Summary of EPRI Synchrophasor Related Activities

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NASPI WG Meeting
Richmond, VA
October 29, 2019

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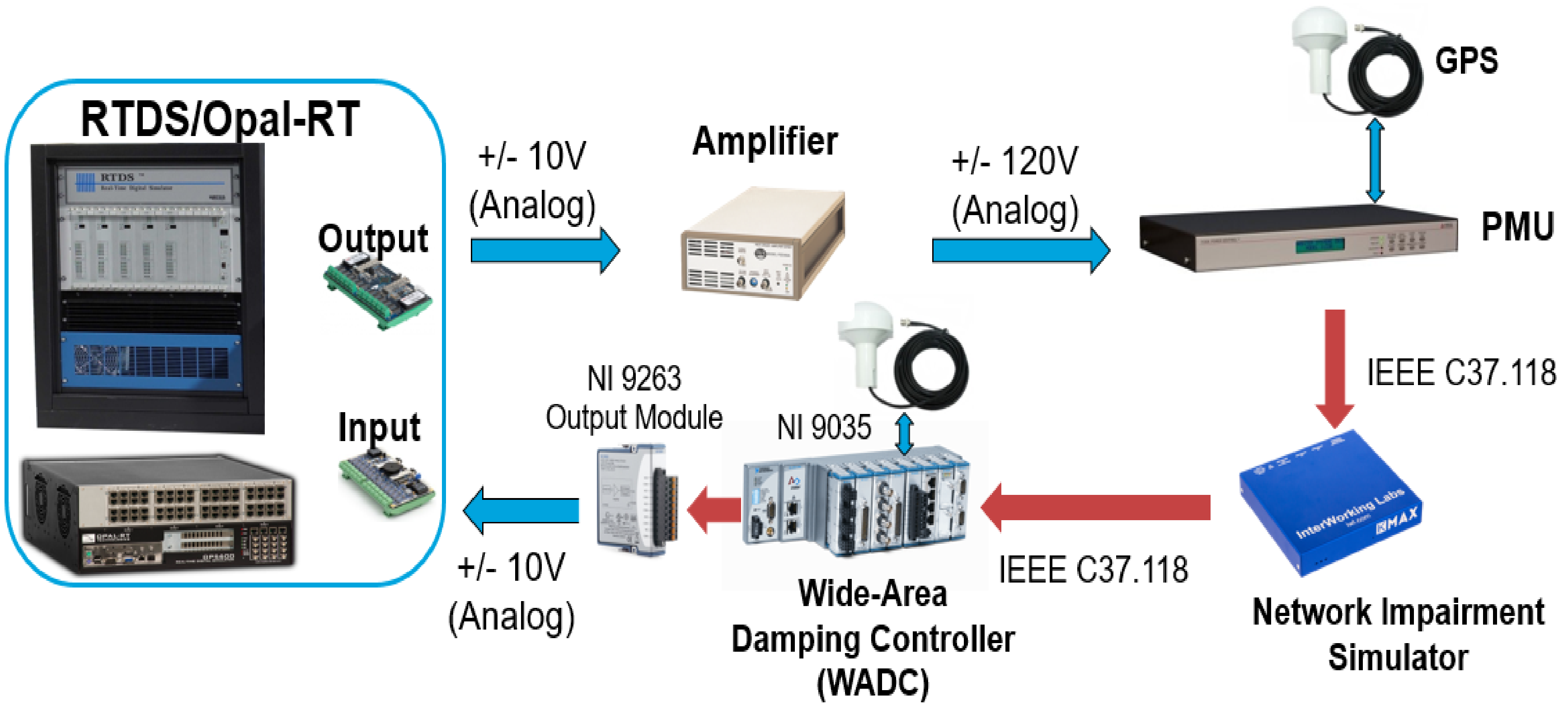
1. Synchrophasor-Based Wide Area Oscillations Damping Controller



In collaboration with University Tennessee Knoxville (UTK)

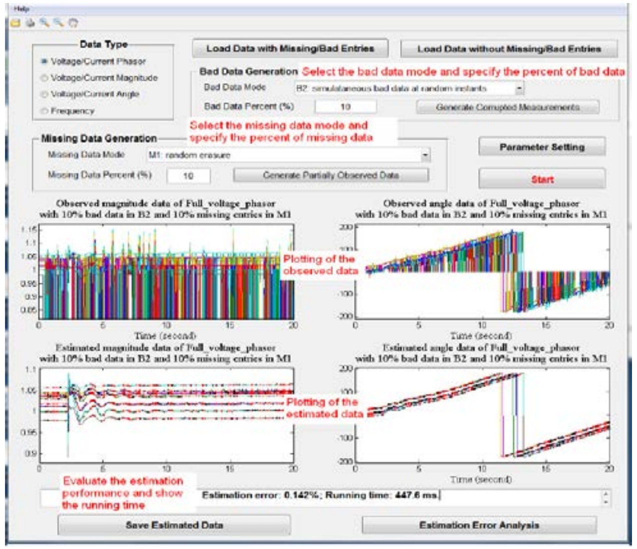
- **Improved Damping of Target Inter-area/Intra-area Oscillations Mode**
- **Application of Synchrophasor Technology in Closed Loop Wide Area Control**

- WADC via additional input to generator excitation system or FACTS/HVDC controller
- Adaptive controller
  - Measurement-derived transfer function model
- Ongoing case studies with NYPA, TERNA (Italy) & SEC (Saudi Arabia)
- Ongoing: Hardware-In-the-Loop (RTDS/Opal-RT) implementation and demos

2. Data Quality Conditioning of Streaming Synchrophasor Data

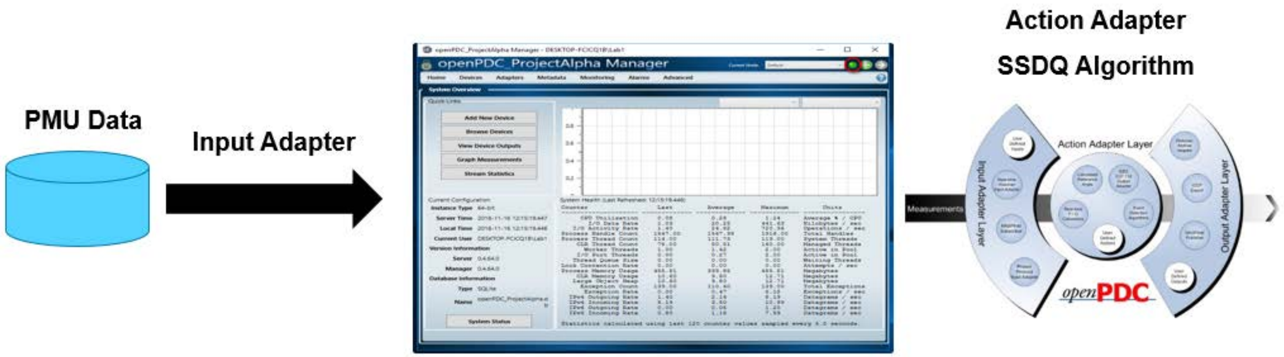
- Goal: Improve synchrophasor data quality by estimating missing data and replacing bad data in synchrophasor streams
- Model free technique, no need for topology information or system parameters
- Computationally efficient for real-time implementation
- Algorithms have been tested with recorded synchrophasor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

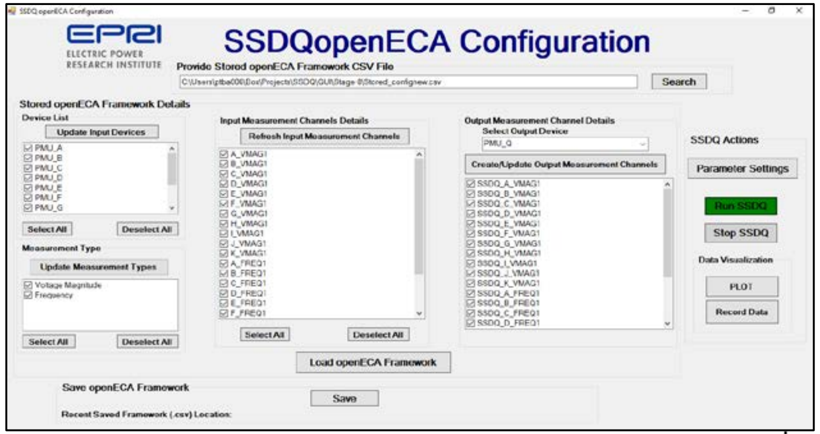
Offline SSDQ Tool



In collaboration with RPI

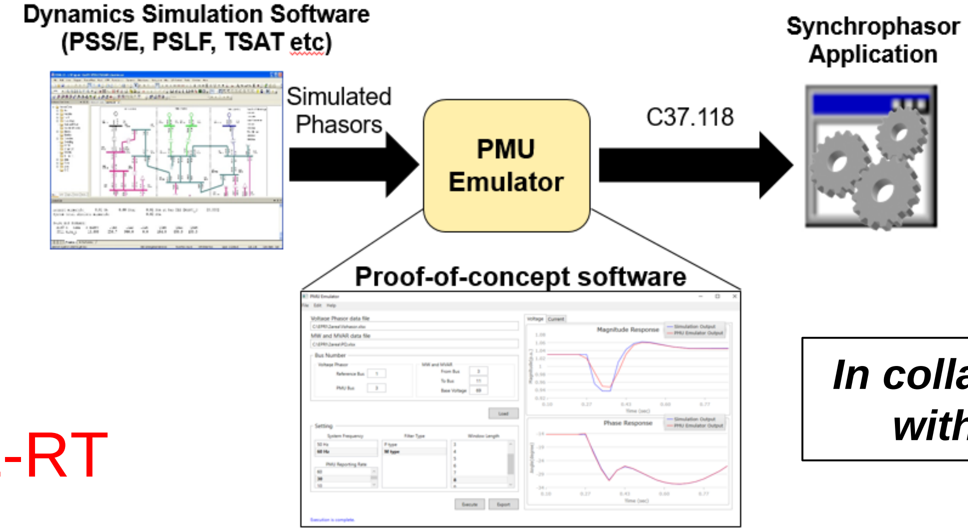
Online SSDQ Tool (OpenPDC & OpenECA)





3. PMU Emulator

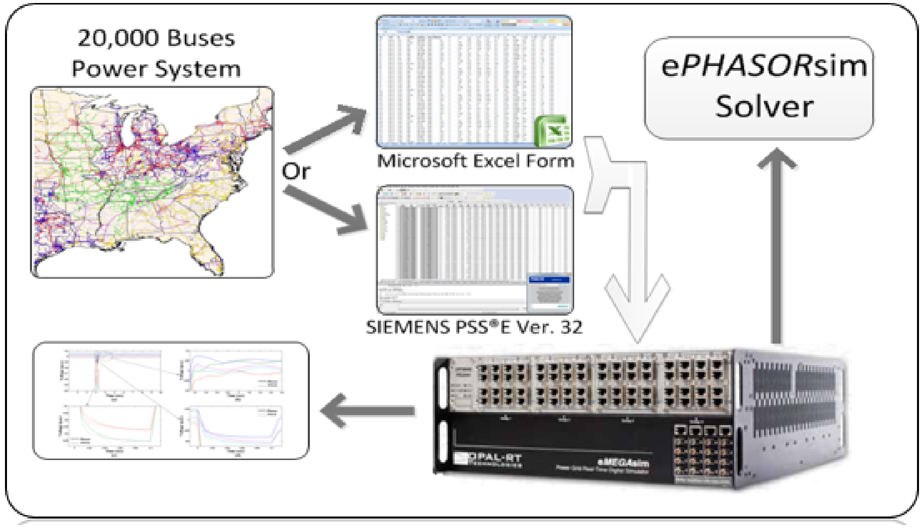
- Interfaced with power system dynamics simulators to produce "simulated synchrophasors" taking into account PMUs internal signal processing
- Implementation of PMU Emulator with OPAL-RT ePHASORSIM

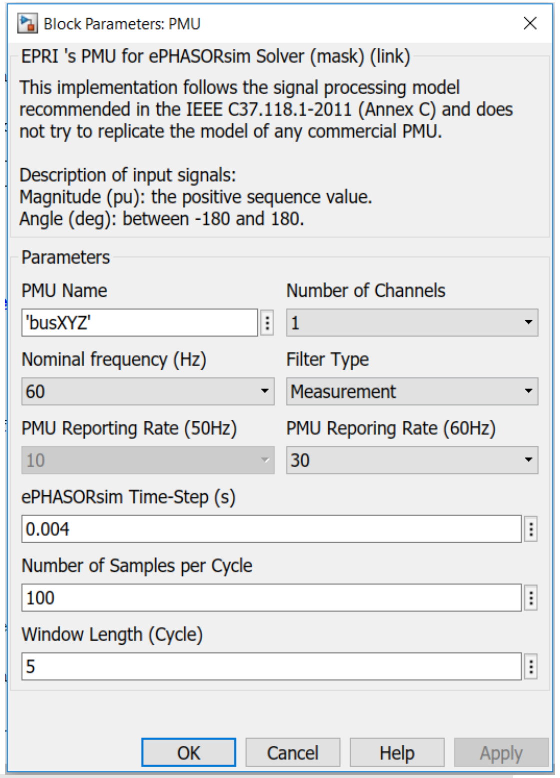


In collaboration with WSU

Vendor Engagement

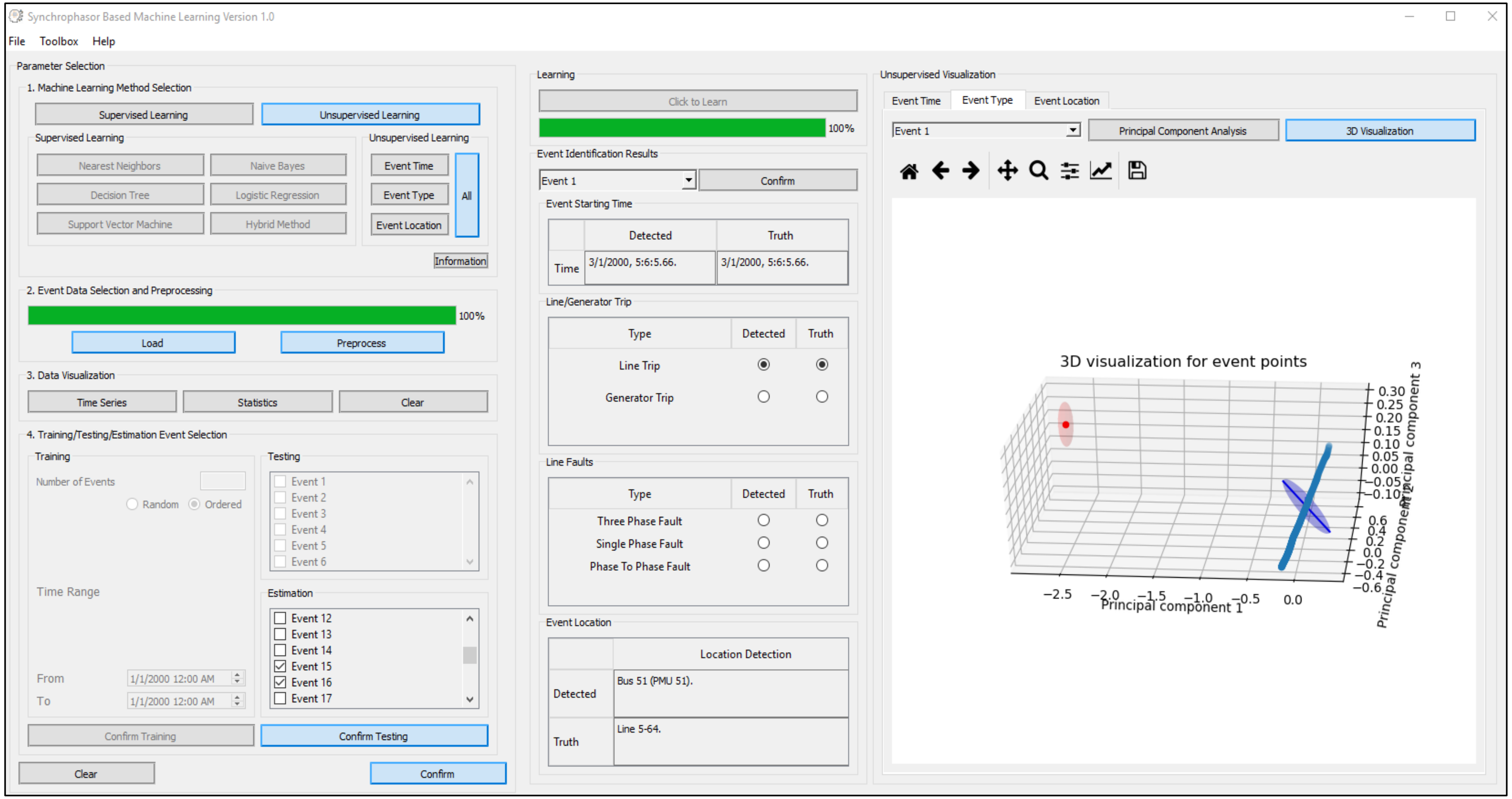
OPAL-RT - ePHASORsim





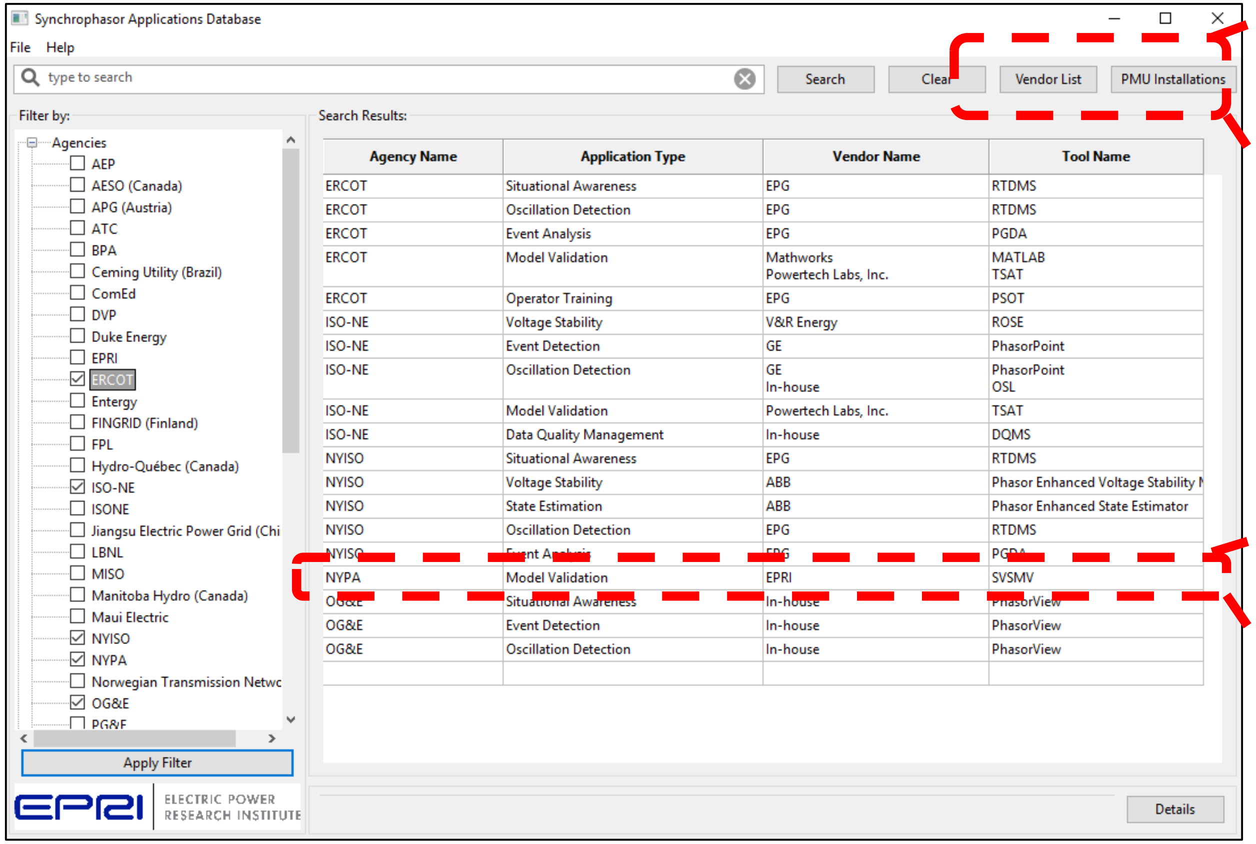
4. Machine Learning Using Synchrophasor Data

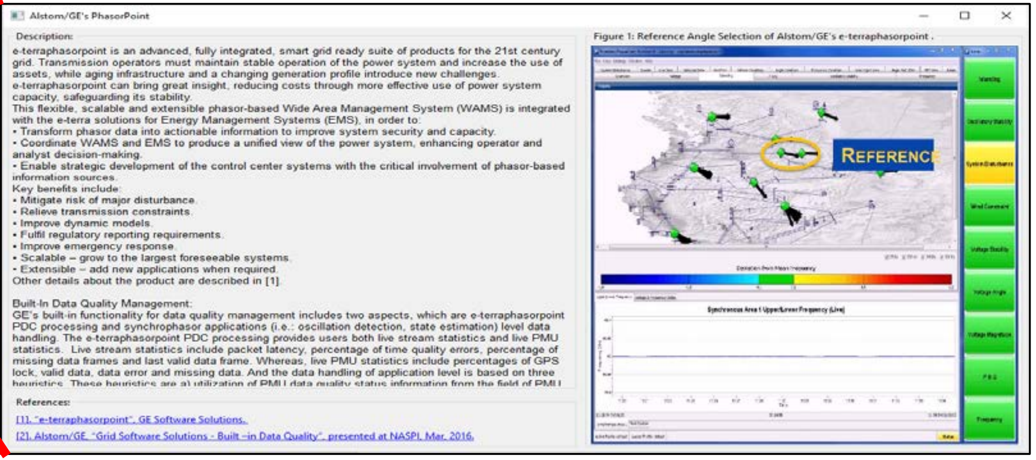
- Event Identification (time, type & location) through supervised & unsupervised machine learning
- Update: Synchrophasor Based Machine Learning (SBML) software

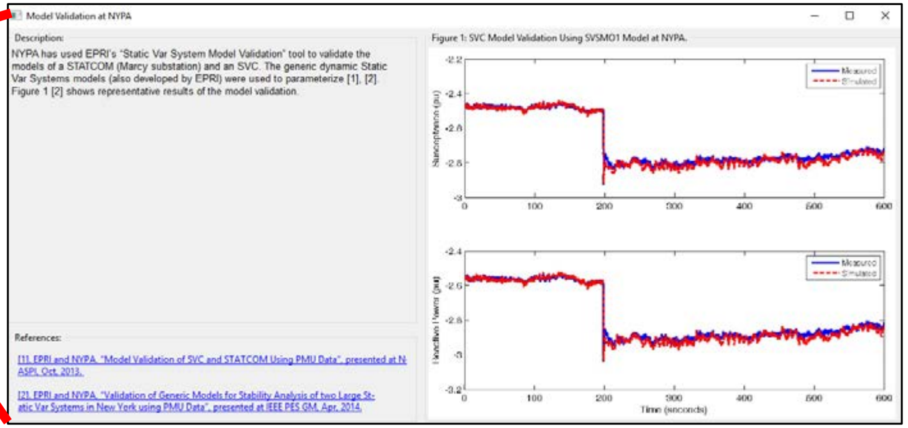


In collaboration with ASU

5. Synchrophasor Applications Database





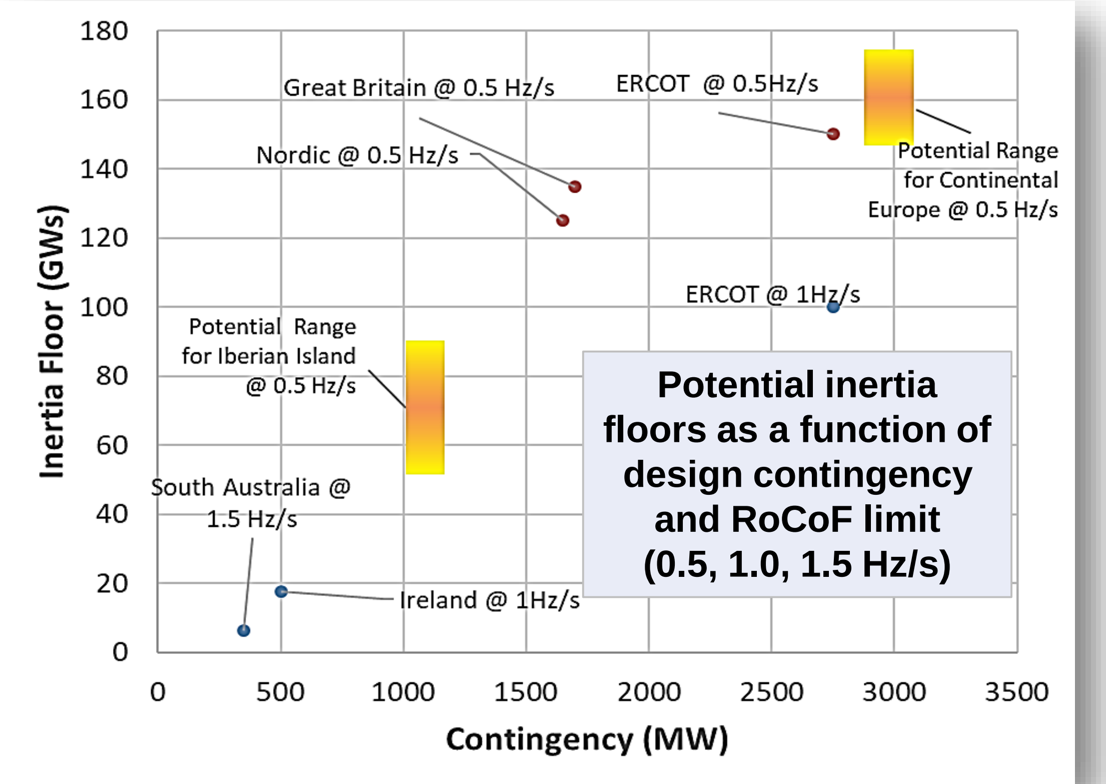


- Entries based on publicly available documents
- For each entry, summary description of application and related references

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

6. PMU Based Inertia Monitoring

- With increasing levels of Inverter Based Resources (IBR), system inertia is decreasing
- Growing interest and need for online inertia monitoring – inertia floor
- EPRI white paper "**Online Inertia Estimation & Monitoring - Industry Practices & Research Activities**"
  1. Present Industry Practices
  2. Research Activities and Proposed Technologies



	Texas (ERCOT)	Great Britain (National Grid)	Ireland (EIRGrid)	Nordic system	Australia (National Electricity Market)
UFLS	59.3 Hz	48.8 Hz	48.85 Hz	48.85 Hz	47.6 Hz
RoCoF	~ 1 Hz/s	0.5 Hz/s	1 Hz/s	0.5 Hz/s	1.5-3.0 Hz/s
Largest Contingency	2.75 GW	1 GW	500 MW	1.65 GW	350 MW
Peak Demand	~73 GW	~60 GW	~6.5 GW	~72 GW	~36 GW
Inertia Floor	100 GWs	135 GWs	23 GWs	125 GWs	6.2 GWs

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