Introduction to Synchrophasor Technology

NASPI-NREL Synchrophasor Technology and Renewables Integration Workshop

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Wide Area Measurement System (WAMS)

Data acquisition devices (continuously recording and time synchronized)

- Phasor Measurement Units (PMU)
  - Inputs from potential transformers (PT) and current transformers (CT)
- Analog signal recorders (with transducer inputs)
- Point-on-wave (POW) recorders (with PT, CT inputs)
- Controller monitors (generators, HVDC, FACTS)
  - Inputs from the controller interface or the controlled device
- Advanced relays and other Intelligent Electronic Devices (IED)
- Digital fault recorders and other sequence of events recorders

Generally **NOT** supervisory control and data acquisition (SCADA), typically a polling architecture that does not collect time-synchronized measurements (time stamps applied when the signals are logged into the energy management system at the control center)

Lessons Learned from August 10, 1996

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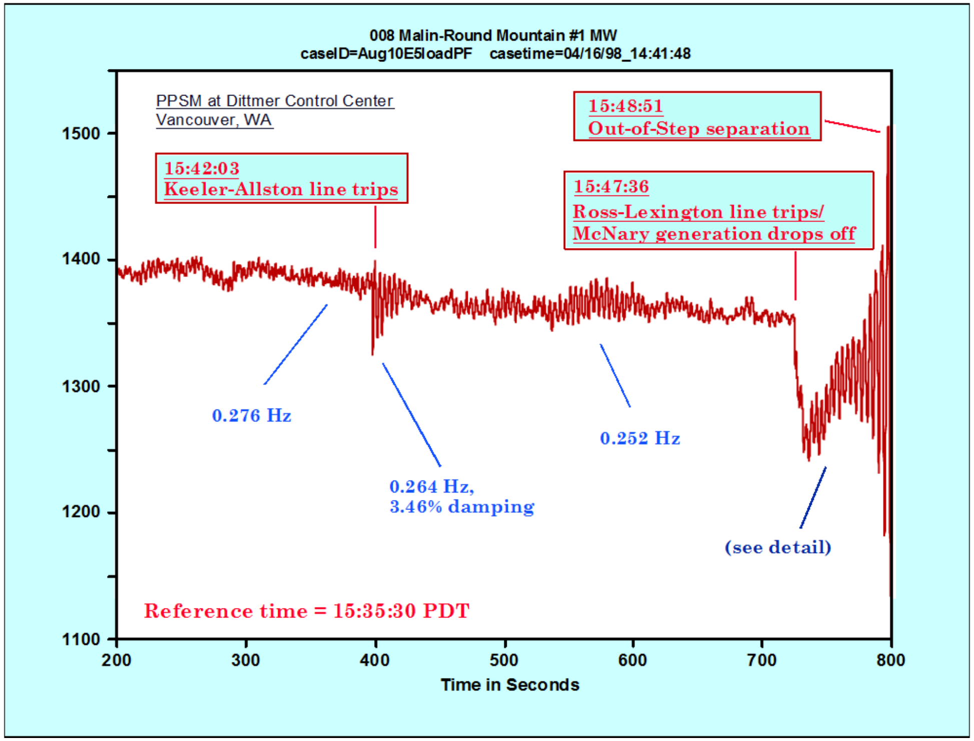
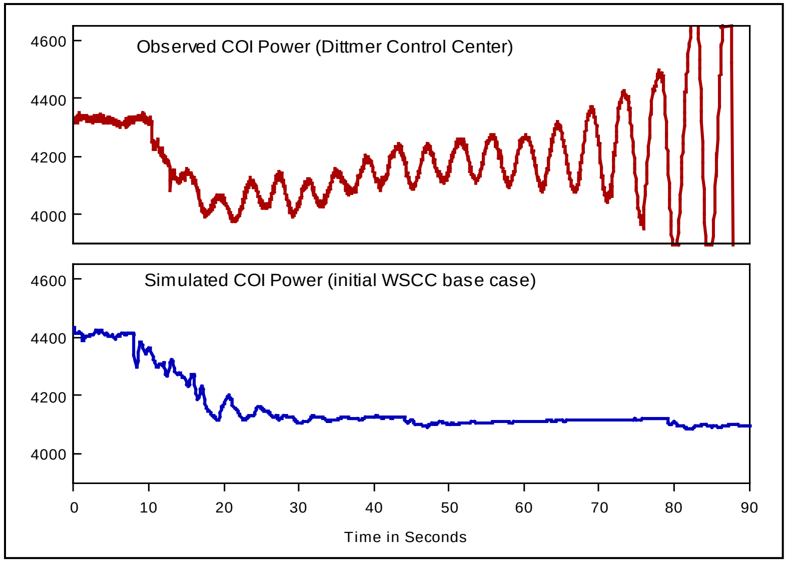
Data captured from WAMS was essential to support the blackout investigation



The need for better model validation was demonstrated



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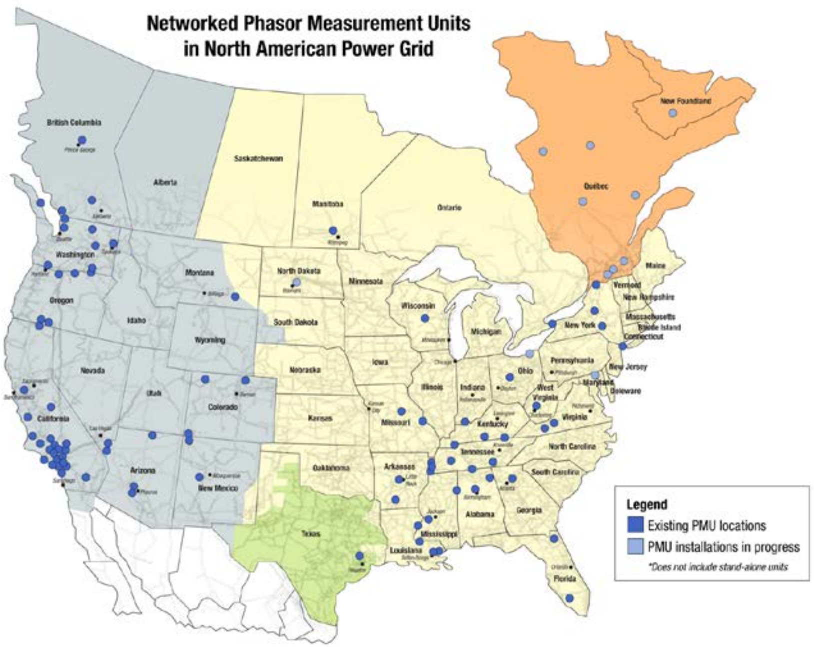
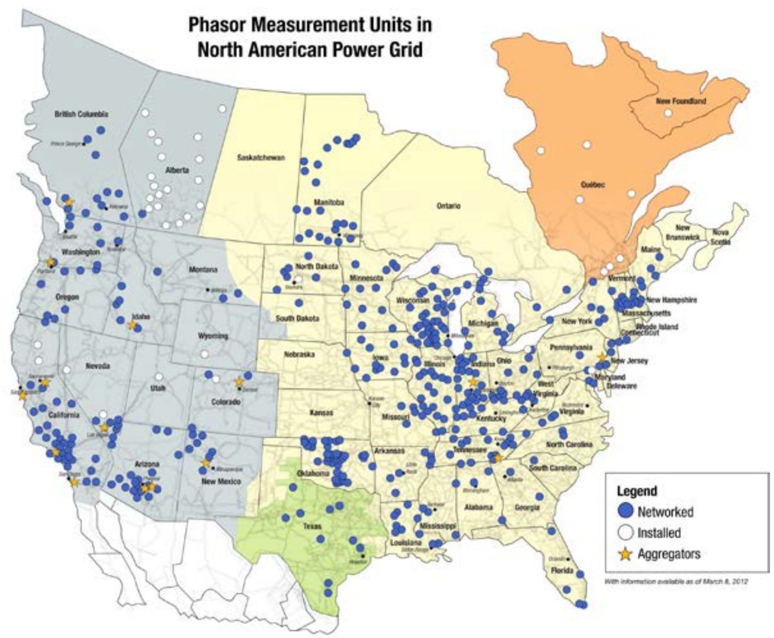
DOE and NERC are working together closely with industry to enable wide area time-synchronized measurements that will enhance the reliability of the electric power grid through improved situational awareness and other applications

April 2007



March 2012



"Better information supports better - and faster - decisions."

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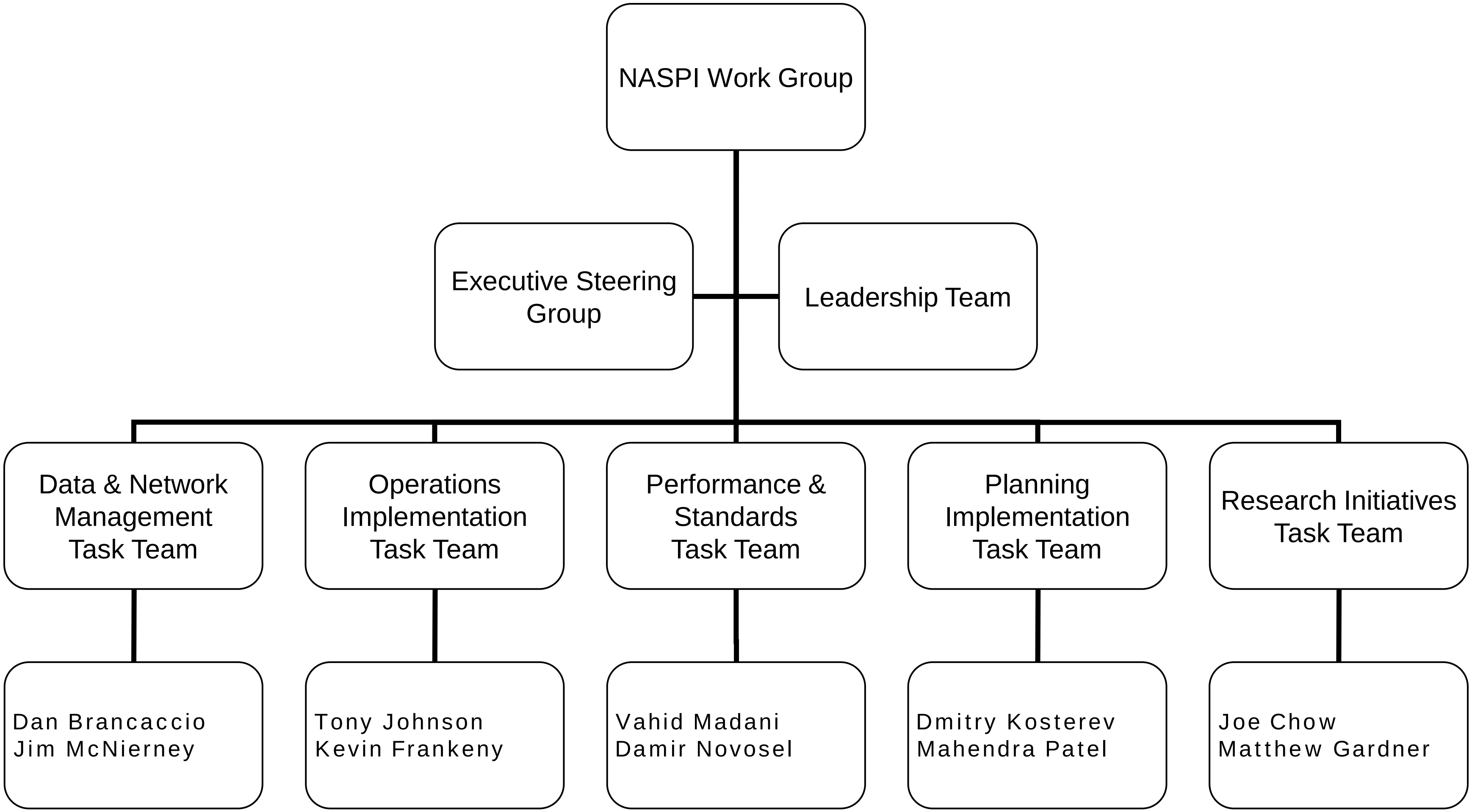
NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

NASPI Organization



NASPI Work Group Meetings: 2009-2011

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Date	Location	Meeting Themes
February 4-5, 2009	Scottsdale, Arizona	Networking and cyber security
June 3-4, 2009	Sacramento, California	Operations and success stories
October 7-8, 2009	Chattanooga, Tennessee	Vendor showcase
February 24-25, 2010	Austin, Texas	Recovery Act projects, technology specifications, intermittent generation
June 8-9, 2010	Vancouver, Canada	International activities and baselining
October 5-6, 2010	Arlington, Virginia	Recovery Act project updates
February 23-24, 2011	Fort Worth, Texas	Technical standards and vendor showcase
June 8-9, 2011	Toronto, Ontario	Success stories
October 12-13, 2011	San Francisco, California	Recovery Act project updates

NASPI Work Group Meetings: 2012

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Date	Location	Meeting Themes
Feb. 29-March 1, 2012	Orlando, Florida	Research initiatives and application training sessions
June 6-7, 2012	Denver, Colorado	Success stories and vendor show
October 17-18, 2012	Atlanta, Georgia	Recovery Act project updates

REAL-TIME SYNCHROPHASOR APPLICATIONS AND THEIR PREREQUISITES

Applications

Wide-area Monitoring
- Visualization
- Frequency and voltage monitoring
- Oscillation detection

- Event detection
- Alarming

- Operator decision support

- Automated wide-area controls
- Reliability Action Schemes

Functions

System protection

Increase in operating transfer capacity

Renewable integration

Congestion management

Outage avoidance

Situational awareness

TODAY → **FUTURE**

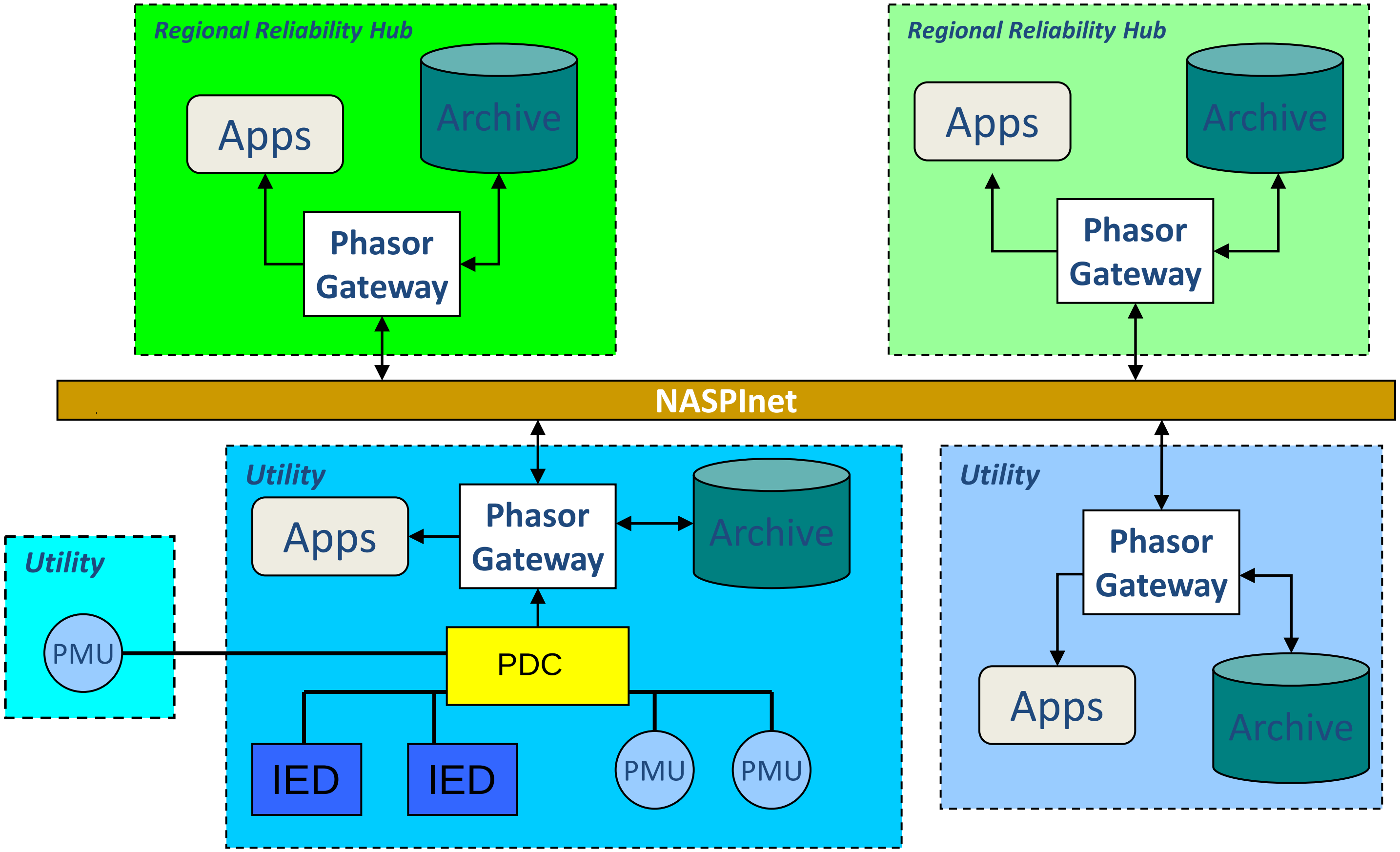
Prerequisites

ANALYSIS	Good data collection	Interconnection-wide baselining	Pattern detection	Model validation – system & elements	System studies
COMMUNICATIONS	Interoperability standards	High availability, high speed	Appropriate physical & cyber-security	Redundant, fault-tolerant	
USERS	Familiarity	Good visual interface	Training		

Technology Maturation Progress

- Sharing users' and vendors' success stories and high-value applications
- Accelerating development of technical interoperability standards
- Focusing and facilitating baselining and pattern recognition research (e.g., oscillation detection) and other R&D
- Early identification of project implementation challenges and community work to develop and share solutions
  - Develop and test PMU device specifications and interoperability
  - Communications network design
  - PMU placement
  - End-to-end data flow and quality
  - Developing requirements for "production-grade" systems
  - Building key software infrastructure (NERC GPA investment)
  - Enhance applications value and operator and user training
  - On the horizon – more technical standards; cyber-security and GPS

The NASPInet Vision –
A Distributed Network for Data Exchange and Sharing



NASPI Application Classification

Class	*Basic Description*	*Sampling/ Data Rate*	*Required Latency*
A	**Feedback Control**	**Fast**	**Fast**
B	**Open Loop Control**	**Medium**	**Medium**
C	**Visualization**	**Medium**	**Medium**
D	**Event Analysis**	**Fast**	**Slow**
E	**Research/Experimental**	**N/A**	**N/A**

Security requirements are a function of the application

Security of Synchrophasors

- Synchrophasors are becoming part of the bulk electric system and will require physical and cyber security
  - ***But these systems shouldn't be treated any differently than other forms of measurement and control telemetry***
- Synchrophasor systems will coexist with other bulk electricity system (BES) cyber infrastructure and will have similar dependencies on common communications and network elements
- System designers and owners are leveraging emerging cyber-security standards and technologies
- Currently available phasor applications require further data analysis, software refinement and operational validation to be fully effective; many are in advanced development and testing and are not in full operational use
  - Therefore, many of these systems are not currently considered critical cyber assets
- Due to nature of continuous, high-volume data flows, new technology will likely be required for measurement, communications, and applications
  - Technology anticipated to undergo rapid change and refinement over the next several years

Conclusions

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- DOE has played a key catalyst role in the development and implementation of synchrophasor technology
- DOE and NERC will continue to support industry efforts to promote and enable widespread adoption of advanced monitoring technologies to ensure grid reliability
- DOE will actively support needed R&D to ensure that the full value of a North American phasor network will be realized
  - ***Hardware*** – measurement technologies
  - ***Network*** –data access and security
  - ***Software Applications*** – focus on reliability management objectives
  - ***Demonstrations*** – regional in scope
- Recovery Act is enabling unprecedented advancement of synchrophasor technology deployment

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http://www.naspi.org/