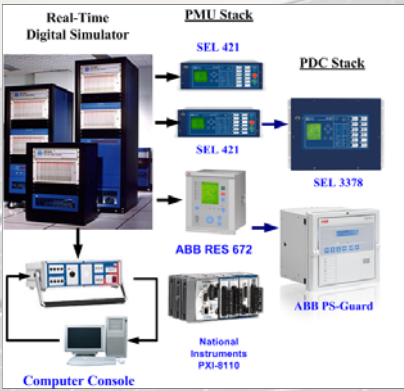


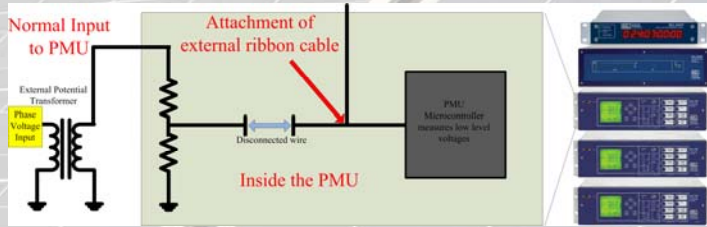
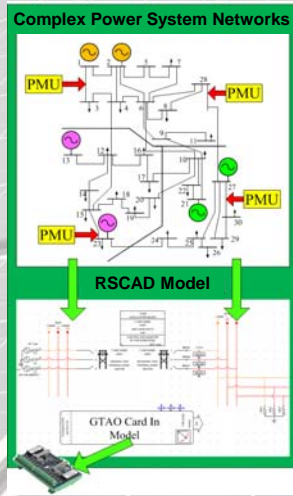
Hardware-in-Loop Testbed for Wide-Area Monitoring & Control

- Real-Time Simulations of Synchrophasors via RTDS

Power system dynamic models are emulated using RSCAD platform in RTDS, allowing us to experiment various faults & disturbances .

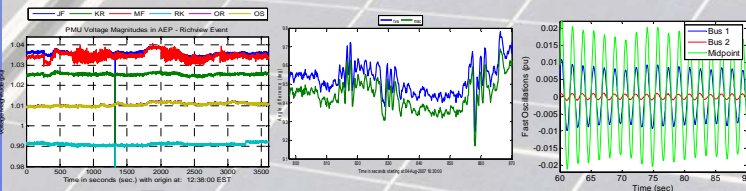


Multi-Vendor PMU-PDC Testbench at FREEDM



Dynamic models of WECC are currently being emulated via this facility in collaboration with Southern California Edison

Inter-campus BEN-PMU Network

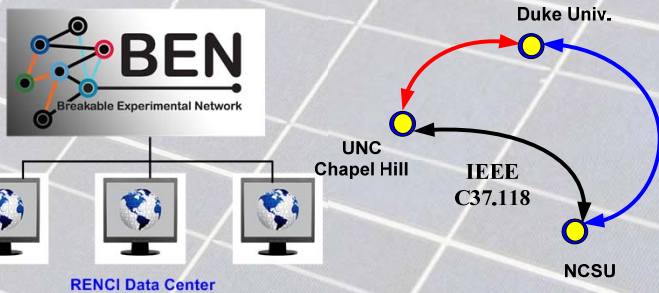


Experimental PMU Data from RTDS

This data can be shared between the Duke-UNC-NCSU for:

- Testing latency
- Communication bandwidth & jitters
- Cyber- Security

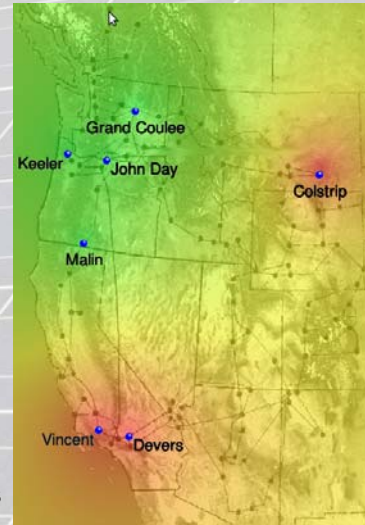
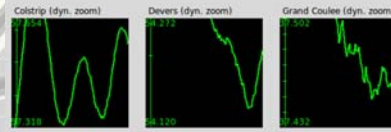
Inter-campus BEN-PMU Network via Distributed Communication



Wide-Area Visual Analytics

We have developed data analysis methods and an associated Graphic User Interface (GUI) named Watchdog to visualize how major disturbances - eg. blackouts and voltage collapses - spread across large electric power grids, using PMU data.

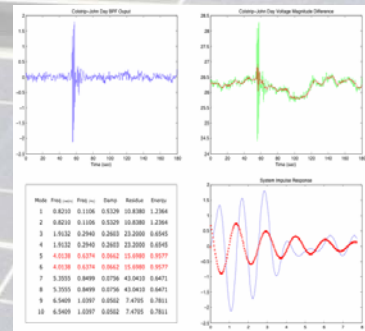
Current software only provides the operator with a station-by-station analysis, largely ignoring inter-system effects.



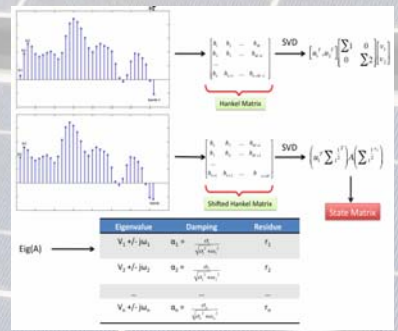
Watchdog offers the operator several intuitive representations of the system that focus on visualization rather than complicated mathematical expressions.



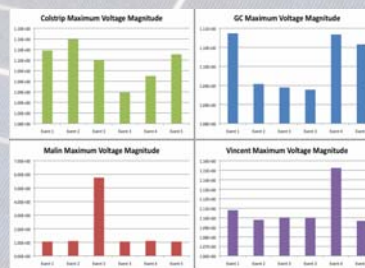
Data describing the system is updated as time progresses and provided in several ways to allow comparison between stations



ERA Extraction



Modal Analysis



Statistical Event Analysis

Watchdog is written in python using the Pygame and Tkinter modules, making it easily extensible and widely compatible.

Other modules include:

- PMU placement
- P-δ curves & margins
- Real-time computations
- Numerical delays
- 3-d surface plots