Synchrophasor-based Power Flow and Contingency Analysis for Dominion Energy Power Grid

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About Dominion Energy

- We've existed in one form or another since 1787
- 3.5 million electric customers
- 31 GW of total electric generating capacity
- 2.2 GW of solar generation capacity
- 65,310 miles of electric transmission and distribution lines
- 1184 PMUs
- 849 relay PMUs

Thomas F. Farrell II Building
Richmond, VA

Need for Enhanced Monitoring

Largest concentration of data centers in the world

- Can cause harmonics on the transmission system

Significant deployment of renewables

- Large numbers of renewables require coordination to avoid oscillations

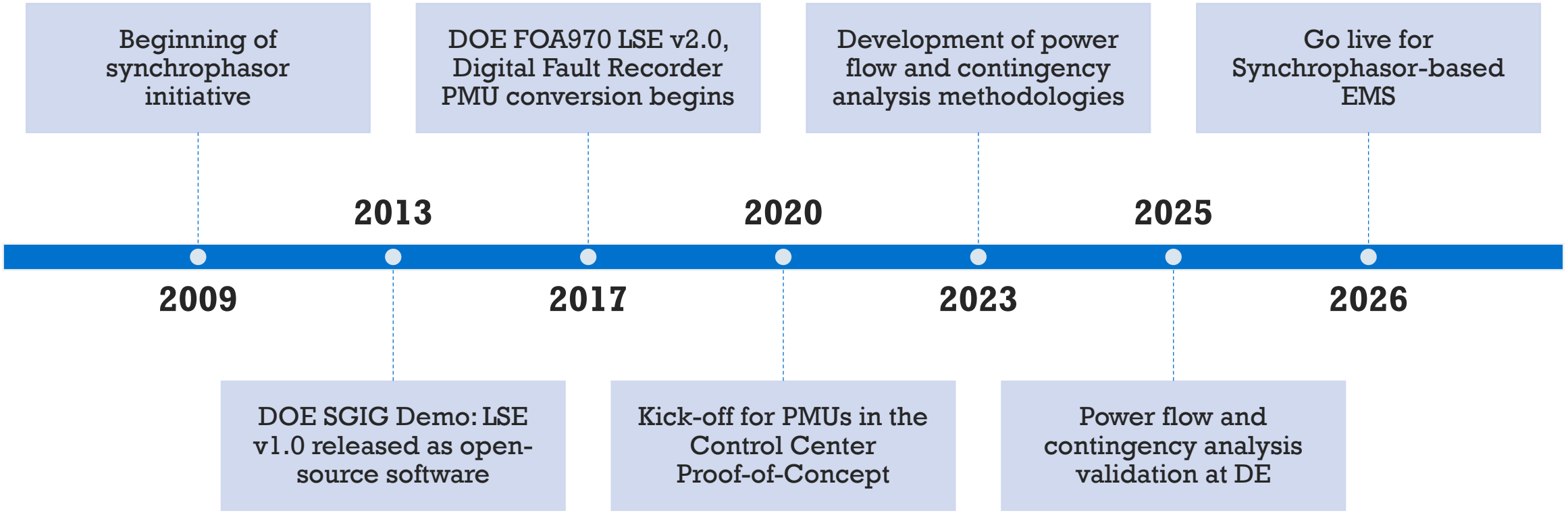
SCADA does not always detect oscillations

- Low sampling rate, lack of precise time synchronization

System observability when current EMS system is down

- PMUs at key location can enable system awareness in the absence of SCADA-based monitoring.

PMUs at Dominion Energy



Vision Statement

To provide operator use of PMU data to support real-time decision making and enhanced system visibility

Mission Statement

Provide our Operations Personnel with new energy management applications that can reveal system changes undetectable through traditional SCADA/EMS. New applications will allow rapid, robust, and redundant analysis that will potentially include wide-area network monitoring, oscillation, and islanding detection, etc.

Benefits

- Ability to detect dynamic phenomena such as oscillations.
- Provide ‘spare tire’ capabilities: system observability during EMS degradation.
- Allow operations staff to have an independent estimation of the grid's state and review events in much greater detail.
- Increase situational awareness, reliability, and accuracy of SOC decisions with the addition of PMU-based telemetry.
- Provide a foundation to develop applications and displays for managing increasing renewables resources.

Synchrophasor-based EMS

- Modern power grids are transitioning to renewables and IBRs with dynamic changes, bi-directional power flows, oscillations, variability in power output, declining inertia and system strength.
- System loads are more dynamic with addition of sensitive data center loads.
- Operators need dynamic intelligence to maintain grid reliability, stability, and power quality.

- Platform for managing smart grids.
- Independent from EMS SCADA.
- Based on high-speed time synchronized data.
- LSE always solves at high-speed.
- Provides assessments of power system dynamics.
- Faster and time-synchronized platform for contingency analysis and real-time assessments.

Synchrophasor EMS Components

- Wide Area Monitoring System
- Linear State Estimator
- Synchrophasor Power Flow (SPF)
- Contingency Analysis (CA)
- Unified display platform with one-lines, tabulars and dashboards
- Dispatcher Training System (DTS) - Study Mode

SPF and CA

Goal

- Develop a platform for Synchrophasor EMS.
- Fast and time-synchronized solution for LSE and advanced applications.
- Near-real time assessment tools.
- Ability to manage grid operations independent of EMS/SCADA.

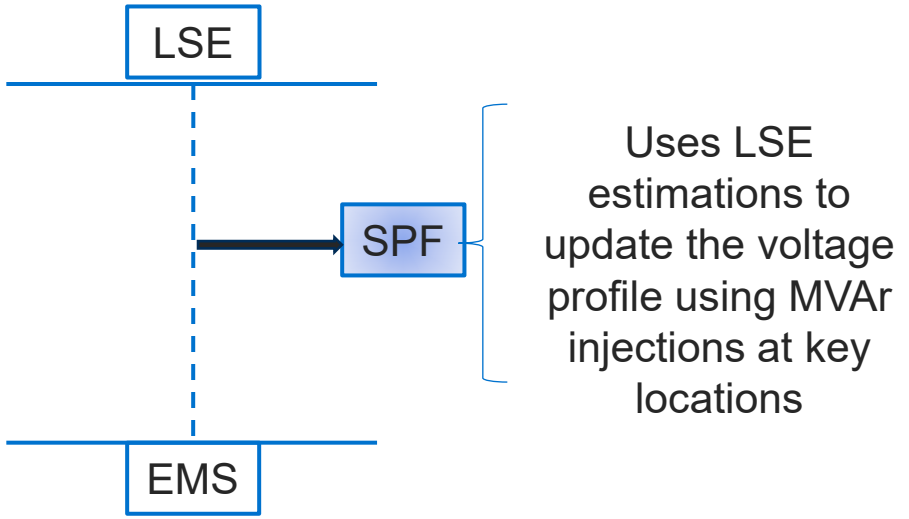
Approach

- Use LSE to generate a base case for near-real time assessments.
- Power Flow driven by LSE data, **providing full system observability and the most up-to-date state of the grid.**
- Integrate high speed Synchrophasor data and slow speed SCADA data to address PMU coverage limitations during transition to full PMU coverage.
- Use SPF as a base to implement advanced applications including RTCA and RTA.

Synchrophasor Power Flow – Methodology

The Synchrophasor Power Flow (SPF) overcomes:

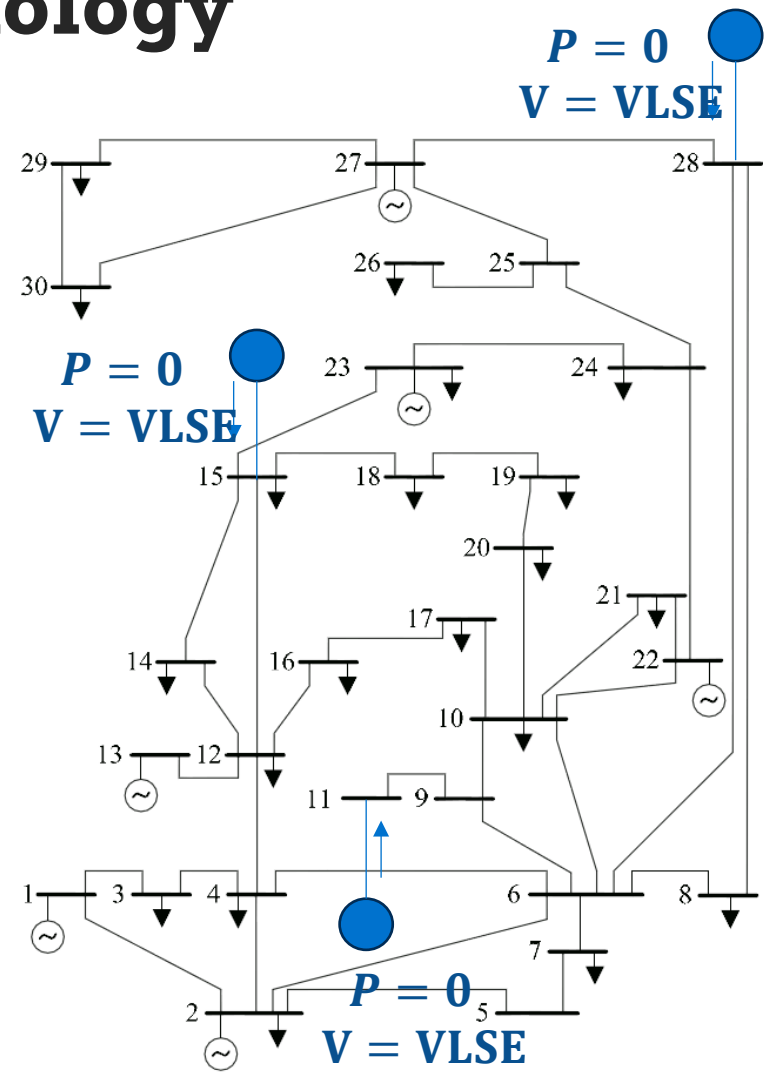
- Lack of convergency in legacy SE (specially during extreme events) – LSE always converge.
- High and slow speed data discrepancies.
- Limited PMU coverage of DE substations.



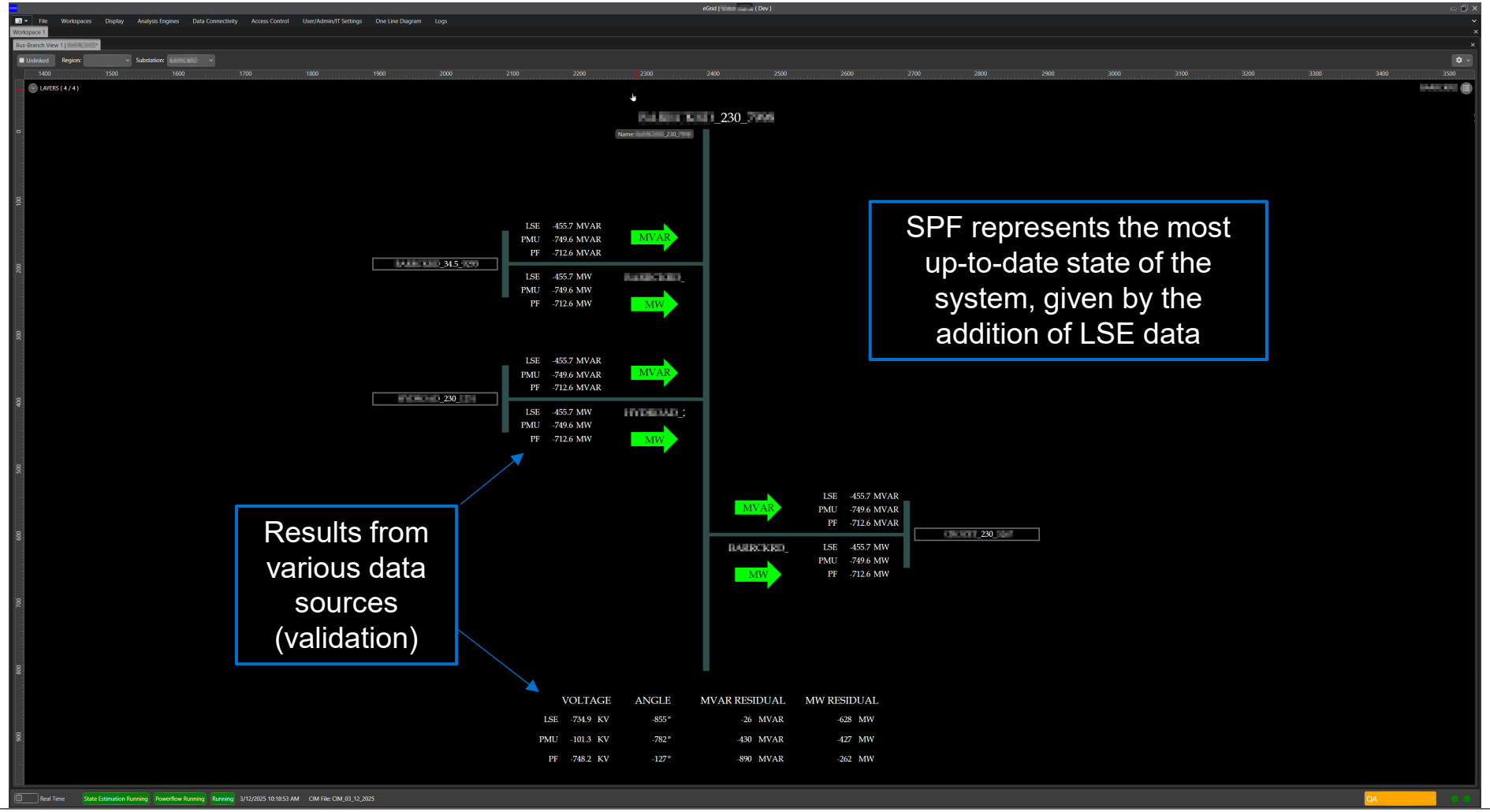
Synchrophasor Power Flow – Methodology

Fictitious Injections in SPF

- Serve as anchor points to adjust the voltage profile based on LSE.
- V-Q sensitivities are used to rank optimal locations.
- Limits on reactive injections are imposed to avoid over-tuning.
- The SPF solution is used to identify real-time violations.
- It serves as a foundation for performing real-time CA.



Synchrophasor Power Flow – Screen Example



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Contingency Analysis – Methodology

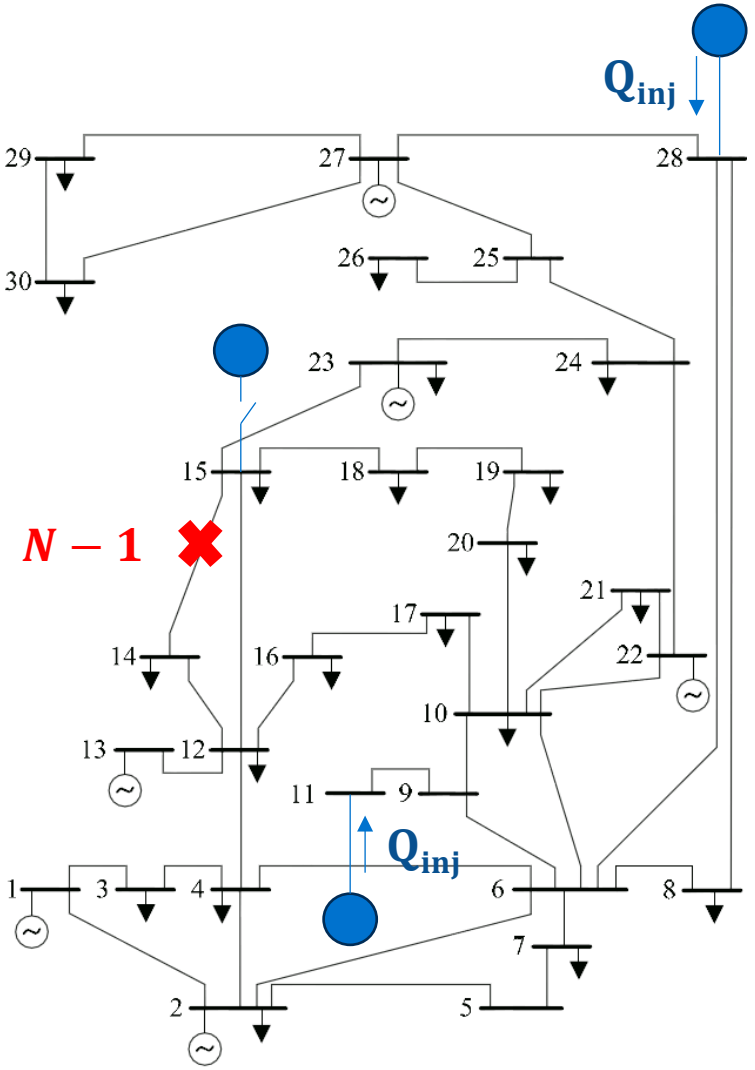
The RTCA allows operators to

- Simulate "what-if" scenarios involving potential grid events.
- Evaluate potential scenarios under the latest and most accurate system conditions.
- Identify voltage and flow violations under N-1 conditions.
- LSE usage to incorporate LSE data and enhance the reliability of CA for operational decision-making.

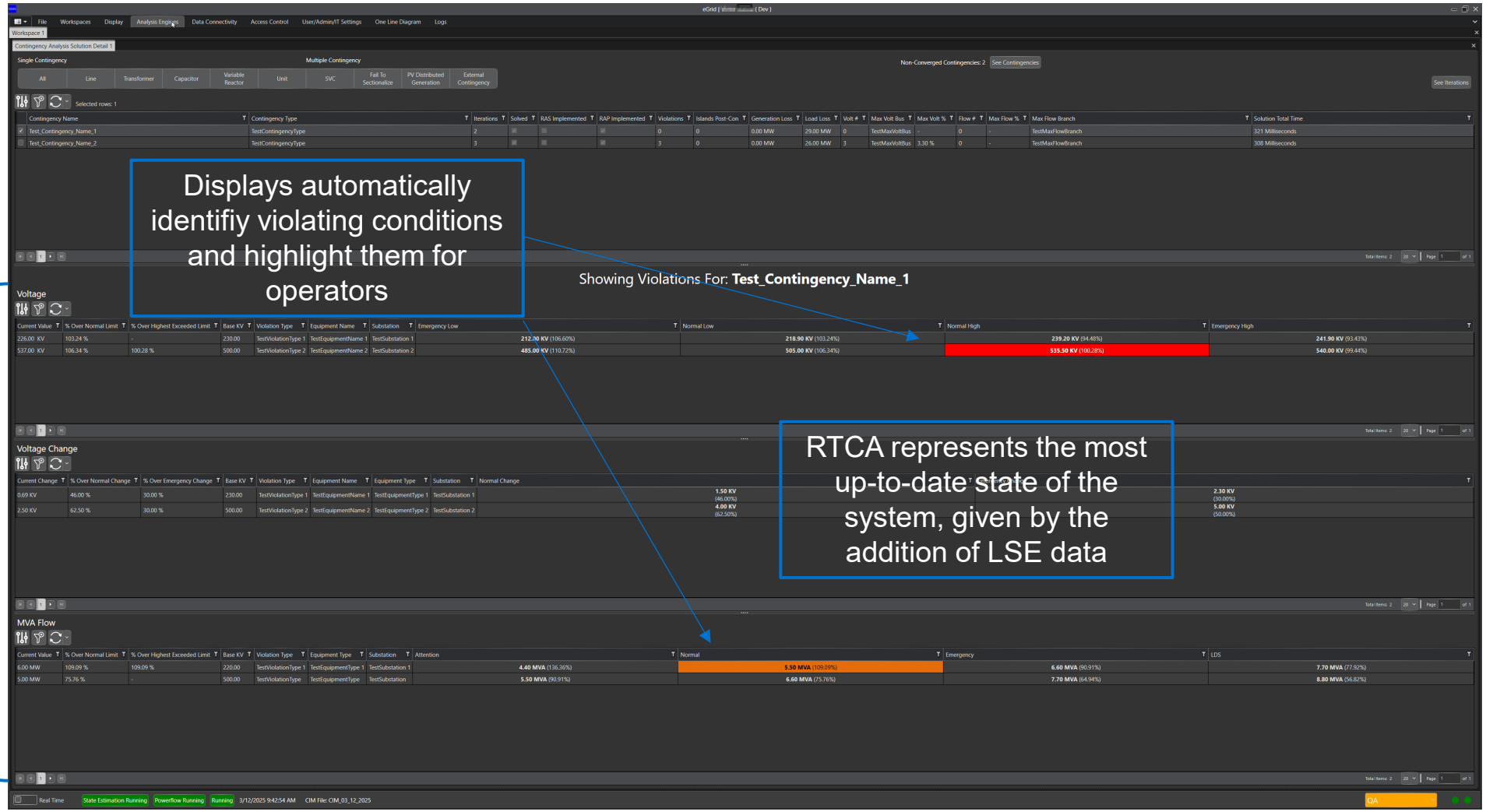
Contingency Analysis – Methodology

CA Methodology

- Fixed fictitious injections instead of PV
- Remove injections when outage contingency is applied close enough.
- This approach minimizes over-tuning and false-positive violations.
- It seamlessly integrate with RAS, area interchange control, and islanding, which are critical components of real-time assessments.



Contingency Analysis – Screen Example

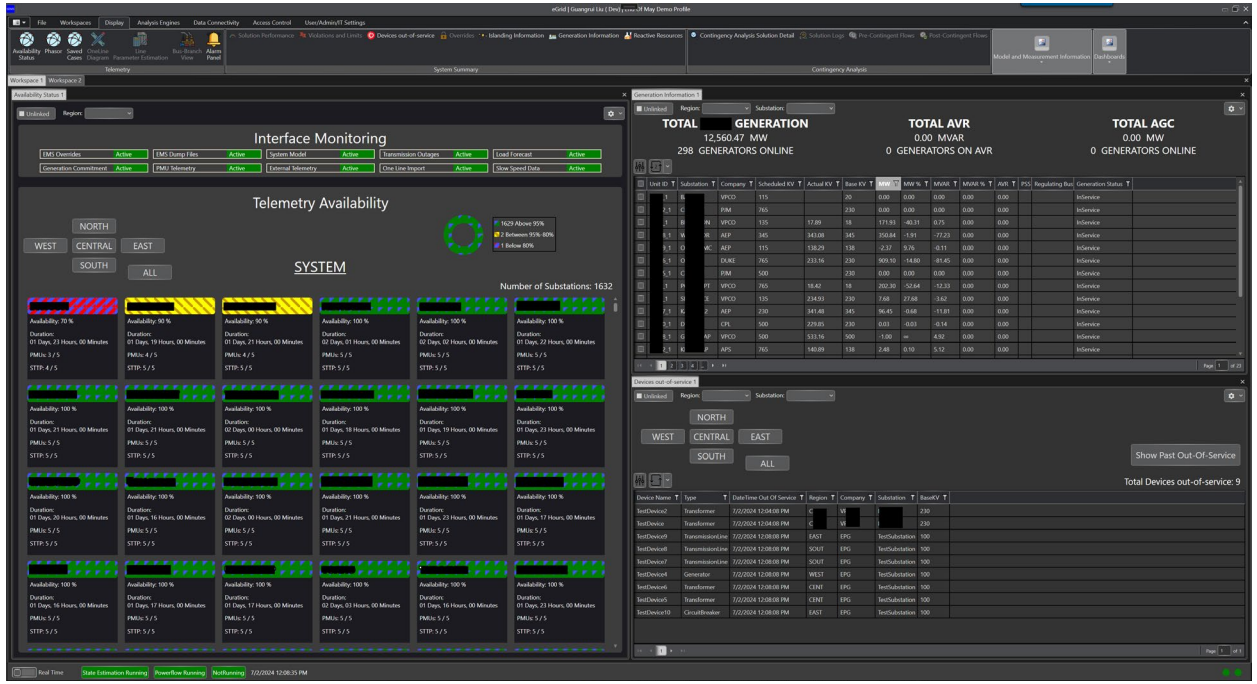


Voltage and flow violations. Components that contribute to **real-time assessment**

Conclusions

SPF and RTCA tools in S-EMS enable operators to manage today's dynamic grid

- LSE provides high-speed time-synchronized data.
- Methodology that incorporate LSE data in power flow and contingency analysis.
- Fast and time-synchronized tools that provide real time assessments of the grid.



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Q&A