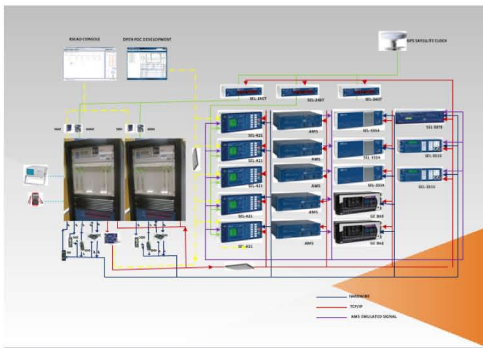


## Goals

- Provide a cyber-physical power grid testbed capable of hardware-in-the-loop testing using a Real-Time Digital Simulator, power system hardware equipment, various software, and metering devices.
- Provide a multisystem research platform and necessary integration tools for high-fidelity research validation.

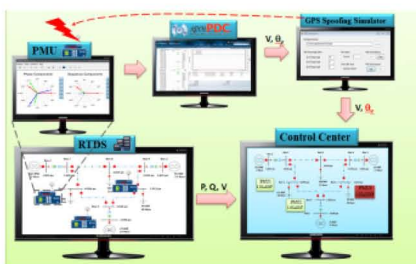
## Equipment



- Two RTDS racks: PB5 (3), GPC (2), GTWIF (2), GTDI (1), GTDO (2), GTAI (1), GTSYNC (2), GTFPI (2), GTAO (2), GTNET C37.118 (1).
- SEL-421 (5), AMS (5), SEL-3354 (3), SEL-2407 (3), SEL-3515 (3), GE-D60 (2).
- OpenPDC, RSCAD, Matlab Simulink, LabView, RTDMS.
- Wireshark, oscilloscopes, meters; Deter/Emulab, GPS.

## Research Examples

1. **PMUs and Bad Data Detection Algorithms: A Demonstration with GPS Spoofing Attack.** *D. Chen, J. Zhang, Z. Kalbarczyk, A. D. Domínguez-García.*

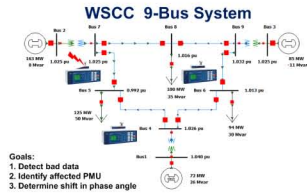


Detection of PMU bad data after satellite spoofing and identification of corrupted PMU



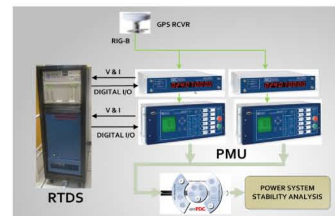
## Research Examples (continued)

2. **Topology Perturbation for Detecting Malicious Data Injection.** *K. L. Morrow, E. Heine, K. M. Rogers, R. B. Bobba, T. J. Overbye.*



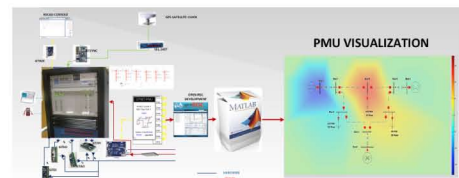
Changing of line parameters by DFACTS via a bad data injection and detection algorithm that uses PMU measurements

3. **On the Application of Phasor Measurements Units to Power System Stability Monitoring and Analysis.** *J. Zhang, A. D. Domínguez-García, P. Sauer, D. Chen.*



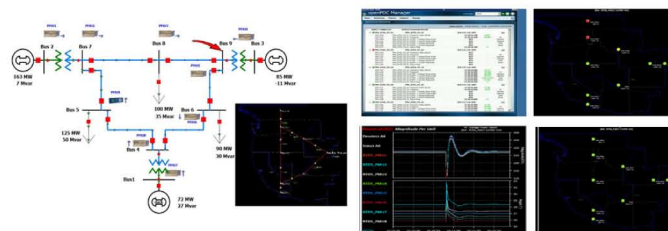
Real-time small signal monitoring and parameter estimation of a wide-area power grid

4. **Integration of RTDS, OpenPDC, and Matlab Platforms for Visualization of PMU Data.** *P. Panumpabi, D. Kholine, K. L. Morrow.*



Real-time visualization of PMU data

5. **Multi-System Experimentation: RTDS PMU Case with OpenPDC & RTDMS.** *P. Panumpabi, D. Kholine, Jeremy Jones, Tim Yardley.*



Automated PMU experimentation demonstrating wide-area situational awareness

## Future Efforts

- RTDS federated simulations.
- Solar panel power-hardware in the loop.
- RTDS capacity expansion via distributed simulation.

