Automated Power Plant Model Verification (APPMV) at ISO New England

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Business Needs and Motivations

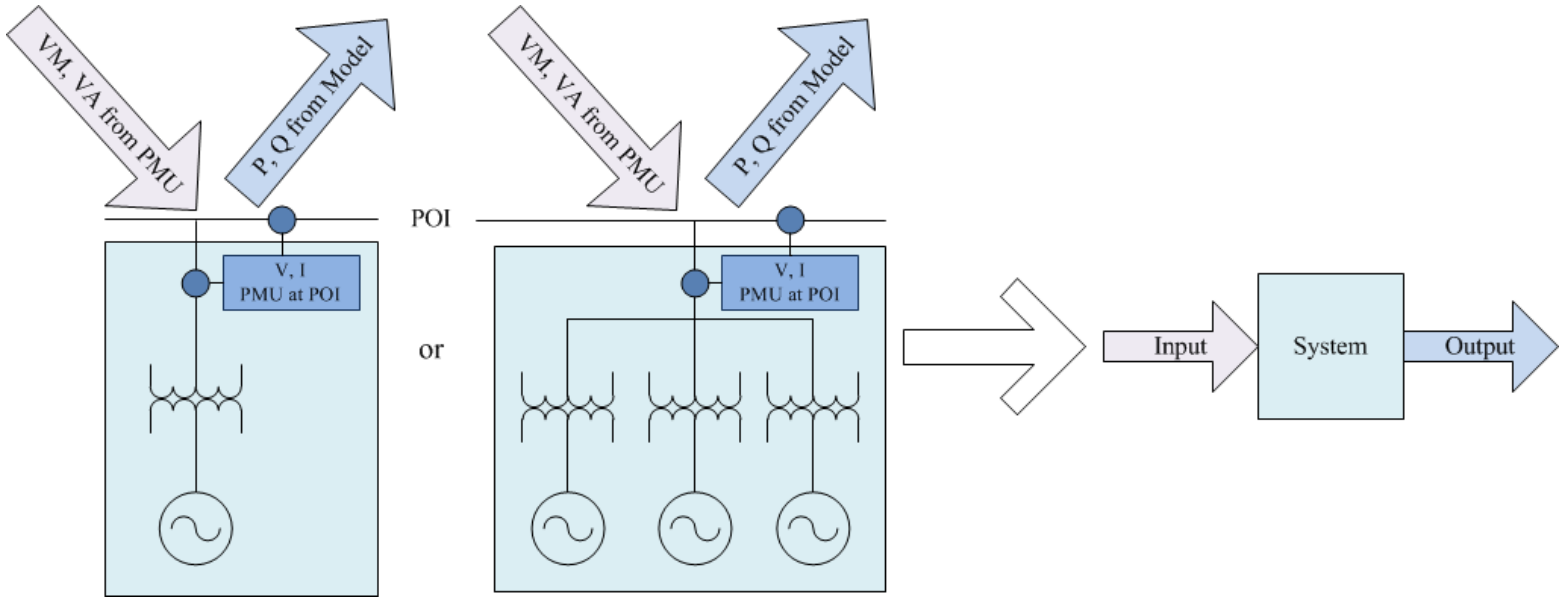
- Determine dynamic model accuracy
  - Confidence when developing operating limits
  - Yes/no answer – no parameter estimation needed
  - In response to NERC MOD-26/27
- Available tools
  - EPRI (PPPD), PNNL, TSAT, PowerWorld, PSS/E, PSLF
- Major constraints about PPMV : Time and effort
  - Manual process
    - Retrieve PMU and SCADA data
    - Set up initial condition and prepare the simulation case
    - Analyze the result
  - Verify one generator at a time
  - About 2 hours per event per generator
- Need an automatic tool that
  - Integrates with our systems
  - Works continuously online
  - Verifies all PMU monitored generators

A Little History

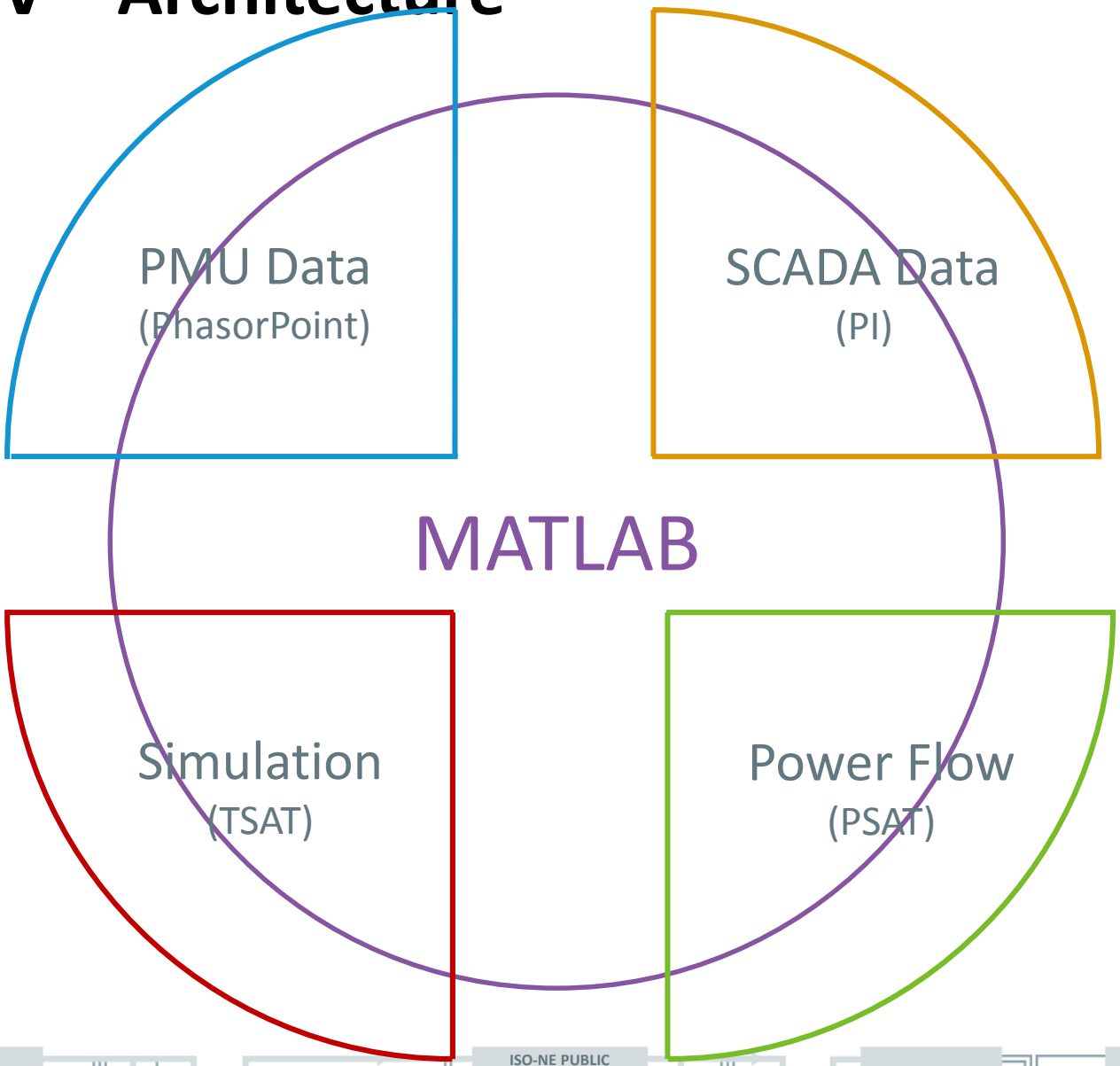
- Batch Power Plant Model Verification Tool (BPPMV)
  - Meng Wu (Summer Intern, 2016)
- Added quantified result analyses to BPPMV
  - Weihong Huang (Fall Intern, 2016)
- Automated Power Plant Model Verification Tool (APPMV)
  - Weihong Huang (Summer Intern, 2017)
- Continued improvements afterwards

BPPMV

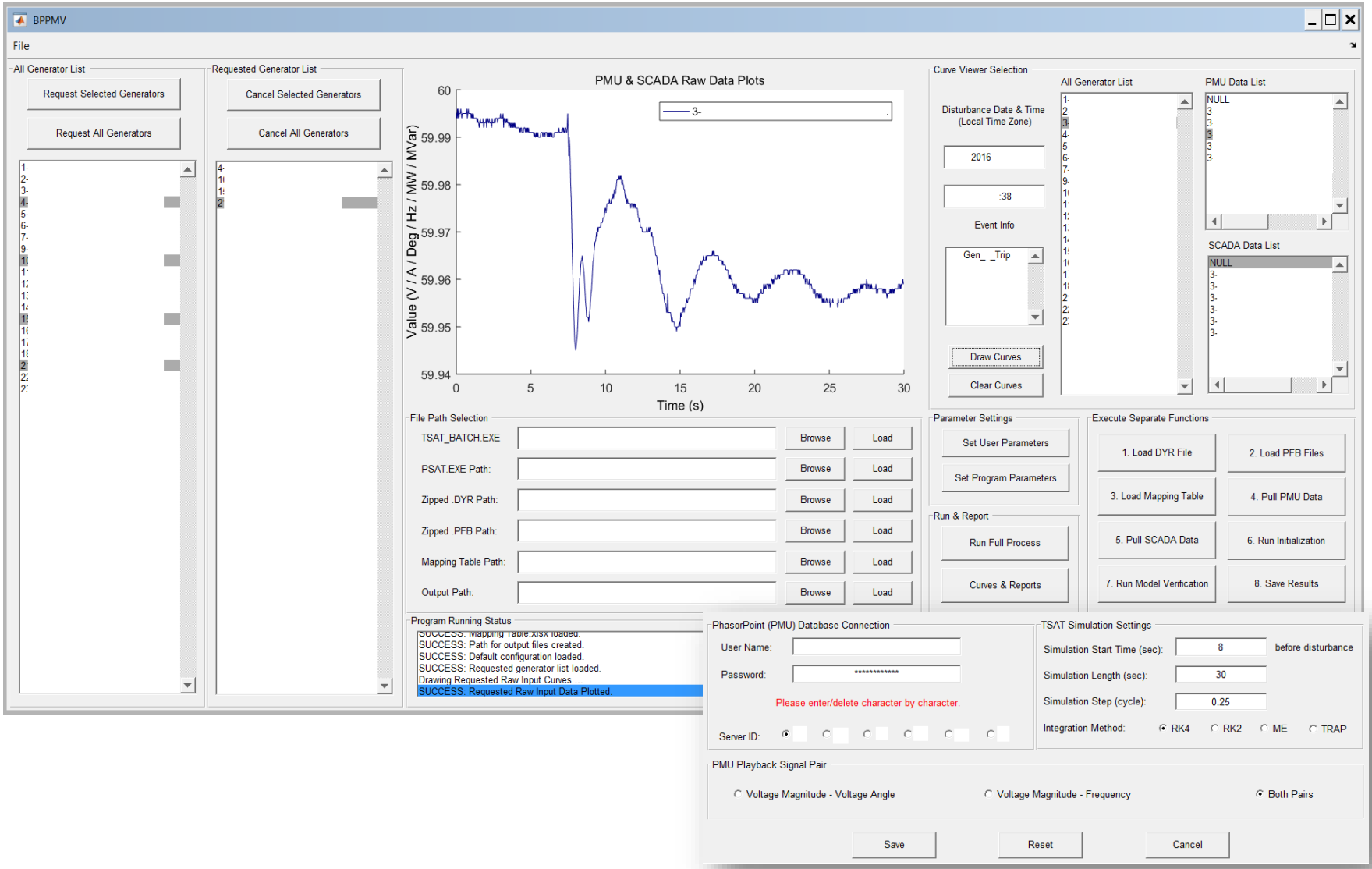
An Offline GUI Tool



BPPMV – Architecture



BPPMV – Main GUI Overview



BPPMV – Process

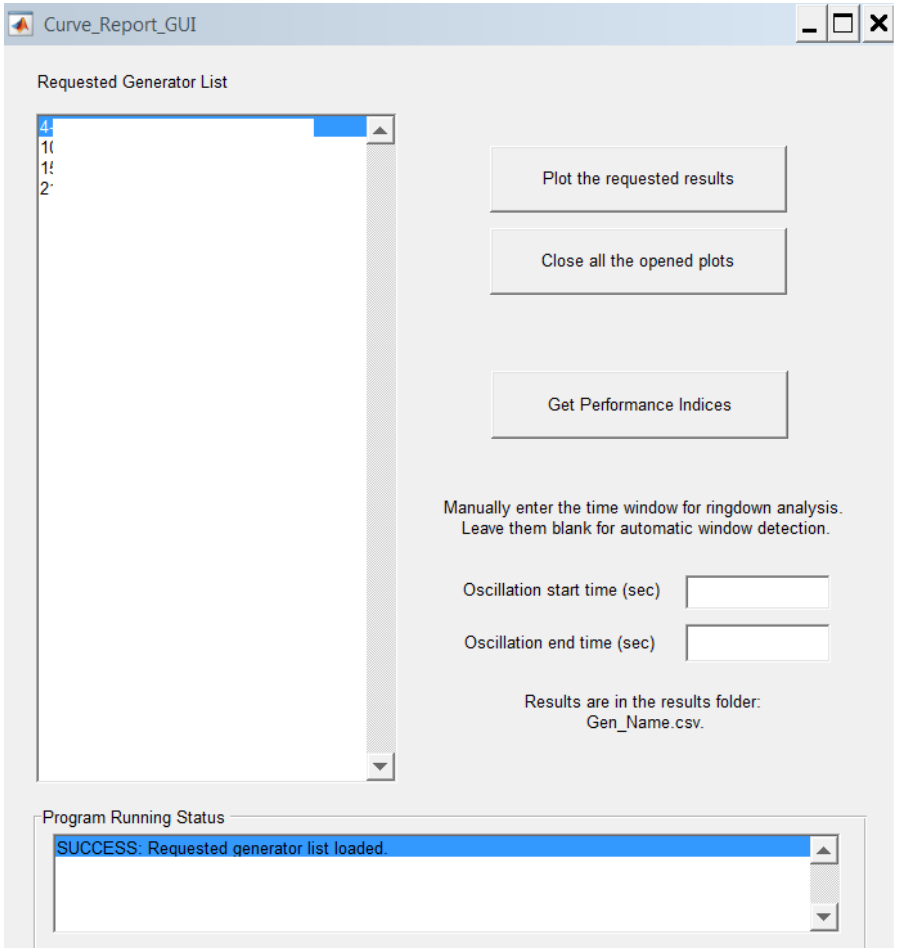
- User Inputs
  - Set parameters
    - First time use
    - Save as profile for later use
  - Enter the disturbance time
  - Enter the event info
  - Selects generators to verify
- Click “Run Full Process”

- BPPMV automatically
  - Pulls PMU data
    - At Point of Interconnection
  - Pulls SCADA data
    - For multi-generator power plants
  - Sets initial conditions
    - By running power flows in PSAT
  - Creates the TSAT simulation cases
  - Runs playback simulations
  - Analyzes the results
  - Generates the plots
  - Saves the results

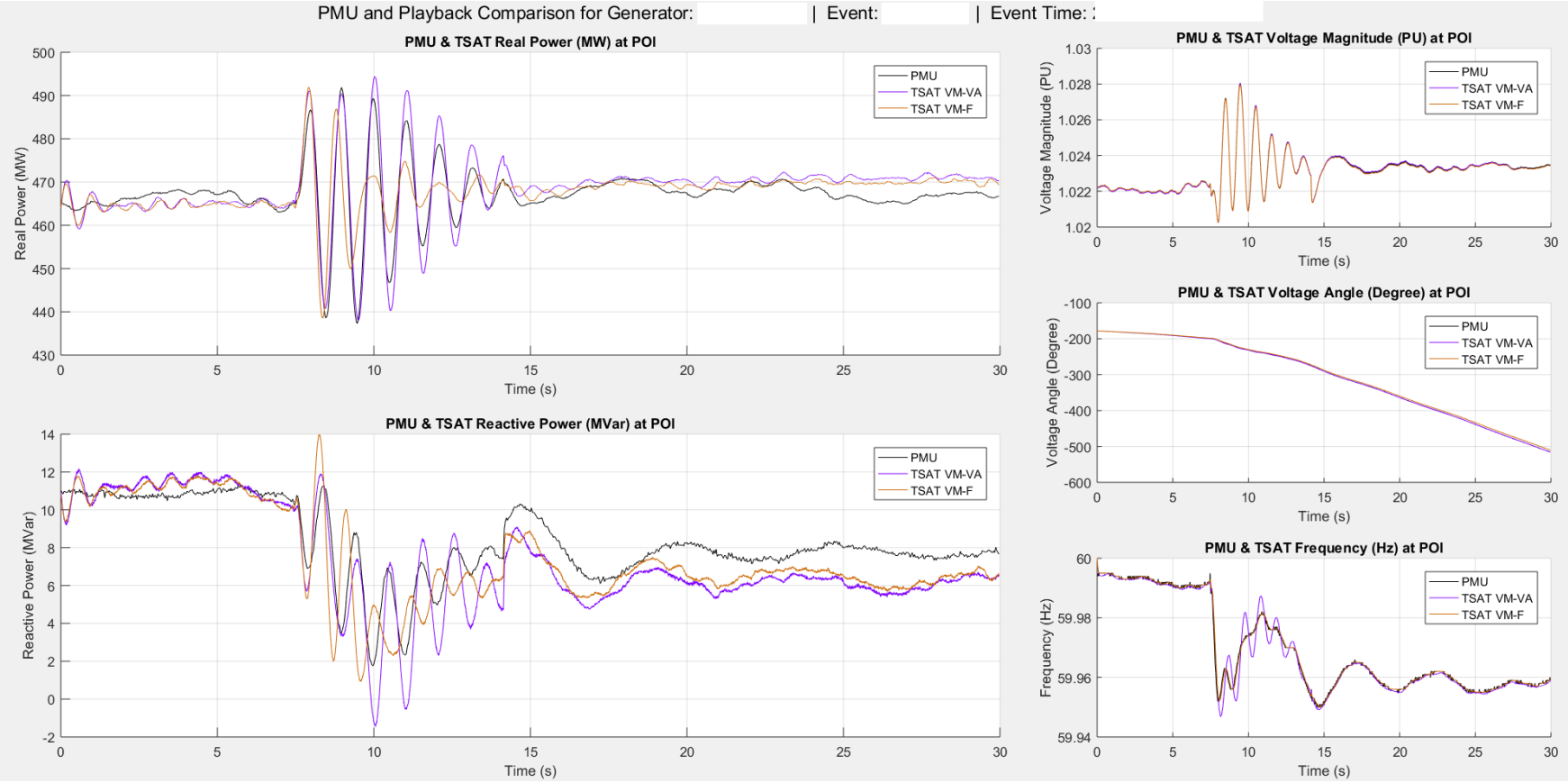
BPPMV – Built-in Intelligence

- Skip offline generators or PMUs
- Generator dispatch (SCADA)
  - Set individual generator's online/offline status
  - Set individual generator's output
- Special cases
  - Pump storage
    - Pumping mode or generating mode
- Result analyses
  - Automatically determine disturbance start/end time

BPPMV – Result Analyses GUI Overview



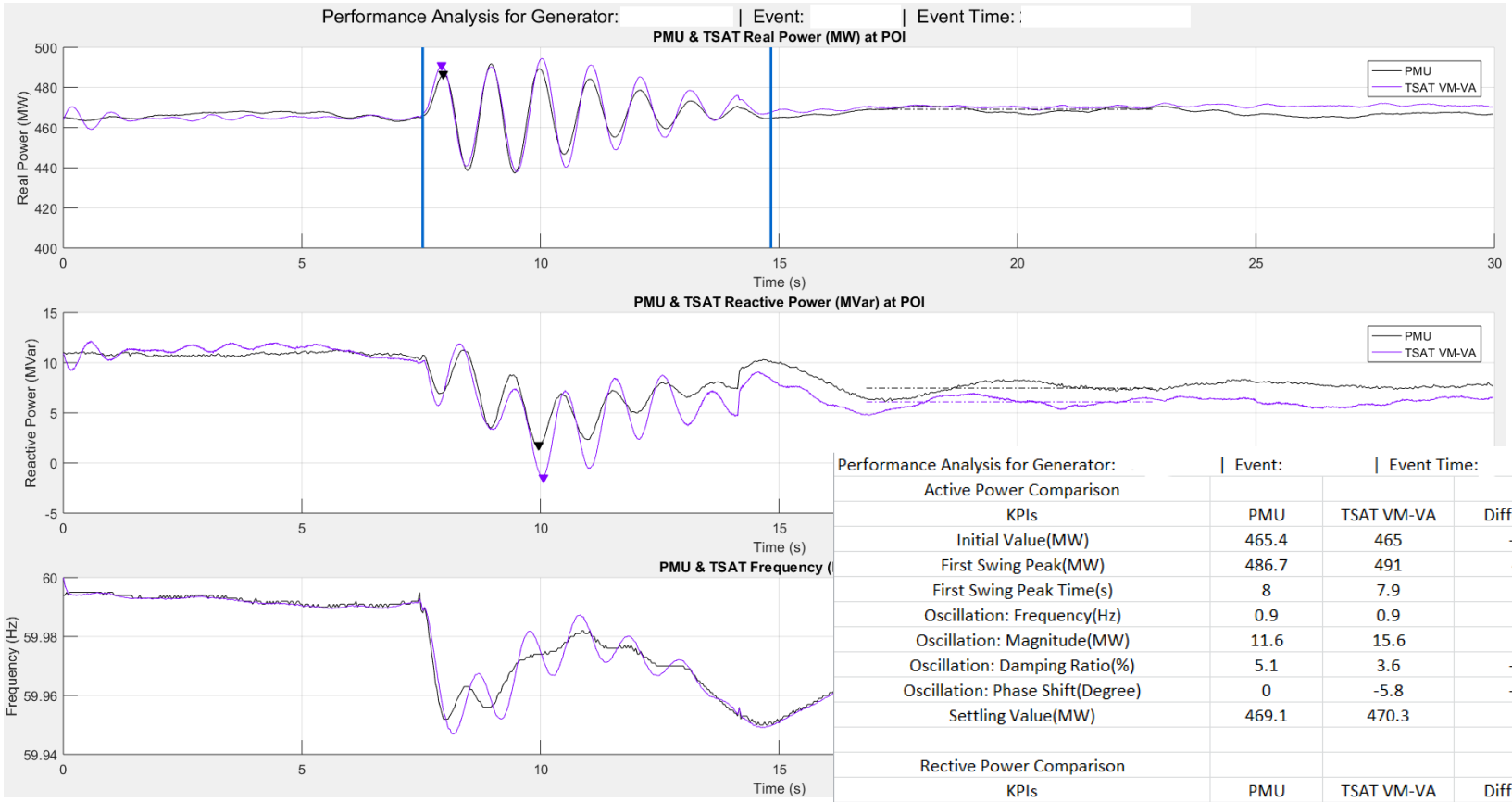
BPPMV – Result Plot



BPPMV – Quantified Result Analyses: Method

- Not based on RMS deviation between simulation and measurement
- Use engineering quantities
- Automatically extracted KPI List
  - Initial Value
  - First Swing Peak & Time
  - Oscillation
    - Frequency, Damping Ratio & Phase Shift
  - Settling Value

BPPMV – Quantified Result Analyses: Output



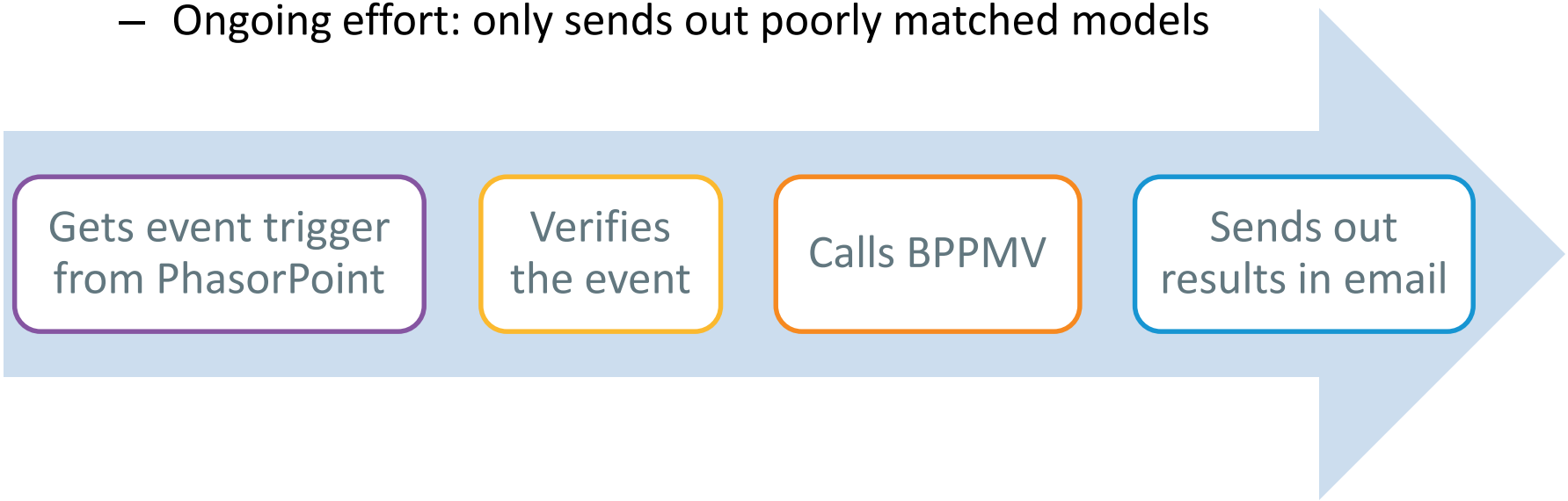
Performance Analysis for Generator:		Event:	Event Time:
Active Power Comparison			
KPIs	PMU	TSAT VM-VA	Difference
Initial Value(MW)	465.4	465	-0.4
First Swing Peak(MW)	486.7	491	4.3
First Swing Peak Time(s)	8	7.9	0
Oscillation: Frequency(Hz)	0.9	0.9	0
Oscillation: Magnitude(MW)	11.6	15.6	4
Oscillation: Damping Ratio(%)	5.1	3.6	-1.5
Oscillation: Phase Shift(Degree)	0	-5.8	-5.8
Settling Value(MW)	469.1	470.3	1.2
Rective Power Comparison			
KPIs	PMU	TSAT VM-VA	Difference
InitialValue(MVar)	10.9	10.8	-0.2
Peak(MVar)	1.8	-1.5	-3.2
Peak Time(s)	10	10.1	0.1
Settling Value(MVar)	7.5	6.1	-1.4
PMU frequency vs. VA calcualted frequency	Different (may be due to PMU frequency errors)		

APPMV

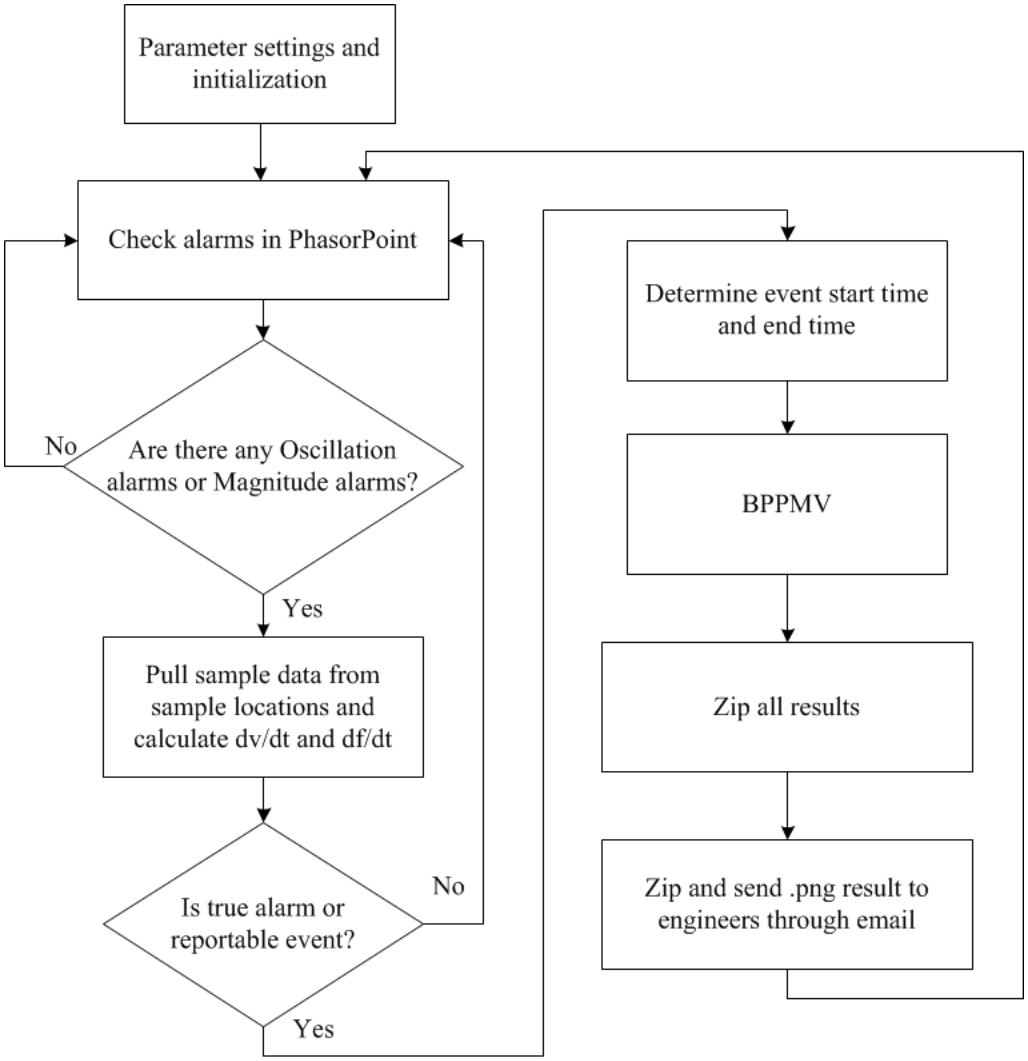
An Online Automated Service

APPMV – Architecture

- APPMV puts another wrapper around BPPMV
  - Runs 24*7 as a service
  - Checks disturbance alarms every minute
  - Runs BPPMV for real events
  - Sends out results through email
  - Ongoing effort: only sends out poorly matched models



APPMV – Flow Chart



APPMV – Built-in Intelligence

- Event verification
  - Use sample PMU data across the system
  - Skip false event alarms
- Determine event start time
- Score the performances (ongoing)
  - Only send out questionable models through email

APPMV – Results

- Email
  - Only from real events and online generators

- Archive
  - For offline analysis
  - Event file has the whole BPPMV case

Questions