The Wide Area View: Synchrophasors
An Intelligent Utility Reality Webcast

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The Wide Area View: Synchrophasors

Phil Carson
Editor-in-Chief
Intelligent Utility Daily

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The Wide Area View: Synchrophasors

Tony Johnson
Consulting Engineer
Southern California Edison

Jeff Younger
Assistant Manager of Electronic Systems
Salt River Project (SRP)

Chantal Hendrzak
Project Manager and Applied Research Director
PJM Interconnection

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Agenda

Introduction
• Our definition of an intelligent utility
• As the grid becomes two-way, so does the conversation

The discussion
• Tony Johnson, Southern California Edison, explains synchrophasor technology and how it applies to SCE
• Jeff Younger, Salt River Project, discusses situational awareness and wide area measurement and control
• Chantal Hendrzak, PJM Interconnection, talks about how this applies to a multi-utility project

Q&A

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Introduction: An intelligent utility operation

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SCE’s Wide Area Situational Awareness System

Anthony Johnson
Anthony.johnson@sce.com
Outline

• What is a SynchroPhasor
• WASAS Design Considerations / Requirements
• WASAS System Design Overview
What is a SyncroPhasor?
Keys to the success of SyncroPhasors

• Accurate time stamp
• Voltage, Current, and Frequency
• Magnitude and angle
• 30 Samples per second
• From points all over the grid
Outline

• What is a SyncroPhasor
• WASAS Design Considerations / Requirements
• WASAS System Design Overview

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WASAS Design Considerations / Requirements

• Not a synchrophasor data only system – a wide-area situation awareness system primarily for use by control center operators
  – EMS/SCADA data
  – Non-electrical data (weather, fire, traffic, earthquake, etc.)
  – More will be added in the future!!!

• Not a standalone system – must interface with variety of external systems
  – Other SCE systems, such as EMS/SCADA, engineering database, etc.
  – External data servers for weather, fire, traffic, earthquake data
  – Synchrophasor data from phasor systems of other utilities (e.g. WECC member utilities)
  – May interface with more SCE internal and external systems in the future

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WASAS Design Considerations / Requirements (cont.)

• Will need to evolve to become a wide-area monitoring, protection and control system (WAMPACS) over time
  – Must be able to support all types of wide-area monitoring, protection and control applications

• System expansion anticipated
  – More phasor measurements from SCE and others
  – Other data (e.g. IED data)

• Will be part of SCE’s overall Smart Grid deployment
  – Leverage SCE existing IT infrastructure and common services
WASAS Design Considerations / Requirements (cont.)

• Current WASAS deployment complete by end of 2011 as an approved GRC project including all procurement, engineering, deployment, installation, and testing processes
SCE’s vision about WASAS

- Separate presentation, application, and data interface parts with interfaces between
  - Presentation and application
  - Application and data input adapter
- Work with NASPI to make interfaces to become open standards

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Outline

• What is a SyncroPhasor
• WASAS Design Considerations / Requirements
• WASAS System Design Overview
WASAS as part of SCE Smart Grid Vision
SCEnet2 Conceptual Architecture

### WASAS System Design Views – Network/Comm

<table>
<thead>
<tr>
<th>Core</th>
<th>Aggregation</th>
<th>Access</th>
<th>Premises</th>
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WASAS System Design Views – Data Flow
MPLS Resource Sharing (backbone)

Sub-networks:
- Admin VPN
- Grid VPN
- CRAS VPN
- DBS VPN
- PMU VPN
- Other VPN

Logical VPN Networks
WASAS System Design Views – Security
Four environments: Operation (OP), Production Test (PT), Development (DEV), and Training (TR)
- Full redundancy for OP and PT
- PT is exactly the same as OP

External access of WASAS data is through WASAS external historian databases
- Data are pushed from OP environment to external historian – no direct access from external
Additional information
SCE’s Wide Area Situational Awareness System

Anthony Johnson
anthony.johnson@sce.com
Office: 626-308-6936
Cell: 661-803-4499
www.sce.com/smartgrid

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SRP
Synchrophasor Activities

Jeff Younger
SRP Electronic Systems
Salt River Project (SRP)

- 3rd largest public power utility
  - ~940,000 electric customers
  - 2,900 sq miles of service territory
  - 90% Residential + 10% C&I
Why Synchrophasors

- Instantaneous view of the state of the electric system
- Once you have the data, there are a variety of applications:
  - Enhanced state estimation
  - Operator visualization
  - Black Start visibility
  - Line impedance derivation
  - Post-disturbance analysis
  - Island phase angle studies
  - Power network model validation
  - Oscillatory mode detection & damping

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Synchrophasor Data Flow – Concerns

- IRIG-B failure
- Communication channel failure
- PDC Software lockup
- Inter-vendor operability issues
- Different C37.118 interpretations
- Inter-utility data-sharing issues
- Data archiving concerns
- Security
Industry Trends

- IEEE C37.118 now widely available
  - Common platform, minimum performance standard
- Ethernet availability
  - Increased bandwidth for wide area control applications
- Software advances
  - Improved operator displays, on-line/real-time analysis
- Government & University R&D
  - Optimal placement of PMUs
  - State Estimation enhancement
- More DFR & relay-embedded PMUs
  - Hathaway, GE, SEL, ABB
Industry challenges

• Inter-operability
  o Can brand G **really** talk to brand S? Reliably?

• Security
  o Data sharing among utilities can be difficult
  o More hooks into substation, relays

• Operator acceptance
  o Must turn **data** into **information**
  o Efficient visualization is key

• Cohesion among utilities
  o Need for a common forum & standards

• Catch-22 application cycle
  o Developer needs installed PMU base
  o Installing PMUs requires a business need
Western Interconnection Synchrophasor Program (WISP)
WISP High-Level Scope

1. Synchrophasor Infrastructure
   - Deployment of 250+ plus PMUs and phasor data concentrators (PDC) throughout the Western Interconnection, data and wide-area network communication infrastructure, IT infrastructure, and the NASPI integration infrastructure

2. Synchrophasor Applications and Tools
   - Real-Time Applications
     - Situational awareness for operators
     - Wide-area controls for automatic safety nets
   - Offline Applications and Tools
     - Power system performance and disturbance evaluation
     - System-wide model validation

3. RC Reliability Improvement Processes
SRP Synchrophasor Team

• An ongoing, multi-departmental effort
  o Computer Applications – EMS, SE
  o Communications Engineering – network
  o Communications C&M – field installation
  o Transmission Planning – model validation & disturbance analysis
  o System Protection – PMU design, settings
  o System Operations – visualization
  o Control Engineering – EMS, SE integration
  o Relay Shop – field installation, maintenance
Team Milestones

- Used real-time PMU data during Black Start exercise
- Installed permanent PMUs for Black Start path
- Installed permanent, redundant PDC network
- Initiated EIPP/NASPI & WISP involvement
- Evaluated GE N60 & L90 & Hathaway DFR PMU capabilities
- Published papers at WPRC, Texas A&M, NAPS, ETEP
- Funding research with Arizona State University
  - Optimal placement of PMUs
  - State estimator enhancement
  - Line impedance verification
  - Tools for operator situational awareness
  - Generator dynamic parameter validation

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SRP Future Efforts

• Hardware
  o 230kV & 500kV expansion plan is underway
  o Evaluating Arbiter 1133A PMU device
  o Hathaway DFR upgrades

• Software
  o State Estimator & EMS integration
  o Evaluating visualization packages (RTDMS)

• Industry Involvement
  o Increased WECC WISP & JSIS involvement
SRP Synchrophasor Contact

For Additional Information:

Steve Sturgill
Steve.Sturgill@srpnet.com
602-236-4387
PJM SynchroPhasor Technology Deployment

Chantal Hendrzak
General Manager – Applied Solutions
PJM Interconnection
PMU Installations in the U.S.

Source: NASPI, April 2010
Pre-Grant SynchroPhasor Deployment

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Production Quality System to Support 80+ Monitored Substations
Voltage Stability Monitoring

Determination of Accurate Operating Limits

Model Derivation & Validation

Inter-area Oscillation Detection & Analysis

Disturbance Analysis

Angle & Frequency Monitoring

Wide-area monitoring

Improve State Estimation

System Restoration

Real-time Control of wide-area network

Detection of imminent Cascading

Real-time control of corridors

Deployment Challenge

1-2 years

2-5 years

>5 years ?

Needs moderate development

Requires more research

Ready to deploy

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When Visibility is Lacking

August 14, 2003 Blackout

Phase Angles Diverged Prior To Blackout

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SynchroPhasor Applications

- Real-time Control of wide-area network
- Detection of imminent Cascading
- Voltage Stability Monitoring
- Improve State Estimation
- System Restoration
- Real-time control of corridors
- Model Derivation & Validation
- Determination of Accurate Operating Limits
- Inter-area Oscillation Detection & Analysis
- Disturbance Analysis
- Angle & Frequency Monitoring
- Wide-area monitoring

Deployment Challenge:
- Requires more research
- Needs moderate development
- Ready to deploy

1-2 years
2-5 years
>5 years?

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Actual System Performance
- unstable system behavior observed.

Model Simulation
- predicted stable system performance.
PJM SynchroPhasor Deployment: System Overview

Event & Alarm Processor → Data Processing → Phasor Data Archive → Displays

EM/SCADA

Super PDC

PJM Displays → TO

PDC → PMU

Data Processing*

Other Monitoring Entities (FERC/NERC, etc.)

* TOs can optionally receive phasor data from PJM
SynchroPhasor Redundant Network

TO Sites

Vendor 1
MPLS Network
(Traffic encrypted from router to router)

Vendor 2
MPLS Network
(Traffic encrypted from router to router)

Future NASPINet Connection*

*Routers will be capable of connecting to NASPINet

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**Metrics / Benefits**

**Economic**
- Reduced Congestion Costs
- Infrastructure Investment
- Construction & Electric Infrastructure Assets (80+ PMUs / 17 PDCs)
- Job Creation

**Reliability**
- Situational Awareness - Visualization & Alerting/Alarming
- Event Capture & Tracking
- Model Validation & Improvements
- Post-Distribution Event Analysis
- Transmission Assets Monitored & MW Flows

**1-3 years**
- Reduced Congestion Costs
- Optimized Operations

**3-5 years**
- Reduced Wide Area Outages and Faster Restoration
- Improved Voltage Stability Tools
- Inter-Area Oscillation Tools
- Lower equipment failures

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For Additional Information on PJM’s SynchroPhasor Deployment

Chantal Hendrzak
hendrc@pjm.com
Office: 610-666-4635
www.pjm.com
Q&A

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Energy Central
Contact Information:
webcastquestions@energycentral.com
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Closing Remarks

Phil Carson
Editor-in-Chief
Intelligent Utility Daily

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