriction for joining the Company
  - Any NERC designated Reliability Coordinator (RC), Transmission Operator (TOP), Transmission Owner (TO), and Balancing Authority (BA) in North America can join as Member or Participant

- Agreements requiring execution
  - Master Confidentiality Agreement
  - Network Service Agreement
  - Member OR Participant Agreement

Staff remarks
(Office of Electric Reliability)

North American SynchroPhasor Initiative (NASPI)
Panel Discussion – Program Updates
April 16, 2020

Note

The views and comments expressed in this presentation are those of the staff speaker and do not represent the views or position of the Commission or any of the Commissioners.

- **SynchroPhasors and related developments**
  - Operations, planning and engineering applications
- **Insight into the grid impact of resource mix change**
  - DOE-PNNL Project - **Wide Area Oscillation Assessment and Trending Analysis**
    - Trends in system performance and properties using captured PMU data
    - Model based analysis for future resource mix scenarios
- **Going forward**
  - Initiatives to facilitate further deployments
  - “Synchronized sample value” or “point-on-wave” discussions
  - Further insight into grid transition
  - Cyber security considerations

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

NERC Update

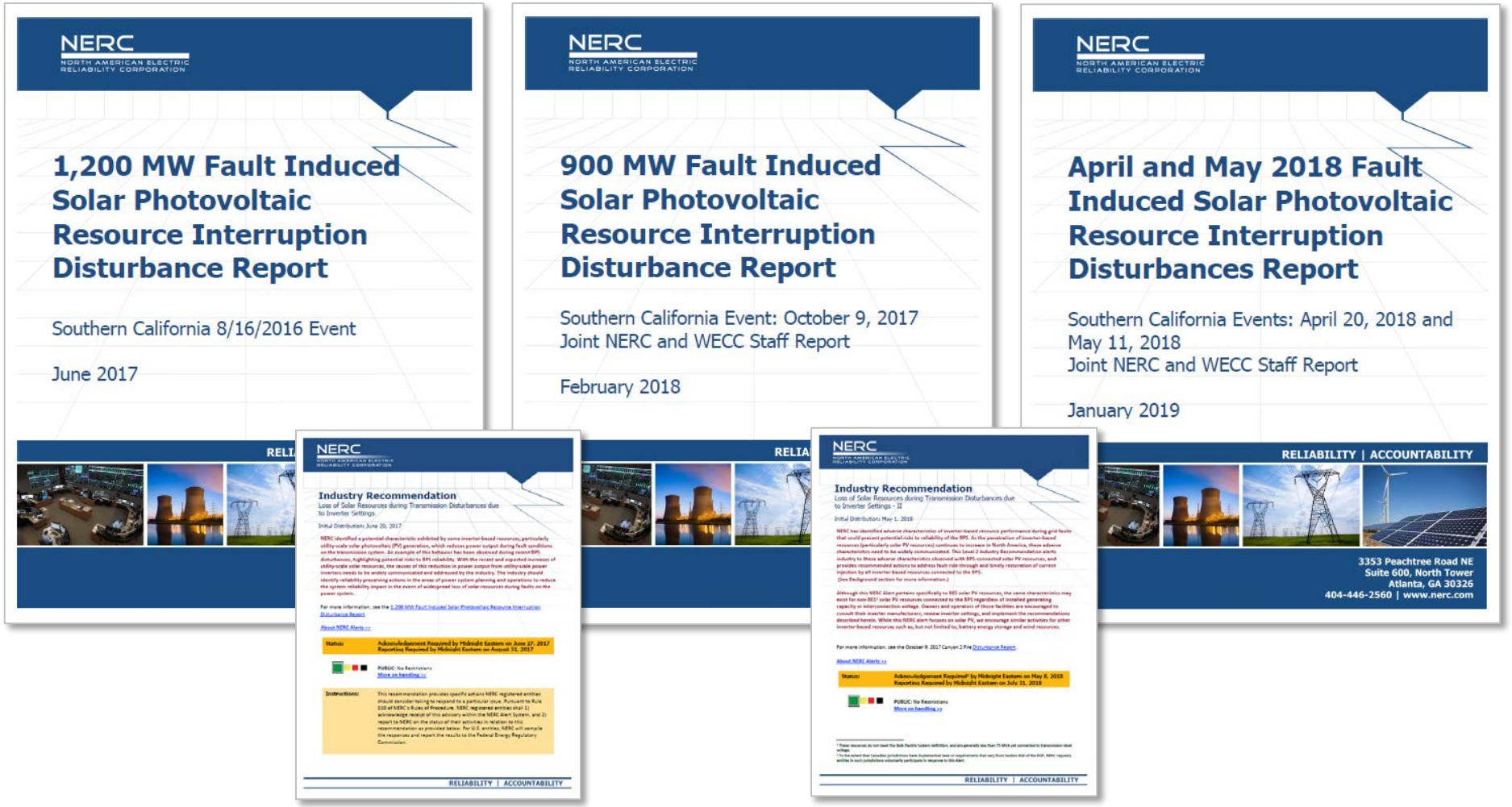
NASPI Webinar

Ryan Quint, PhD, PE
Advanced System Analytics and Modeling, NERC
April 16, 2020

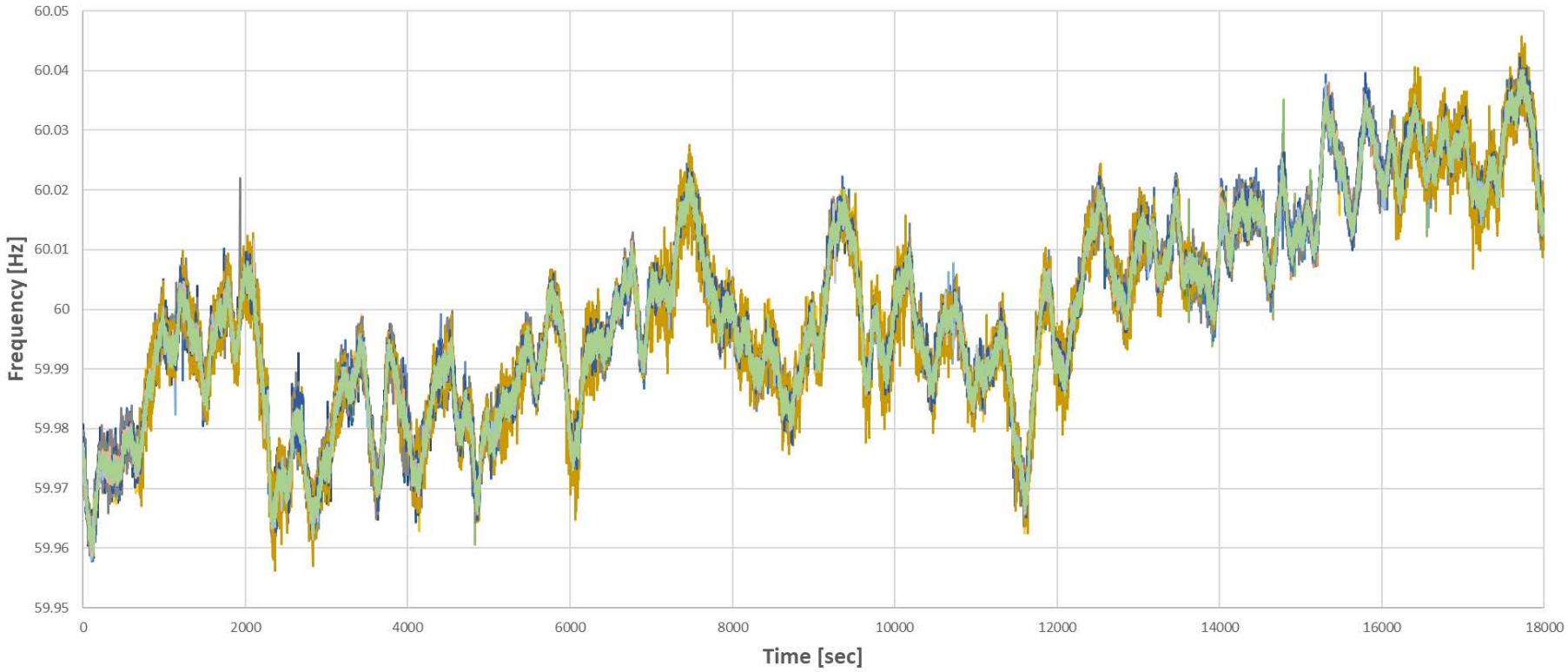
RELIABILITY | RESILIENCE | SECURITY




NERC Disturbance Reports of Solar PV Events



Event Analysis - Limitations

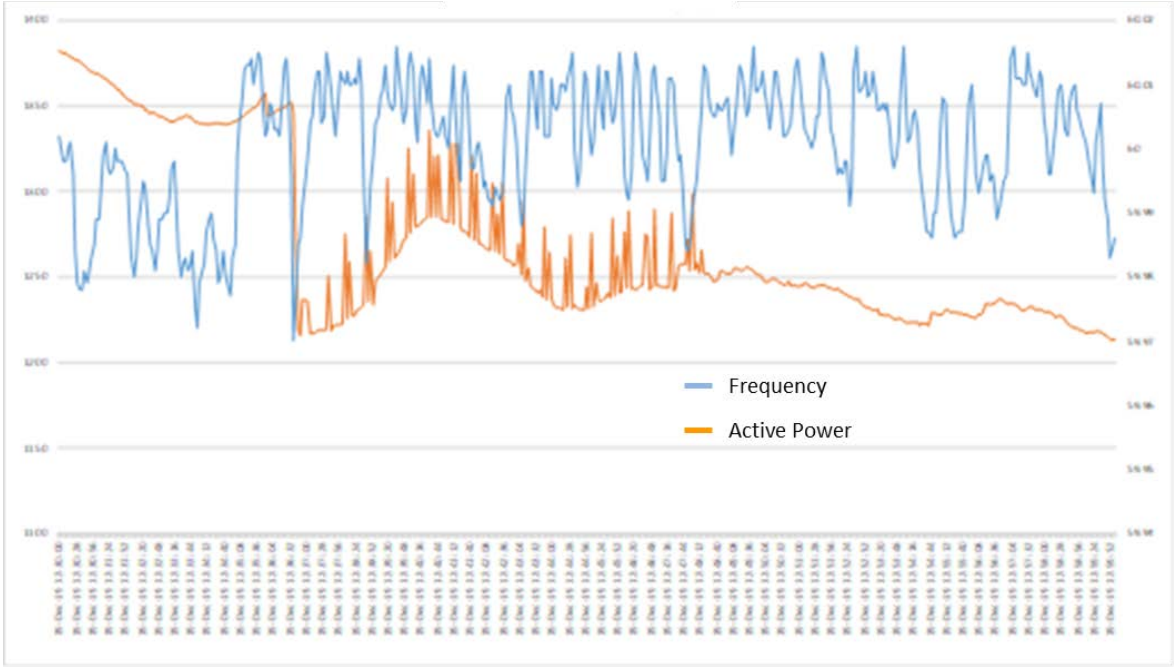


Question: Where is the generation loss event? It's in there…

DFR Data to the Rescue

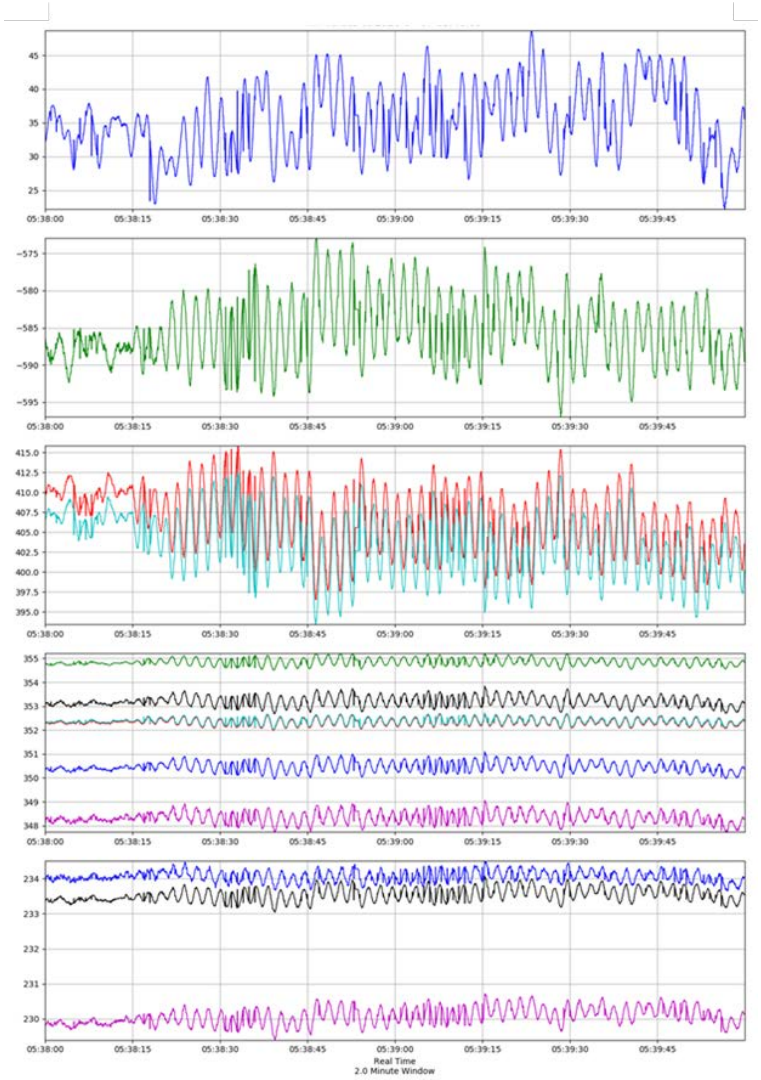
- High resolution data needed to determine root causes
  - 1 sample per cycle is insufficient in today's world…
- This data is typically VERY rare – it shouldn't need to be…

Solar PV Plant Oscillations during Commissioning



- Oscillations occurring during solar PV plant commissioning
- Issue detected within plant – due to momentary cessation and plant controls – and plant testing aborted
- Oscillation frequency near natural system mode

Oscillation Analysis



- Jan 11 2019 Florida Oscillation Event
  - Disturbance Report published
  - Lessons learned disseminated via webinar
  - Focus on interactions between system modes and forced oscillations
- Continue to observe forced oscillations across interconnections
  - Example here shows relatively small oscillation across ISO in Eastern Interconnection; source not determined

Request for Future Industry Efforts

- The industry needs better capabilities on the following:
  - Improved operational procedures and communication for widespread oscillations
  - Faster source location detection – commercialization and testing of oscillation tools
  - High speed data recordings (much faster than PMUs) at “new” locations
    - Transmission-distribution interface for high DER conditions
    - Point of interconnection (or measurement) of inverter-based resources
  - More sensitive triggering or recording of grid events to capture the behavior of inverter-based resources

Questions and Answers

Ryan Quint, PhD, PE
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Advanced System Analytics and Modeling
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NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Synchronized Measurement Subcommittee (SMS) Meeting Update

Aftab Alam, Tim Fritch

April 16, 2020

RELIABILITY | RESILIENCE | SECURITY




Summary

- Meeting held over webex on 14 April 2020
- White Paper on Recommended Monitoring for Inverter Based Resources
  - Approved
- Update on Organization changes from NERC
- Updates from various entities and working groups
- Discussion on new SMS task item: Oscillation Analysis for Monitoring and Mitigation
- Initial briefing on Eastern Interconnection Oscillation event

Questions and Answers

NASPI Control Room Solutions Task Team Update

April 16, 2020

CRSTT Mission, Goals, and Objectives

- CRSTT's mission, goals, and objectives can be found on the NASPI CRSTT webpage: https://www.naspi.org/crstt

- Ongoing work items on the CRSTT web page:
  - CRSTT Work Plan
  - Use case documents, mis-operations with PMU Data Summary Table
  - PMU versus SCADA video events summary video

Time-Synched Measures Training Update

2019: TRS and PNNL collaborated to develop a *Use of Time-Synchronized Measurements in the Real-time Ops Horizon* training course (8 CEH).

2020: TRS and PNNL to build on existing training by developing a *Time-Synchronized Measurements Simulation Training* course (8 CEH).

Related Objective: Work with industry to develop improved operational use cases that clearly demonstrate how synchrophasor technology can be used to perform reliability-related tasks.

Ops Use Cases – General Strategy & Approach

- Engage Industry – Collaborate with grid operators and electric utilities, vendors and others to develop cases.
- Focus on Reliability-Related Tasks – Build cases that highlight use of synchrophasor technology to perform reliability-related tasks.
- Apply Consistent Structure – Create a common framework for presenting cases.
- Present All Pertinent Info – Expand beyond sub-set of PMU data trends presented in most current cases.
- Introduce Enhanced Visualizations – Make it easier access info and understand how it can be used to inform operational decisions.

CRSTT – Primary Contacts

Name: Michael Cassiadoro

Email: mcassiadoro@totalreliabilitysolutions.com, Phone: 360-836-9008

Name: Jim Kleitsch

Email: jkleitsch@atcllc.com, Phone: 608-877-8102

Name: Sarma Nuthalapati (NDR)

Email: ndrsarma@ieee.org; Phone: 512 801 3191

Next NASPI CRSTT Conference Call:
Tuesday April 28, 2020

Data & Network Management Task Team Update

Co-Chairs:

Dan Brancaccio, Quanta Technology

Matthew Rhodes, Salt River Project

April 16, 2020

D&NMTT Mission Statement Update

- **Mission Statement**

The mission of the Data & Network Management Task Team (DNMTT) is to provide guidance for synchrophasor data networking, archiving and access issues and to review new archiving and networking technologies for the best fit to synchrophasor application realization.

D&NMTT Work Plan

- **Planned Activities**
  - NASPI Report on utility and industry archive strategies – Data Archive Strategy report (tentative title)
  - Synchrophasor Application-Based Guide for Archive and Network Strategies (SABGANS)
  - Develop recommendations for a PMU Registry

D&NMTT Work Plan

- **NASPI Report on utility and industry archive strategies**
  - Collect utility perspective on existing and desired archive strategies – Survey complete and results summarized. **Thanks to John Volpert for his assistance in summarizing the survey results.**
  - Release Call for Papers to the industry to collect in-service or proposed advanced archiving strategies – Due December 2021.
  - Proposed advanced presentations at Fall 2020 NASPI meeting to encourage early paper submissions.

D&NMTT Work Plan

- **Synchrophasor Application-Based Guide for Archive and Network Strategies (SABGANS)**
- Review new and existing industry archiving and network concepts for best fit for application development.
  - Discussing basic structure for such an application guide.
  - *Example: ML for Asset Failure tracking - best fit to cloud-based offline analytics structure; Real-time operator visualization - best fit to local PDC based architecture.*

Thank you for participating!

Distribution Task Team (DisTT)

Mission Statement

The mission of the NASPI Distribution Task Team is to foster the use and capabilities of networked PMUs at the medium-voltage distribution level, beyond the substation.

This group shares information in support of effective research, development and deployment of distribution PMUs.

We aim to create a community to solve technical and other challenges specific to distribution PMU technology and applications.

NASPI

DisTT Report in Preparation

Members of the Task Team are in the process of drafting an update report on emerging use cases for synchronized measurement data in the distribution context.

The purpose is to help inform requirements for sensors and infrastructure going forward.

Examples include:

- Fault detection and localization
- Asset Health
- Topology Identification
- Distributed Energy Resource (DER) Integration
- Microgrid Control
- Distribution State Estimation

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NASPI North American SynchroPhasor Initiative

Distribution Task Team (DisTT)

Co-Leads: Sascha von Meier
Adjunct Professor, Electrical Engineering and Computer Science
UC Berkeley vonmeier@berkeley.edu

Dan Dietmeyer
Senior Engineer, System Protection and Control Engineering, SDG&E
ddietmeyer@sdge.com

Engineering Analysis Task Team

Evangelos Farantatos (EPRI) – Co-Lead

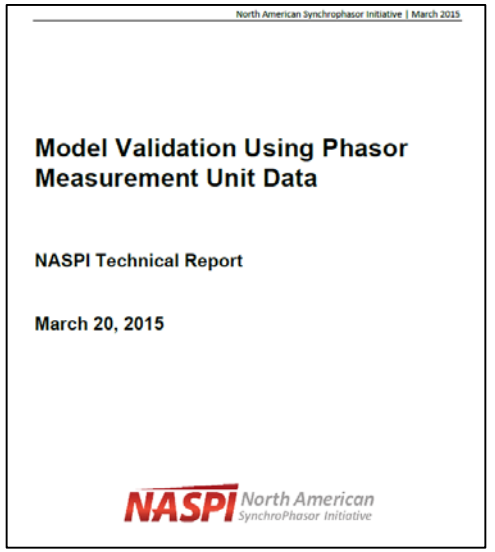
Shaun Murphy (PJM) – Co-Lead

NASPI Web-Meeting

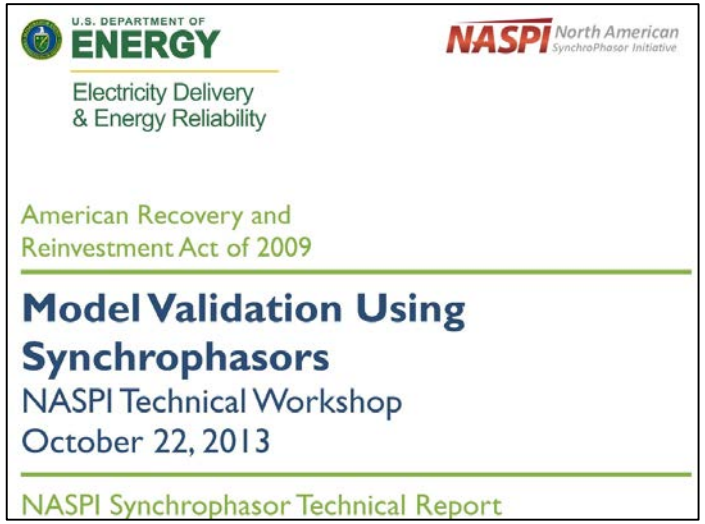
April 16 2020

Advanced Model Validation & Calibration

- New EATT White Paper
- Lead: Honggang Wang (GE)



Objective: Document industry advancements in model validation and calibration



Proposed Outline

1 Introduction
- 1.1 Motivation for Model Validation & Calibration
- 1.2 Datasets and Data Requirements for Model Validation & Calibration
- 1.3 State-of-the-Art Methods and Tools for Model Validation & Calibration
- 1.4 Limitations of Existing Methods and Desired Features of Enhanced Model Validation & Calibration

2 Enhanced Model Validation
- 2.1 Proposed Method (GE)
- 2.2 Other Proposed Method
- 2.3 Performance Metrics

3 Enhanced Model Calibration
- 3.1 Enhanced Parameter Selection
  - 3.1.1 Trajectory Sensitivity Approach
  - 3.1.2 PCA and Similarity Based Methods (GE)
  - 3.1.3 Other
- 3.2 Enhanced Model Parameter Tuning/Estimation
  - 3.2.1 Estimation Based Approach
    - 3.2.1.1 Kalman Filter (PNNL)
    - 3.2.1.2 Other
  - 3.2.2 Optimization Based Approach
    - 3.2.2.1 Efficient Trust Region Approach (GE)
    - 3.2.2.2 Other
- 3.3 Performance Metrics

4 Multiple Event Based Model Validation & Calibration
- 4.1 Event Selection
- 4.2 Aggregation of Performance Metrics Across Multiple Events
- 4.3 Multiple Event Model Calibration

NASPI North American SynchroPhasor Initiative

Performance Requirements, Standards & Verification Task Team

- Task Team Co-Leaders:
  - Farnoosh Rahmatian, NuGrid Power
  - Jim O'Brien, Duke Energy
- Task Team Support:
  - Teresa Carlon, PNNL

PRSVTT – 04/16/2020

IEEE Updates

- C37.242 Guide for Synchronization, Calibration, Testing, and Installation of Phasor Measurement Units (PMUs) for Power System Protection and Control – Allen Goldstein
- C37.118.2 Standard for Synchrophasor Data Transfer for Power Systems – Vasudev Gharpure
- P2664 Standard for Streaming Telemetry Transport Protocol – Ken Martin

PRSVTT – 04/16/2020

IEEE Updates

- PSRC Task Force C41 Investigate Performance Requirements for Distribution PMUs – Ken Martin

PRSVTT– 10/29/2019

Ongoing Work

1. Analyzing PMU performance requirements for Synchrophasor based Control Applications – Pratim Kundu
2. Survey of instrument transformers connected to installed PMUs – Farnoosh Rahmatian

NASPI North American SynchroPhasor Initiative

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NASPI Webinar series

Phasors, the Next Generation

Terry Boston, PJM (retired)

Russell Robertson, Grid Protection Alliance

May 6, 11 am PDT / 2 pm EDT

Details will be posted here:
https://www.naspi.org/webinars

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Thank you for attending the NASPI Spring 2020 Working Group Webinars

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