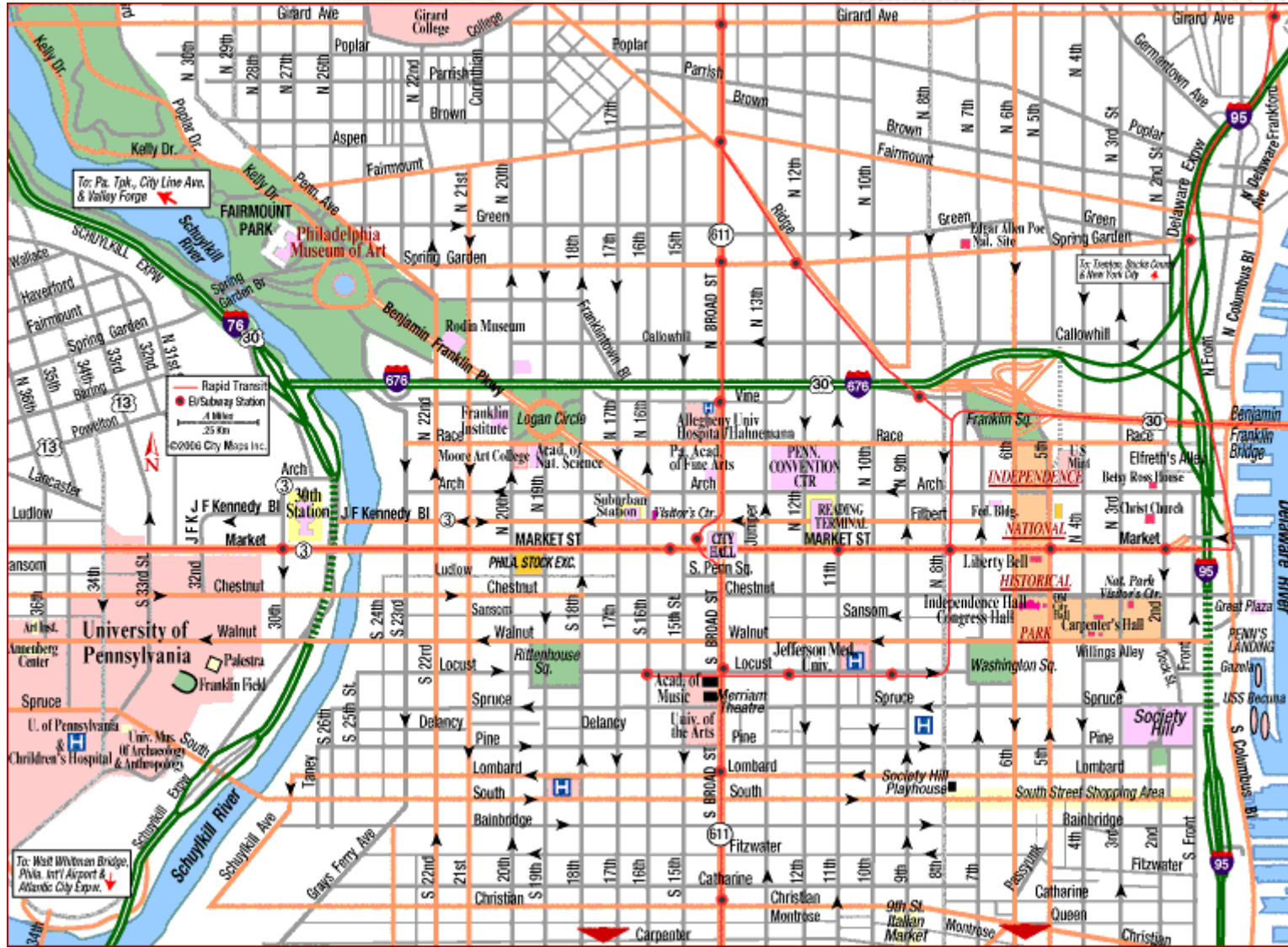




Synchrophasors at PJM

Mike Bryson
VP, Operations

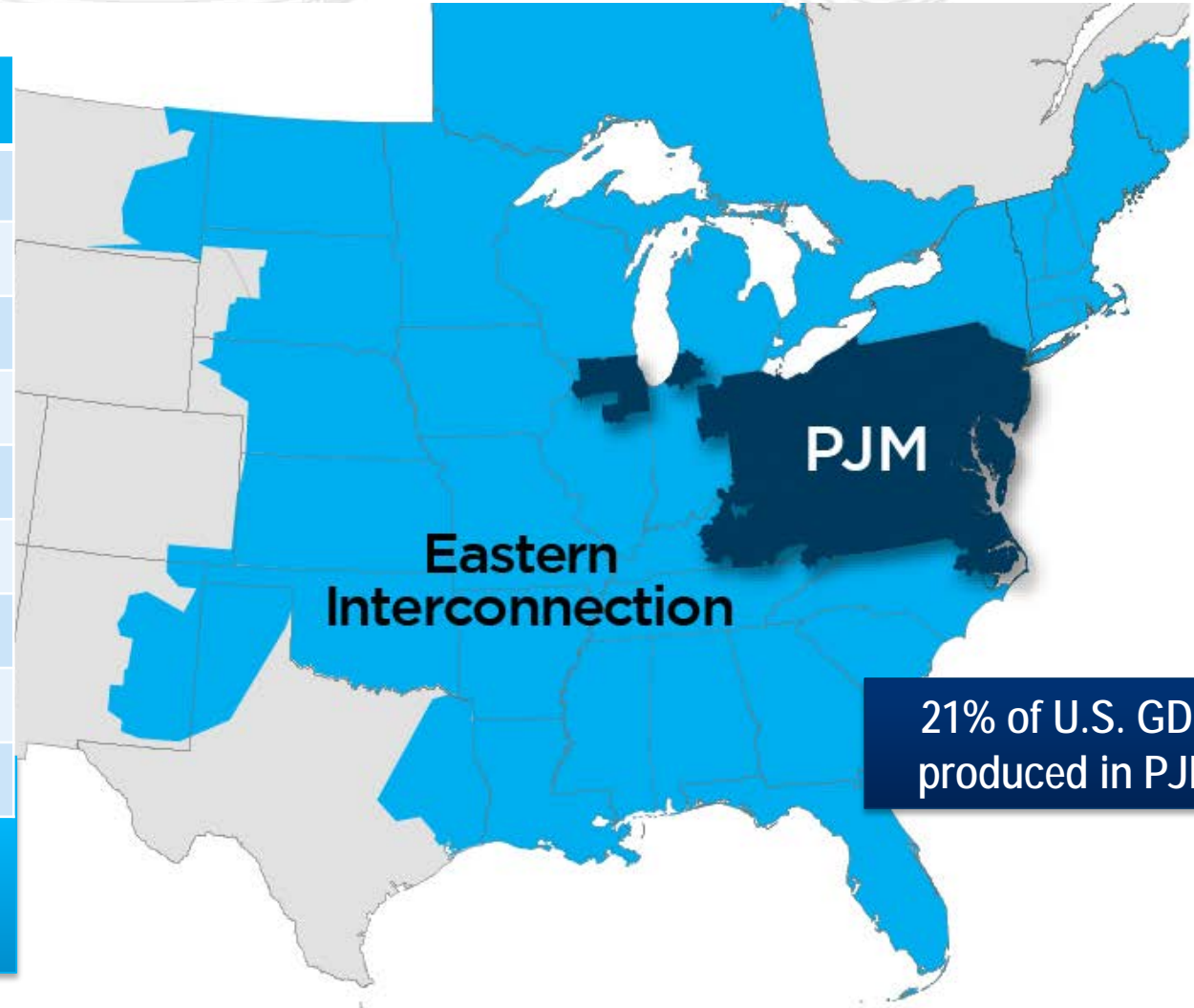
NASPI WG Meeting
October 23, 2018



Key Statistics

Member companies	1,040+
Millions of people served	65
Peak load in megawatts	165,492
MW of generating capacity	178,563
Miles of transmission lines	84,042
2017 GWh of annual energy	773,522
Generation sources	1,379
Square miles of territory	243,417
States served	13 + DC

- 28% of load in Eastern Interconnection
- 20% of transmission assets in Eastern Interconnection



As of 2/2018

Unprecedented number of changes in the power industry



Storage technologies



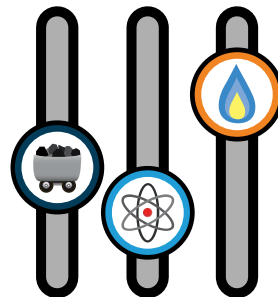
Distributed energy resources



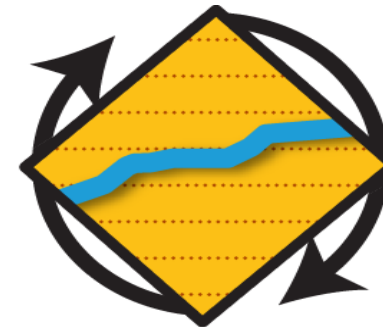
Intermittent renewables



Alternative technologies



Fuel Swap



Changes in customer expectations



Risks / Dependencies:
 Extreme Weather | Physical/Cyber Attacks | Fuel Source/Security

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Prepare

- Assess Risks**
Targeted risk management
- Strengthen Infrastructure**
Make critical assets less vulnerable
- Increase Coordination**
Cross-sector & public/private partnerships

Operate

- Strengthen Operations**
Expand coordination and communications
- Enhance Continuity**
Planned response exercises
- Apply Innovative Approaches**
Microgrids & distributed energy resources

Recover

- Stabilize the System**
Prioritize interdependent infrastructures for system survivability
- Regain Critical Functions**
Balance industry and societal priorities
- Make Enhancements Based on Lessons Learned**

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PJM Synchrophasor Project History

2010

PJM and 12 Transmission Owners began the \$27 M Synchrophasor Project with ~\$14 M in DOE matching funds.

2014

- Synchrophasor project implementation completed.
- New generators larger than 100 MW required to install PMUs.

	Initial Infrastructure	Today
PMUs	301	381 (835 including external)
Transmission Substations with PMUs deployed	85	115
Data	21 Phasor Data Concentrators (TO-Level)	42 GB stored per day
	2 Super Data Concentrators (PJM)	New applications developed and deployed

2013

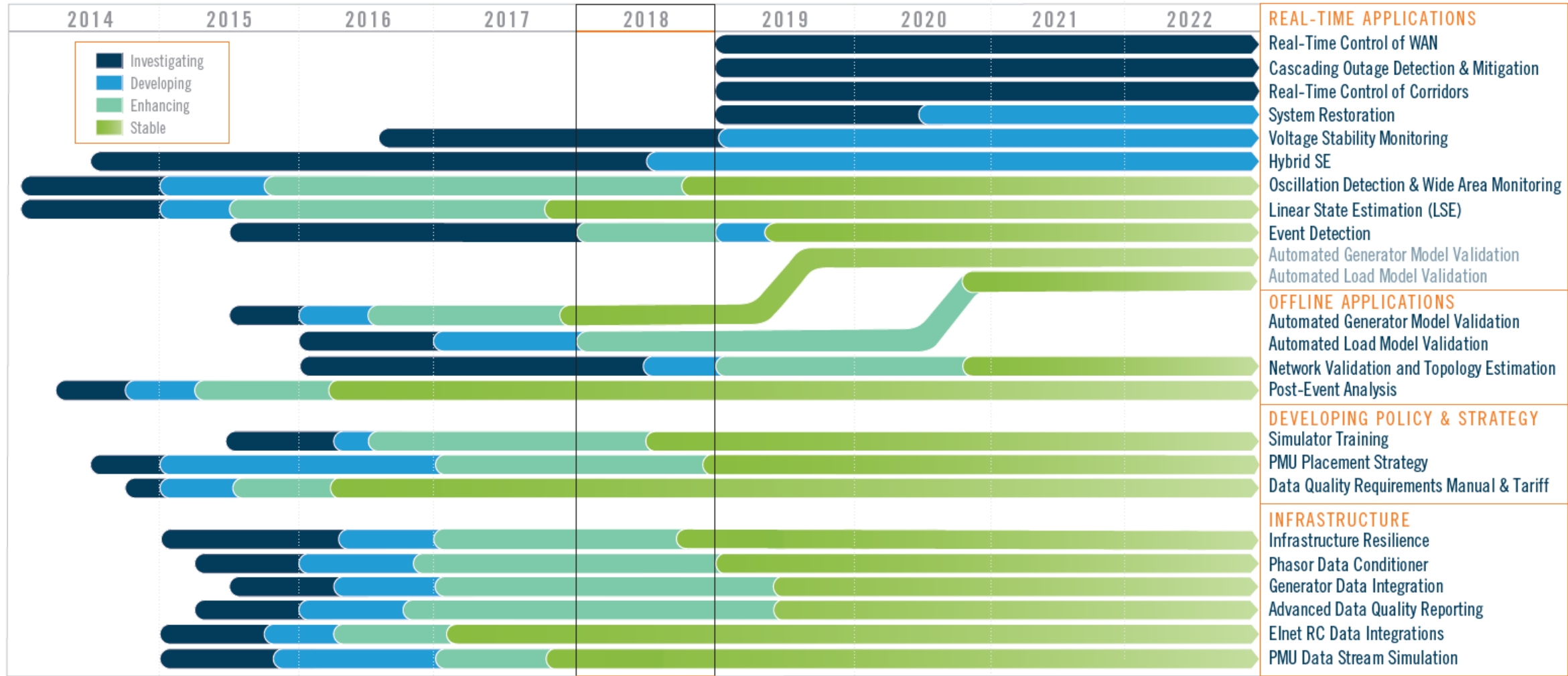
Phasor Data Quality Task Force (PDQTF) stakeholder group established to improve Synchrophasor data quality performance and reporting.

2018

PJM continues to use and expand our Synchrophasor infrastructure.

PJM SYNCHROPHASOR TECHNOLOGY ROADMAP

USED & USEFUL	Year Started	Year Stable
Phasor Data Concentrator	2013	2015
TO DOE Project Data Integration	2013	2016



New version of RTDMS tested and installed— focus on oscillation detection

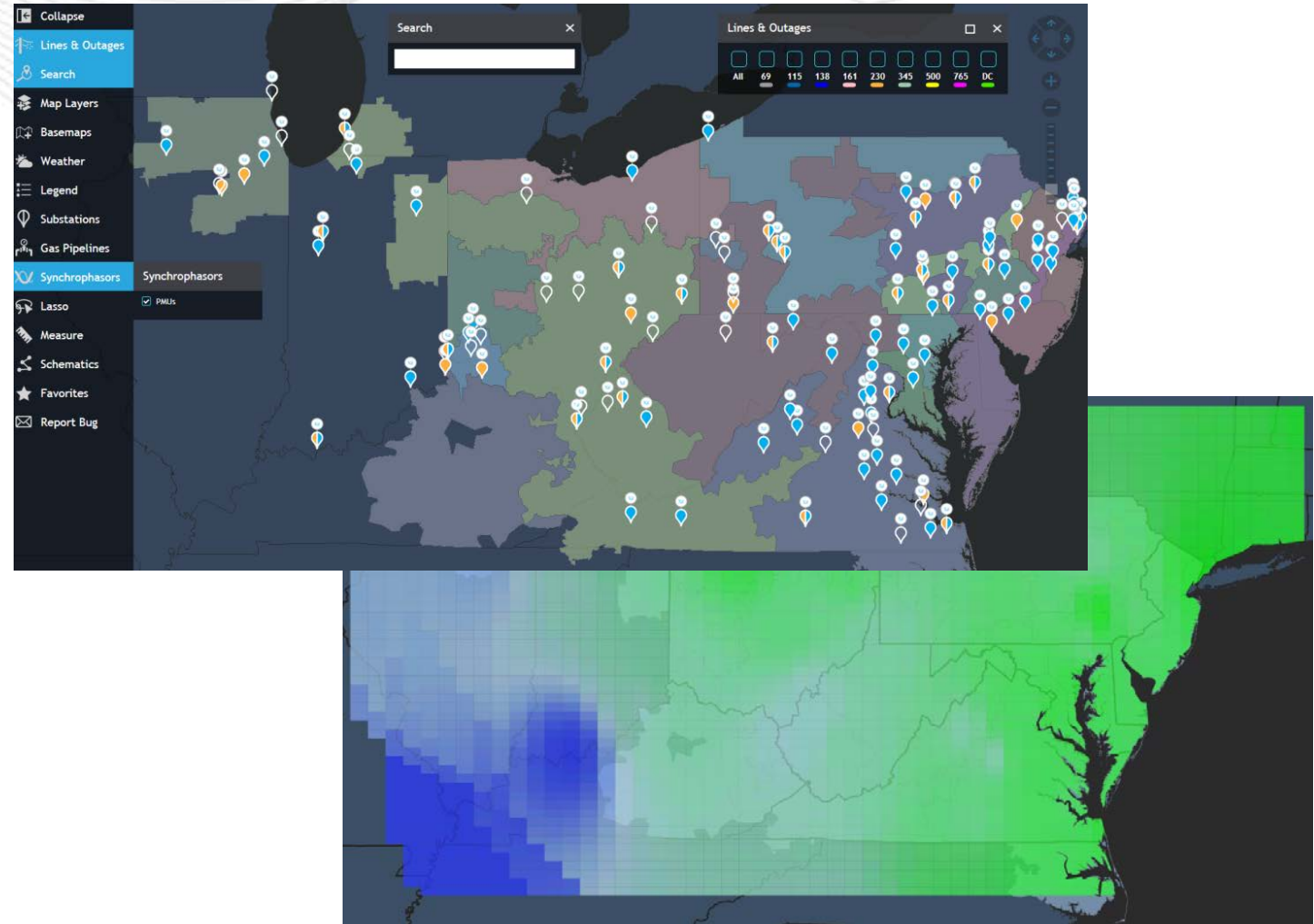
Formalized PMU event analysis team

Simulator-based operator training

Interconnection – wide situational awareness tool

Visualization

- PMU location information in DIMA
- Data heat maps



How can Synchrophasor data improve PJM's operational resilience?

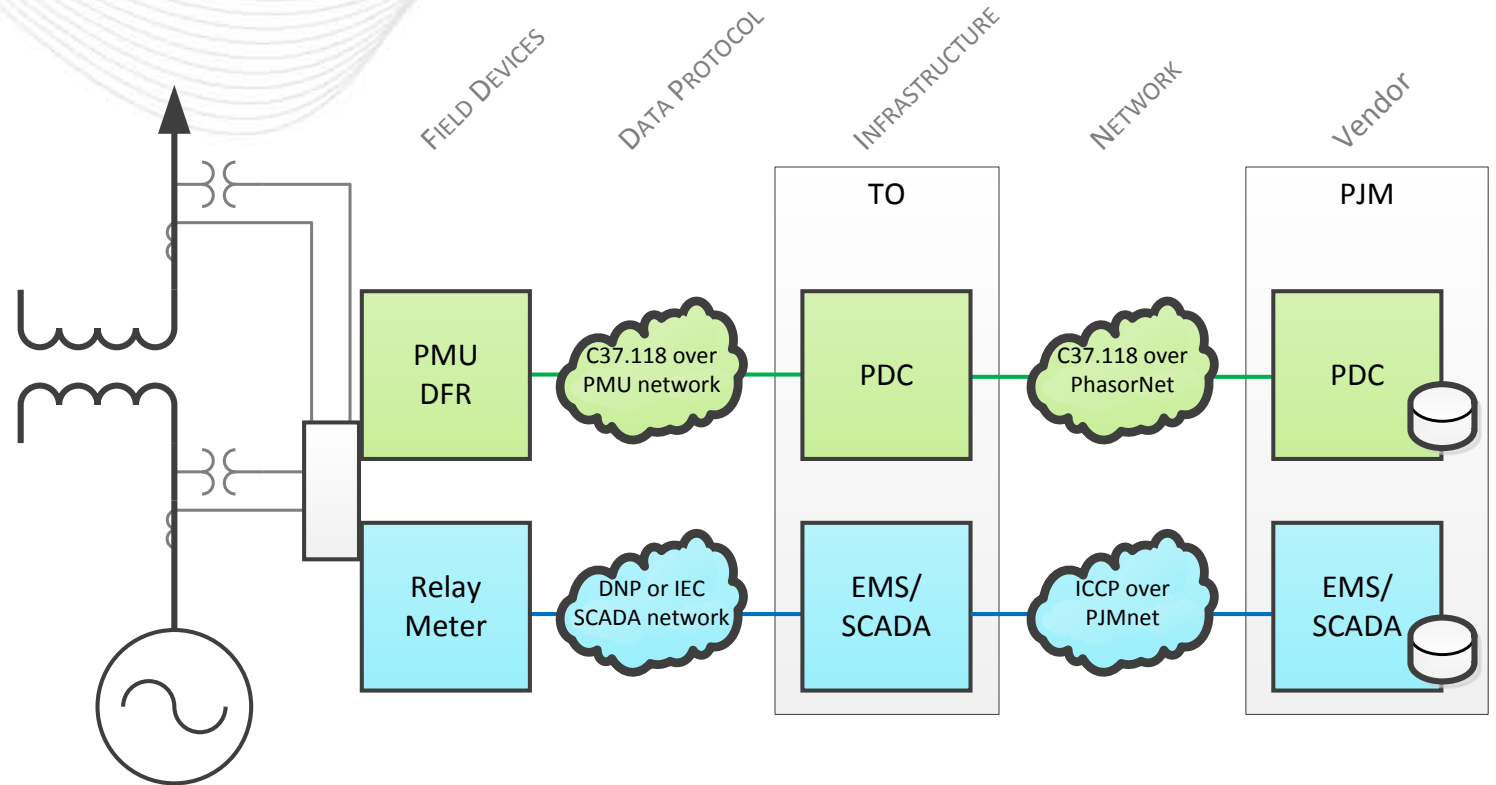
PMU data can be used to replicate and reinforce existing operational functions:

- State Estimation
- IROL
- ACE
- Voltage monitoring
- Thermal monitoring

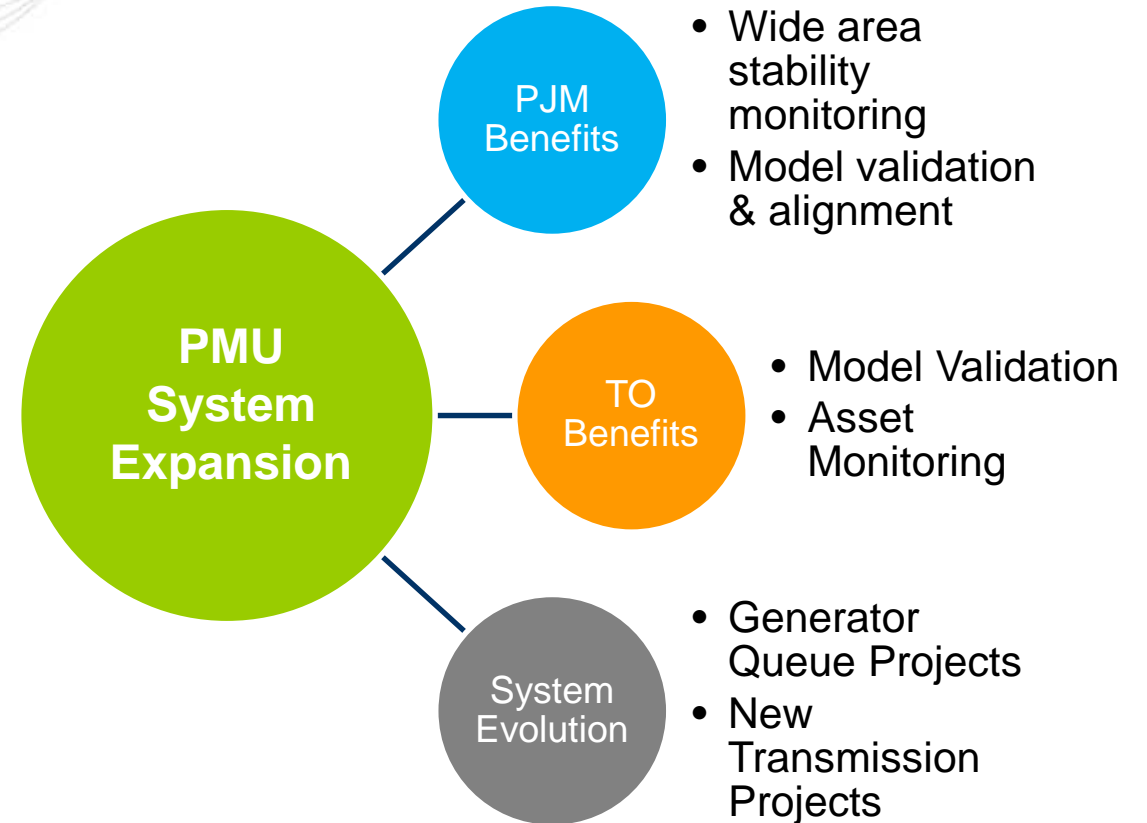
In-use applications unique to synchronized measurements

- Detecting system islands
- Oscillation monitoring

- Real-time tools:
 - Oscillation Detection
 - GIS Visualization
- Improve PMU Data Quality
- Strategic PMU Installations



- PMUs improve real time dynamics monitoring
 - Oscillations
 - System Islands
- PMUs improve model validation
- Needs for System Resilience
 - Improve visibility
 - Backup essential functions



- Generator model validation
- 2019 project to automate gen. model validation with event detection application
- Down the road: transmission and load model validation