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Building Grid Operator Monitoring and Control Assistant based on Synchrophasor Data

PRSP Update: SOPO Task 5.0 Voltage Stability and Linear State Estimation

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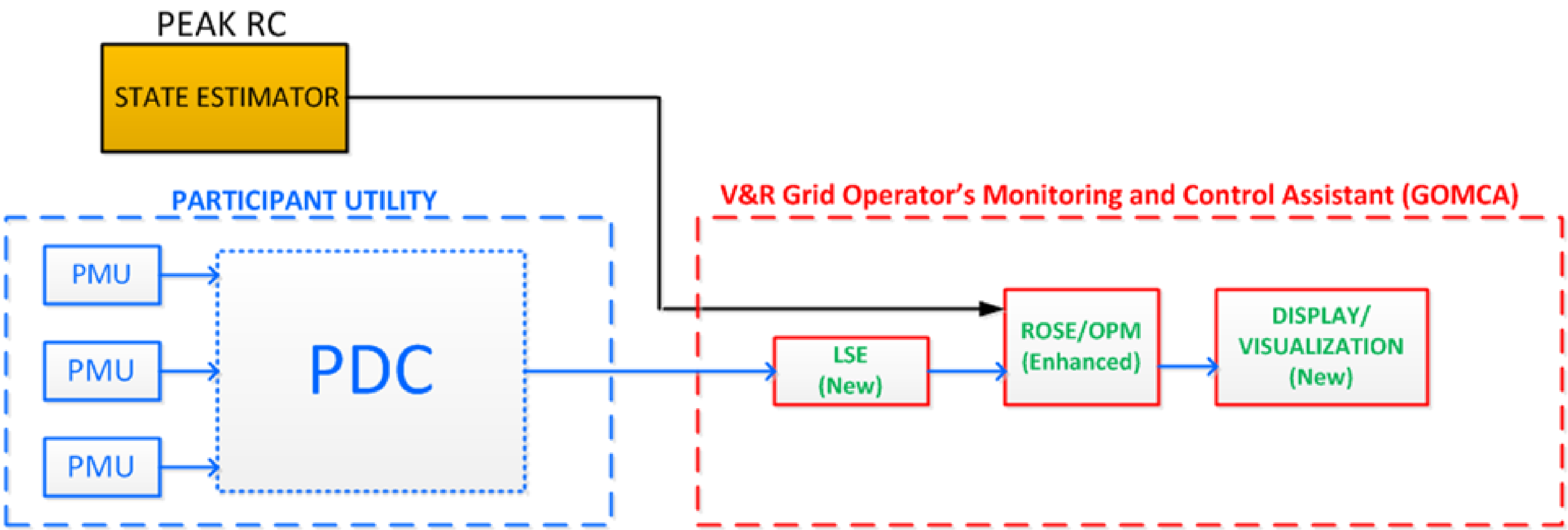
DOE PRSP Grant

- Grid Operator Monitoring and Control Assistant (GOMCA) under Peak Reliability Synchrophasor Program (PRSP): Peak RC, CAISO, SCE, SDGE, IPC, BPA
- GOMCA Project Objectives include:
  - Demonstration of V&R Energy's LSE, including:
    - Observability analysis;
    - Bad synchrophasor data detection and conditioning;.
  - Measurement-based analysis:
    - Measurement-based voltage stability analysis;
    - Automatic determination of corrective remedial actions;
    - Situational awareness wall to visualize in an easy effective way synchrophasor data, and results of voltage stability analysis.
  - ROSE integration with EMS/PDC systems of the project participants
  - ROSE Enhancements
  - Technology transfer to project participants, training workshop

High Level Architecture PRSP – Voltage Stability and Automated Corrective Actions



Source: SCE

Lessons Learned: Data Validation

- Data validation for the PRSP is quite broad and can be very extensive tasks depending upon the number of PMUs, PDCs, the documentation, and the storage systems in place for the synchrophasor data
- Access to the equipment and documentation is critical to the success of the data validation piece of the PRSP
- The data validation process started at the PMUs and moved towards the storage device
- **Verification of the PMU connections and programming were deemed the most critical and were also the most time consuming piece of the data verification**
- A six-step process to improve synchrophasor system accuracy

Framework for Measurement-Based Analysis

Linear State Estimation

- Observability Analysis
- Bad Data Detection/Conditioning

Advanced Applications

- Contingency Analysis
- Voltage Stability Analysis
- Automatic Corrective Actions
- Phase Angle Limit Computation
- Analysis of Cascading Outages

Visualization/Alarming

Visualization of:
Limits
Critical Contingencies/Cascades
Trending

Alarming on:
Voltage/Transient Stability Limits
Phase Angle Limit
Critical Contingencies/Cascades

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PRSP Analysis

- Observability Analysis:
  - Identifies observable portions of the system
  - Determines optimal locations of additional installations of PMUs to maintain observability of the electric power system network:
    - A set of PMU locations such that the system is observable
    - One “best” next location for system observability
    - Locations of user-defined “x” number of PMUs
    - PMU locations to satisfy a user-defined portion of the system to be observable (e.g., 50% of the system to be observable)
  - Demonstrated approach requires a smaller number of PMUs to achieve system observability as compared to published algorithms

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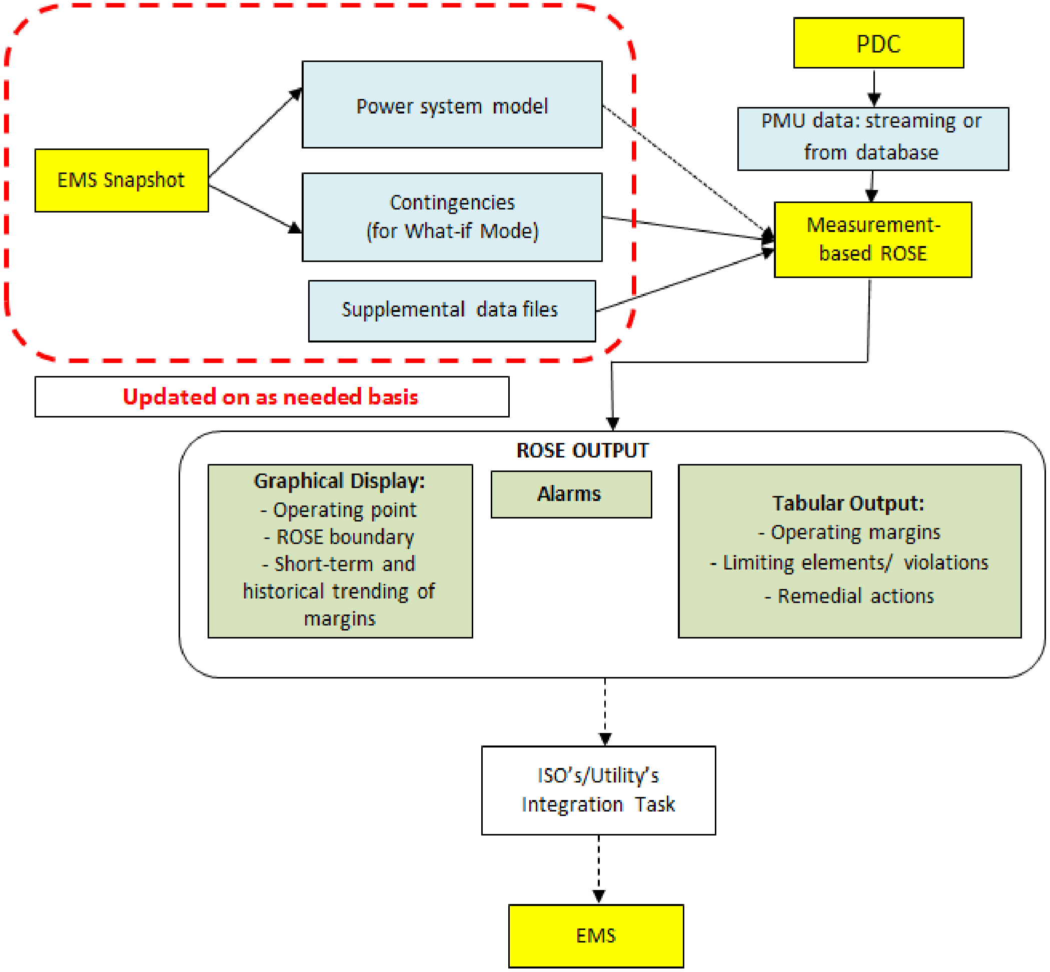
PRSP Analysis (continued)

- Bad data detection
- Linear State Estimator
- Additional apps developed by V&R :
  - WSMViewer tool simplifies and saves time when creating PMU/SE mapping files
  - PMUViewer tool simulates reading, streaming, saving, providing statistics on PMU data

Architecture for Measurement-Based Analysis

- Main input is synchrophasor data
- Additionally, a power flow case is needed to obtain model parameters, locations of PMUs
- Supplemental files as needed to perform contingency analysis, voltage stability analysis, etc.



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Measurement – Based Analysis

- Cases created by LSE may be used to perform:
  - AC contingency analysis;
  - Voltage stability analysis, etc.

Advantages of Linear State Estimator

- Speed of state estimation due to using a direct non-iterative solution;
- Improving quality of PMU data;
- A check for conventional SE;
- May replace conventional SE when it looses its output.

PRSP Conclusions

- Linear State Estimation (LSE) is a solid foundation for measurement-based advanced applications.
- Use of the power system model created using LSE allows to perform contingency analysis and determine power system operating limits.
- LSE allows to utilize synchrophasors to the full extent.
- LSE will transition from the concept to an operational tool as:
  - The number of PMU installation increases;
  - The methodology/process of LSE is tested and validated by the industry.