# Summary of EPRI Synchrophasor Related Activities

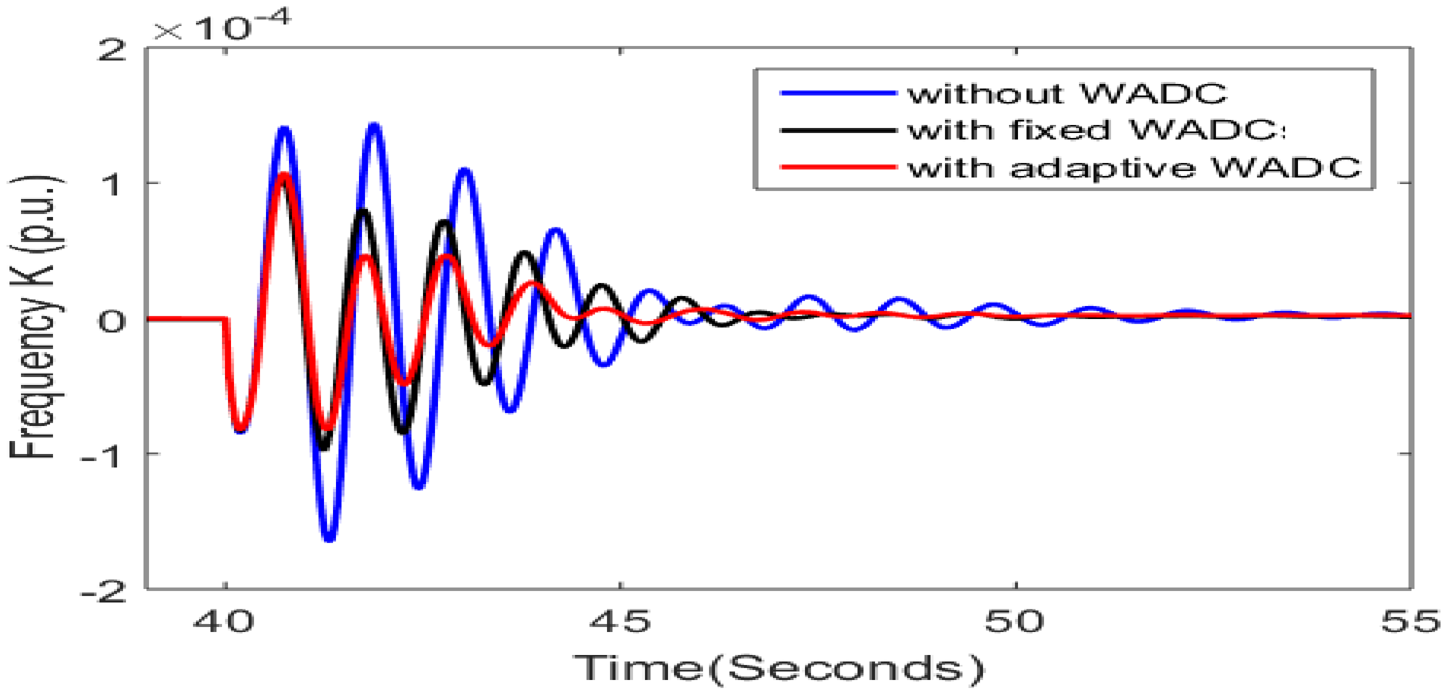
**Mahendra Patel**

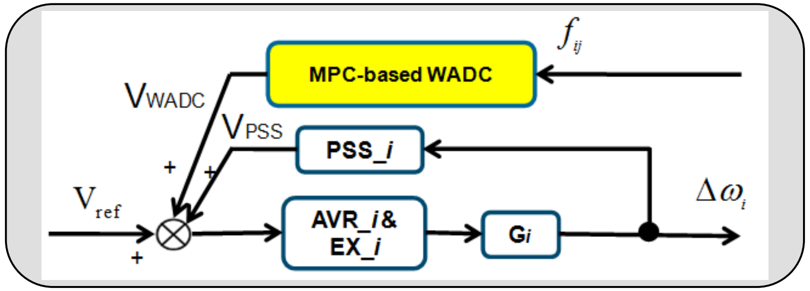
**Evangelos Farantatos**

**Paul Myrda**

**NASPI WG Meeting**
**Philadelphia, PA**
**October 23, 2018**

# 1. Synchrophasor-Based Wide Area Oscillations Damping Controller



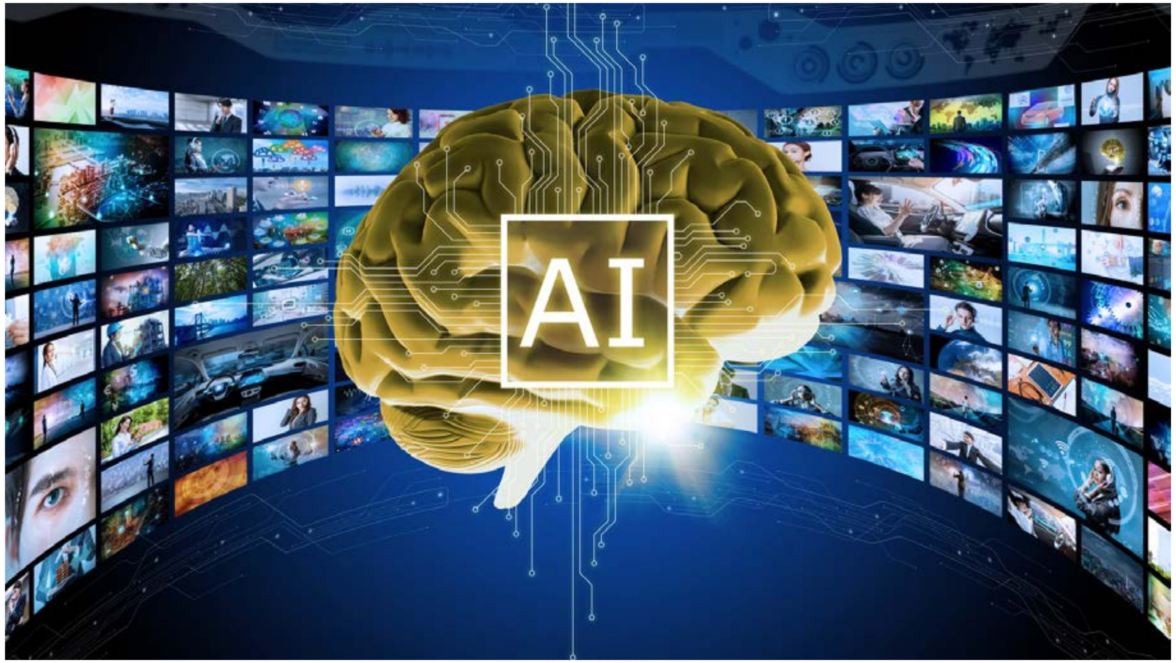

***In collaboration with University Tennessee Knoxville (UTK)***

- Adaptive controller
  - Measurement-derived transfer function model (Probing signal or ringdown data)
- Ongoing case studies with NYPA, TERNA (Italy) & SEC (Saudi Arabia)
- Hardware-In-the-Loop implementation
  - Measurement delays
  - Missing/Bad data

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

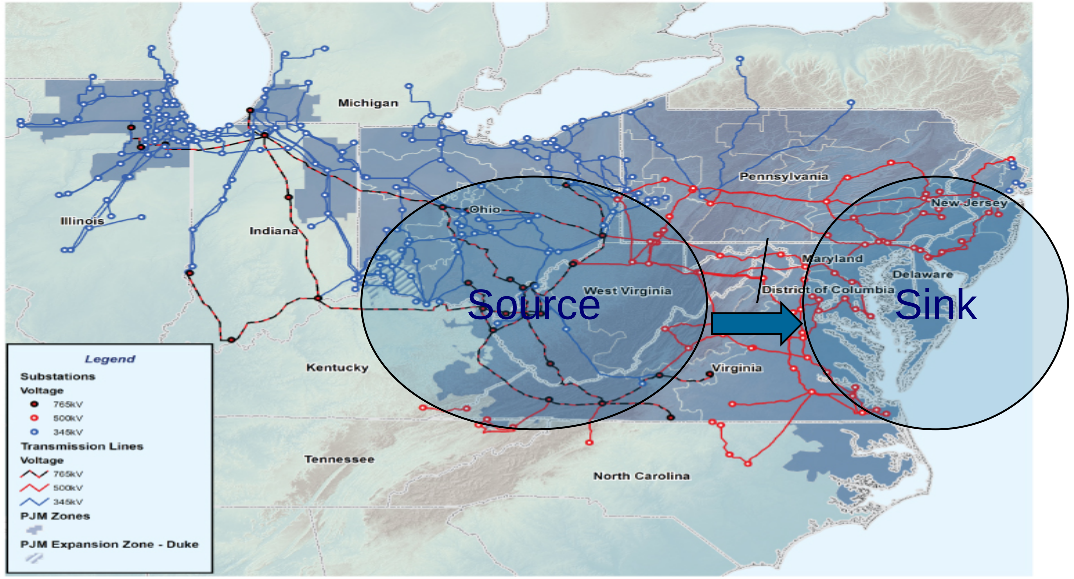
# 2. Data Mining and Machine Learning Techniques Using Synchrophasor Data

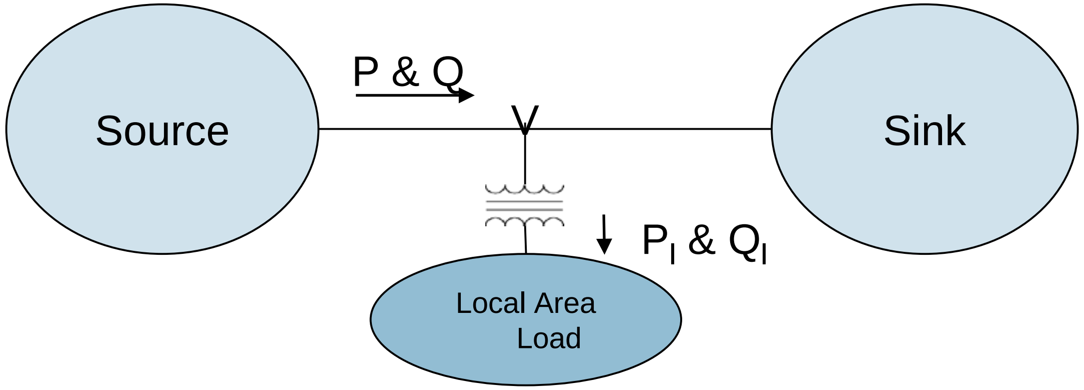
- Data mining/pattern recognition/machine learning techniques that use streaming synchrophasor data to:
  - Identify Events
  - Classify secure vs insecure operating conditions
  - Provide guidance to operators for potential mitigation actions
  - Define metrics as precursors of system insecurity
  - Define system performance indicators (Grid Health Index)



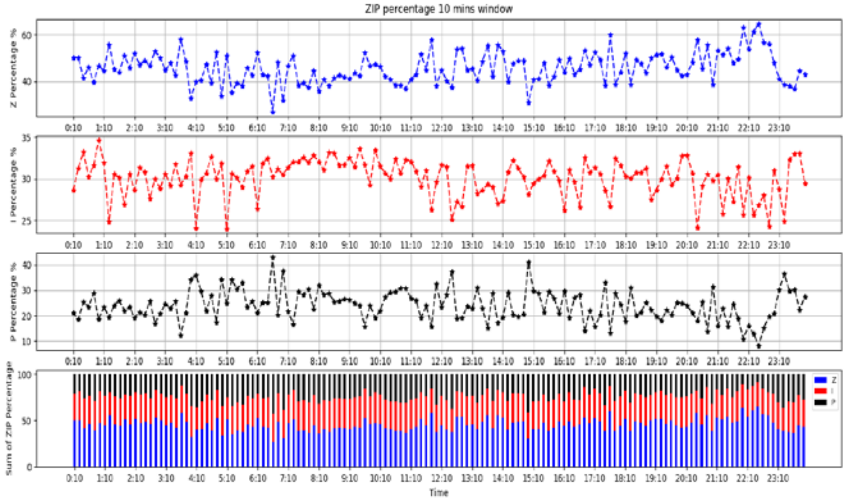

**Value: Increased System Reliability Through Advanced Situational Awareness**

# 3. Voltage Sensitive Static ZIP Load Model Using Synchrophasor Data




**software being tested with member data**




*In collaboration with WSU*

- Develop Analytical Tools to Determine Voltage Sensitivity of Local Loads
  - Use Synchrophasor data for bus voltage & load at the critical bus
  - Filter out random noise & bad data
  - Determine appropriate measurement window required
- Represent Voltage Sensitivity of Load as a ZIP Load Model

$$P_{ZIP}=P_0\,[A\,(V/V_0)^2 + B\,(V/V_0) + C]$$

$$Q_{ZIP}=Q_0\,[D\,(V/V_0)^2 + E\,(V/V_0) + F]$$





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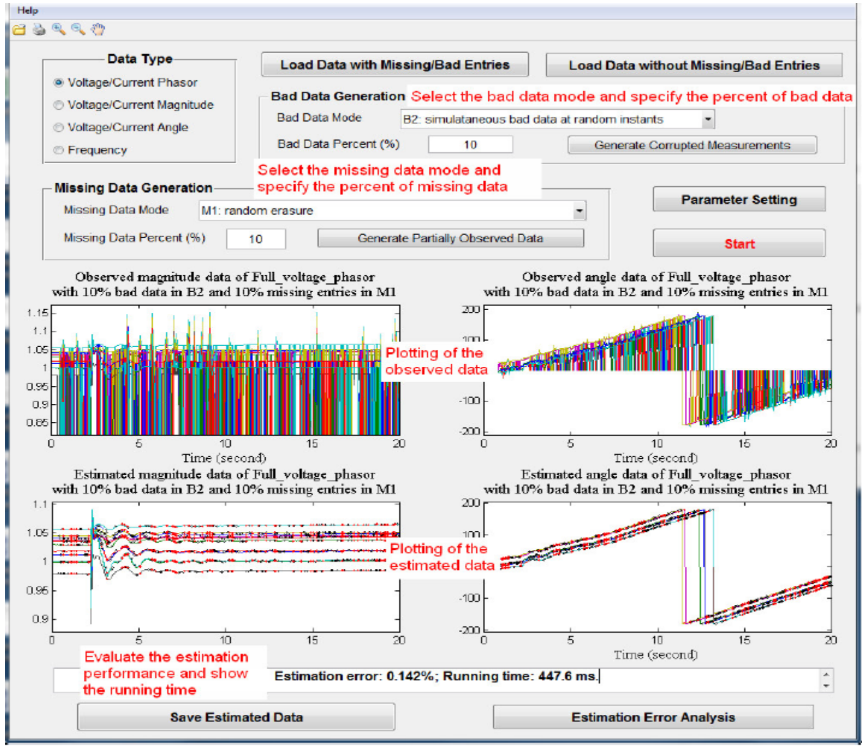
# 4. Data Quality Monitoring and Mitigation of Streaming Synchrophasor Measurements

- 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 are being tested with recorded synchrophasor data provided by EPRI members
- Next: Demos with streaming synchrophasor data hosted by utilities/ISOs
- Next: Collaboration with vendors for implementation in commercial platforms

## Offline Tool



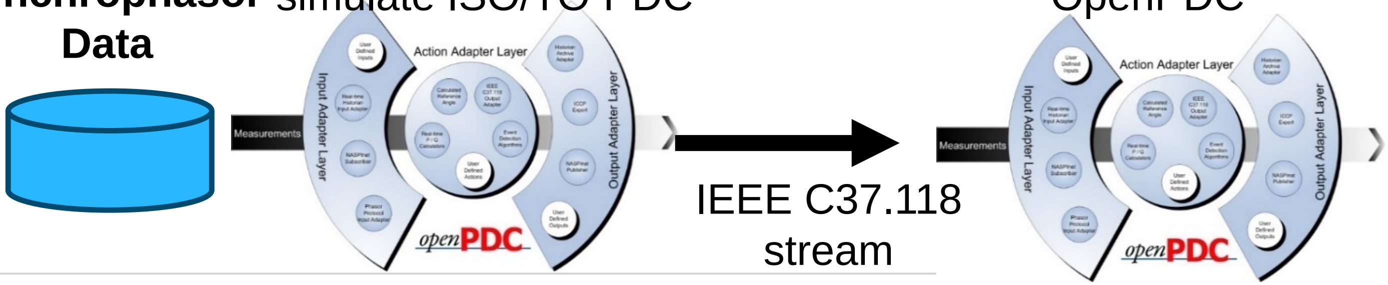

*In collaboration with RPI*

## Online Tool

**Synchrophasor Data**

OpenPDC Server to simulate ISO/TO PDC

SSDQ Algorithms in OpenPDC





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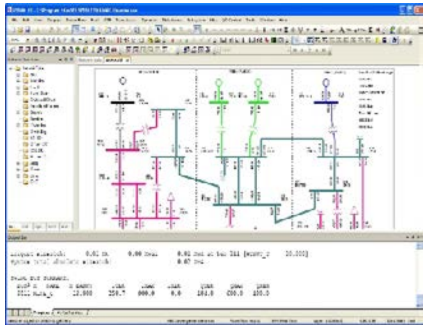
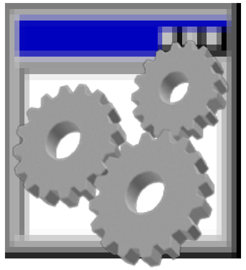
# 5. PMU Emulator

- Phasor values obtained from dynamic simulation tools may differ from synchrophasors measured by PMUs in the field
- How a PMU works:
  - Analog signal sampling - A/D Conversion
  - Digital filtering → magnitude attenuation & phase offset
  - Phasor estimation
    - algorithm e.g. DFT
    - window length - P & M class PMUs
- PMU Emulator: interfaced with power system dynamics simulators, and produces “simulated synchrophasors” taking into account PMUs internal signal processing

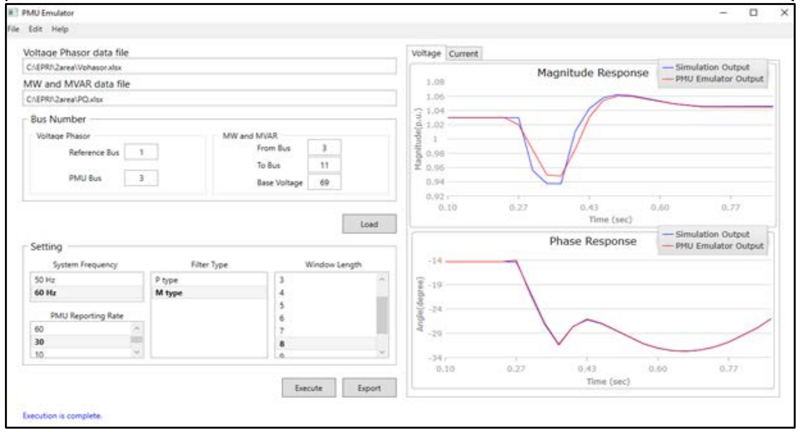
**Dynamics Simulation Software (PSS/E, PSLF, TSAT etc.)**



Simulated Phasors → **PMU Emulator** → C37.118 → **Synchrophasor Application**



**software ready for implementation**




***In collaboration with WSU***

- Hardware-In-the-Loop benchmarking (RTDS & hardware PMUs)
- Use cases: Model validation, synchrophasor applications offline testing (especially control applications), operator training, etc.
- Vendor PMU library
- Next: Collaboration with vendors for implementation in commercial platforms





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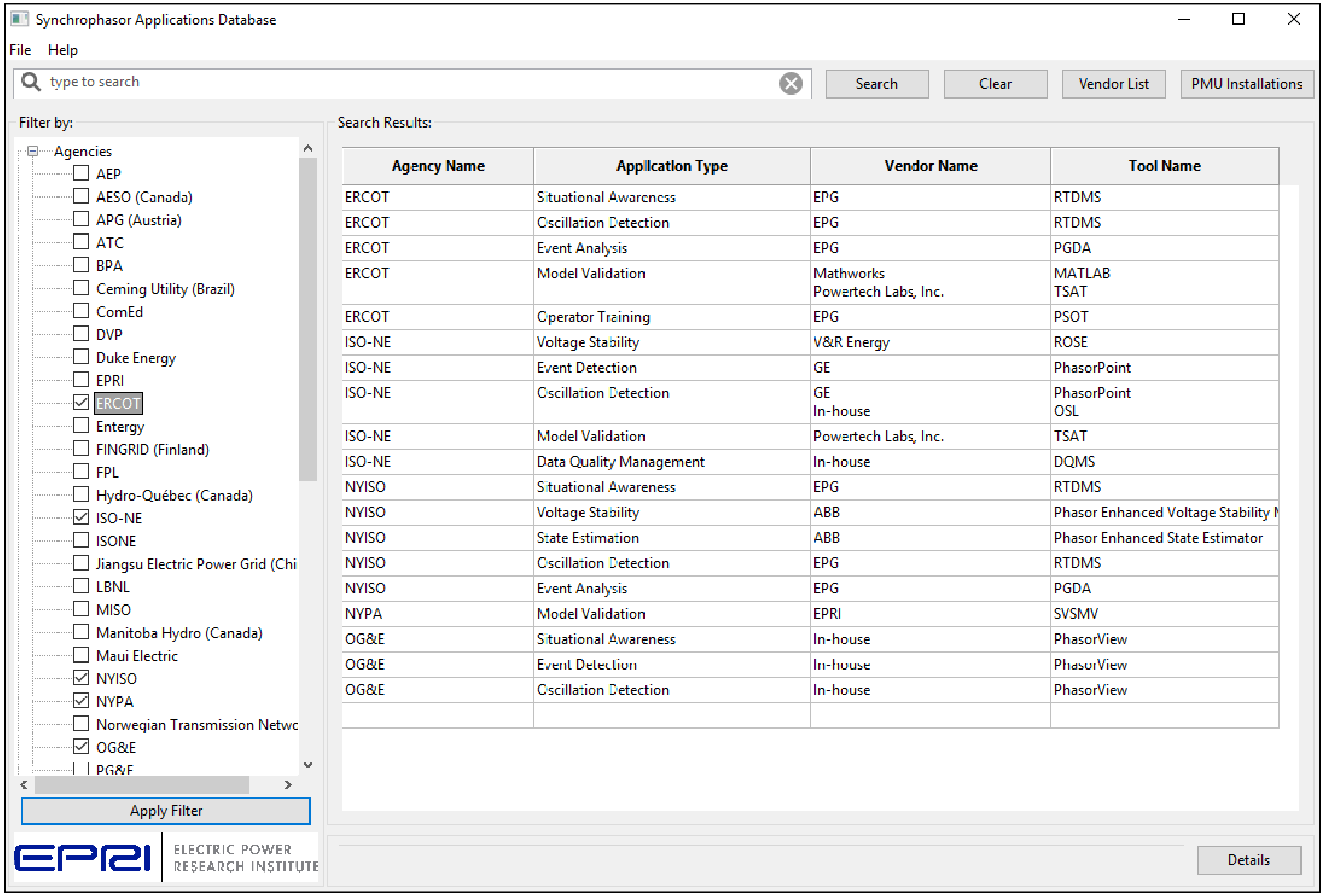
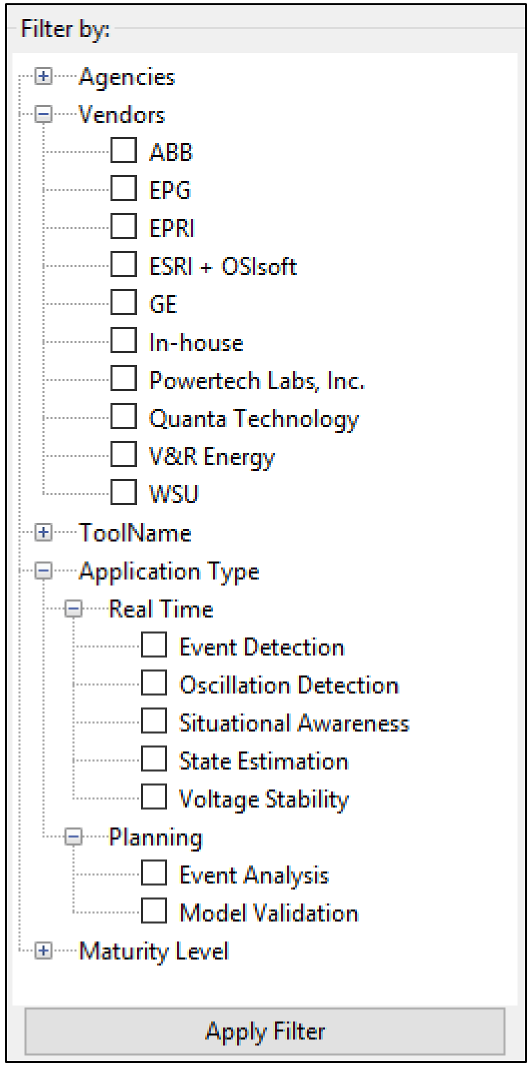
# 6. Synchrophasor Applications Database




| Agency Name | Application Type | Vendor Name | Tool Name |
|---|---|---|---|
| ERCOT | Situational Awareness | EPG | RTDMS |
| ERCOT | Oscillation Detection | EPG | RTDMS |
| ERCOT | Event Analysis | EPG | PGDA |
| ERCOT | Model Validation | Mathworks<br>Powertech Labs, Inc. | MATLAB<br>TSAT |
| ERCOT | Operator Training | EPG | PSOT |
| ISO-NE | Voltage Stability | V&R Energy | ROSE |
| ISO-NE | Event Detection | GE | PhasorPoint |
| ISO-NE | Oscillation Detection | GE<br>In-house | PhasorPoint<br>OSL |
| ISO-NE | Model Validation | Powertech Labs, Inc. | TSAT |
| ISO-NE | Data Quality Management | In-house | DQMS |
| NYISO | Situational Awareness | EPG | RTDMS |
| NYISO | Voltage Stability | ABB | Phasor Enhanced Voltage Stability |
| NYISO | State Estimation | ABB | Phasor Enhanced State Estimator |
| NYISO | Oscillation Detection | EPG | RTDMS |
| NYISO | Event Analysis | EPG | PGDA |
| NYPA | Model Validation | EPRI | SVSMV |
| OG&E | Situational Awareness | In-house | PhasorView |
| OG&E | Event Detection | In-house | PhasorView |
| OG&E | Oscillation Detection | In-house | PhasorView |




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





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