• PJM Leads:
  – Project Manager: David Ulmer (ulmerd@pjm.com)
  – SynchroPhasor Technical Lead: Mahendra Patel (patelm3@pjm.com)

• Vendor Partners:
  – Electric Power Group (visualization software)
  – Quanta Technology (engineering/project management)
  – Virginia Tech University (PMU/PDC device testing)
<table>
<thead>
<tr>
<th>Transmission Owner</th>
<th># of Substations with PMU Installations</th>
<th># of Central PDCs</th>
</tr>
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<tbody>
<tr>
<td>Allegheny Power</td>
<td>8</td>
<td>2</td>
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<td>American Electric Power</td>
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</tr>
<tr>
<td>Baltimore Gas &amp; Electric</td>
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<tr>
<td>Commonwealth Edison</td>
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<td>1</td>
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<tr>
<td>Duquesne Light</td>
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<td>FirstEnergy Services</td>
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<td>PECO Energy</td>
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<td>Public Service Electric &amp; Gas</td>
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<tr>
<td>Rockland Electric</td>
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<td>VA Electric &amp; Power (Dominion)</td>
<td>11</td>
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</tr>
</tbody>
</table>
PJM SynchroPhasor Deployment: System Overview

TO

PJM Displays

Data Processing (optional)

PMU*

PMU

PDC*

1-2 per TO

> 60 Stations

Other Entities (ISOs/RTOs, etc.)

* TOs select PMU and PDC vendors based on PJM project requirements and device testing

PJM

Displays

Event & Alarm Processor

Data Processing

Phasor Data Archive

PJM PDC

EMS/SCADA

Redundant at Two Sites
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
- Included in Project

- 1-2 Years
- 2-5 Years
- >5 Years
Generator Model Validation
Load models are the least accurate component of the power system model.

Having synchrophasor data will help better characterize and represent loads in system studies.
PJM SynchroPhasor Security Framework

SynchroPhasor Security Framework

Cyber Security & Regulatory Compliance

Benefits
- Detection
- Response
- Mitigation
- Correction
- Restoration

Elements of Security

- Requirements and Design
- Logging and Monitoring
- System Testing
- Network Segmentation
- Perimeter Protection
- System and Communication Protection
- User Security
- Centralized Auditing and Monitoring

NERC CIP Standards (Elements of Compliance)

- CIP-002
- CIP-003
- CIP-004
- CIP-005
- CIP-006
- CIP-007
- CIP-008
- CIP-009
Forging Great Relationships

Transmission Owners
- Allegheny Power
- PECO Energy
- Virginia Electric & Power
- American Electric Power
- Commonwealth Edison
- PPL Electric Utilities
- Baltimore Gas & Electric
- FirstEnergy Services
- Public Service Electric & Gas
- Duquesne Light
- PEPCO Holdings Inc.
- Rockland Electric

Security Partnership

Benefits
- Security influence
- Knowledge sharing
- Effective practices
- Networking
• Vendor review matrix, to facilitate the uniformity of the vendor evaluation process.

• Standard, minimum audit log requirements (IEEE 1686 standard) to ensure PJM and TOs receiving /monitoring the same data sets

• Discuss industry events and impact to project
Telecommunications Network: Initial Phase

- Multiprotocol Label Switching (MPLS) networks with existing vendors
- Mimics existing ICCP/SCADA networks (proven technologies)
- Highly scalable
- Protocol agnostic transport
Telecommunications Network: Final Phase

Vendor 1 MPLS Network

Vendor 2 MPLS Network

Traffic encrypted from router to router

PJM Site 1
- Catalyst 4948 Switches
- Cisco 3845 Routers
- Catalyst 4948ASA 5520 Firewalls

PJM Site 2
- Catalyst 4948 Switches
- Cisco 3845 Routers
- Catalyst 4948ASA 5520 Firewalls

TO Sites
- PPL PDC
- CE PDC
- DLCO PDC
- PS PDC
- AEP PDC
- RECO PDC
- PHI PDC
- BGE PDC
- DOM PDC
- 2 PMUs
- 11 PMUs

Application Servers

*Hub Routers will be capable of connecting to NASPINet
• High-level Project Challenges
  – Evolving standards, technologies, and security guidelines
  – Coordination of all project stakeholders (TOs, Vendors, ISO/RTOs, DOE)

• Architecture, Design, and Communications Challenges
  – Project requirements/design lead standards development
  – Confidence in the performance of PMU/PDC equipment
  – Ensuring the architecture is scalable (more PMU’s in the future)
  – Ensuring the architecture is extensible (supporting more applications in the future)
  – Complexities of sharing data between organizations
• Other Project Updates
  – PJM and MISO to begin real-time data sharing in Q2 2011

• Opportunities for NASPI
  – Continued forum to discuss optimal architectures, project requirements, performance of equipment, and lessons learned
  – Take a lead role in further expansion of NASPInet Use Cases and the development of an implementation of the NASPInet functions