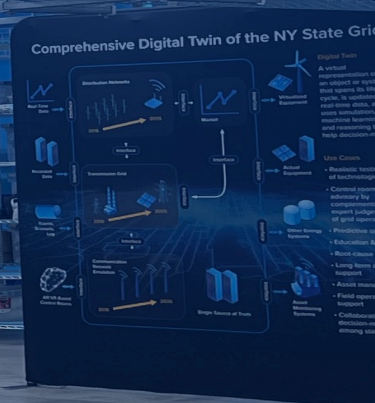


NASPI Hybrid Work Group Meeting and Vendor Show  
September 23-24, 2025 - Charlotte, NC

# Specialized Utility Testing Facility for Evaluation of PMU Solutions

Reza Pourramezan

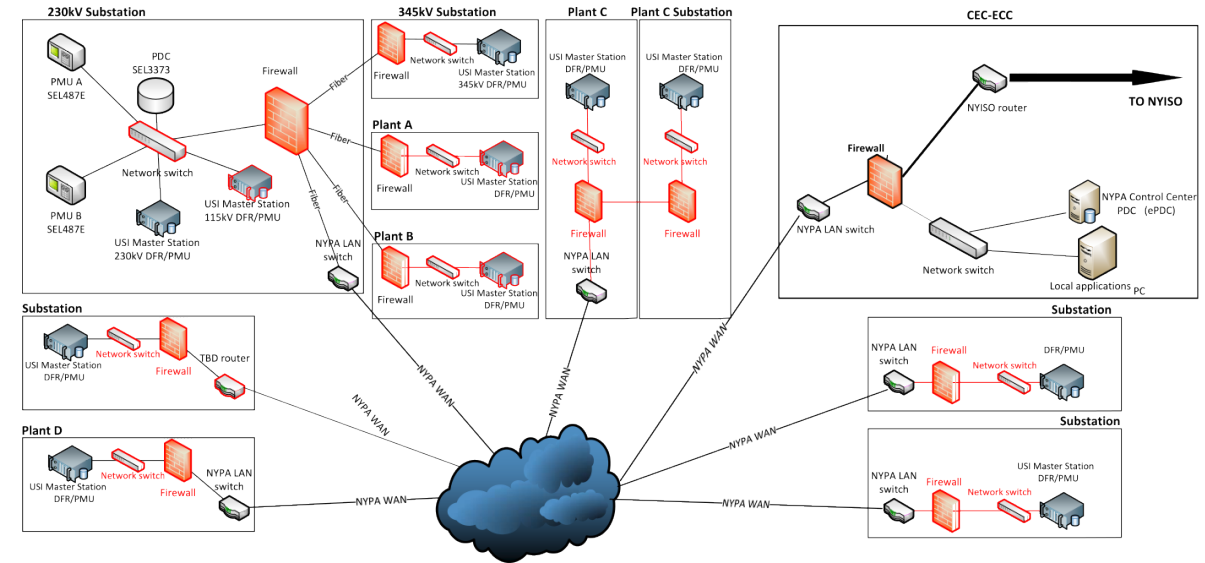
*Manager, Advanced Grid Innovation Laboratory for Energy (AGILE)*



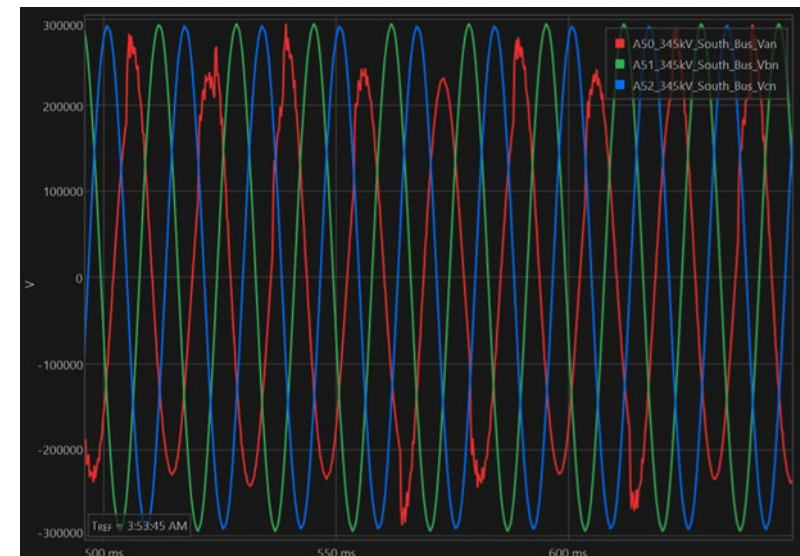


# Why Field Pilots Aren't Enough

- Fault Recording and Dynamic Disturbance Recording (DDR) are mandated for BES elements under **NERC PRC-002**.
- PMUs & DFRs streaming to the ISO PDC are **accepted as DDR-compliant**.
- Utilities want to **leverage existing devices** for asset health management, operations, and advanced analytics.
- **Conventional field pilots are too slow** — they rely on rare events or faults.
- **High effort, low yield** — months of testing may not expose critical scenarios.
- **Unclear use cases** — pilots often stall before scaling.
- As a result, most **utilities fail to unlock the full value of their PMUs**.

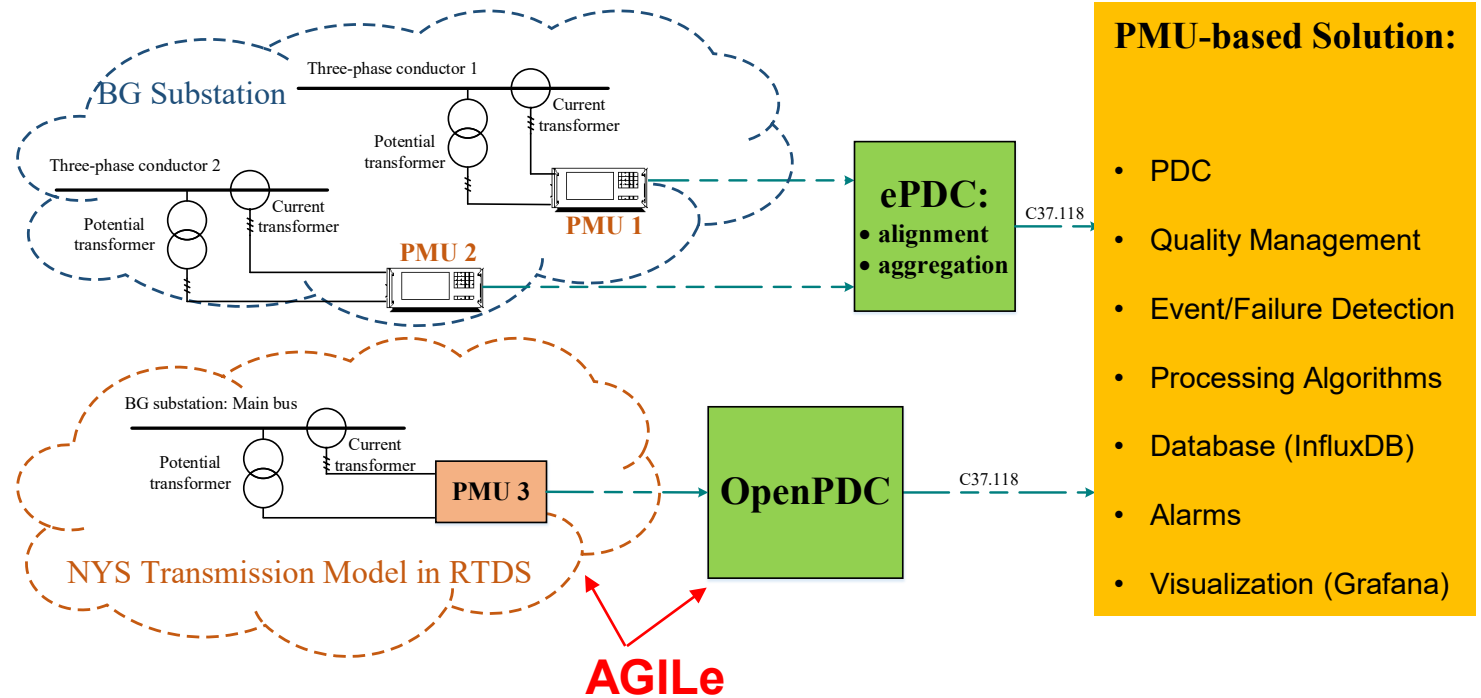


*PMUs are already in place for compliance—yet utilities struggle to unlock their full value!*



# Accelerated Validation Through Utility Testbeds

- **Concept:** Replace years of slow, uncertain field pilots with **controlled, repeatable lab evaluations** → get results in weeks, not years.
- **Utility-owned environment:** Independent from vendors, aligned with operational need. → utility sets the agenda
- **Scalable validation:** solutions are tested across different **substations, equipment, and use cases** → confidence in results, no surprises in the field
- **Reliability focus:** PMU-based solutions may not directly control the grid, but their outputs guide asset health decisions and model accuracy. They must be **secure, reliable, and free of false alarms**.
- **Risk reduction:** Avoids reliance on rare faults/events while ensuring fidelity → ensure confidence that when an alarm is raised or a model is flagged, utility can trust the result.



*From rare filed events → to accelerated test cycles*

# About the New York Power Authority

- Established by the NY State Legislature in 1931, and NY State Canals is a subsidiary since 2017
- NYPA is the largest state-owned electric utility in the United States

**17**

Generating  
Facilities

**1,550**

Circuit-Miles of  
Transmission  
Lines

**1,000+**

Customers

**67**

PMU/DFR

@ 11 Locations

1544 Channels

**\$10.4 Billion**

Total Assets

**\$3 Billion**

Operating Revenue



# NYS Ambitious Decarbonization Goals

## STATE ENERGY POLICY MANDATES

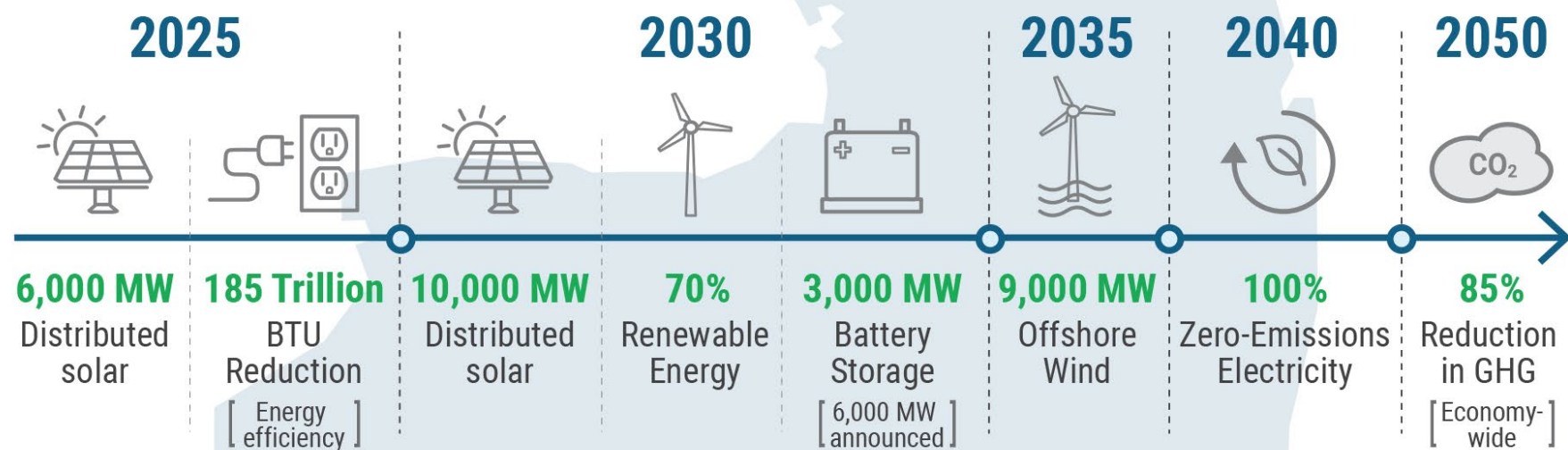


Image Source: Page 13 of

<https://www.nyiso.com/documents/20142/2223020/2023-Power-Trends.pdf/#:~:text=Originally%20published%20June%207%2C%202023,Public%20Policy%20Transmission%20Need%2C%20and>



## Advanced Grid Innovation Laboratory for Energy

A Digital Service of the New York Power Authority

### Enabling an Affordable, Reliable, Low-Carbon Future



**Grid of the Future**

- Need a platform to evaluate the grid of the future
- Need a facility to prototype solutions
- Need a platform to safely and realistically test and demonstrate solutions



**AGILe**

**A state-of-the-art power systems laboratory to enable an affordable, reliable, low-carbon future power grid by providing a close-to-real testing environment that facilitates identifying and solving grid related challenges**

# AGILE Components and Capabilities At-A-Glance

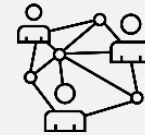
## Capabilities Outcomes



Grid Modeling and Simulation



Real-time hardware & software in the loop simulation



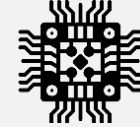
Communication Network Emulation



Economic Analysis

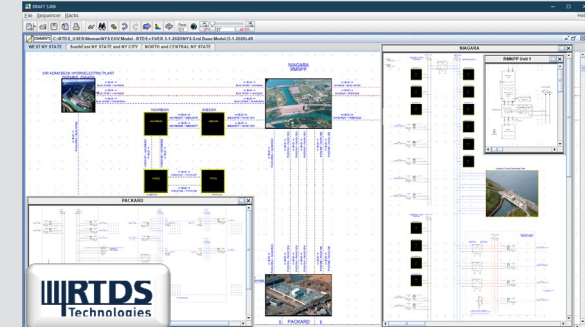
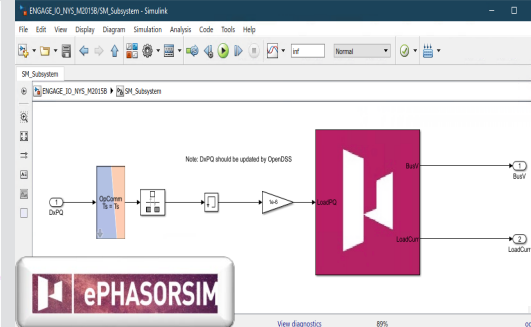
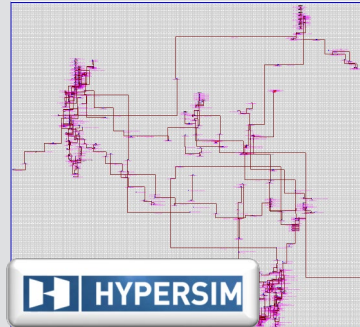
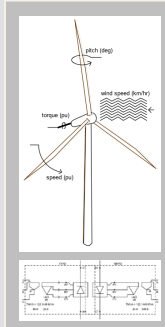
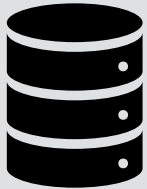


Application Development



Hardware Testing

## NYS Grid Models & Data



## Apps

OpenDSS

PSCAD

PSSE

EMTP

MatLab

DSATools

CYME

RSCAD

HYPERSIM

ePhasorSim

EXATA

GE-MAPS

## Servers Simulators

RTDS

OPAL-RT

TSAT Server

Communications Emulator

MAPS Server

Work Stations

## Hardware Devices

Relays

Intelligent Electronic Devices

Amplifier

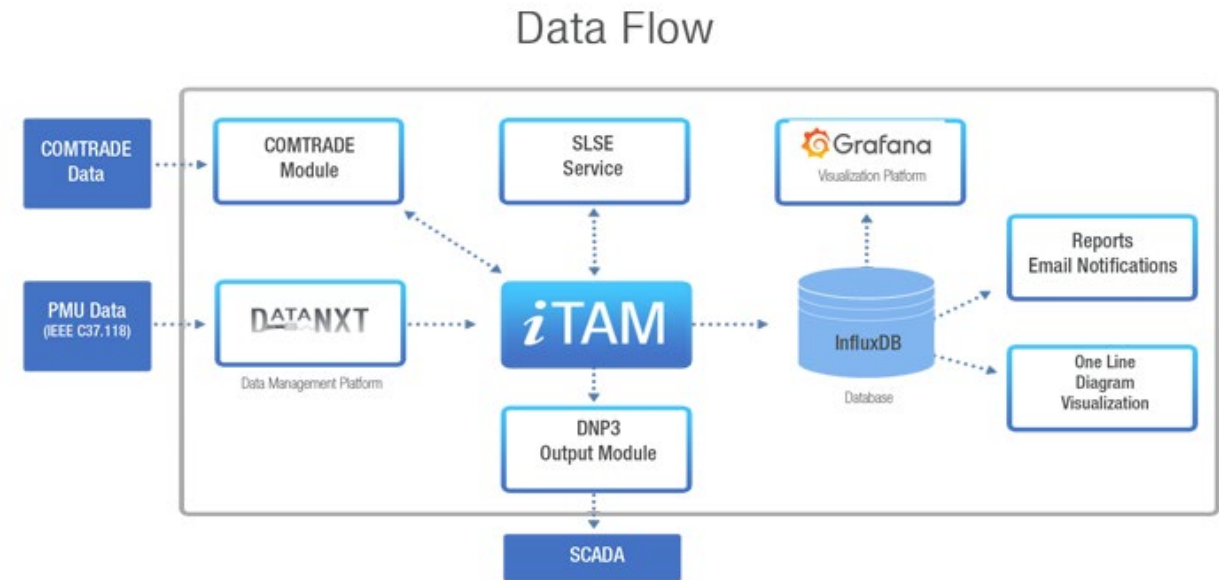
GPS Clock

Substation Mockup

# Overview of Piloted Solutions

## Intelligent Transmission Asset Monitor (iTAM) by *Electric Power Group*

- ❑ Monitors and analyzes equipment signatures and alert relevant personnel to facilitate pre-emptive checking, repairs and other actions to prevent potential catastrophic failures.
  - Monitoring of all three phases
  - Failure detection using three different methods: one model based and two data-driven methods
  - Alarm panel with nine alarms for each equipment
  - Alarms visualized in real time on one-line diagrams, alarm panels and on historical dashboard
- ❑ Architecture layers:
  - Data conditioning layer for PMU data quality validation.
  - Database for storing real-time and historical data.
  - Web-based visualization platform with alarm
  - Email Notifications for Alarms

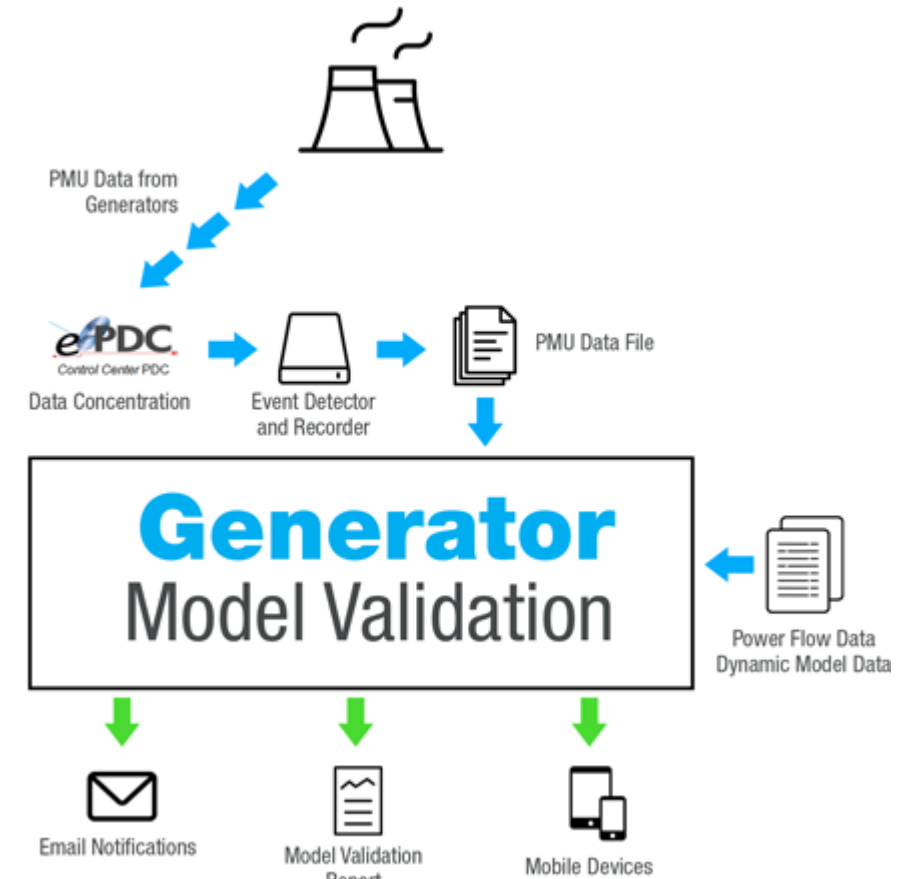




# Overview of Piloted Solutions

## Automated Generator Model Validation (AGMV) by *Electric Power Group*

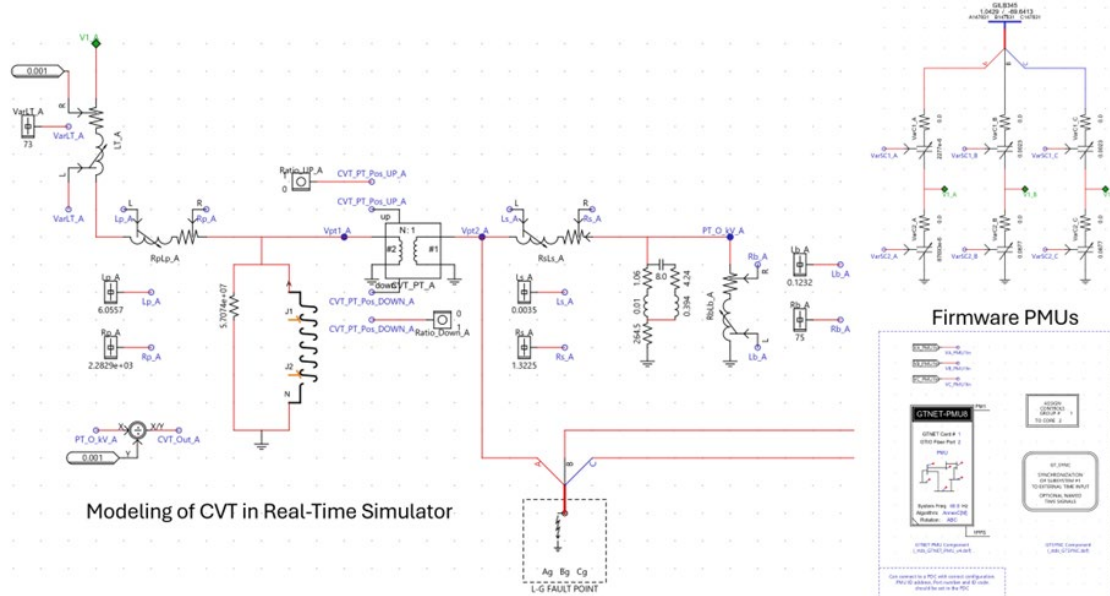
- ❑ Validates generator dynamic models against PMU/DFR-measured responses.
  - Data acquisition and conditioning of PMU streams.
  - Automated Event detection and recording to identify events.
  - Dynamic simulation and comparison of generator response.
  - Quantification of mismatch between simulation and generator response
  - Sensitivity analysis and calibration to fine-tune model parameters.
  - Automated reporting and notifications for compliance and documentation.



# EMT Modeling for Real-Time Simulator

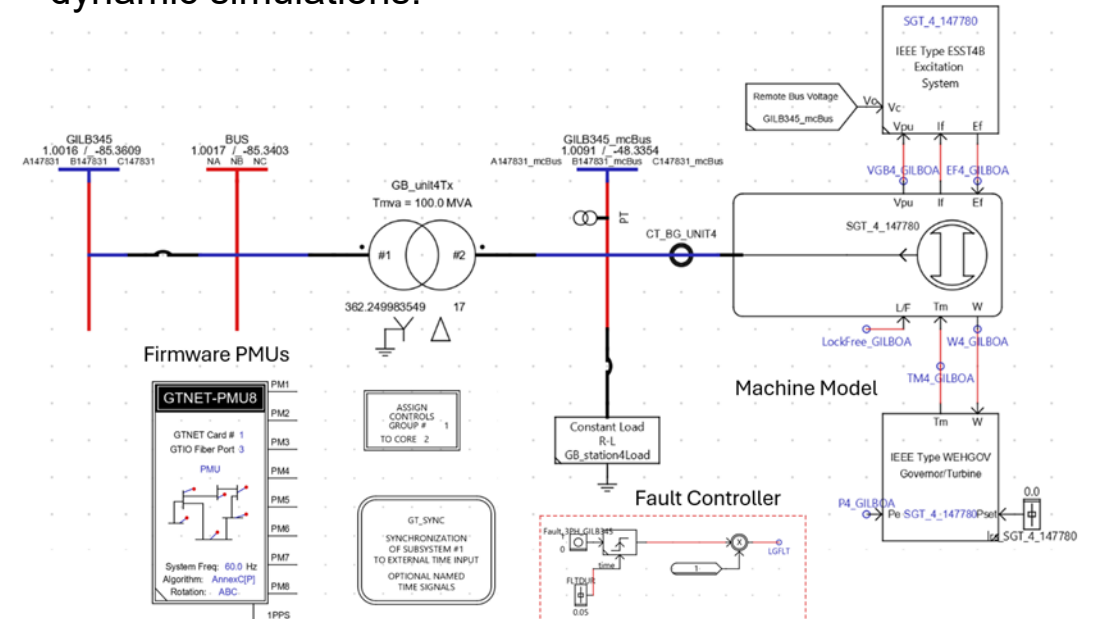
## Capacitive Voltage Transformer (CVT) model

- Detailed EMT model of CVT implemented in the real-time simulator
- Includes CT/PT representation to capture realistic measurement behavior
- Additional blocks add noise and harmonics for realistic PMU inputs
- Fault controller enables simulation of internal and external fault scenarios
- Provides synthetic PMU data for testing AITM



## Synchronous Generator & Controls Model

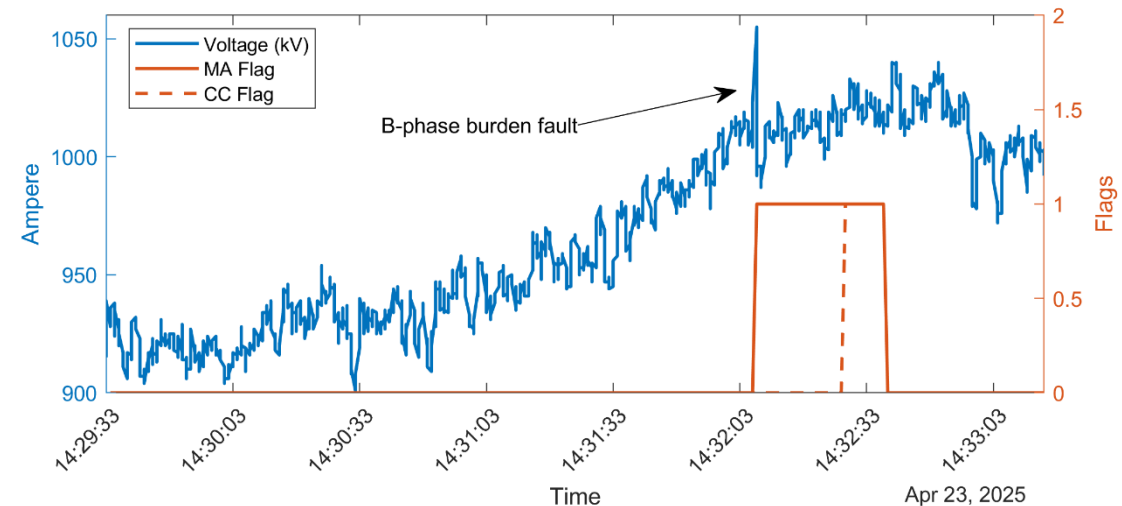
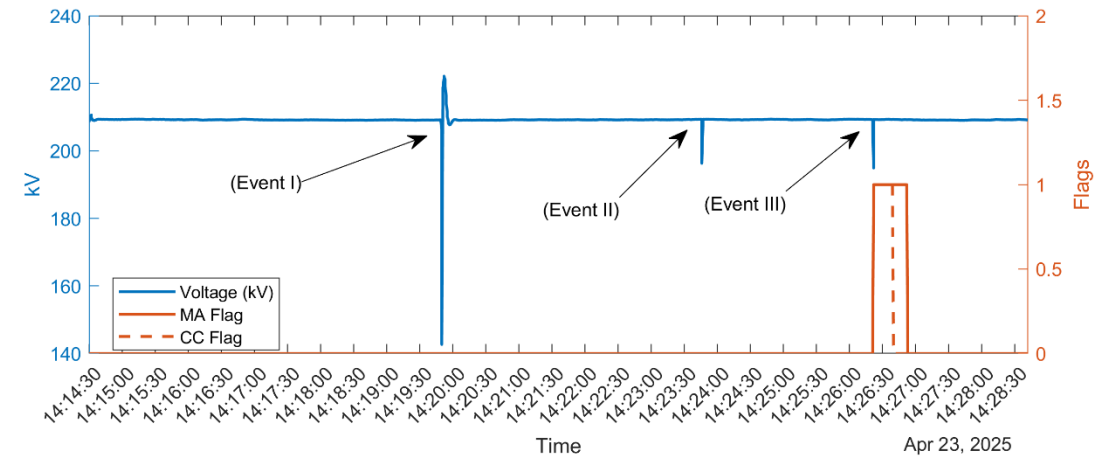
- Detailed synchronous generator model with exciter and governor controls.
- Connected via step-up transformer to represent realistic plant conditions.
- Firmware PMUs capture CT/PT data from the low-voltage side of the GSU.
- Data streams synchronized and sent via openPDC to the AGMV application.
- Supports event replay and model validation against dynamic simulations.





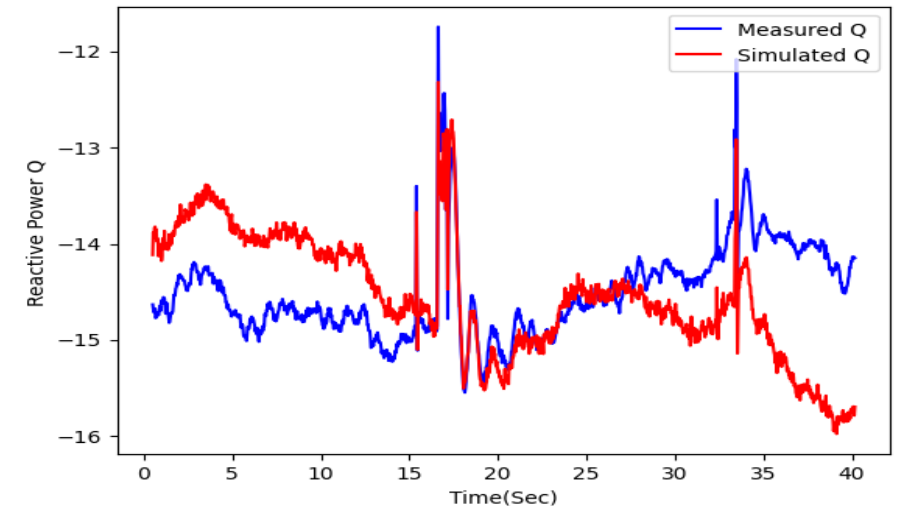
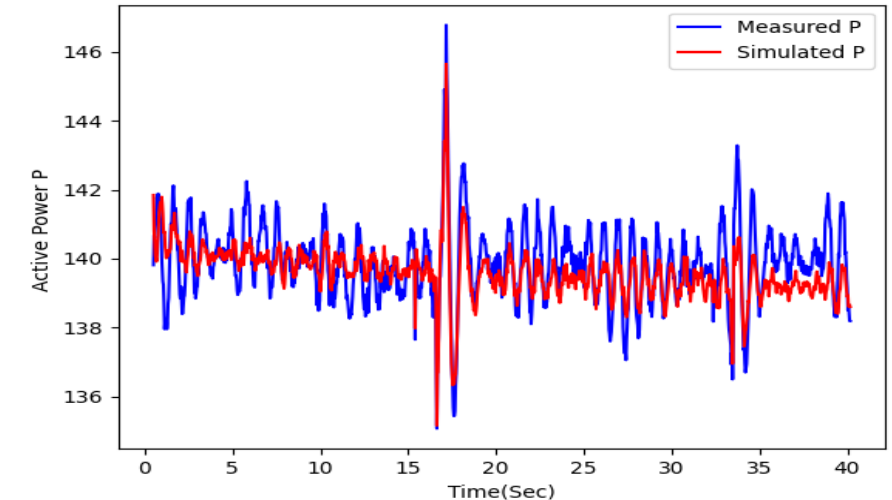
# Key Findings: iTAM

- **Evaluation approach:** Diverse CT/PT/CVT faults emulated in real-time simulator (RTS).
- **Algorithms tested:** Control Chart (CC) and Moving Average (MA) flags.
- **Event I (system-level):** Correctly ignored → no false alarms.
- **Event II (3-phase CVT fault):** not flagged → detection logic not yet implemented.
- **Event III (single-phase CVT fault):** successfully flagged.
- **Burden fault (CT B-phase):** flagged as anomaly, confirming capability.
- **Accuracy matters:** Effective at distinguishing true equipment faults from normal disturbances.
- **Value to utility:** Builds **confidence in alarms** for asset monitoring; reduces wasted effort from false alarms while ensuring real faults are caught.



# AGMV Validation using Field PMU Data

- **Scenario:** Real **line trip** event on the New York State transmission system.
- **Method:** “Playback” approach — field PMU voltage/angle data fed into generator dynamic model.
- **Results:** Simulated **active (P)** and **reactive power (Q)** closely matched PMU measurements.
- **Accuracy metrics:**
  - $\text{RMSD} = 0.0058 \text{ (P)}, 0.053 \text{ (Q)} \rightarrow \text{within } <0.1 \text{ criteria.}$
  - $\text{Comprehensive Similarity} = 0.722 \text{ (P)}, 0.457 \text{ (Q).}$
- **Observations:** Slight mismatches due to generator operating in its **rough zone** (<50% rated capacity) causing oscillations.
- **Limitation:** Positive-sequence simulations can't fully capture fast real-world dynamics.
- **Takeaway:** Field validation shows AGMV can **credibly verify generator models** against actual disturbances

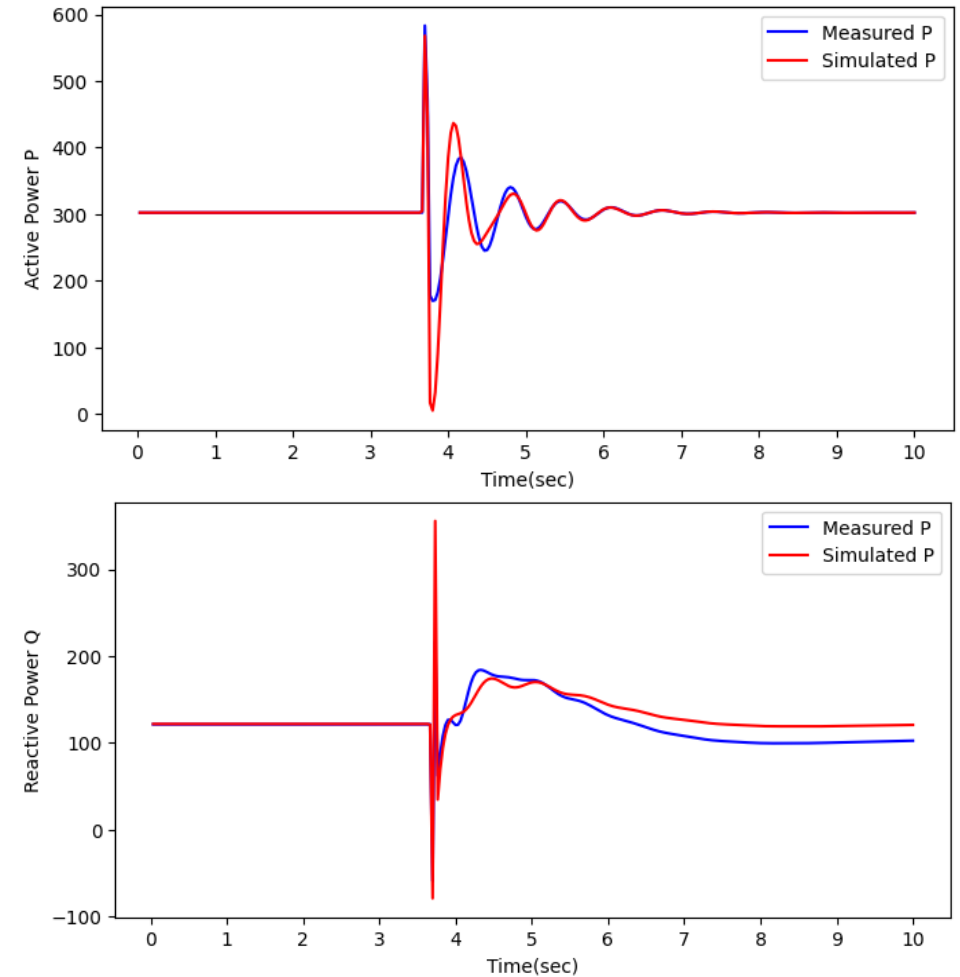


Variable	P	Q	Criteria
RMSD	0.005804	0.053066	<0.1
Comprehensive Similarity	0.722	0.457	>0.7



# AGMV Validation with RTS-Synthesized Event

- **Scenario:** Synthetic **3-phase fault** applied at 345 kV bus near generator in RTS.
- **Method:** RTS in-built PMU emulator provided measurement streams; AGMV compared against positive-sequence simulation..
- **Results:** Simulated **active (P)** and **reactive power (Q)** tracked RTS PMU outputs closely.
- **Accuracy metrics:**
  - RMSD = 0.0445 (P), 0.0869 (Q) → within <0.1 criteria.
  - Comprehensive Similarity = 0.759 (P), 0.732 (Q).
- **Observations:** Small mismatches due to time-step resolution differences (EMT-level RTS vs positive-sequence simulation).
- **Added Value:**
  - Controlled, repeatable events possible without waiting for rare faults.
  - Ability to inject noise, harmonics, and transformer effects → more realistic validation.
  - Supports systematic testing of AGMV logic before scaling in the field.
- **Takeaway:** RTS-based validation shows the unique value of utility testbeds in accelerating PMU application evaluation



Variable	P	Q	Criteria
RMSD	0.0445	0.0869	<0.1
Comprehensive Similarity	0.759	0.732	>0.7

# Lessons Learned and Path Forward

- ❑ **Utility testbeds accelerate validation:** Controlled, repeatable simulations reduce reliance on rare field events, shortening pilot cycles.
- ❑ **Confidence in applications:** AITM and AGMV showed capability to detect true anomalies and validate models, while also exposing current gaps for improvements.
- ❑ **Alarm reliability is critical:** Reducing false positives is as important as detecting real faults — trust in PMU-based alarms determines usefulness for asset management.
- ❑ **Integration opportunities:** Event correlation with EMS/SCADA data can strengthen asset management insights.
- ❑ **Scalability potential:** Framework can be extended to other generator units and equipment types, supporting utility-wide deployment.
- ❑ **Future improvements:**
  - Incorporate logic for complex CT/PT/CVT event types (e.g., 3-phase CVT faults).
  - Enhance algorithms to filter noise and avoid false alarms on CT secondary circuits.
  - Perform sensitivity analysis and parameter tuning to improve AGMV robustness.
  - Improve event classification using ML training and validate against field events.
- ❑ **Strategic value:** Utility-owned testbeds de-risk vendor solutions, reduce cost of field pilots, and set a model for global adoption of innovative PMU applications.



# AGILE

Advanced Grid Innovation Laboratory for Energy



## Fueling Innovation

Smart Solutions for Exploring an Affordable,  
Resilient, and Reliable Future Grid

## Catalog of Services

For ISOs, Electric Utilities, Industry,  
Government and Academic R&D



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