WAMS at Manitoba Hydro

NASPI

Fall 2022

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Manitoba Hydro

Agenda

- Introduction to WAMS at MH
- Uses of WAMS at MH
- WAMS Roadmap Overview
- Next Steps
- Discussion

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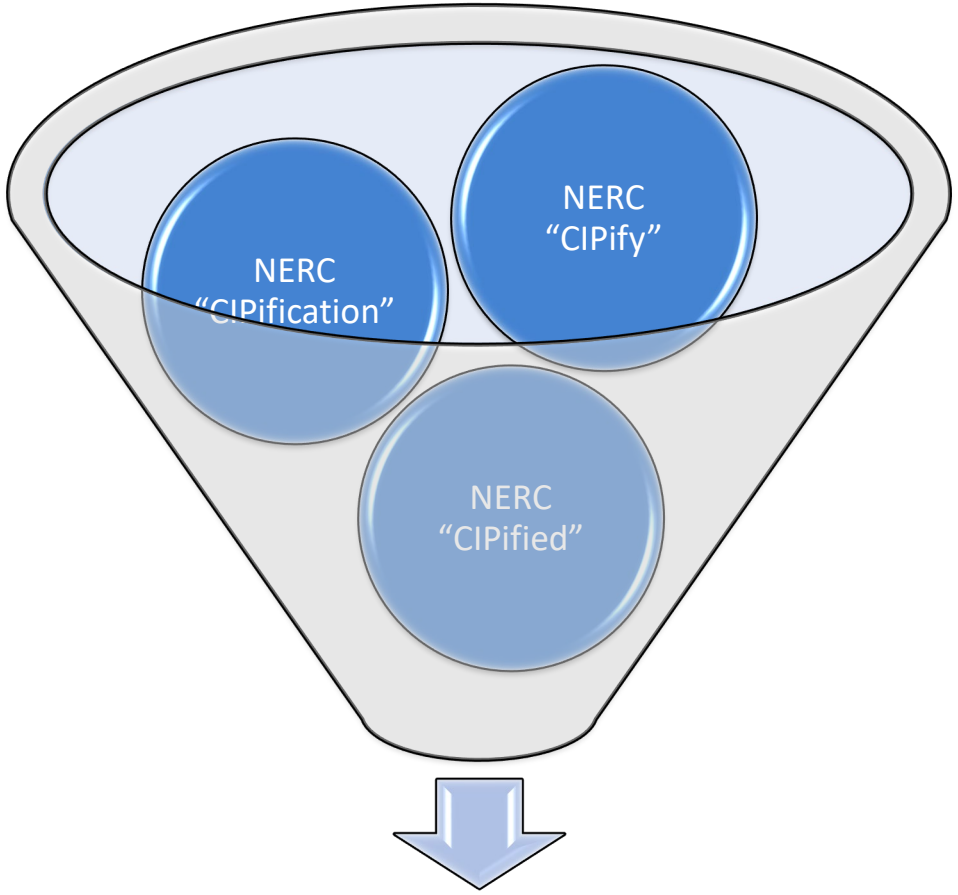
NERC CIP Sales Pitch! New Terminology …



Enables PMU data use in Real-Time Operating Decisions!

- **NERC "CIPify":** The act of meeting NERC CIP standards and requirements.
- **NERC "CIPification":** The process of applying NERC CIP standards and requirements.
- **NERC "CIPified":** Past tense of CIPify whereby NERC CIP standards and requirements have been met.

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Contributors

Thanks to those that provided input:

- Various Staff members of the following MH departments/divisions
  - System Performance
  - System Support
  - Telecommunications
  - Grid Infrastructure Planning
  - Digital and Technology
- ERL Phase Power Technologies
- GE
- NASPI

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WAMS Overview at MH

Introduction

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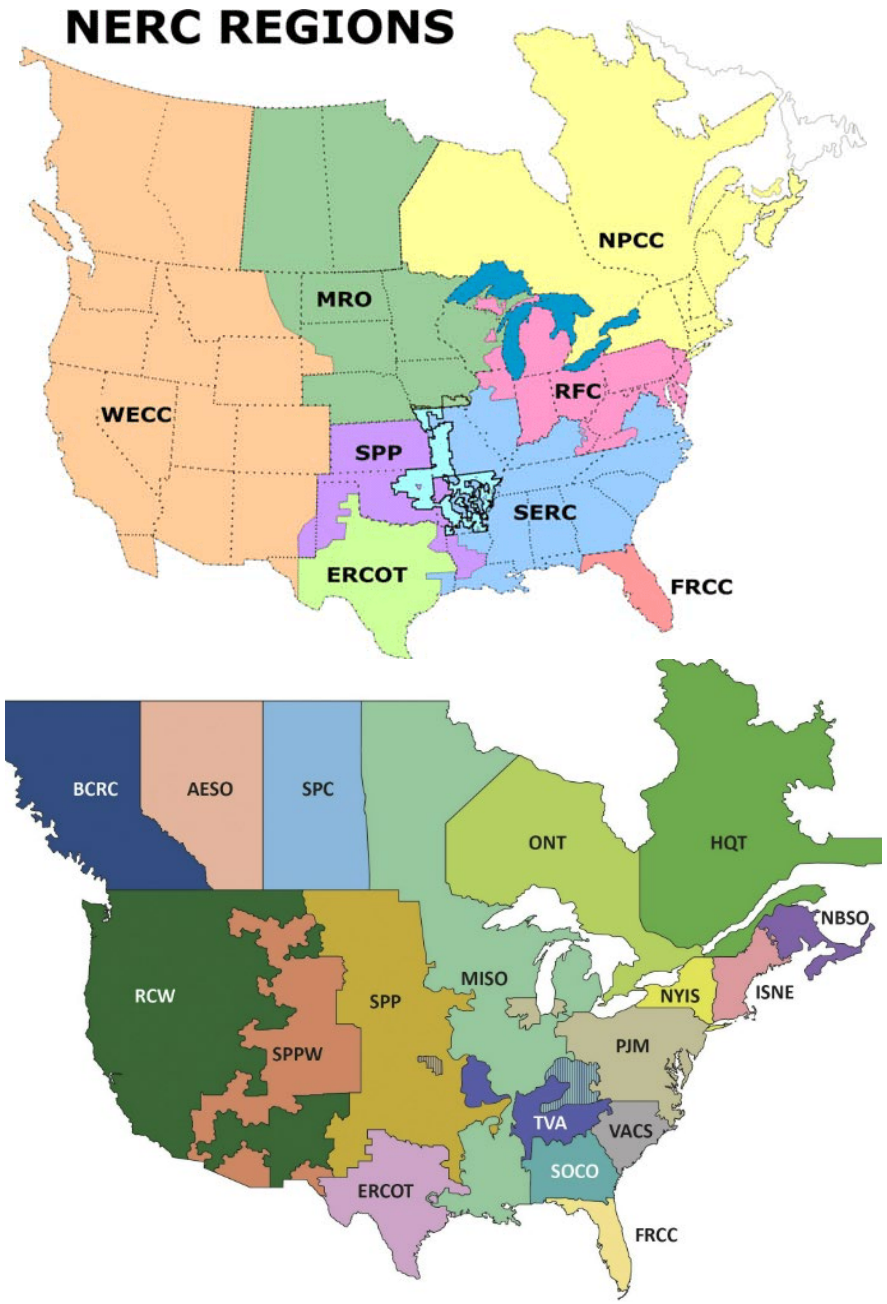
Exactly, where is Manitoba?

- Manitoba is a province in the center of Canada
  - Land size is 94% that of Texas
  - Population is approximately 1.4 Million or a little less than 5% of Texas
  - Capital city Winnipeg is the coldest city in the world (with a population greater than 600,000)
- We are part of the Midwest Reliability Organization (MRO) and a member of Midcontinent Independent System Operator (MISO)



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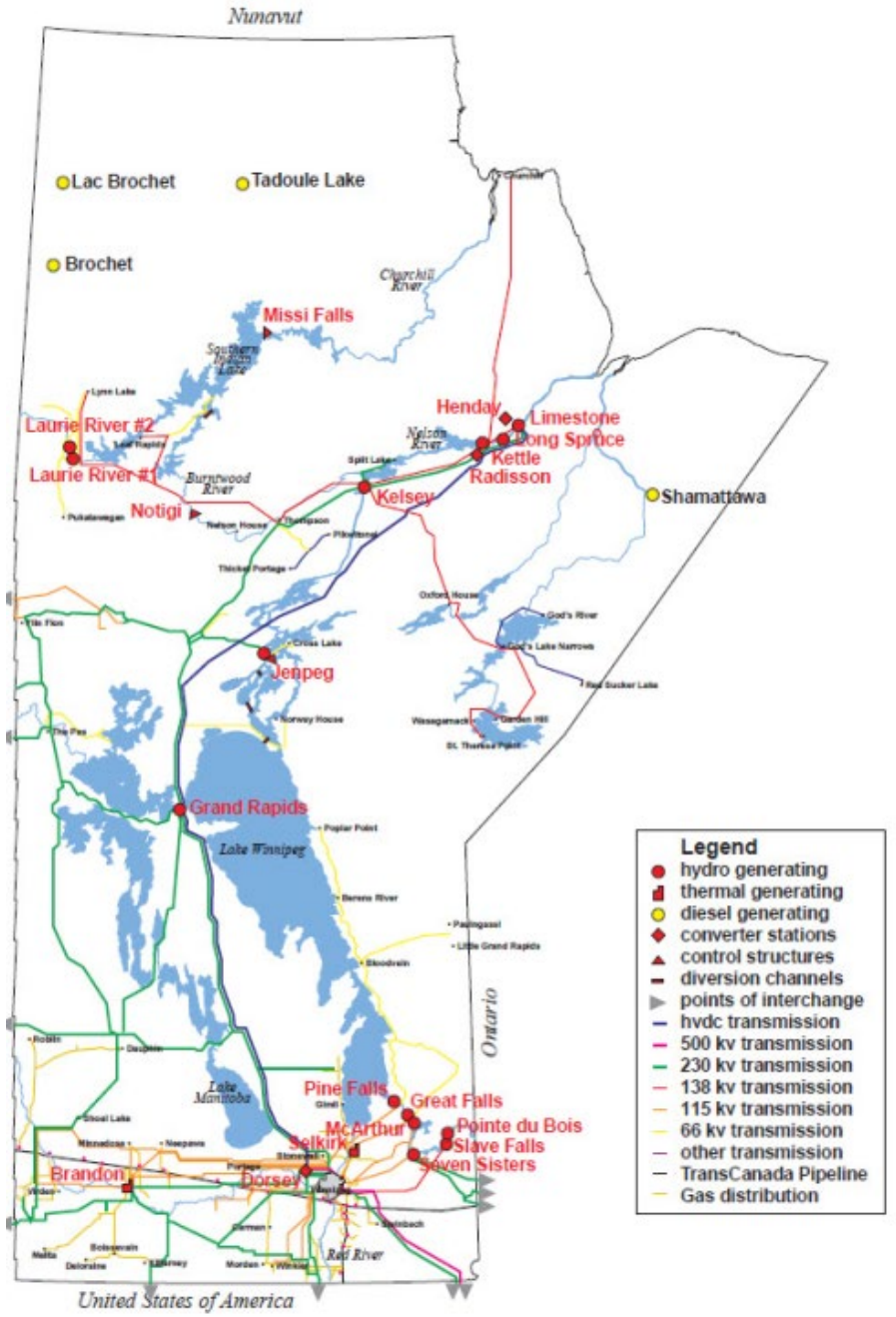
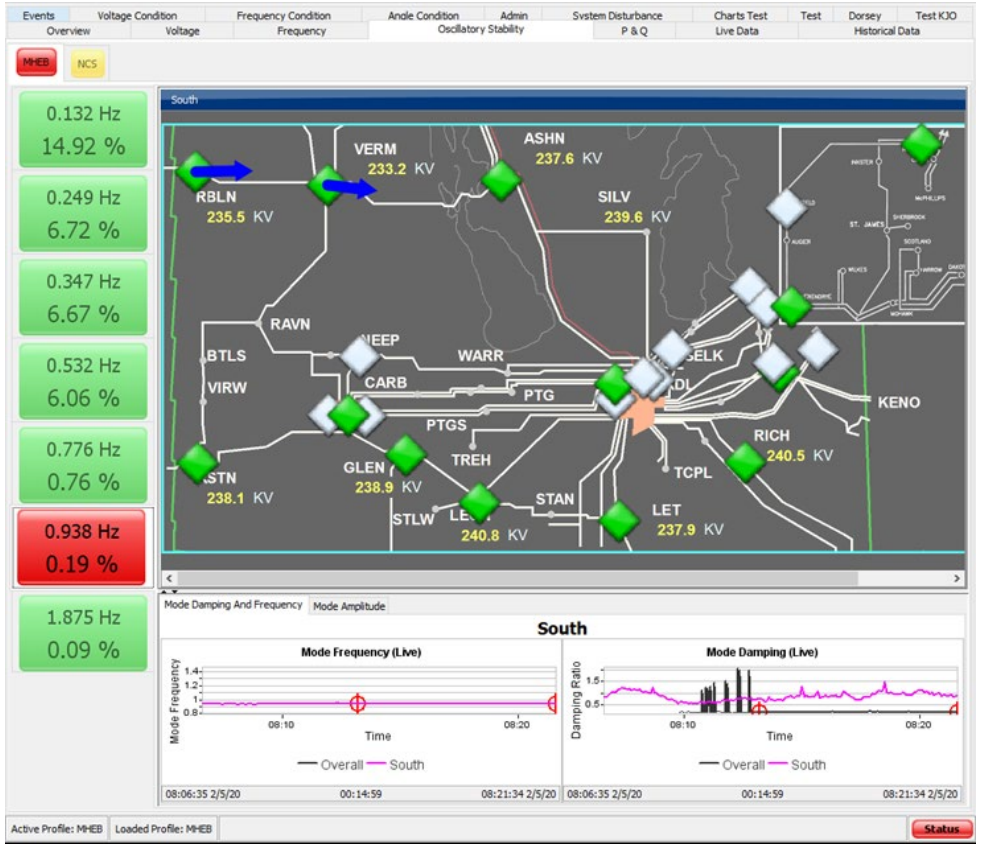
- Manitoba Hydro is vertically integrated and responsible for power generation, transmission, and distribution in the province of Manitoba
- System features:
  - ~6200 MW Gen and ~5000 MW Peak Load
  - ~95% Hydro and ~11,000 kM of Transmission Lines
  - Asynchronous Norther Collector system island connected by 3 HVDC Bipoles
  - Variety of SPS/RAS, 2 SVCs, Phase Shifters on the interface and internally, fast switching capacitors
  - Tie lines to SaskPower, MISO, Hydro One



Initial Drivers for WAMS at MH

- To support commissioning of new and existing equipment
- To monitor and assess stability issues in the northern AC areas of the MH system.
- To share phasor data with MISO and NASPI



Operations saw an Opportunity

- Combined with participation with NASPI and continued involvement with GE Users group, System Operations staff saw an opportunity to leverage WAMS data for the future.
- Projects were identified for the use of Phasor data in real-time operations for additional visibility, SE robustness, backup real-time assessment, angular visibility, … and more
- First big hurdle?
  - NERC CIP …

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NERC CIP Hurdle

- NERC requirements stopped progress in their tracks!
- MH pivoted and regrouped … opportunity to move data into operations in “phases” (pardon the pun)
- We sought approval at various levels … this took effort, but persistence paid off …
  - Our CIP experts in System Operations offered to help other asset owners to define requirements, implement and train.
  - The key is communication and collaboration

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WAMS Timeline at MH

2005

1st PMU at MH: Around 2005, PMU installed at Dorsey to provide its phasor data to NASPI's super phasor data concentrator over a dedicated internet connection.

2010

WAMS Phase 1: Initial MH WAMS and PMU project with US DOE funding and MISO SynchroPhasor Deployment Project. Sites at MH: Wuskwatim, Birchtree, Kelsey, Ponton, Grand Rapids, Dorsey. Goal to commission SVC, Damping Controllers and Power System Stabilizers (PSS) in the north.

2013

SE PMU Data Integration: Initial EMS Phasor Data integration project included upgrade, licensing, and real-time environment. Actual EMS integration placed on hold due to NERC CIP requirements for PMU's.

2016

Tesla 2000/3000 Upgrade: TESLA exchange/upgrade program to upgrade TESLA 2000/3000 to PMU enabled TESLA 4000 models across MH.

2022

WAMS Phase 2: NERC CIP"ified" PMU's integrated into the EMS SCADA/State Estimator for Real-time Situational Awareness. Project ongoing for NERC Medium AC and HVDC stations.

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WAMS Architecture at MH

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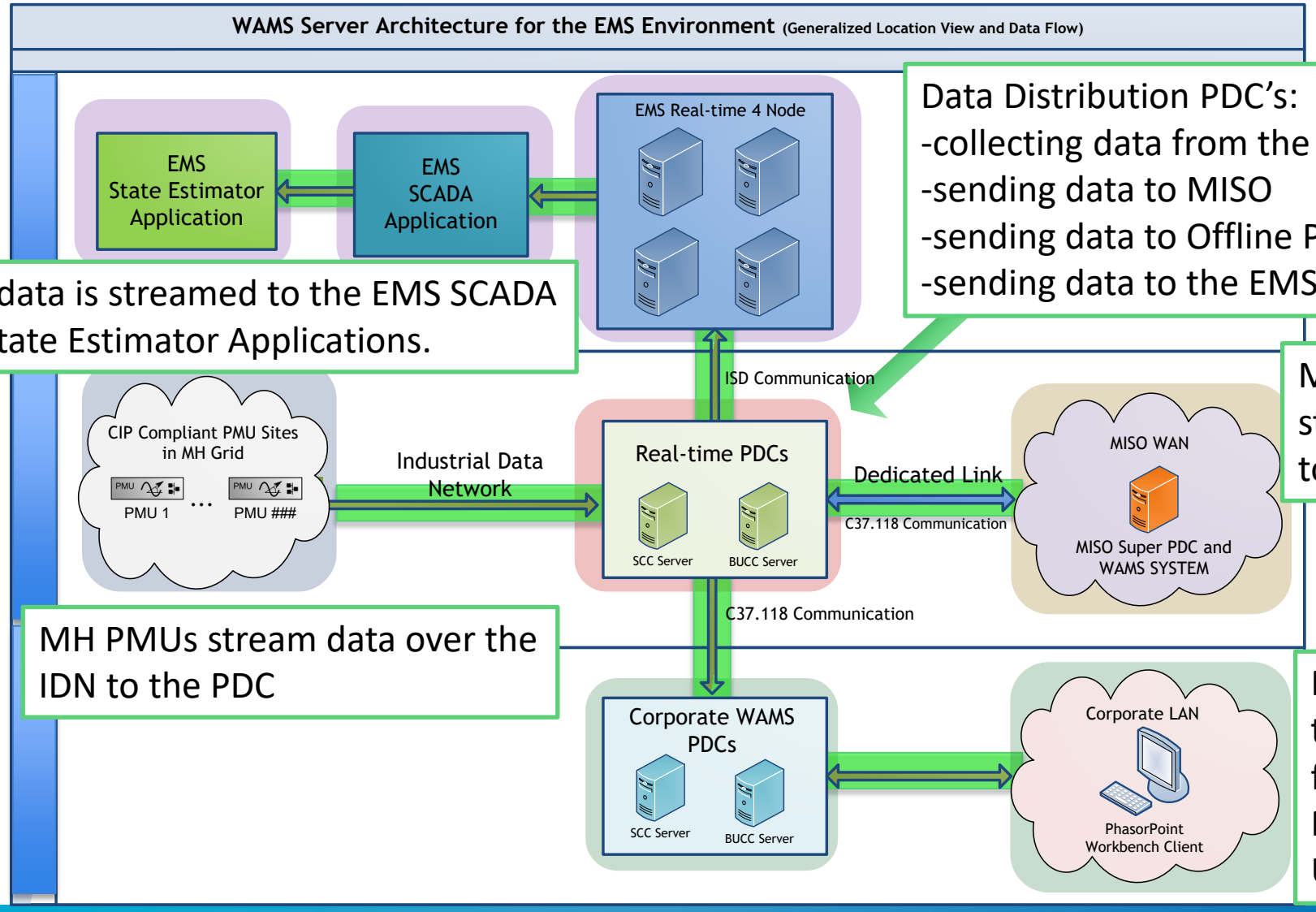
WAMS Architecture at MH

- The PMU data streaming on the Industrial Data Network (IDN) from around the province is collected in our PDC located at the System Control Centre.
- MH's WAMS system, developed by GE, consists of two sets of redundant PDCs: a Data Distribution pair and a Historian pair.
  - Data distribution WAMS is "online" and used for collecting live data from the PMUs in the field and distributing phasor data to: MISO , MH EMS and Historian WAMS
  - Historian WAMS is "offline" and used for monitoring, post event analysis, commissioning

WAMS Architecture at MH



PMU data is streamed to the EMS SCADA and State Estimator Applications.

Data Distribution PDC's:
-collecting data from the field
-sending data to MISO
-sending data to Offline PDC's
-sending data to the EMS

MH PMU data is streamed from our PDC to MISOs Super PDC.

MH PMUs stream data over the IDN to the PDC

PMU data is streamed to the Historian PDCs for use with PhasorPoint and Offline Users.

NOTE: The clouds indicate data transferring out of the swim lane domain into a separate network.

Uses of WAMS at MH

How does SO use WAMS technology, today?

- Grid Analysis (offline):
  - Monitoring and analysis of modes
  - Commissioning
  - Data to support model validation
  - Disturbance Event Analysis
- Real-time Analysis (online):
  - Streaming voltage and current phasors to the EMS SCADA/State Estimator applications
  - EMS Model verification and troubleshooting

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Offline Uses

Oscillation Monitoring	FACT devices controller and POD commissioning	PSS commissioning
BP3 controllers and damping controller commissioning	Model validation	Event analysis
Voltage monitoring	Integration into dynamics simulation Tools	Geomagnetic Disturbance investigations

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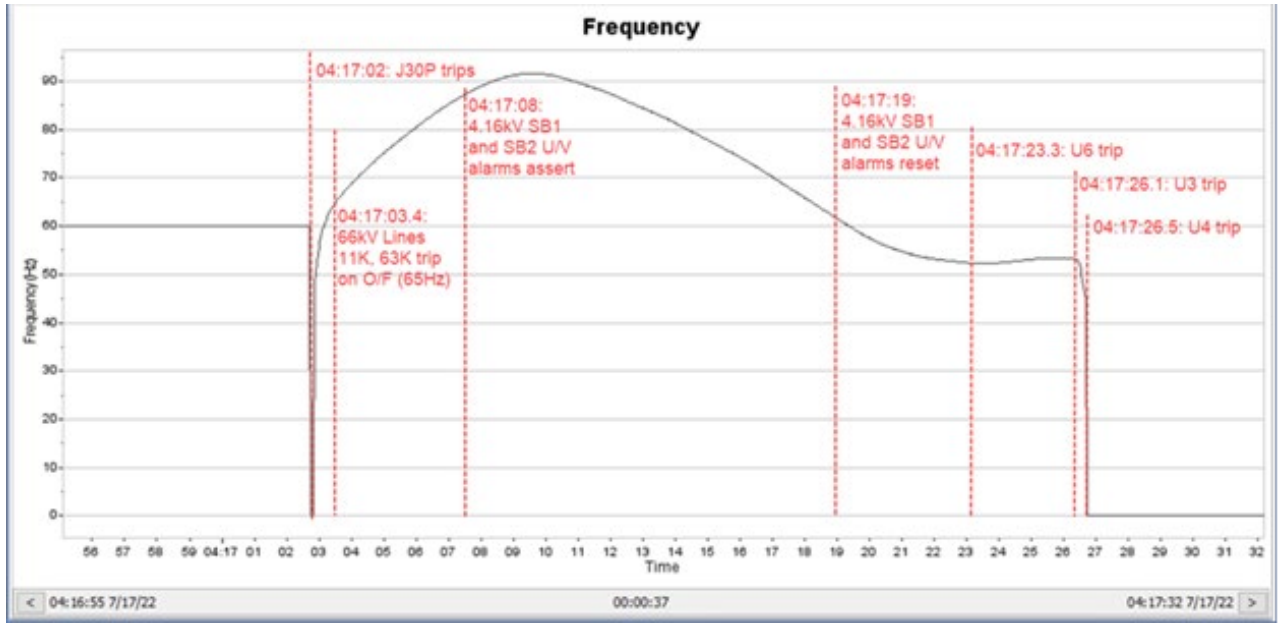
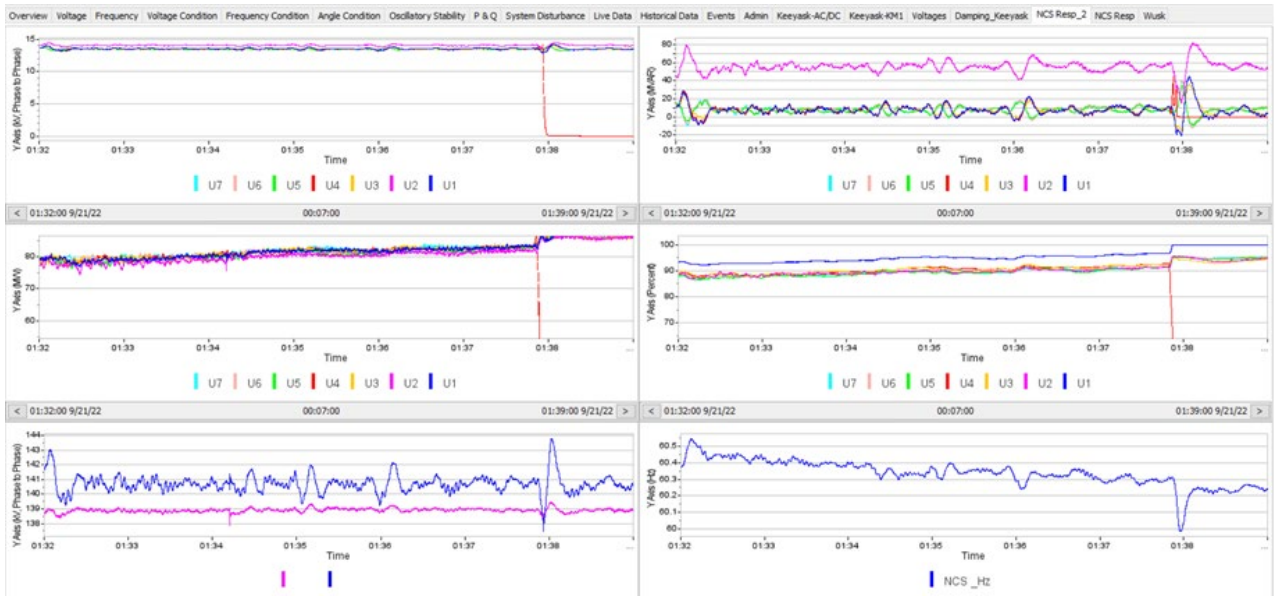
Event Analysis Example 1



- 2022-07-17: Line tripped, Generating Station became islanded.
- PMU located at the islanded station provided the station freq. response with accurate time stamps which allowed us to review the response of various systems at the station relative to the station frequency.

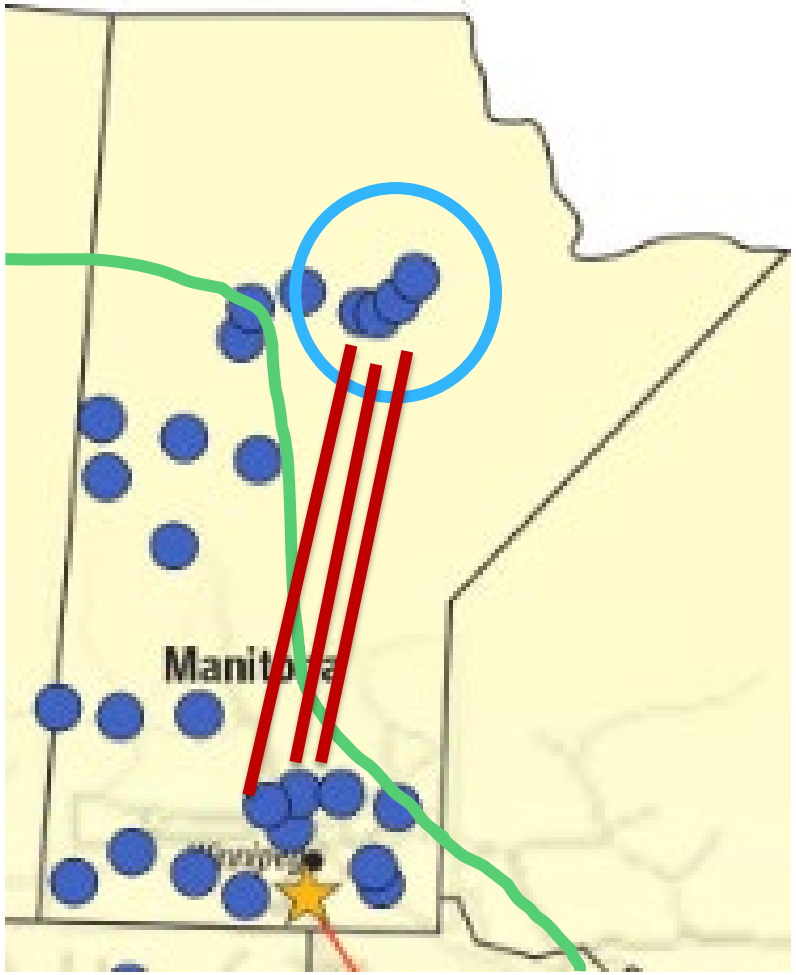
Event Analysis Example 2

- 2022-09-21 Generating Unit Trip
- PMU data reviewed:
  - Unit voltage, MW, MVAR, and gate position of each unit at GS.
  - Area freq. and bus voltage at GS and another station in the area.
- Initial reports indicated that the unit may have been tripped due to system voltage swings however a review of the PMU data indicated that the unit was not tripped due to system issues or GS Unit stability issues.

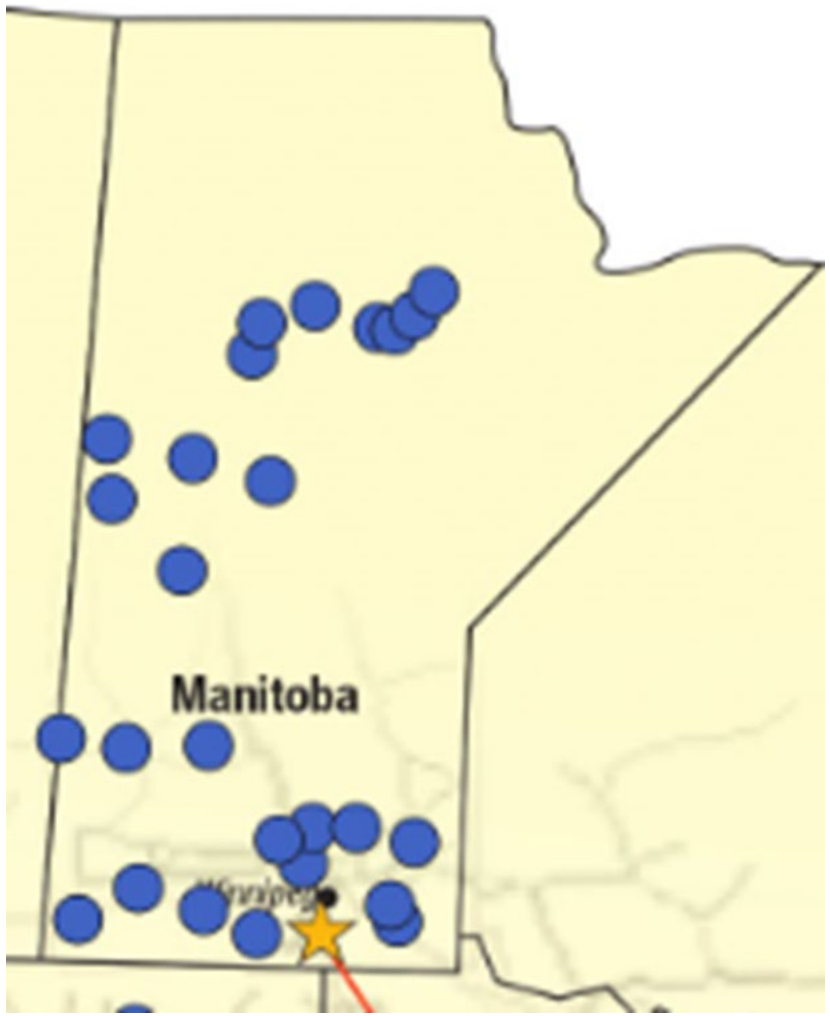


Online Uses

- MH has > 175 PMUs collecting data on the transmission and distribution systems using PMU Enabled ERLPhase TELSA 4000 Transient Fault Recorders.
- Phasor data utilized in the EMS SCADA and State estimator applications for additional visibility, backup measurements, and improved quality.
- PMU and Phasor stats:
  - BES Coverage ~ 80% of stations
  - Monitoring of two asynchronous islands



Online Uses



Approx. PMU and Phasor stats:
• 86 PMUs used in EMS SCADA/SE (8 more coming)
• 58 EMS Stations with PMU (some multiple PMUs)
• # of phasors in the EMS = 481
• Voltage 500 kV to dist. (24 kV) and gen. levels (13.8 kV)

- Additional measurements:
  - 70-80 PDC calculated MW/MQ analogs on 24KV and 65.1 where only RTU AMP metering is available
  - Working on adding 250 external phasor measurements from MISO PDC to MH historian PDC for event analysis.
  - Note: Not all data in the PDC is for use with the EMS, this includes Individual Gen Unit PMUs/TFRs with unit Speed, gate pos, field voltage/current metering and hvdc quantities.

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Online Uses

- Commissioning and Model Validation:
  - Long standing Phase shifter issue resolved using phasor data on high and low side confirmed incorrect PST modeling and tap step.
    - Fix for this issue resolved issues in SE solution and RTCA performance
  - Glenboro Series Phase Shifting Transformers
    - Phasor measurements across the PSTs enabled model validation of RTU data, tap modeling and transformer parameters during commissioning
    - Commissioning tests resulted in appropriate SCADA and Network modeling changes to allow proper operation of the power flow controller

Online Uses

- Commissioning and Model Validation:
  - Issue with Parkdale Station
    - Phasor data used to verify power flow changes per high impedance tap step during parallel line operations at 66 kV level.
    - Data used to prove long standing issue and to tune the state estimator transformer models.

01/26/2021 11:08:11s	-2.120	-2.256	-2.159	-2.120
01/26/2021 11:09:11s	-2.120	-2.256	-2.159	-2.120
01/26/2021 11:10:11s	-2.120	-1.983	-2.159	-2.120
01/26/2021 11:11:11s	-2.120	-1.963	-2.159	-2.120
01/26/2021 11:12:11s	-3.116	-2.803	-2.589	-2.628
01/26/2021 11:13:11s	-3.116	-3.038	-3.175	-3.116
01/26/2021 11:14:11s	-3.116	-2.979	-3.175	-3.116
01/26/2021 11:15:11s	-3.116	-2.979	-3.175	-3.116
01/26/2021 11:16:11s	-3.116	-3.214	-3.175	-3.116
01/26/2021 11:17:11s	-4.073	-4.269	-4.132	-4.112
01/26/2021 11:18:11s	-4.581	-4.679	-4.601	-4.581
01/26/2021 11:19:11s	-4.581	-4.679	-4.601	-4.581
01/26/2021 11:20:11s	-4.581	-4.444	-4.601	-4.581
01/26/2021 11:21:11s	-4.581	-4.679	-4.601	-4.581
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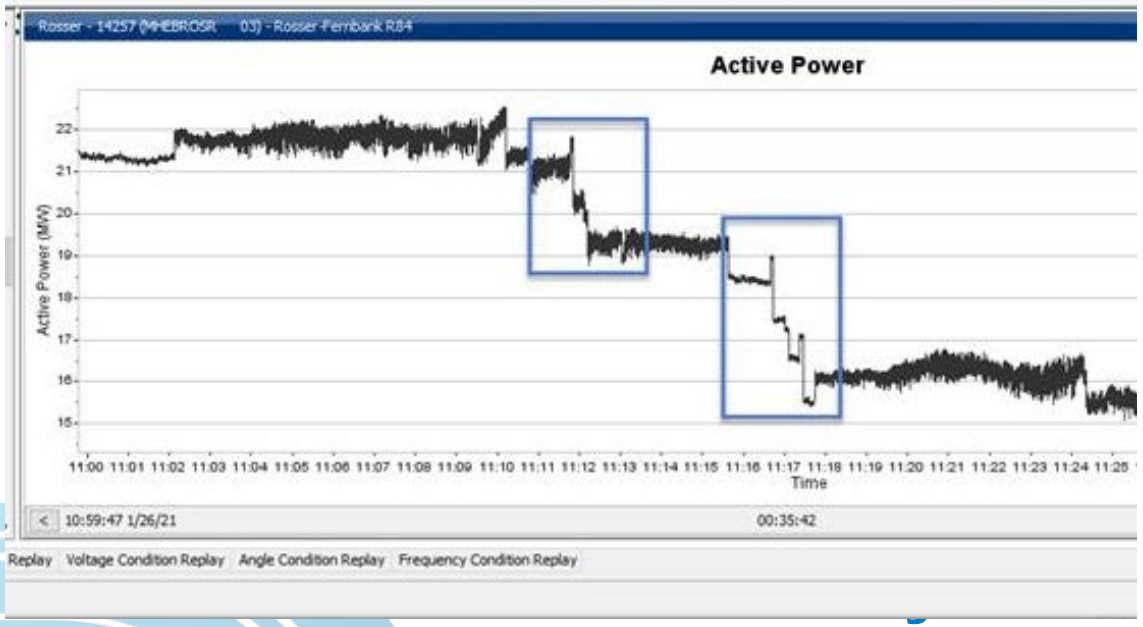

Future of WAMS at MH

WAMS Roadmap Content

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WAMS Roadmap High Level Overview

WAMS Roadmap Drivers:

-Operational Situational Awareness of Grid Stability for both Real-time and Post Event Analytics utilizing synchrophasor data and GE WAMS applications.

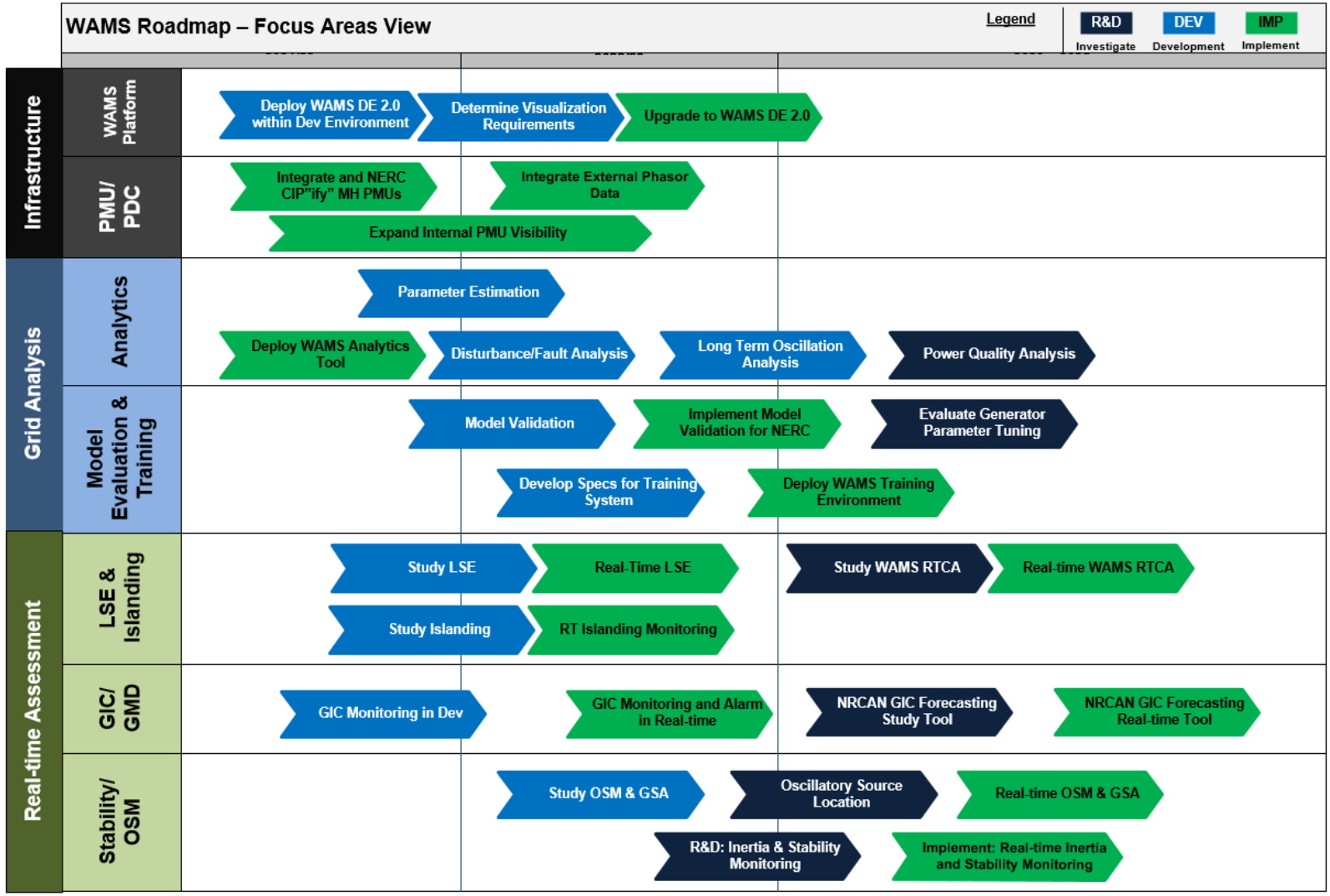
-Support NERC Standards for Real-time Monitoring/Assessment, Quality Assessment, Post Disturbance Analysis and Quality Verification of Models

3 key concepts: Platform, Participation and Applications

Roadmap Views

Focus Areas View:

- Provides a high-level roadmap view of the future direction for the WAMS ecosystem.
- Includes roadmap concepts in streams according to time
  - Infrastructure
  - Grid Analysis
  - Real-time Assessment



Roadmap Key Concepts

1. **Platform Development:** Continue to develop and leverage GEs WAMS ecosystem
   - Upgrading to the new GE Digital 2.0 technology
   - Providing interactive geospatial visualization solution using GE's Vision application
   - Integrating all MH PMUs and select MISO PMUs into the PDC/EMS
   - Developing training and study environments
   - Implementing applications into Real-time ops

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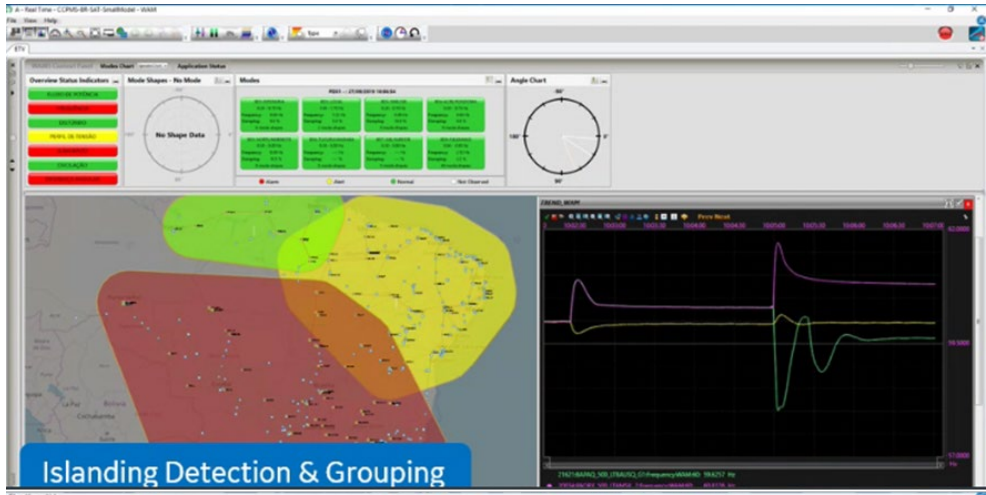
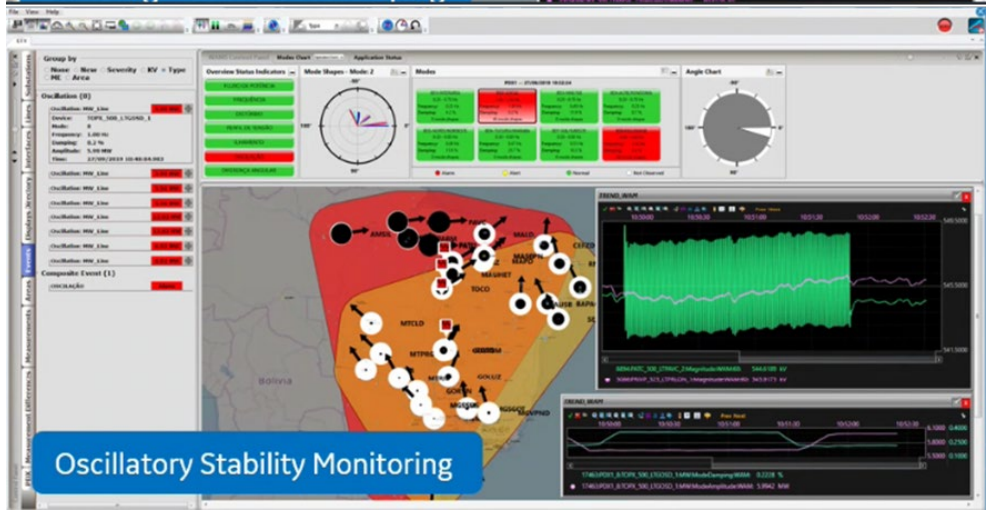
Roadmap Key Concepts

2. **Participation:** Provide direction, engage stakeholders and share experiences with internal and external expertise to maximize WAMS return on investment through attendance and participation with:
   - NASPI
   - GE User Group
   - MH WAMS User Group
   - EPRI

Roadmap Key Concepts

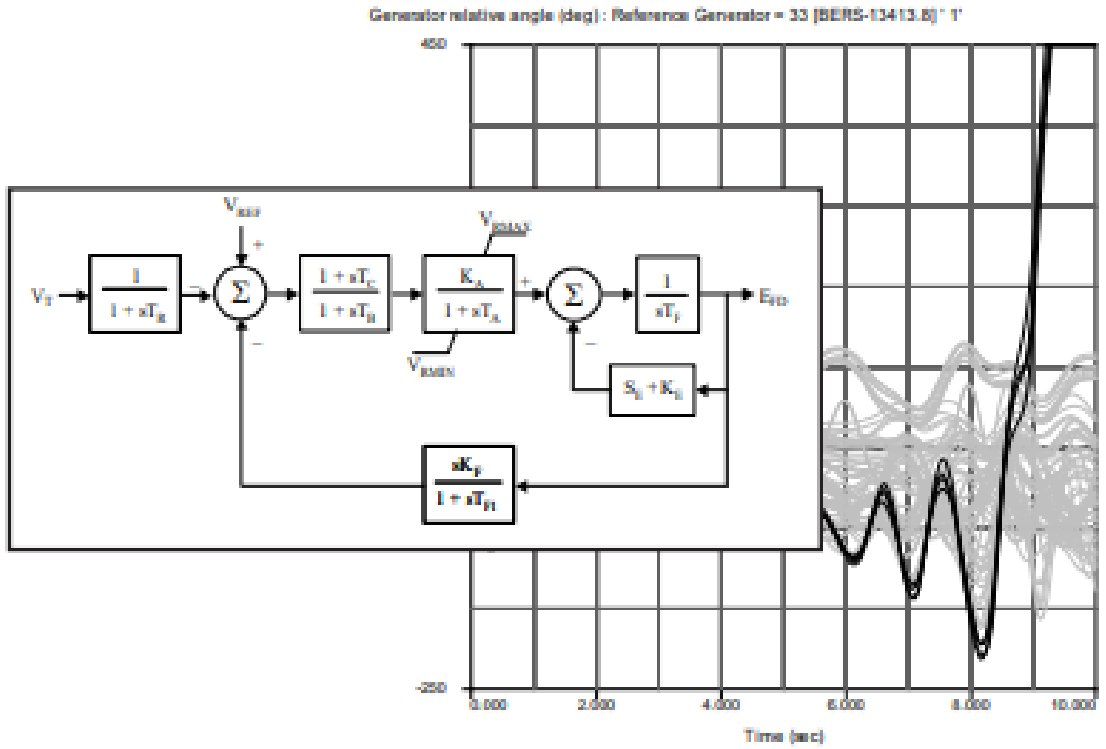
3. **Applications:** Develop and implement WAMS applications in several key focus areas in both real-time operations and grid analysis environments:
   - **Real-time Assessment:** Implement applications that aid in RT monitoring and assessment in support of TOP-001 R13 and TOP-10
     - Stability monitoring for inertia, voltage, transient, and undamped oscillations
     - Island detection, location and alarming
     - Linear state estimator (LSE) and LSE-RTCA tools for BES contingency monitoring
     - Geospatial visualization of stability, RTCA, and real-time quantities
     - GIC Monitoring





Roadmap Key Concepts

3. **Applications continued:**
   - **Model Validation:** Implement features to aid in dynamic model validation in support of MOD-026-1 and MOD-027-1
     - Support of model validation for dynamic models
     - Potential for assistance in generator model tuning
   - **Analytics:** Implement features to assist in post event analysis in support of PRC-4 and PRC-12 and long-term analytics
     - Post event analysis of system disturbances
     - Long term oscillation analysis



Roadmap Impacts

System Control Operators:	• New tools/display/alarms to support real-time assessment
System Performance & Planning:	• New applications for performing existing/new work functions
System Support:	• New applications, servers, database management • Modeling/display management
Telecommunications:	• Network infrastructure and support

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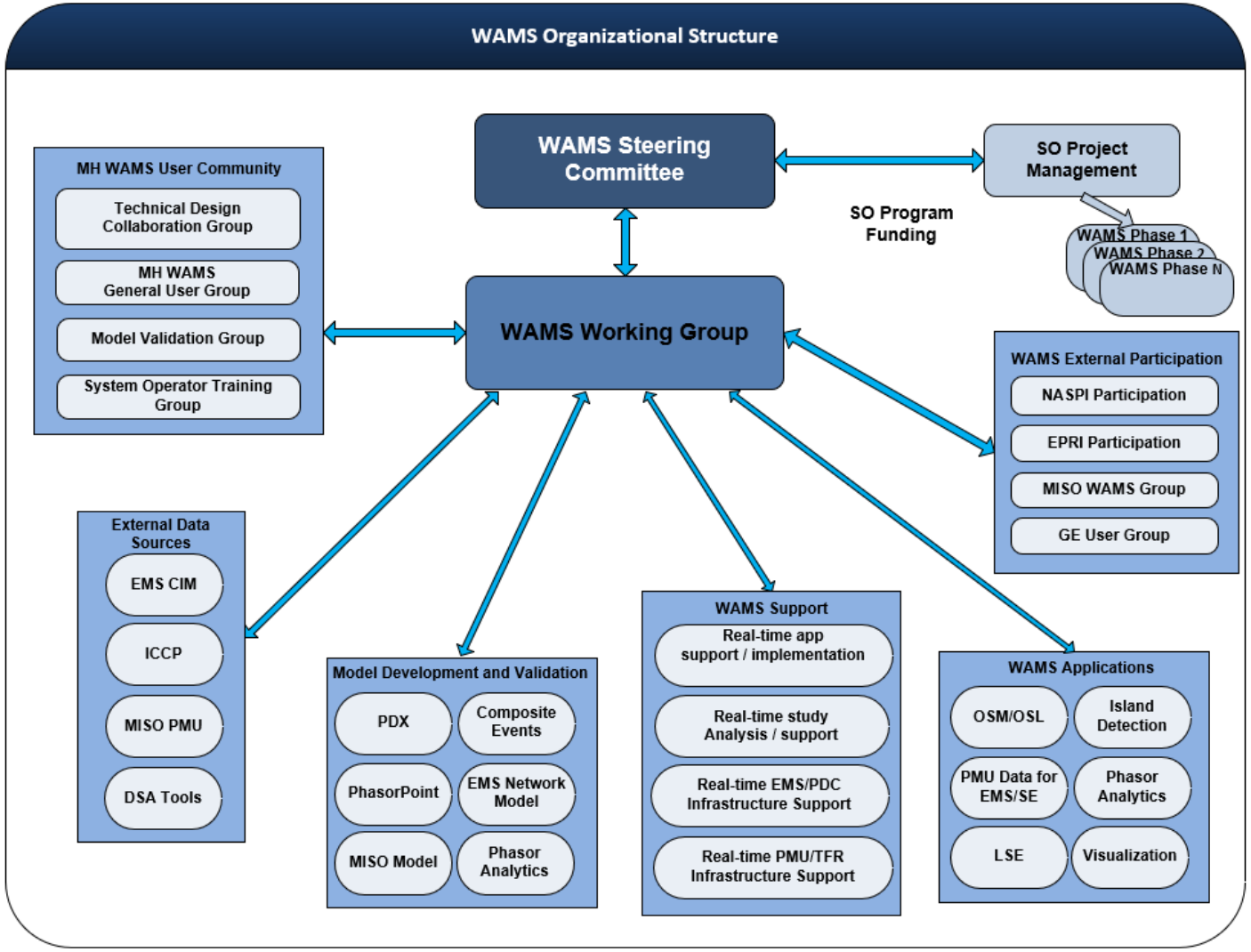
WAMS Org Structure



- To that aid in managing these impacts, we propose a steering committee / working group concept
- Develop Terms Of Reference(TOR) document in support of moving the roadmap forward and keeping it up to date
- Determine WAMS interfaces within MH and externally
  - Participation is key to maintaining the roadmap and future vision
  - Who will interface at various levels on behalf of MH?

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Next Steps …

- Develop standards for interconnection requirements
- Present roadmap at various levels
- Roadmap Development … It's a living document!
  - Gain consensus on roadmap content
  - Revise and update roadmap based on stakeholder input meetings
  - Determine who/what/where/etc. (staffing requirements)
  - Analyze impacts to stakeholders & determine when/where to engage
  - Draft org structure TOR and seek approval to proceed

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Discussion

- The End... Thank you!

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