Development and Demonstration of a Phasor-Driven Tool for Adaptive Stability Model Calibration using GE PSLF

presented by

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Team:
PNNL – Renke Huang, Yuanyuan Li, Pavel Etingov, Henry Huang, Xinya Li, Shaobu Wang
GE Energy Consulting – Juan Sanchez-Gasca, Brian Thomas
GE Grid Solutions – Manu Parashar, Guru Pai
PEAK RC – Slaven Kincic, Alex Ning

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BONNEVILLE POWER ADMINISTRATION

PEAKRELIABILITY assuring the wide area view

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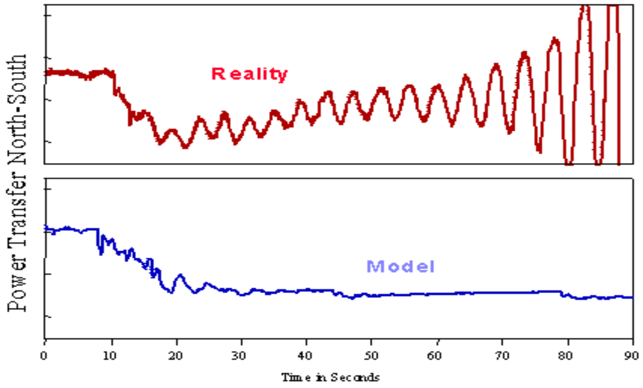
Goal: help industry to better meet NERC compliance requirements

- More stochastic and dynamic behavior observed in today's power grid
- Good model quality is critical for secure and economic planning and operation



- WECC policy and NERC standards requiring periodic model validation

NERC standards	Requirements
MOD-033	Steady-state and dynamic system model validation
MOD-026	Model&data for exciters
MOD-027	Model&data for governors

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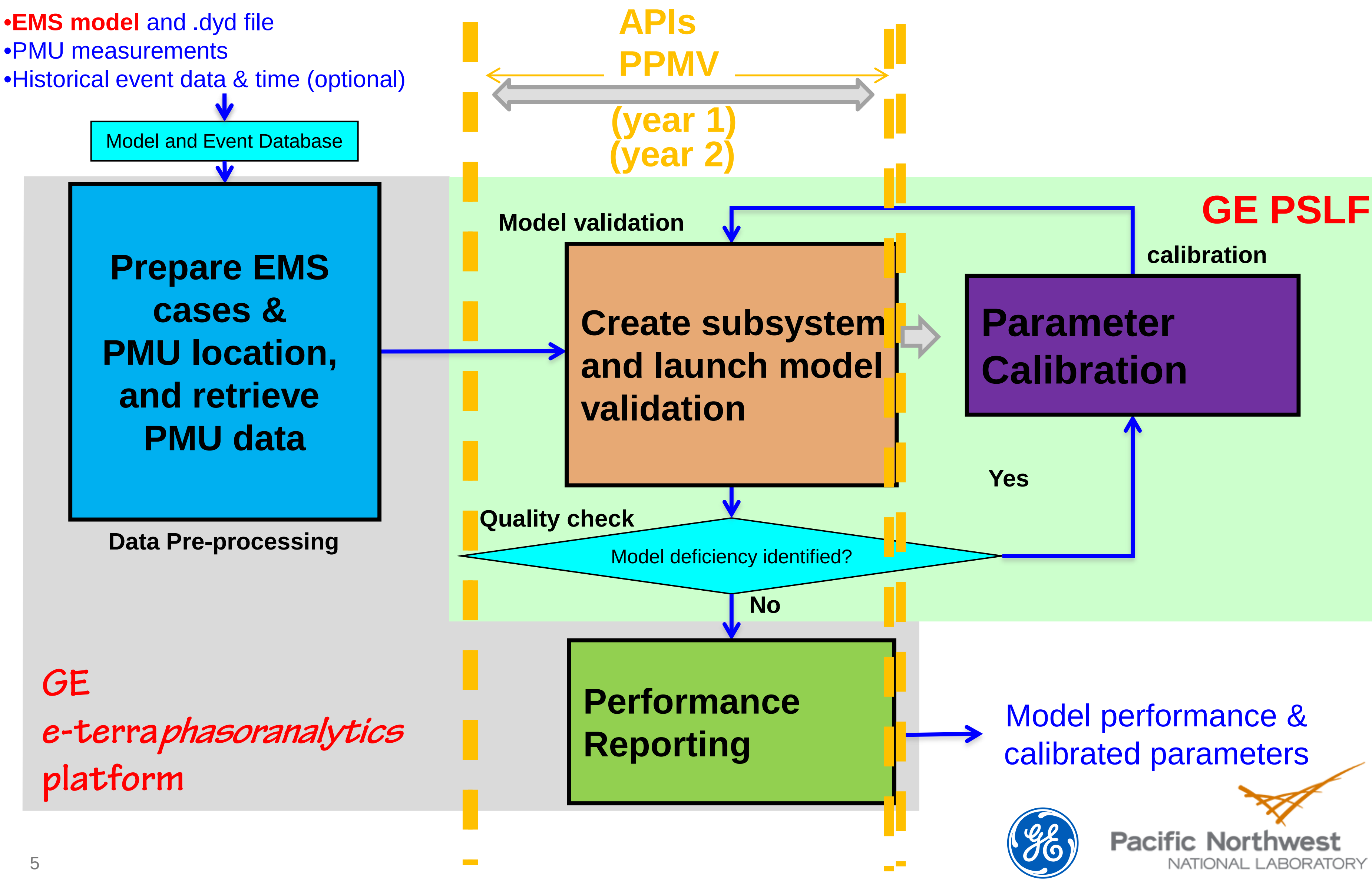
Overview of the Project

- Funded by the 2016 BPA Technology Innovation program; with cost share provided by DOE AGM program
- Objective: to develop a phasor driven tool for on-demand model validation and parameter calibration
- Project Team
  - PNNL: Ruisheng Diao, Henry Huang, Renke Huang, Pavel Etingov, Shaobu Wang, Yuanyuan Li
  - GE Energy Consulting: Brian Thomas, Juan Sanchez-Gasca
  - PEAK: Slaven Kincic, Alex Ning
  - GE Grid Solutions: Manu Parashar, Guru Pai
  - BPA: Gordon Matthew, Dmitry Kosterev, Steve Yang, Thong Trinh, Tony Faris, Greg Stults
- Timeline: Oct. 2015 – Sept. 2017

Key Innovation

- Gaps
  - Not easy to prepare cases for model validation studies
    - Link to PMU measurements
    - Link to operational information
  - Available calibration techniques are standalone tools, not integrated with validation function in commercial packages. Not easy for users
- We are developing a more integrated tool
  - Directly use real-time EMS cases for validation
  - Ease of use in creating archives of data needed for model validation/calibration, e.g., PMU data, EMS snapshots and calibrated parameters
  - Develop and study metrics for comparison of measured and simulated data

Architecture Design of the Tool



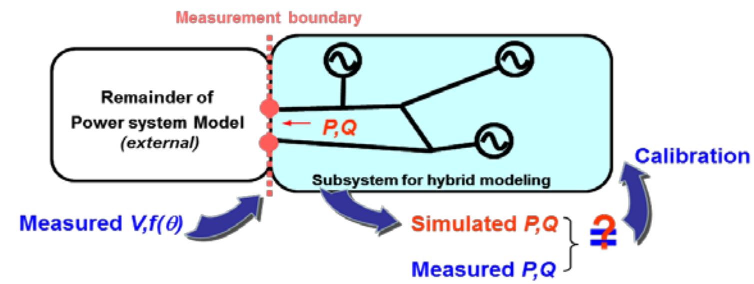
Developed Model Validation and Parameter Calibration Procedures

- **Step 1**: model validation via PPMV
  - Inputs: voltage, freq (or phase angle)
  - Outputs: active and reactive power

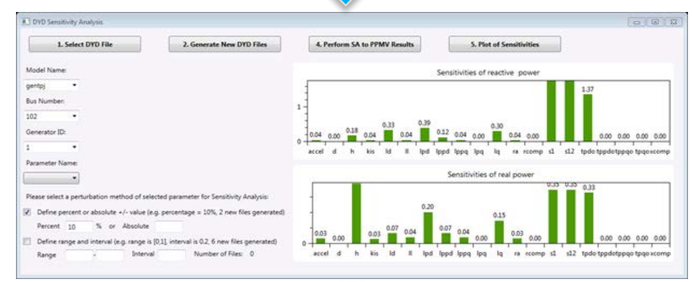
- **Step 2**: identification of problematic parameters
  - Sanity check: find unrealistic pars and status of controllers
  - A trajectory sensitivity approach

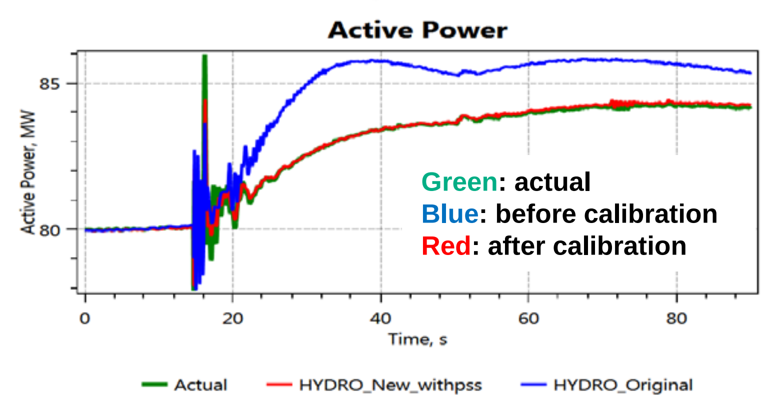
- **Step 3**: calibrating parameters using an ensemble Kalman filter approach

- **Step 4**: model verification using multiple events

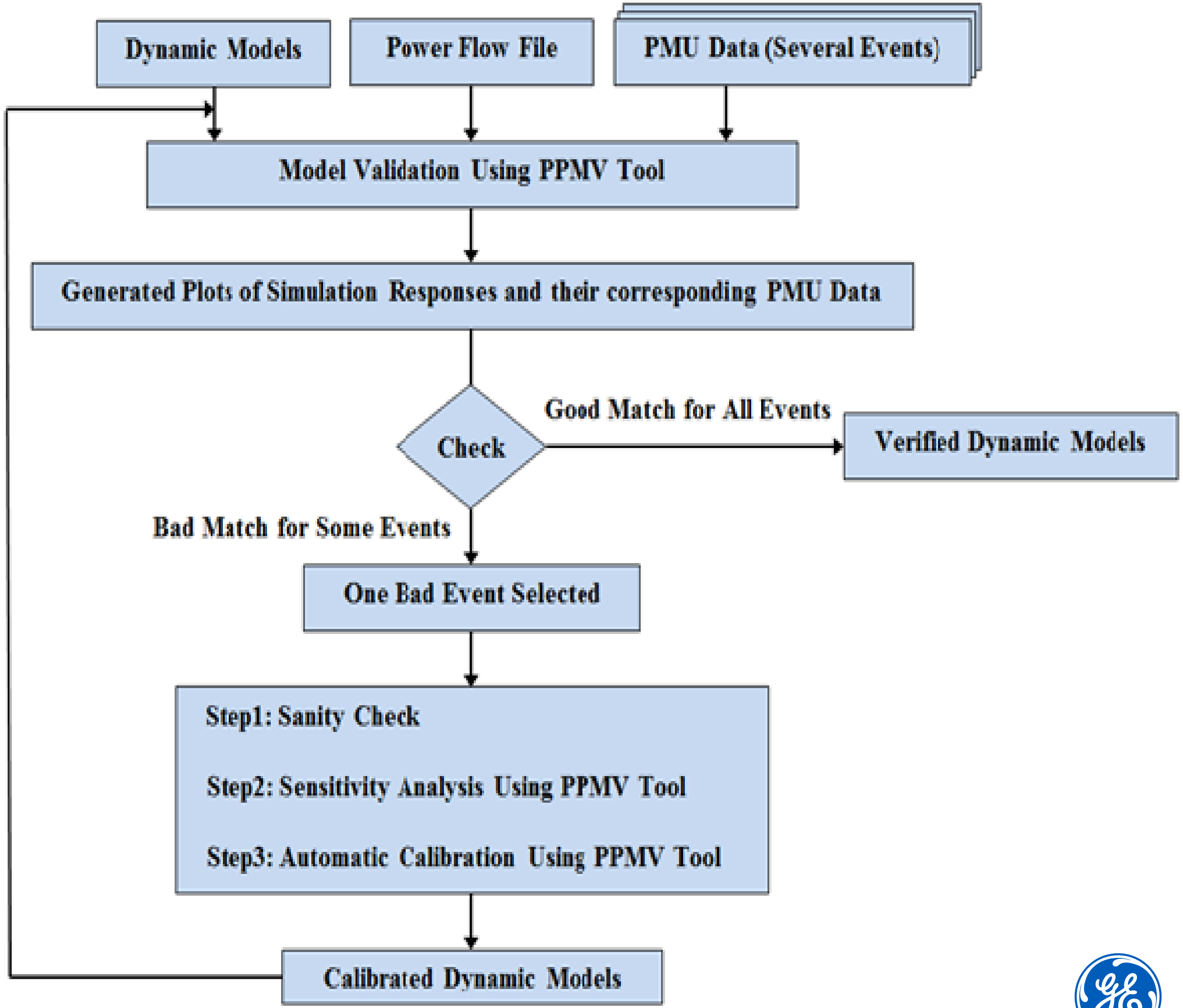


$$\begin{cases} \alpha_1 = \alpha_0 + \Delta\alpha \\ \alpha_2 = \alpha_0 - \Delta\alpha \end{cases} \rightarrow s(t) = \frac{x_1(t) - x_2(t)}{2(\Delta\alpha / \alpha_0)} \rightarrow S = \frac{1}{n}\sum_{t=1}^{n} |s(t)|$$





Main Flowchart



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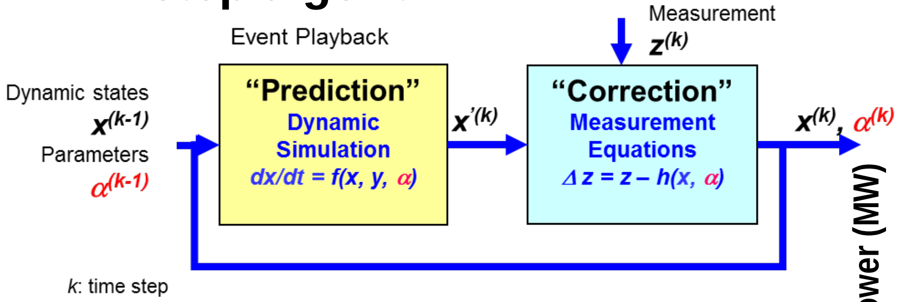
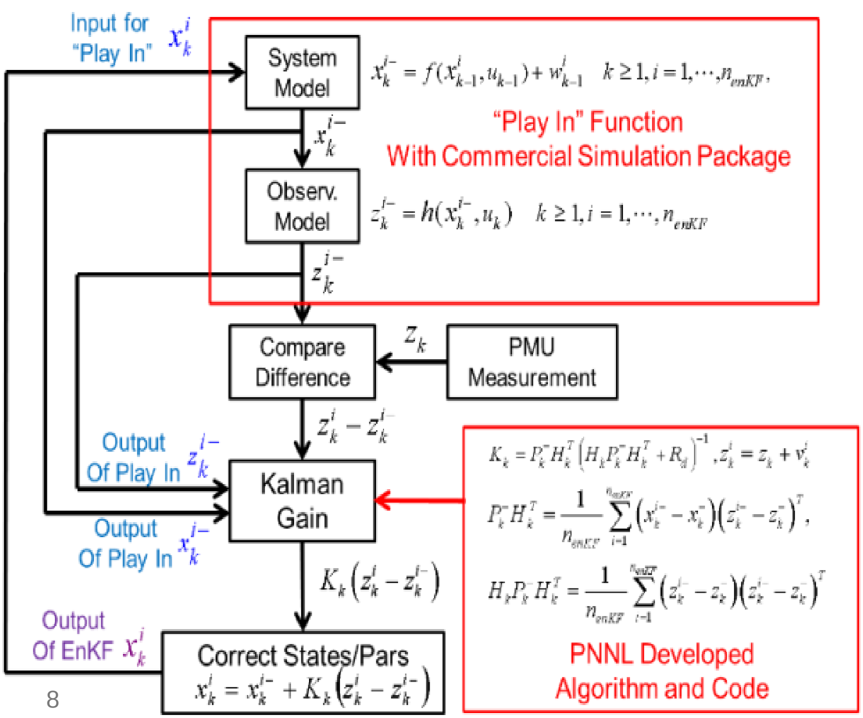
EnKF-Based Calibration Algorithm

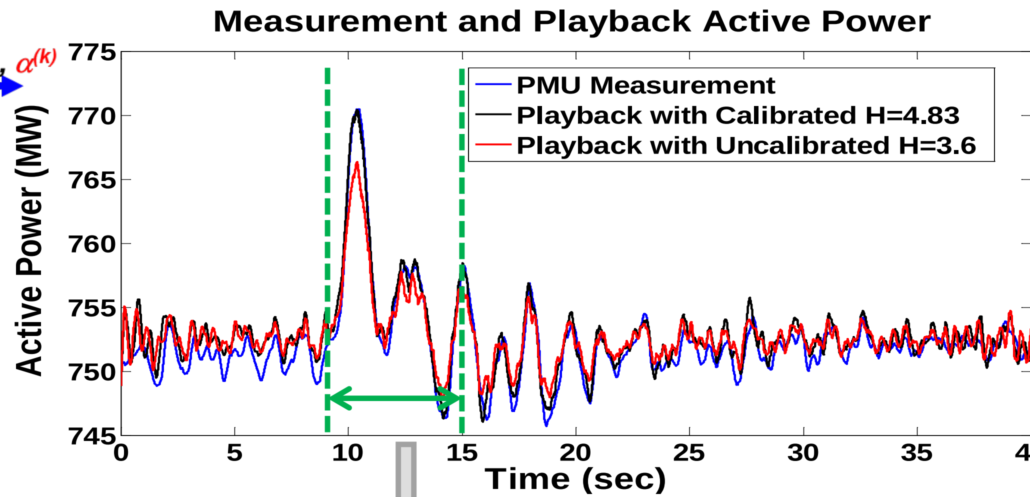
- **A 2-step algorithm**

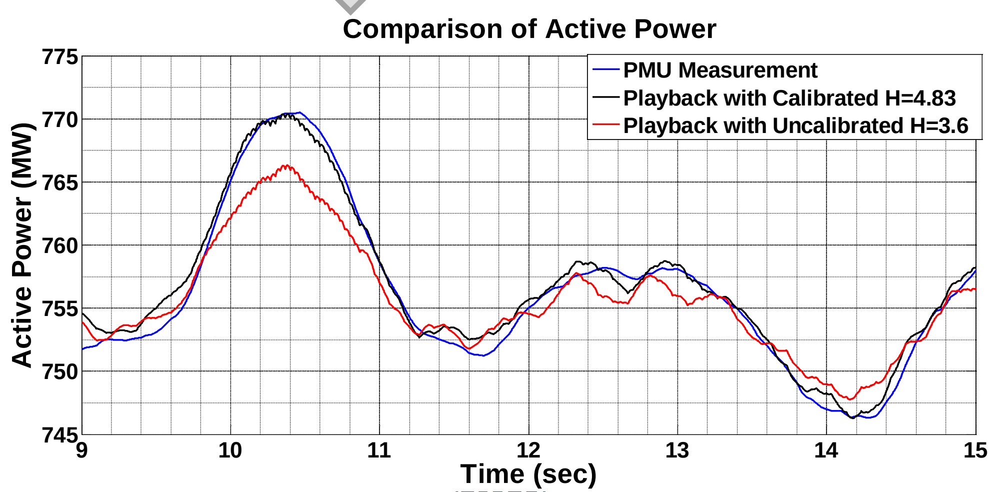


- **Main flowchart**



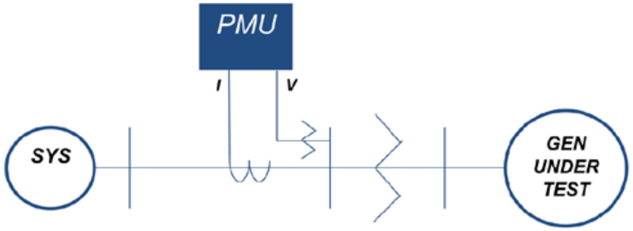
- Achieved good performance on actual WECC power plant



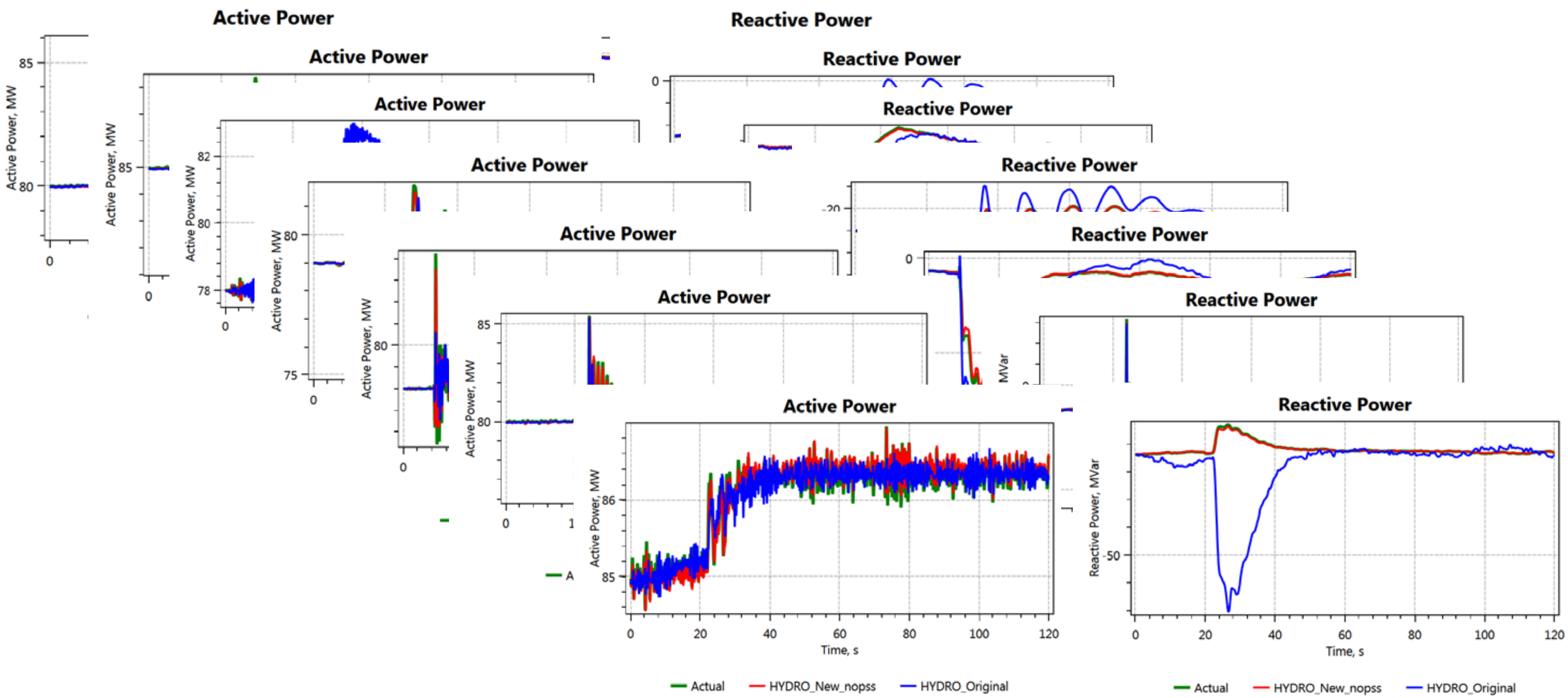


Calibration Performance on a Hydro unit

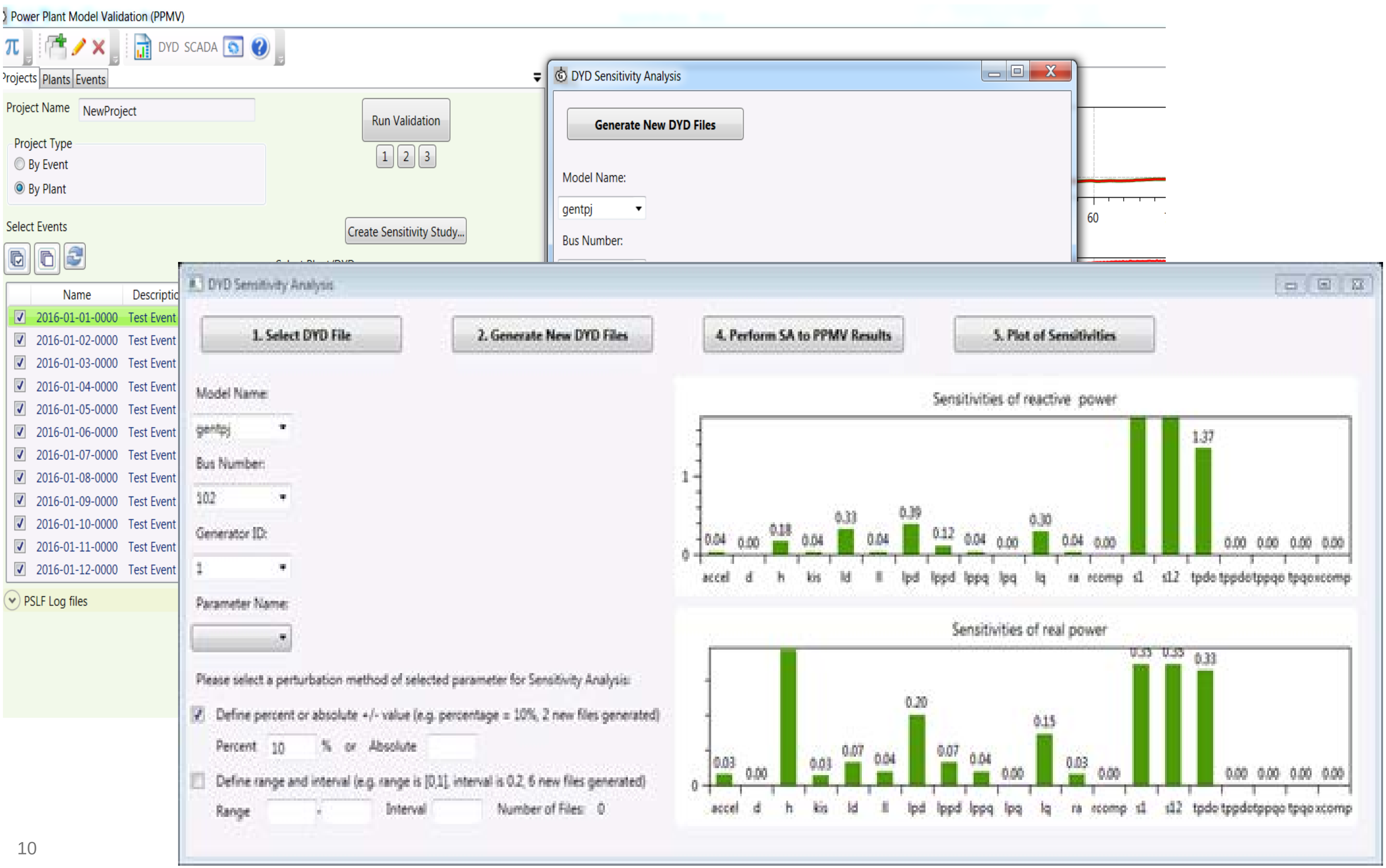
- A 75 MVA hydro unit, with unknown bad parameters and PMU measurements under 12 events
- Model performance after calibration



GENTPJ
ESST1A
IEEEG3
PSS1A



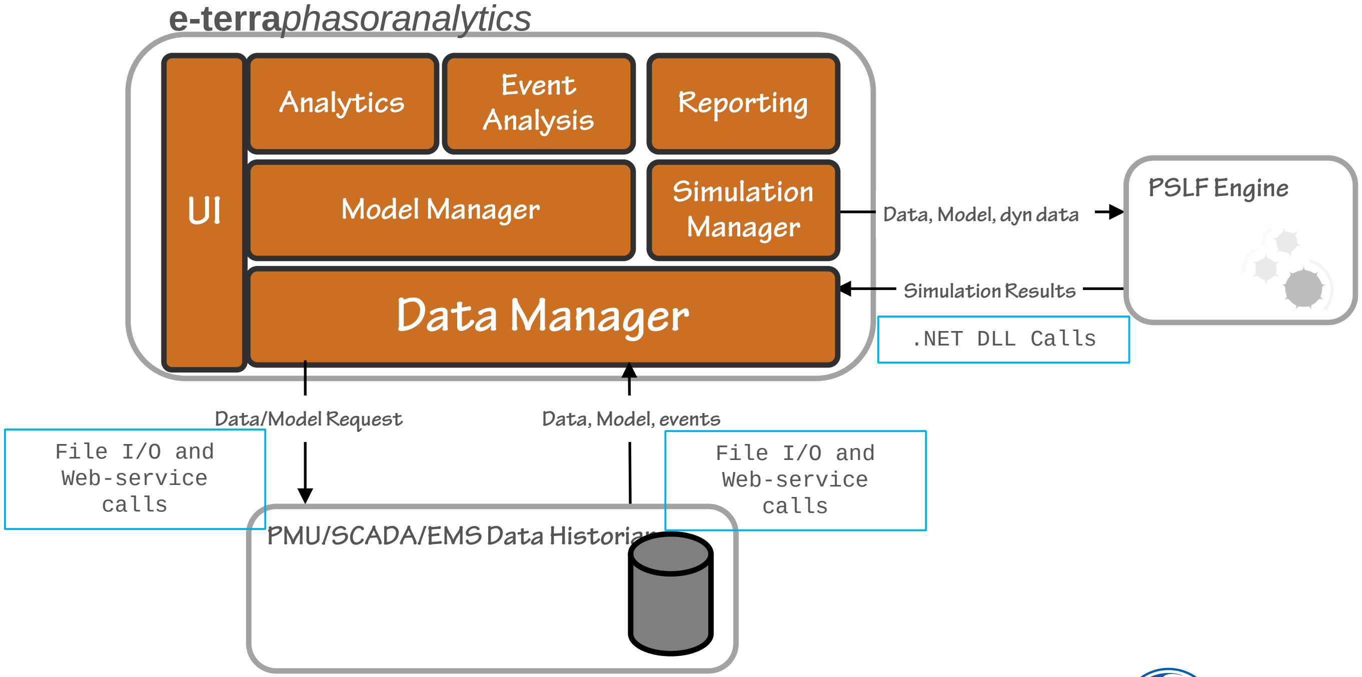
PPMV Tool with Sensitivity Analysis



e-terra*phasoranalytics*

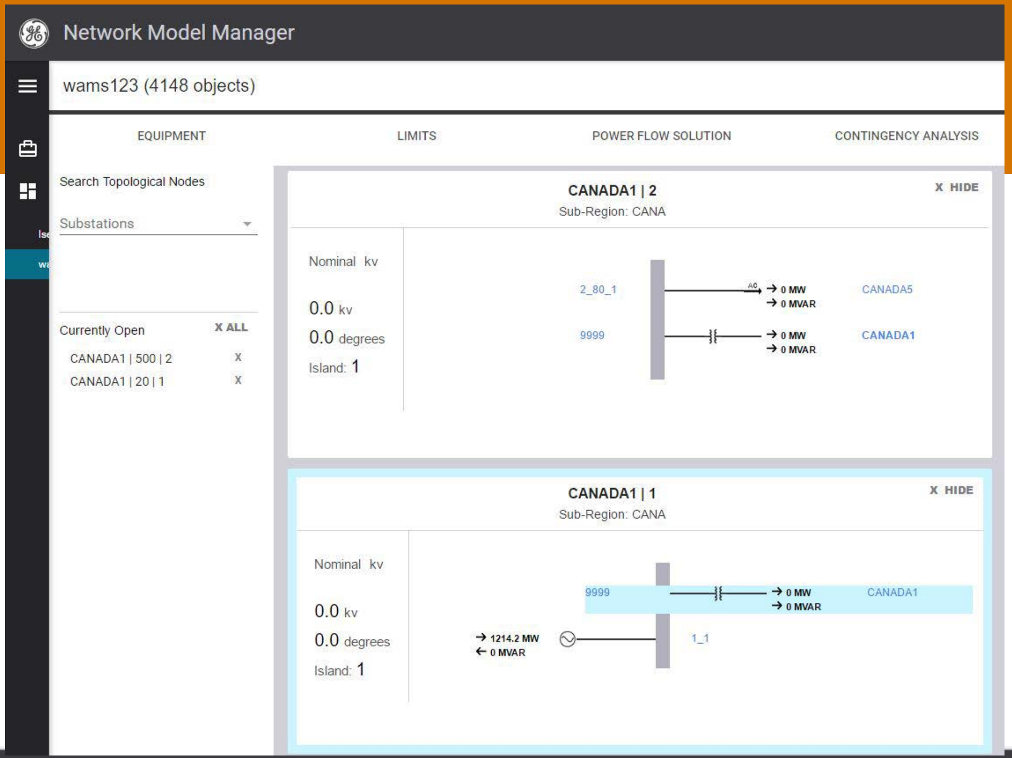
Integration Architecture

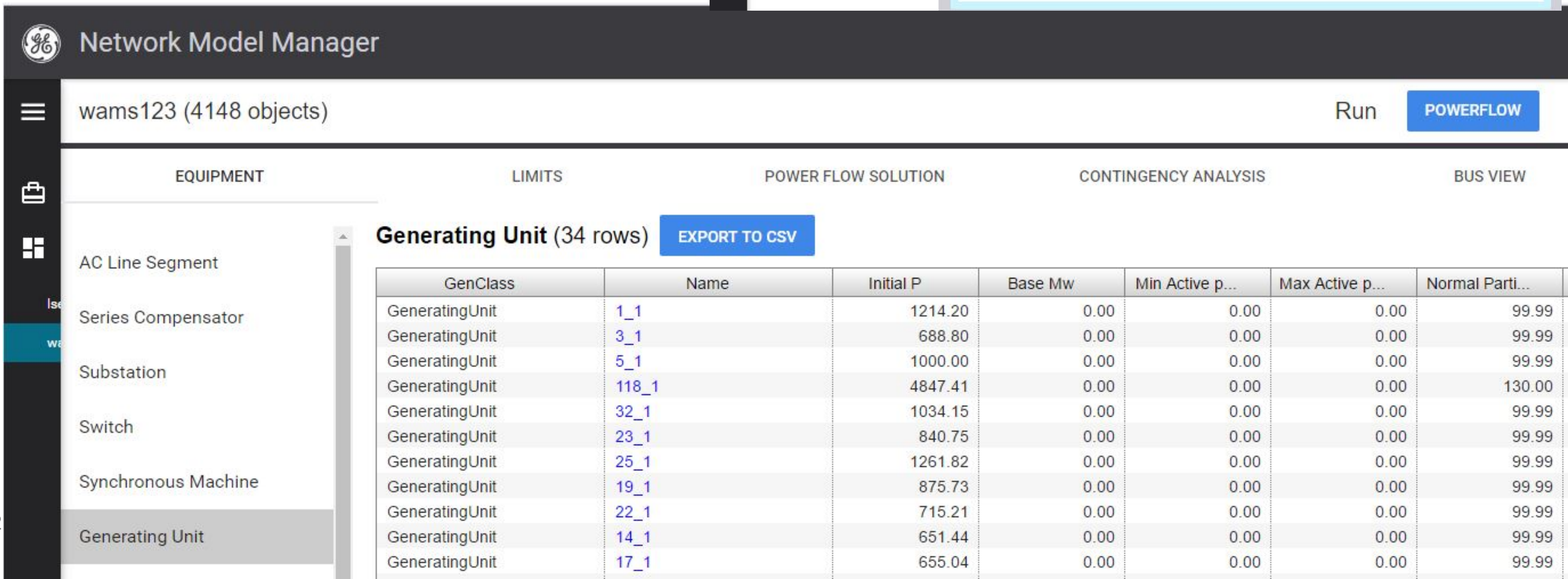
- Event based PMU data retrieval, from the PMU data repository.
- Consumption of operations Network case, and mapping to PMU measurements.
- Case preparation and launch PSLF.
- Retrieve, display and analyze simulation reconstruction with PMU observations.



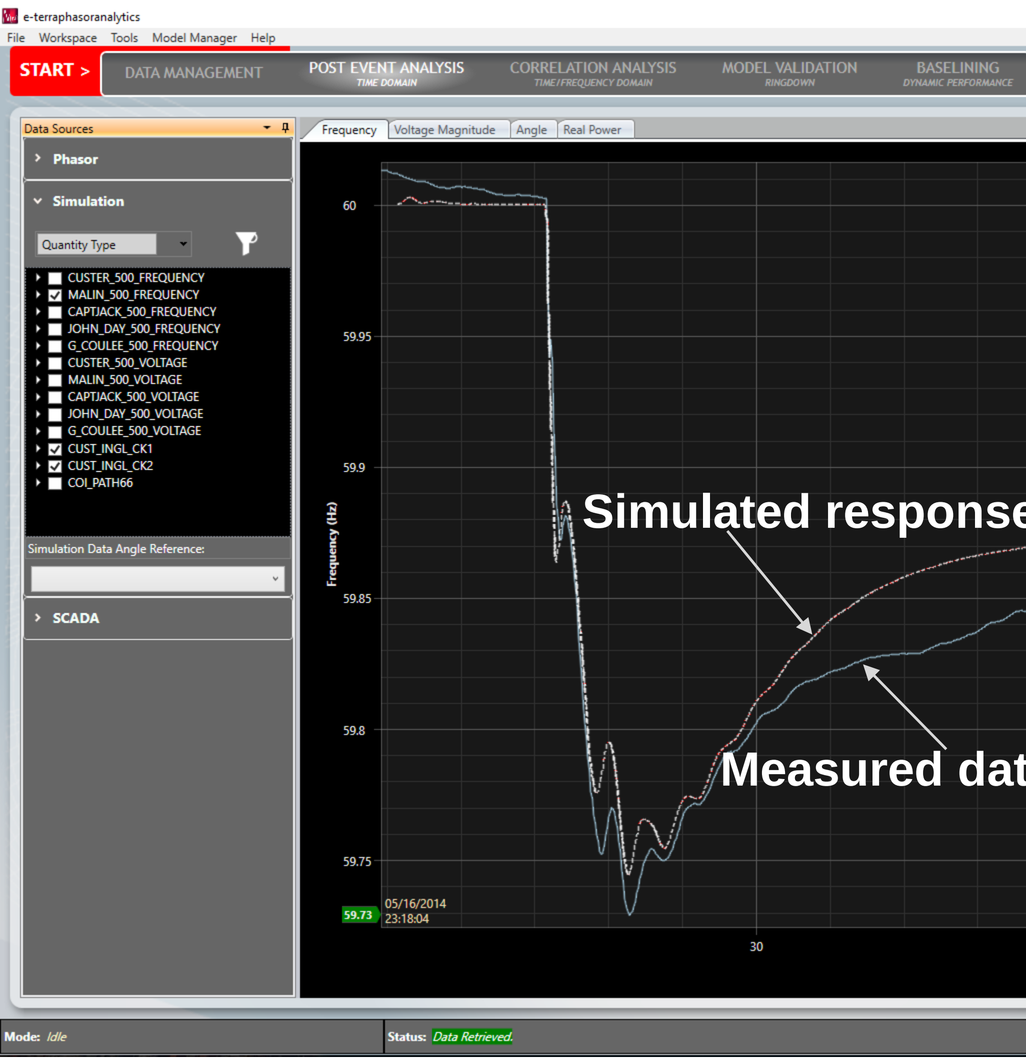
Model Manager

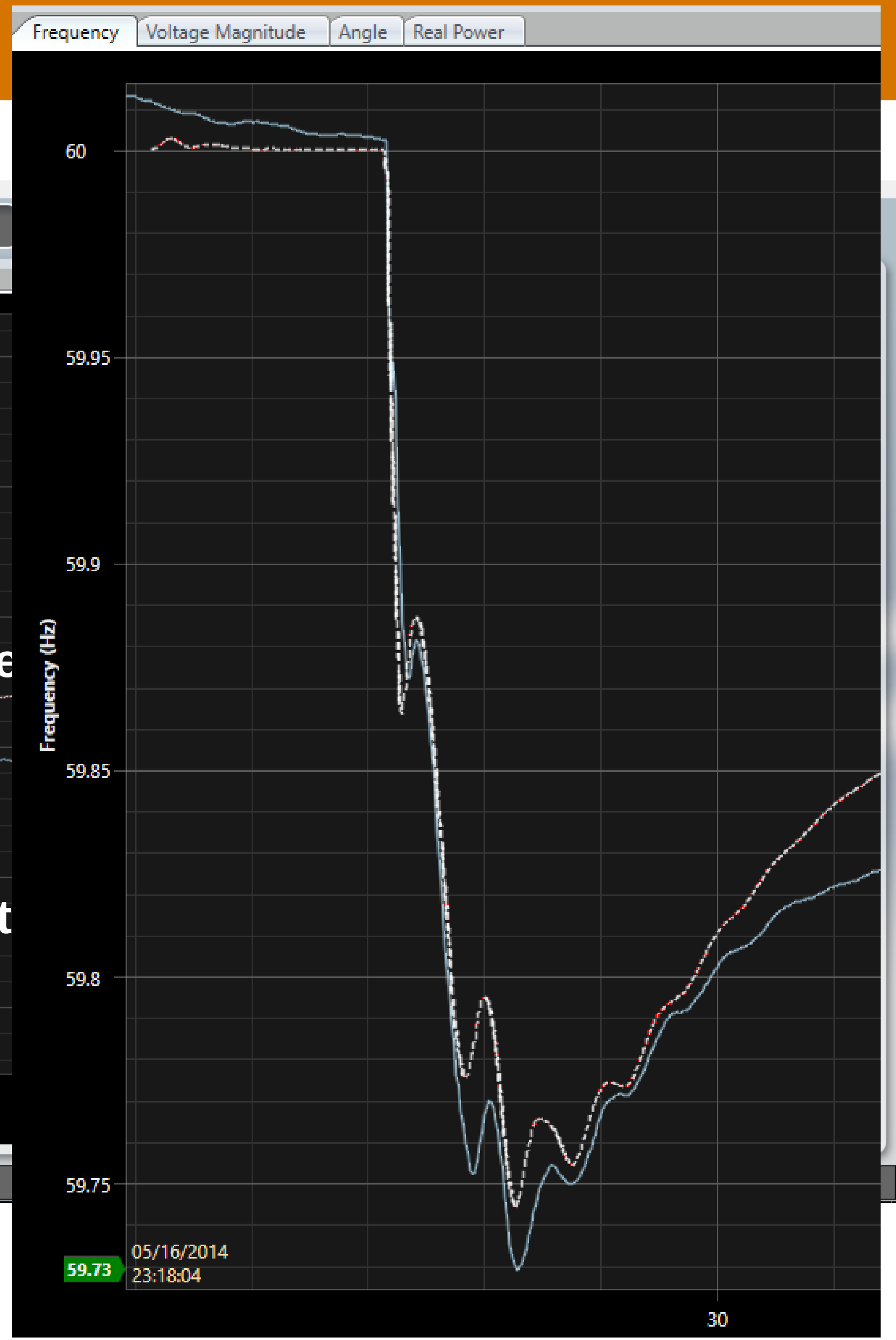
Allows the user to
- visualize the model
- Make changes
- Solve power flow
- Map PMU measurements to model "node" elements





Visualization of Results





Thank you!

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Publication:

Y. Li, R. Diao, R. Huang, P. Etingov, J. Sanchez-Gasca, B. Thomas, X. Li, Z. Huang, S. Wang, “An Innovative Software Tool Suite for Power Plant Model Validation and Parameter Calibration using PMU Measurements,” to be submitted to the 2017 IEEE PES general meeting.

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