Power System Oscillations & ESAMS

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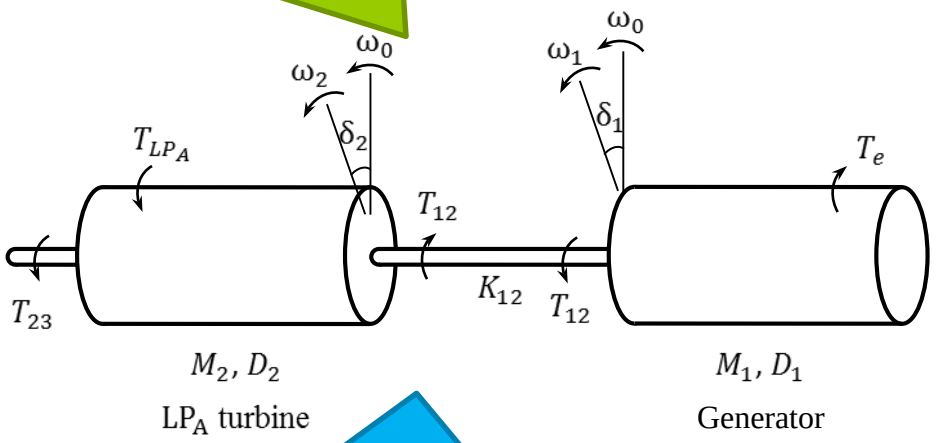
Agenda

- Introduction
- Eastern Interconnection Data Sharing Network (EIDSN)
- Oscillation Detection at PJM
- Eastern Interconnection Situational Awareness Monitoring System (ESAMS)
- Conclusion

Introduction

Electromechanical oscillations: interaction of rotating masses



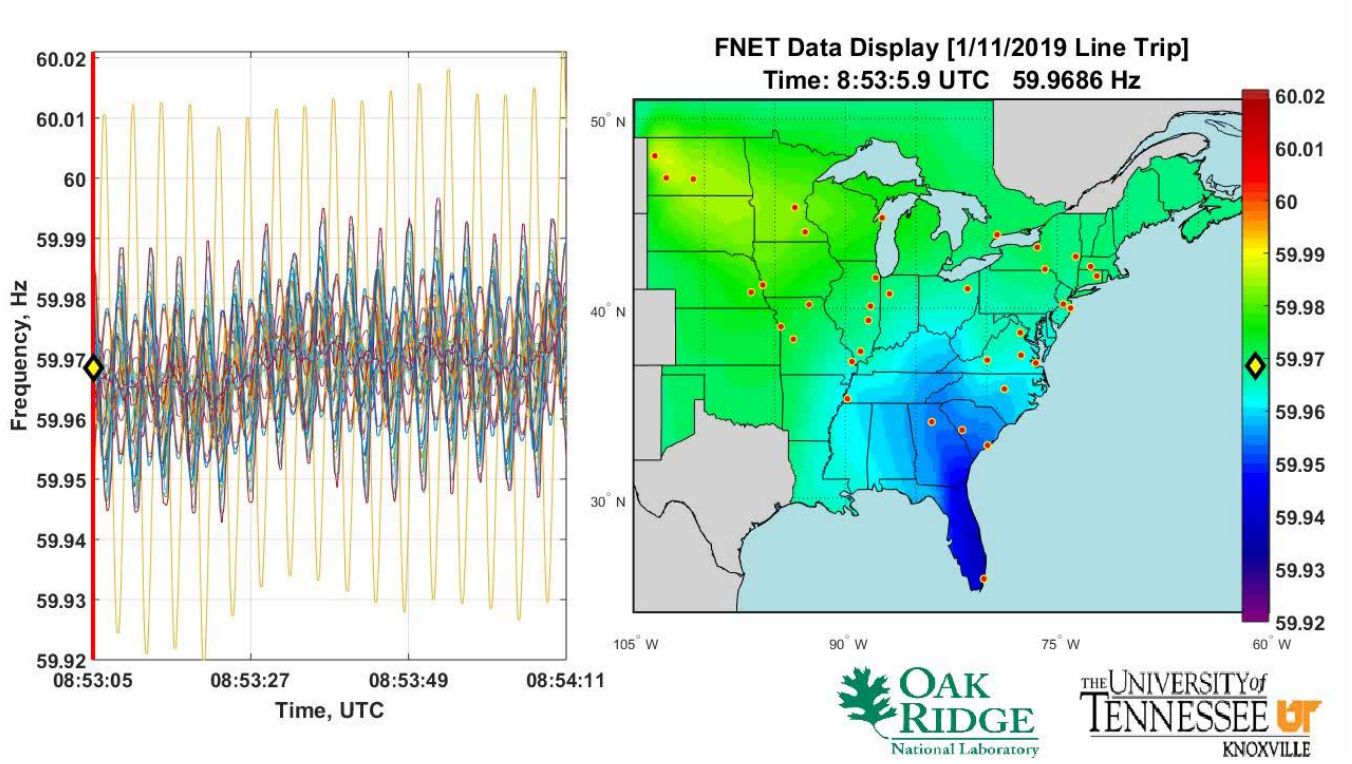
Complex function of: system strength, inertia, load, controllers, etc.

Diagnosis using PMUs

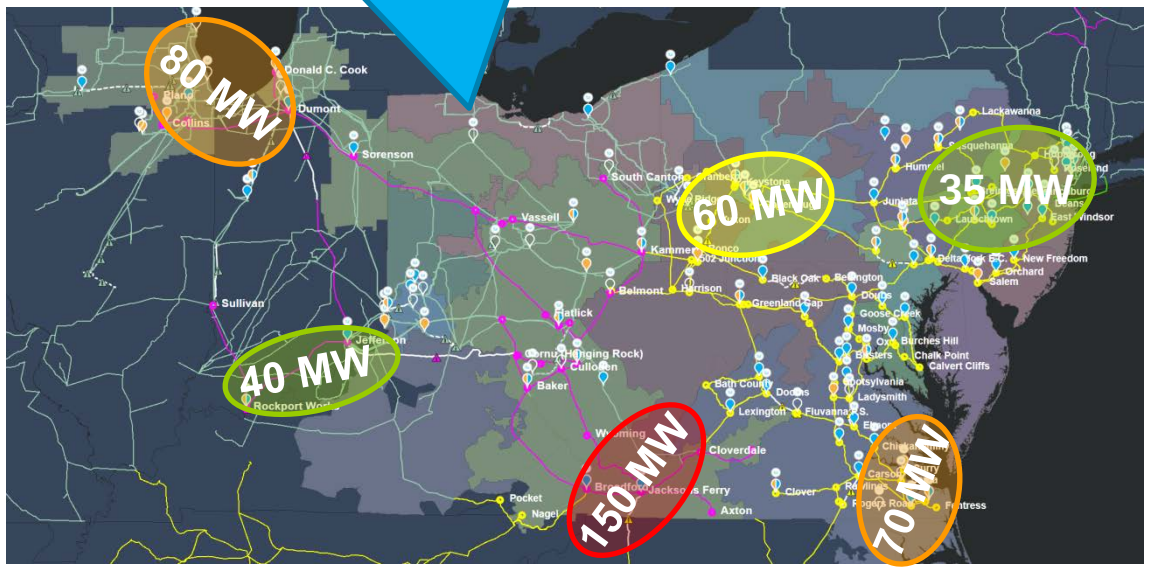
Oscillation Mode

- Amplitude
- Frequency
- Damping
- Shape

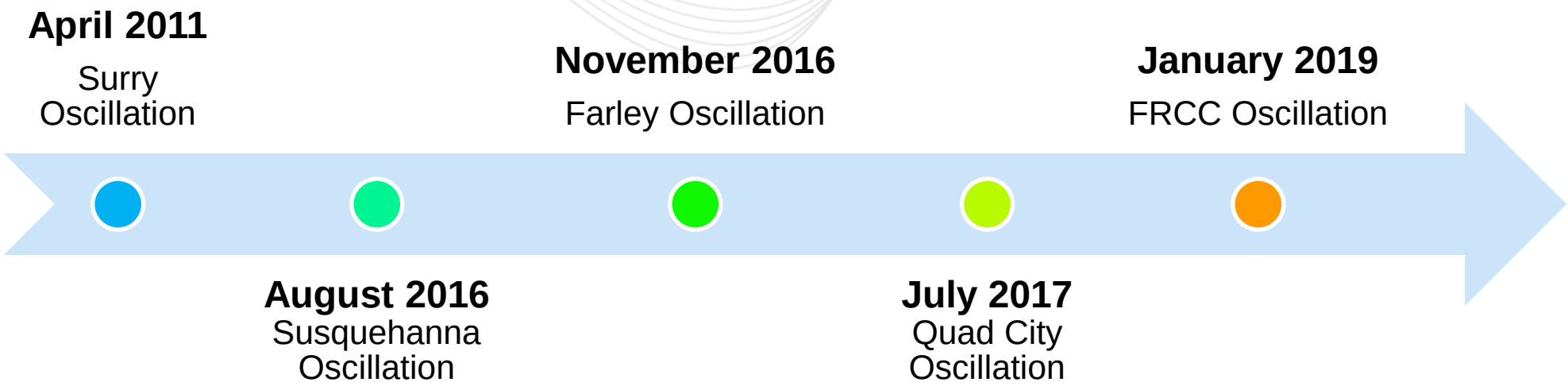
Introduction



0.25 Hz (Inter-Area)
South and North-West of PJM



Introduction



Eastern Interconnection Data Sharing Network (EIDSN)

- Data sharing network built to replace NERCnet
- Built for sharing real-time data between Balancing Authorities for situational awareness
  - SCADA
  - Synchrophasors
- Master agreement streamlines the data privacy / non-disclosure process

Oscillation Detection in Operations (Real Time Dynamics Monitoring System - RTDMS):

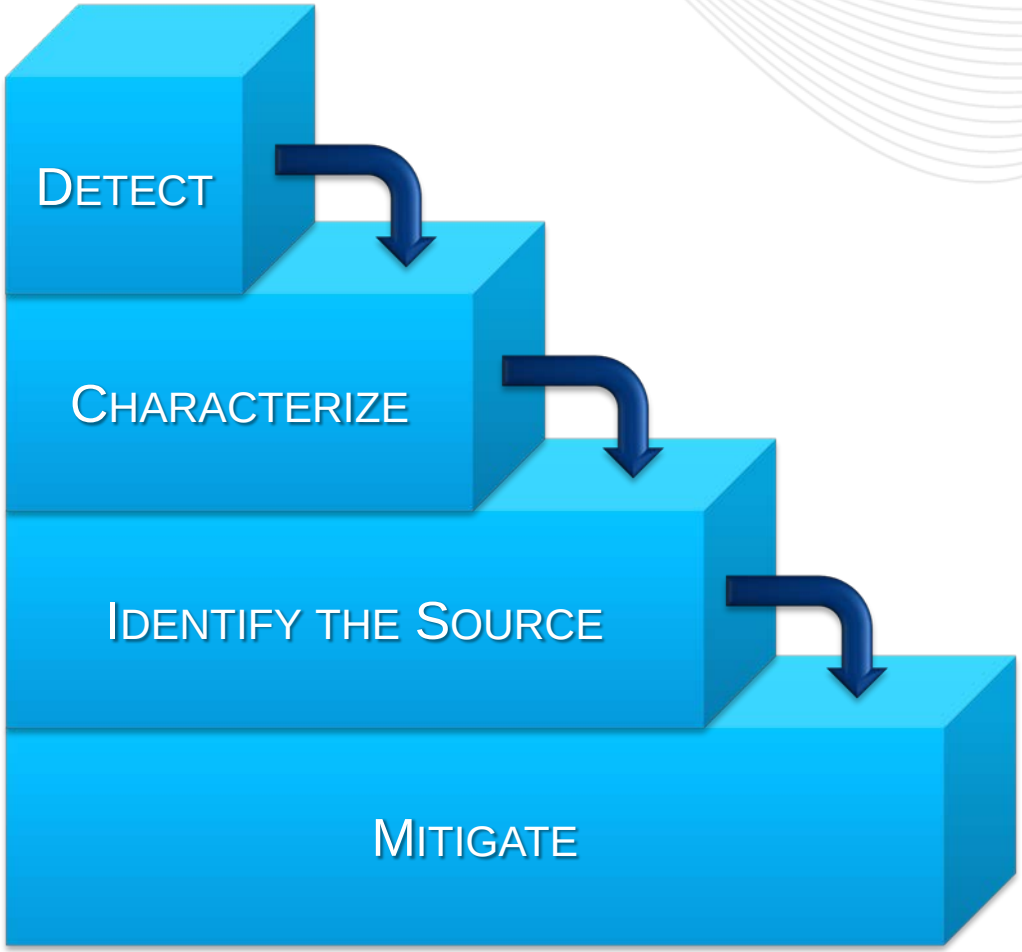
Oscillation detection -

- RTDMS has algorithms to detect major system oscillations and categorize the type (forced, local, and inter-area) based on frequency.
- RTDMS can detect oscillations in system voltage, voltage angle or voltage angle derivative, real and reactive power flow signals.
- Based upon the oscillation frequency, it will detect and categorize the oscillations in 4 bands: Speed Governor, Inter-area, Local Control System, and Torsional Dynamics.

Mode Meter monitoring -

- Monitors known oscillations (natural/system) and can also provide mode shape.

Real Time Oscillation Detection



- Operator training
- Notifications/alerts for operators
- Coordination with members and external BAs
- Data exchange between BAs (EIDSN*)
- Widespread PMU coverage for oscillation characterization and source localization
  - External tie-lines to find if the source is with-in our footprint or outside our footprint
  - Internal tie-lines to find member/TO area when the source is with-in our foot print (find smallest possible area)
  - Other geographic area (tie-lines) to find source far from our footprint as much as if possible.

Eastern Interconnection Situational Awareness Monitoring System (ESAMS)

DOE Prototype Demonstration Project ESAMS

Overall Project Objective:

To introduce a common, high-level interconnection-wide view based on Synchrophasor information in order to foster discussion within and among Eastern Interconnection operating entities

Key Elements of the initial high-level view will include:

1. Detect and identify forced and natural oscillations
2. Monitor phase angle pairs and identify when values are outside of normal operating ranges
3. Detect atypical behavior from an ensemble of measurements and identify which ones are contributing to the atypicality

Information Delivery Methods (by subscription):

Emailed reports (daily, weekly, monthly)

DOE Prototype Demonstration Project ESAMS

Continuation of CERTS baselining project with:

- LBNL and PNNL
- PJM, NYISO, ISONE and MISO
- EPG

Goal: Create a prototype oscillation detection and baselining tool for a large portion of the Eastern Interconnection

Focus on information sharing

Coming soon to a BA near you!

Challenges in Wide-Area Localization

- Direct extension of existing methods would require:
  - Streaming data for every PMU-monitored generation plant
  - Analyzing data for every PMU-monitored generation plant
  - Centralized one-line diagrams
- Severely limited in regions with low penetration of PMUs

Sample Report

Summary (Eastern Daylight Time)

Issue	Event Time	Additional Information
Natural Oscillation *EPG RTDMS® -Mode metering algorithm*		No natural oscillation event detected
Stressed Angle Pair *EPG method-Statistical analysis*	**00:00-01:38** *Time for event with the longest time under stress*	**2 stressed angle pair(s) detected** Angle pair with the longest time under stress: • Angle Pair: [redacted]
Wide Area Disturbance *EPG method-Control chart analysis*	**05:39** *Time for event with the most angle pairs participating*	**4 disturbance event(s) detected** Key info for event with the most angle pairs participating: • Number of Angle Pairs participating: 2 • Most sensitive angle pair during the event: [redacted]
Ringdown Detection *PNNL Oscillation Tool-Advanced spectral analysis*	**00:07-00:12** *Time for event with the earliest event time*	**15 ringdown event(s) detected** List of angle pair(s) for event with the earliest time: [redacted]
Anomaly Detection *PNNL tool-Multivariate analysis*	**08:36** *Time for event with the most angle pairs participating*	**5 atypicality event(s) detected** List of angle pair(s) contributed most to the event with the most angle pairs participating: [redacted]
Forced Oscillation *EPG RTDMS®-Mode metering algorithm PNNL periodogram-based sinusoid detector*	**23:42-23:53** *Time for event with highest energy*	**3 forced oscillation event(s) detected** Key info for event with highest energy: • Signal: [redacted] • Type: Real Power • Frequency: 1 Hz • Value: 7.732 MW • Source Area: Unconfigured Area
PMU Data Availability *EPG DataNXT® -Six modules approach*		

Vision for ESAMS

- Prototype will provide a cohesive view of the Eastern Interconnection
- Fast alerting with actionable information:
  - Mode parameters – including mode shape
  - EI → BA Location → BA zone(s)
  - Dissipating Energy Flow
- Oscillations affect the entire interconnection. Operators from different BAs must view and collaborate on a shared information set.
- Transition to EIDSN application portal
- Shared (rotating) monitoring responsibility - similar to time error correction monitor

Questions?