Phasor Technology Research Road Map to Improve Grid Reliability and Market Efficiency

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Background

- Power Grid has evolved from a vertically integrated system to a mixture of regulated and deregulated competitive market system
- Power grid management is shifting from local utilities to regional ISOs and RTOs
- Power grid operators are experiencing:
  - Increase in transactions
  - Fast changing and unpredictable flow patterns
  - Gaps in operating and planning data
- California control areas are faced with many challenges such as:
  - Interregional Power Transfers
  - Voltage Management
  - Resource Adequacy
  - Price Volatility

Causes of Recent Major Grid Outages in North America and Europe

- Lack of Data on System Status
- Limited Visibility of System Conditions Beyond Control Area
- Multiple Contingencies
- Operation in Unsafe Zone with Inadequate Safety Margin
- Deficiencies in Communication and Coordination
- State Estimation Not Solving
- Disconnects Between Planning Models & Observed System Performance
- Noncompliance with Standards
- Performance Standards Inadequate

Industry Consensus

- August 2003 Eastern Interconnection blackout and experience with operating large regional grids and markets has resulted in industry consensus on:
  - Need for wide-area visibility and situational awareness to address problems before they propagate
  - Need for time-synchronized real time data
  - Development of real time wide area monitoring tools for system operators and reliability coordinators
  - Better reactive power and voltage management practices
  - Better system models
  - Need for research on reliability related tools and technologies

Challenges for the California Power Grid

- High congestion costs - CAISO estimates annual costs of $400 million/year
- Limited wide area visibility and monitoring tools – avoid 1996 type system collapse
- Lack of an early detection system for low probability but high impact system conditions - improve grid security and reliability
- The need for additional transmission transfer capability - improve existing asset utilization
- Limited post disturbance assessment capability – better understanding of what happened during events and why they happened.
- Inaccurate power system models – enhance model simulations and state estimation

Value of Phasor Technology in Meeting the Challenges of the Power Grid

- Technology transition - Phasor technology is transitioning from lab to field, with growing utility and vendor interest
- Data quality – Date is sub-second high resolution data (30 samples/second) and is time-synchronized
- Reduce congestion costs – Identify real-time grid margins and enhance state estimation results
- Managing a complex grid - Provide real-time operations with wide area visibility and monitoring tools
- Improve reliability - Develop and implement an early detection system for low probability but high impact system conditions
- Increase asset utilization – Develop and implement dynamic thermal ratings and stability nomograms
- Improve off-line tools - Enhance the post disturbance assessment capability and simulation models to more accurately forecast the performance of the grid, under various conditions

Proposed Research

Parallel Research Tracks, Support Activities and Technology Transfer

- **Infrastructure** – Support user education and needs identification
  - Monitoring equipment and associated hardware
  - Topology and identification of new locations for PMUs
  - Communications
  - Data Management
- **Applications** – Research, demonstrate and transfer to commercial vendors
  - Real time, e.g., monitoring, alarming, protection and control
  - Visualization, human factors and training
  - Near real time, e.g., improved state estimation, security assessment
  - Off-line, e.g., post disturbance analysis and improved system modeling
- **Policies and Procedures** – Provide forum for issues and resolution
  - Standards for components and devices
  - Network maintenance and management
  - Data acquisition and management guidelines
  - Non-disclosure agreements

Research Road Map - Infrastructure

	Phase 1 Initial Network	*Phase 2* *Expanded Network*	*Phase 3* Operational System
HARDWARE	• Few PMUs and PDCs • Proprietary and custom protocols	• Prototype the next generation of PMU • Increase system coverage with PMUs PDCs and other monitoring devices • Standard protocols – sampling, quality, time-synchronization	• Maintenance standards • Commercial quality • Vendor supplied and supported
COMMUNICATIONS	• Point-to-point	• Communication protocols • Network(s)	• Adequate, secure, with redundant back up
DATA MANAGEMENT	• Acquisition • Local Storage • Limited data retrieval	• Archiving with expanded data retrieval • Data quality • Standard protocols	• Remote data repository • Commercial • Data management • Software

Research Road Map - Applications

	Phase 1 Research & Development	*Phase 2* Field Demonstration	*Phase 3* Operational/ Commercial Systems
Real Time Monitoring	• Grid-3P™ platform for monitoring, tracking, notification • System metrics – ACE Frequency, Voltage, Angles and Flows	• PG&E – local and wide area monitoring • CAISO – RTDMS (Real-Time Dynamics Monitoring System) – Frequency Monitoring System for NERC Compliance	Functional specifications for applications and displays vendor system
Security Assessment	Algorithms and prototypes – damping, reactive margin, thermal limits	Test and validate in CAISO environment for dynamic nomograms and ratings	Functional specs for vendor system
State Estimation	Research and develop algorithms and system architecture	SDG&E state estimation to state measurement • Improvements • Integration with SCADA	Functional specs for integration of phasor data into state estimation Transfer lessons learned to CAISO state estimation
Post Disturbance Analysis	• System signature • Disturbance recognition • Oscillation/dynamics (BPA) • Frequency response • Model validation (BPA)	Test and validate in CAISO and/or utility environment	Functional specs for vendor supplied system
Control	Algorithms development and validation	SCE demonstration on the south of Control 115 kV system	Functional specs for vendor supplied system

■ = Already exists ■ = Work in progress ■ = Scheduled to be done in 05/06 ■ = Would like to do in the future

Research Road Map – Policies and Procedures

	Phase 1 **Research and Prototype**	***Phase 2*** **Demonstrate and Validate**	***Phase 3*** **Operating System**
Network Maintenance and Management	Collaborative	Define requirements – latency, data quality, resolution, reliability	Vendor developed and maintained
Standards for Components and Devices	Test and Analyze	Define requirements and standards	Commercial offerings
Data Acquisition and Management Guidelines	Non-disclosure agreements in place to ensure project progress Utilize currently available data	Define standards, protocols, requirements	Commercial offerings

Research Milestones

Key Milestones – Near Term

The following milestones have or will support the strategy of building on existing investments and research with an objective to further deploy phasor technology in the Western Interconnection:

2004 and Prior

- Establish starter phasor network in WECC
- Develop wide area monitoring platform – Grid-3P
- Develop RTDMS

2005

- Research on wide area security assessment
- Enhance RTDMS
- Expand network connectivity to include PG&E, SCE
- Research and project planning for field demonstrations (PG&E – monitoring; SCE – control; SDG&E – state estimation)
- Develop frequency monitoring application to meet NERC requirements
- Research on alarming, protection, control
- Vendor developed PDC – acquire and test

2006

- Expand network connectivity to include Desert Southwest area (e.g. PNM, APS)
- Field demonstrations and validation
  - CAISO – RTDMS, Frequency, Voltage
  - PG&E – Monitoring
  - SCE – Monitoring, alarming and control
  - SDG&E – State Estimation

Project Status and Accomplishments

Accomplishments for Project Years 2004-05-06

Joe Eto and Virgil Rose to provide
based of project information provided
by EPG

Research Is Addressing Grid Challenges

Research Will Address Grid Challenges

Validate Value Proposition

	Wide Area Visibility	Improved Security and Reliability	Improved Asset Utilization	Reduce Congestion Cost
Real-Time Dynamics Monitoring	√	√		
State Measurement	√	√		
Security Assessment		√	√	√
Dynamic Line Rating		√	√	√
State Estimation		√	√	√
Post Disturbance Analysis		√	√	
Model Validation		√		
Protection and Control		√	√	
Smart Switchable Network		√	√	√

Summary Research Road Map

INFRASTRUCTURE	Point-to-Point System	Network – Adequate, Secure with Redundant Backup	Expanded Coverage/ Full Observability and Commercial Quality
APPLICATIONS	Research	Prototype, Demonstrate	Standardize and Commercialize/ Technology Transfer
POLICIES & PROTOCOLS	Define needs	Develop Standards	Monitor Performance
	2005-2006	**2005-2009**	**2010**