

Synchrophasor System Deployment

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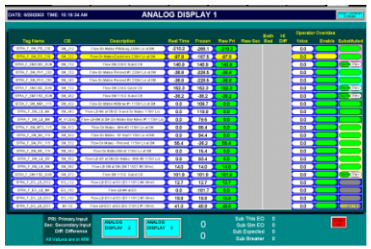
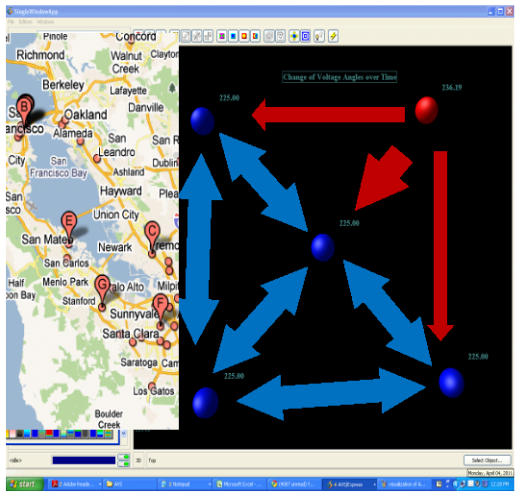
Pacific Gas and Electric Company®

NASPI North American SynchroPhasor Initiative

Before	Now	2014	2020
 First PMU		Standard feature (relays, DFR, controllers, equip. monitors)	Thousands of PMUs world-wide
			Higher data rates
			Also in Distribution
		On major interconnections	Fast Adaptive Protection
 Analog Displays		Improved comm. infrastructure, including control	Integrated in standard business and operational practices
		Standard SW tools included in EMS/SCADA	Distributed NASPI-Net type comm. architecture, fully integrated with EMS / SCADA
		Interoperability standards deployed	

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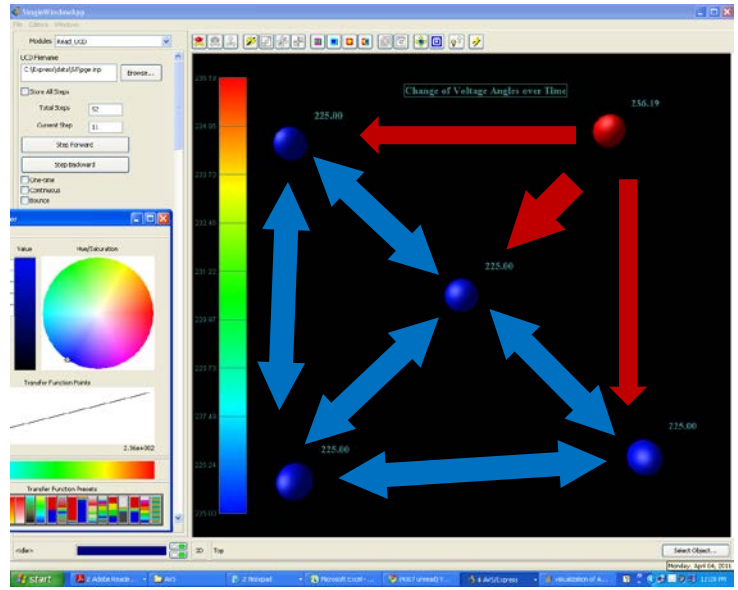
Synchrophasor Project Background

- PG&E has undertaken deployment of a large scale Synchrophasor measurement system to improve PG&E/WECC grid reliability
  - Sub-recipient of the ARRA Smart Grid Investment Grant (SGIG)
  - Open, Flexible, Interoperable, Secure, and Expandable
- Industry pioneering initiative to utilize advanced technology for various applications
- Proof of Concept (POC) facility plays a critical role in:
  - Risk Management – No time for “Redoing” or “will figure it out later”
  - Help prevent delays at time of field installation
  - Valuable state-of-the-art test tools
    - Transition from development to operation for training future users
    - Fine tuning applications for functionality and performance
  - Tests so far have been:
    - A conduit to the industry standards
    - Have identified and remedied some product and system integration issues with potential for serious delays or malfunctions during commissioning

PG&E Use of the Technology

- Use by operation for better indication of grid stress to trigger corrective actions to maintain system reliability:
  - Outage reduction and blackout prevention
  - Switching, islanding and restoration
  - EMS/SE improvements
- Data Analysis
  - Engineering post-event analysis
  - Model validation
  - Fault location and type
- Looking Ahead - Closed-loop control, adaptive protection
  - FACTS/HVDC enhanced controls
  - RAS/SIPS
  - Wind integration
- Market Operations
  - Congestion Management



Benefits of using the same infrastructure for variety of applications

Benchmarking Synchrophasor Technology Projects

3-YEAR DEPLOYMENT

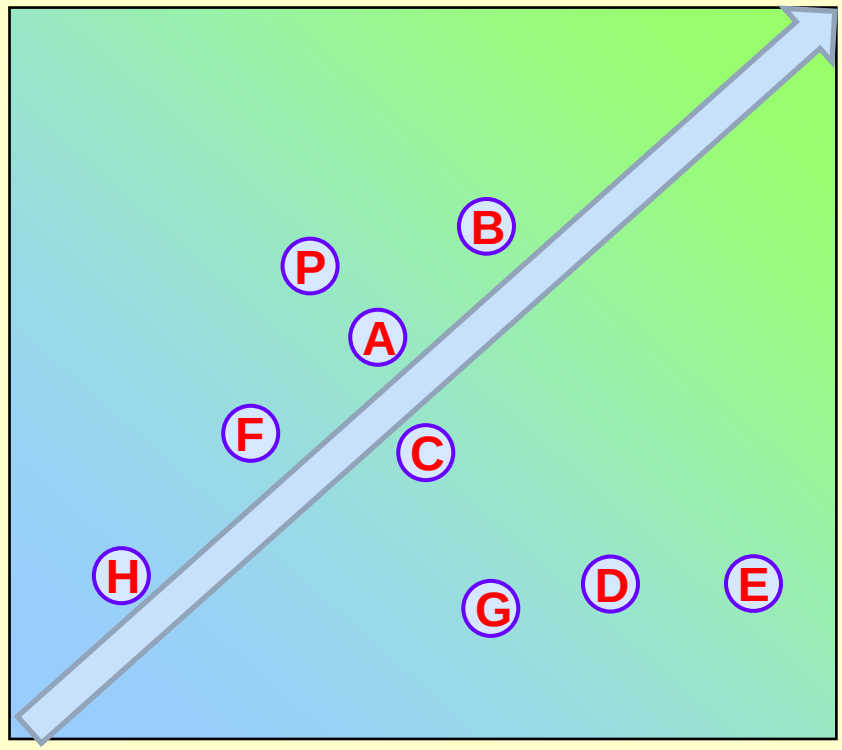
Applications

Big bang – all real-time closed loop control, protection, operation & other applications

Control room functions; some real-time applications

Data visualization and operation analysis in control room

Monitoring; visualization & operation analysis outside of control room



X — *On-going US Synchrophasor Projects*

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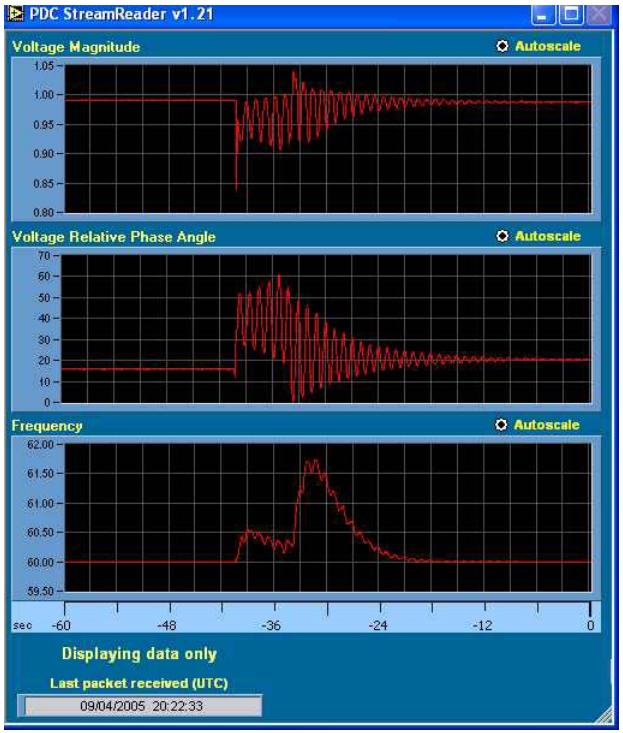
Project Highlights 1 (2)

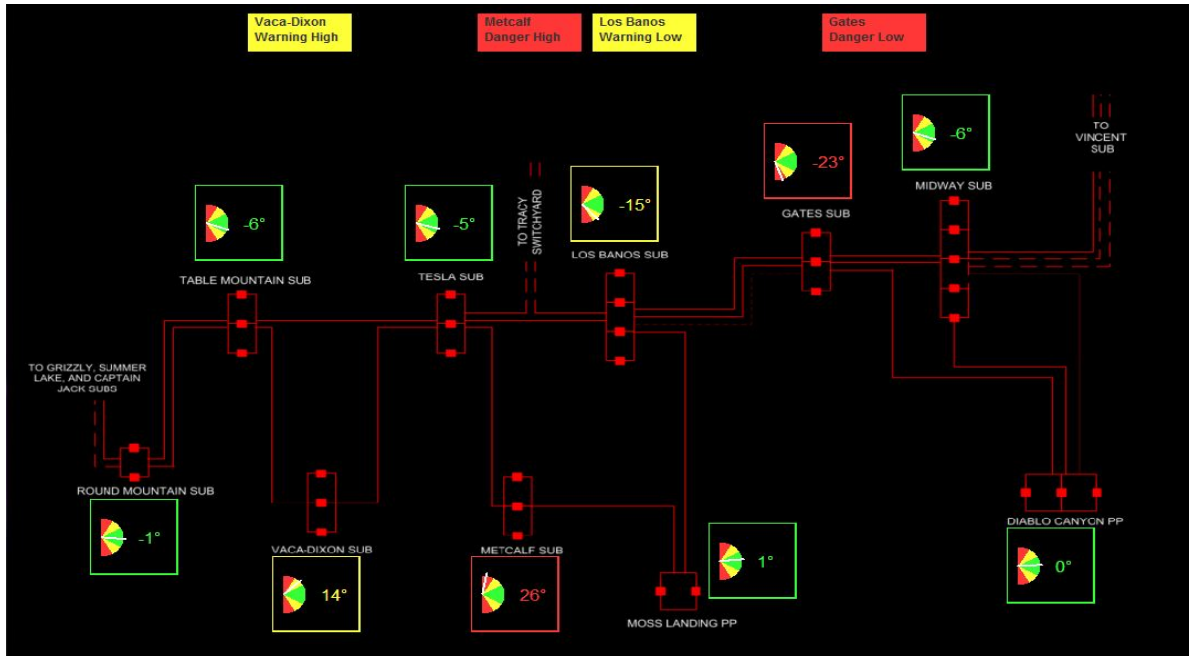
- Install PMUs and PDCs that communicate in IEC 61850-90-5 standard and 120 phasors
  - Our team has determined more sustainable over life cycle compared to other standards
  - For support of planned and future functions, the PMUs, substation PDCs, and substation communications and data storage facilities designed to capture 120 measurements/s
- Developing application settings and procedures for use of PMU using the POC facility
  - Improved modeling and validation:
    PG&E model is integrated in
    Real-Time Digital Simulator and other tools
  - Training materials and workshops for operating personnel and other end-users of the system
  - Convey to operators a more practical view of the control center additions, creating a needed understanding of how phasor data adds to the monitoring tools they already have

Detail	Present (PG&E)	WECC DB21 (PG&E)	Merged Model (PG&E)
Substations	2,561	6,475	7,638 (2,345)
Buses	4,059	12,182	13,177
Lines	3,655	10,298	11,103 (3,290)
Units	700	2,689	2,743
Transformers	975	4,763	4,854 (775)

Situational Awareness Analysis 1 (3)



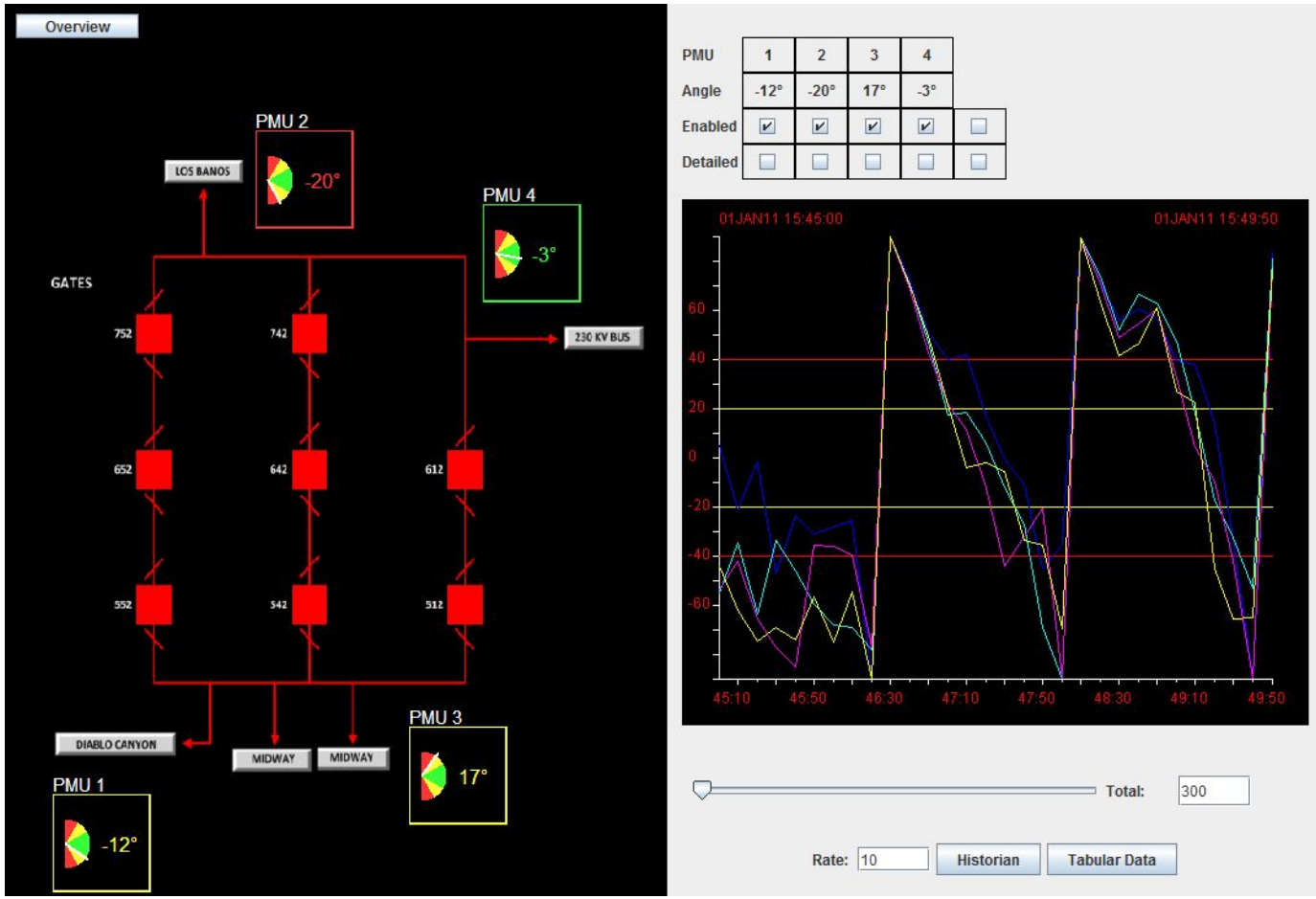
Measurements



Speedometer

Situational Awareness Analysis 2 (3)

Substation View Speedometers



Situational Awareness Analysis 3 (3)

Voltage Stability Analysis
Nose Curve