The Wide Area View: Synchrophasors

An *Intelligent Utility* Reality Webcast

July 8, 2010

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The Wide Area View: Synchrophasors

Phil Carson
Editor-in-Chief
Intelligent Utility Daily

The Wide Area View: Synchrophasors

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

Chantal Hendrzak
Project Manager and Applied Research Director
PJM Interconnection

Agenda

Introduction

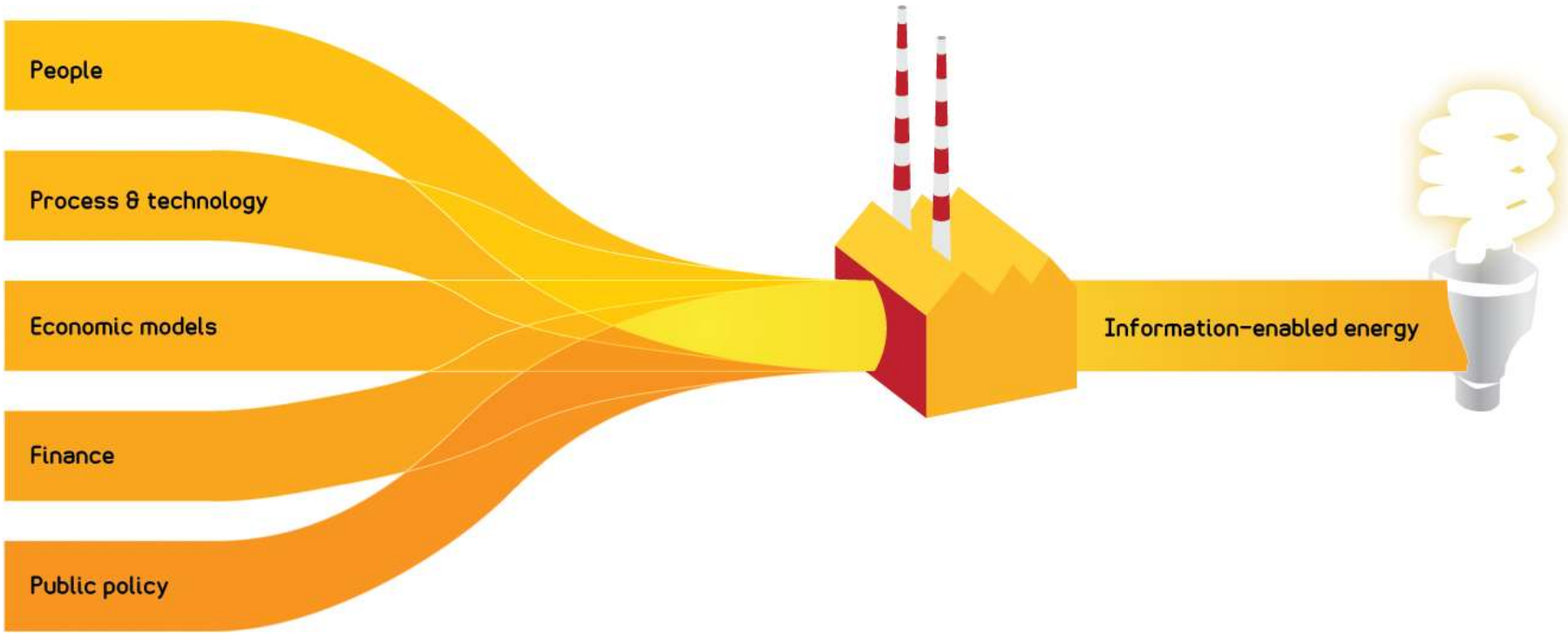
- Our definition of an intelligent utility
- As the grid becomes two-way, so does the conversation

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

Introduction: An intelligent utility operation



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SCE's Wide Area Situational Awareness System

Anthony Johnson
Anthony.johnson@sce.com

SOUTHERN CALIFORNIA EDISON
An EDISON INTERNATIONAL Company

Outline

- What is a SynchroPhasor
- WASAS Design Considerations / Requirements
- WASAS System Design Overview

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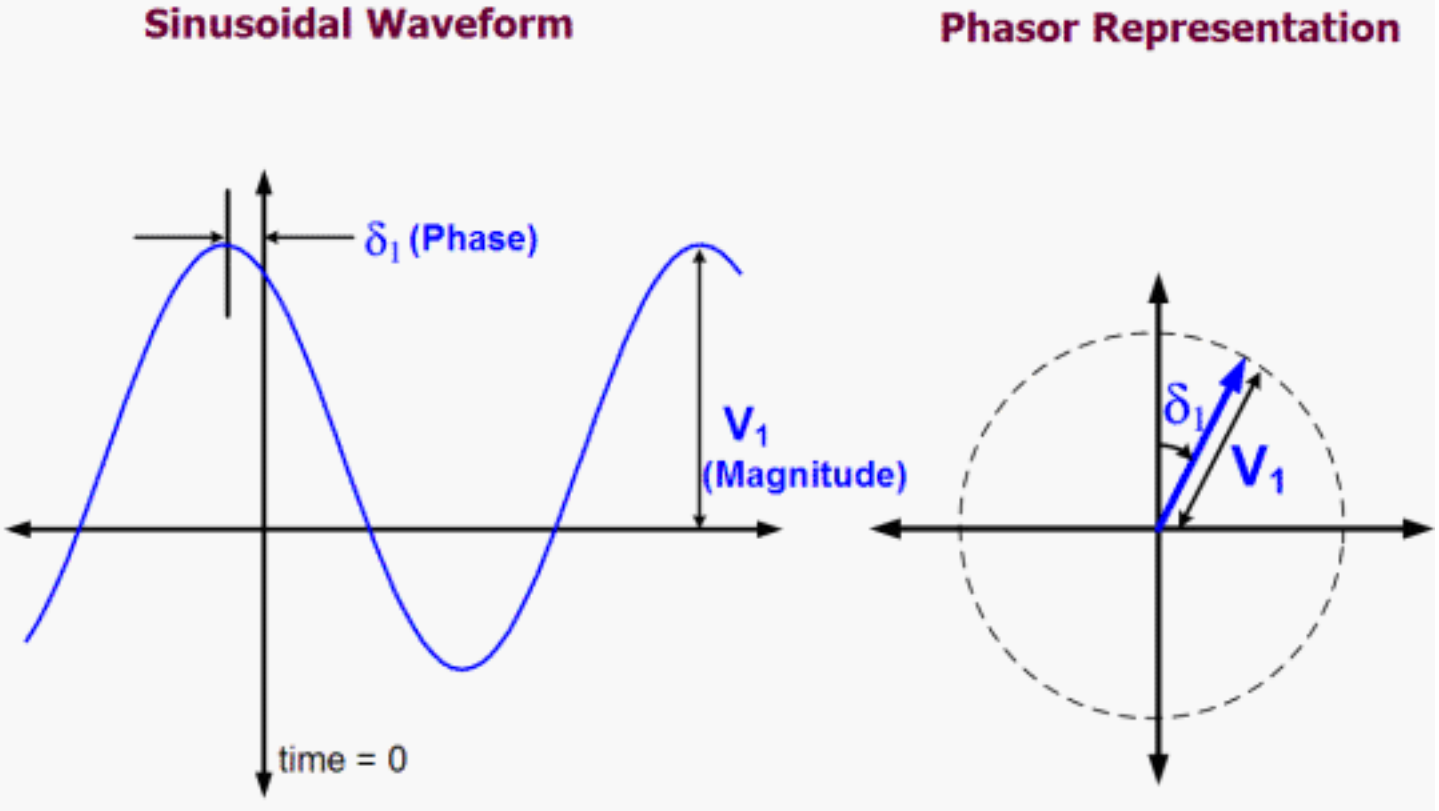
What is a SyncroPhasor?



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

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WASAS Design Considerations / Requirements

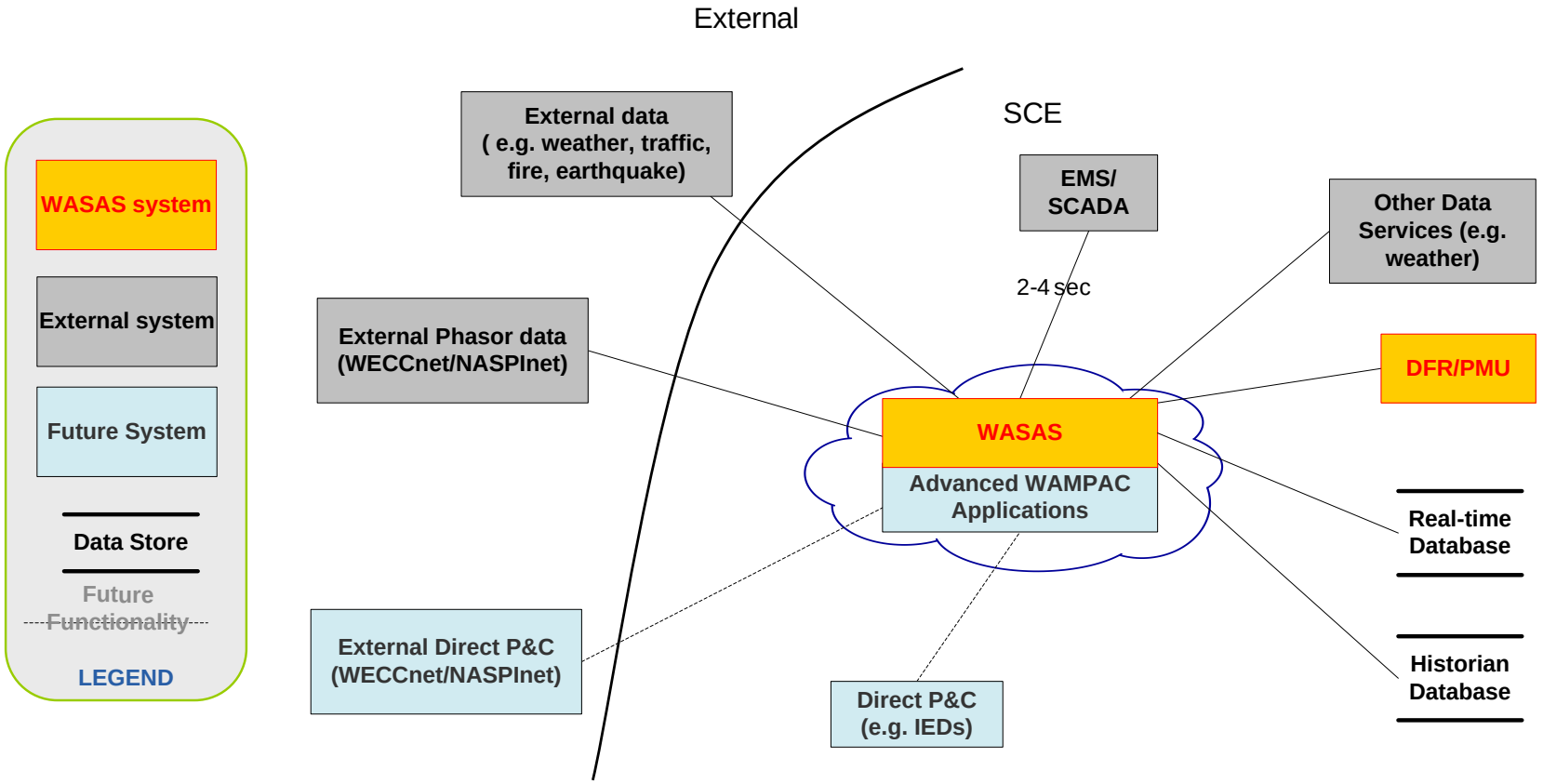
- Not a synchrophasor data only system – a wide-area situation awareness system primarily for use by control center operators
  - EMS/SCADA data
  - Non-electrical data (weather, fire, traffic, earthquake, etc.)
  - More will be added in the future!!!
- Not a standalone system – must interface with variety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

WASAS Design Considerations / Requirements (cont.)

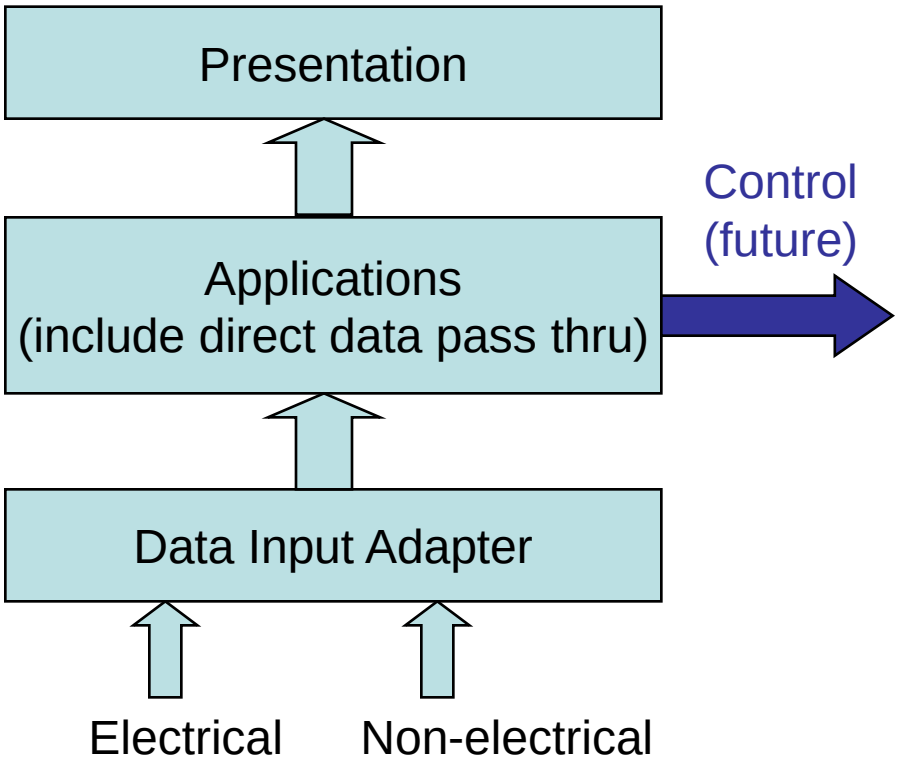
- Will need to evolve to become a wide-area monitoring, protection and control system (WAMPACS) over time
  - Must be able to support all types of wide-area monitoring, protection and control applications
- System expansion anticipated
  - More phasor measurements from SCE and others
  - Other data (e.g. 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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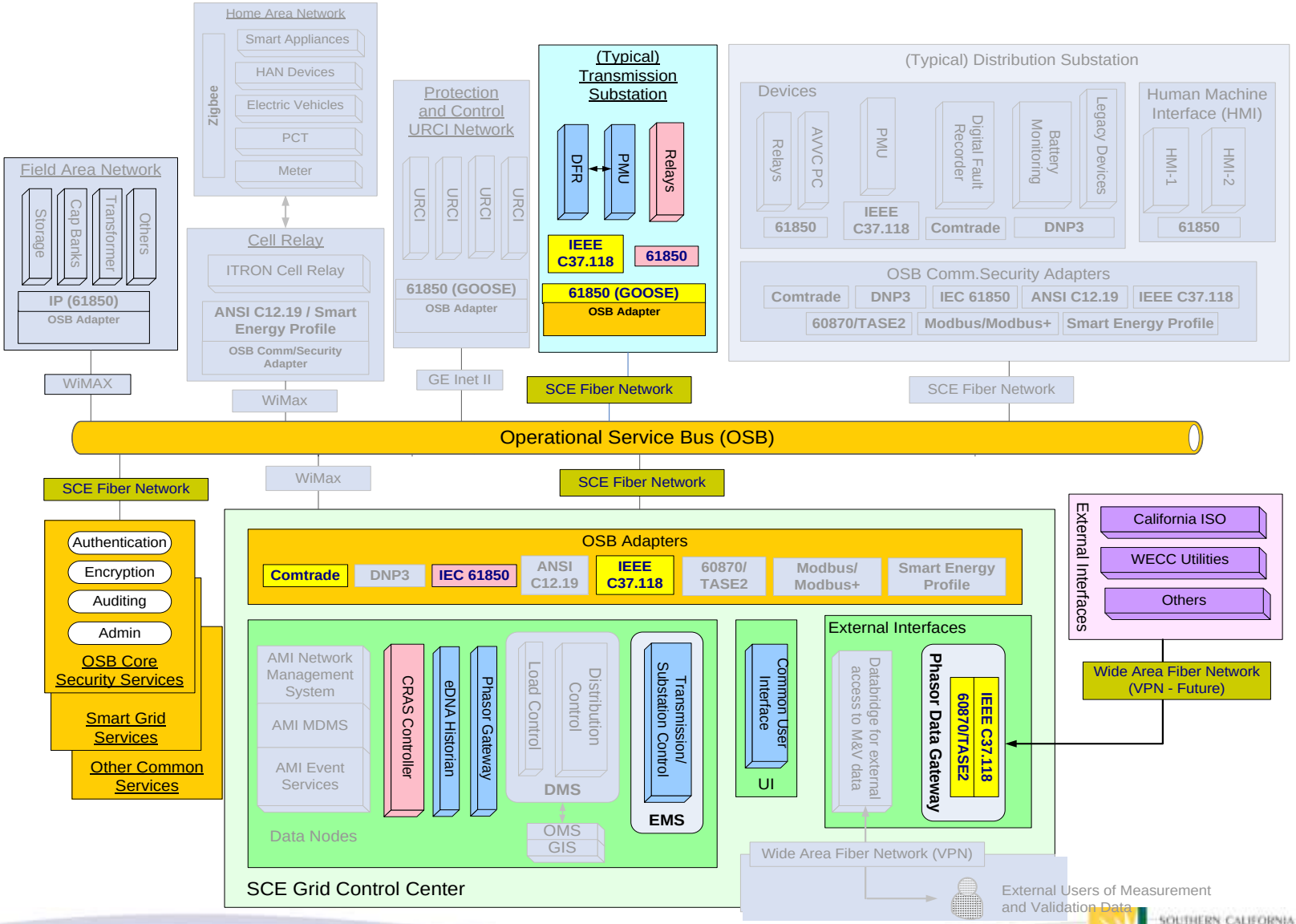
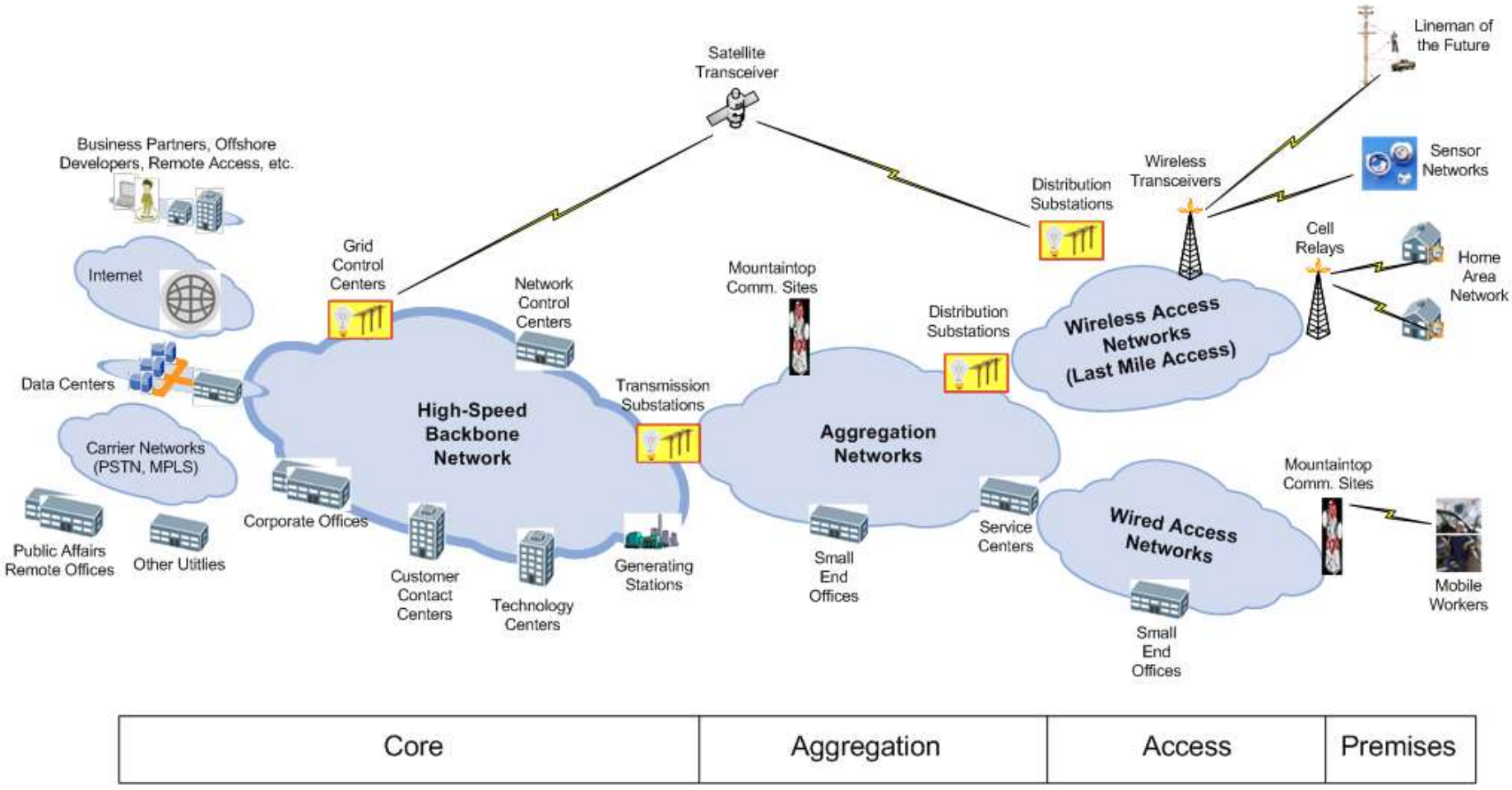
WASAS as part of SCE Smart Grid Vision

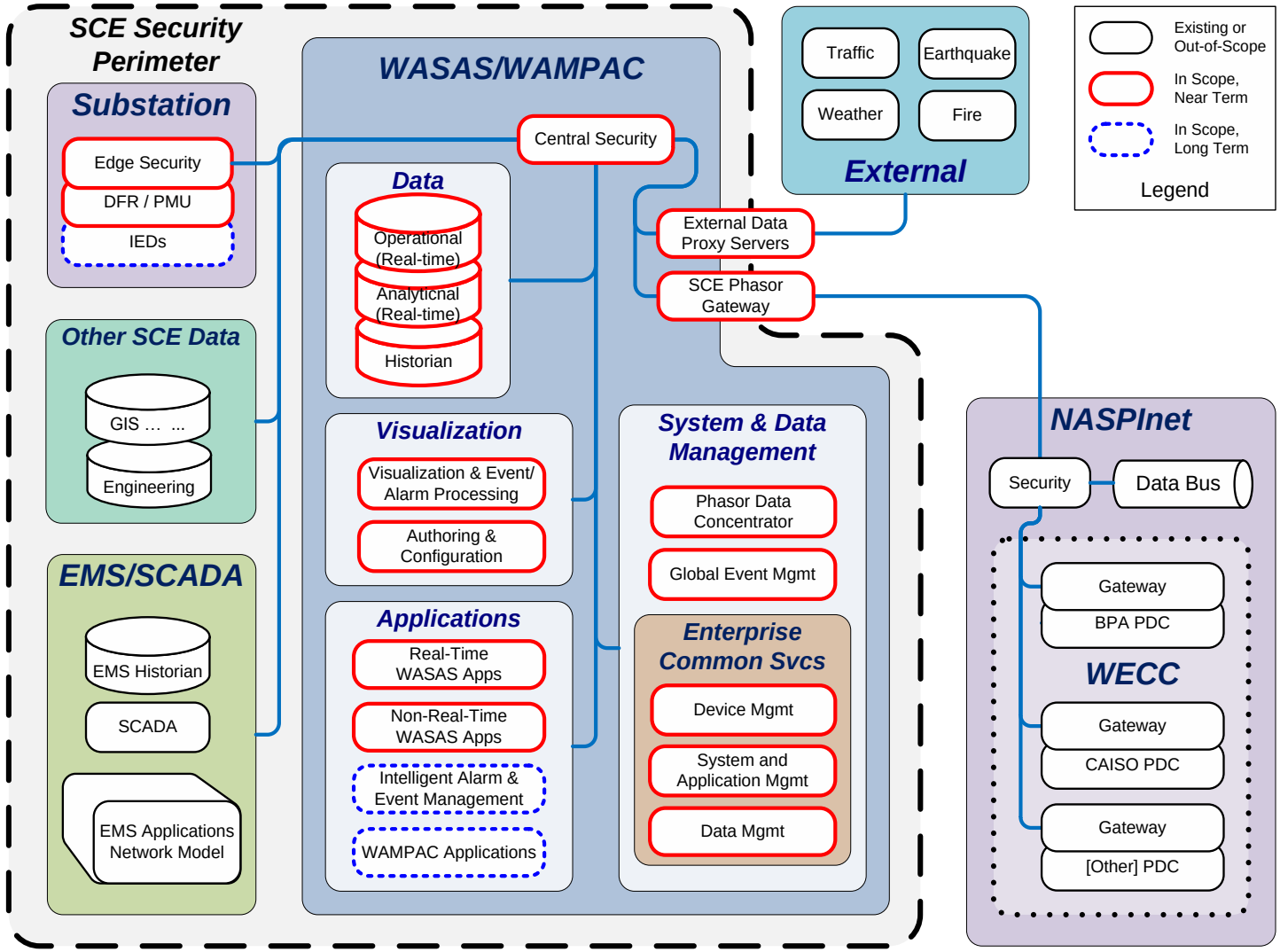


WASAS System Design Views – Network/Comm

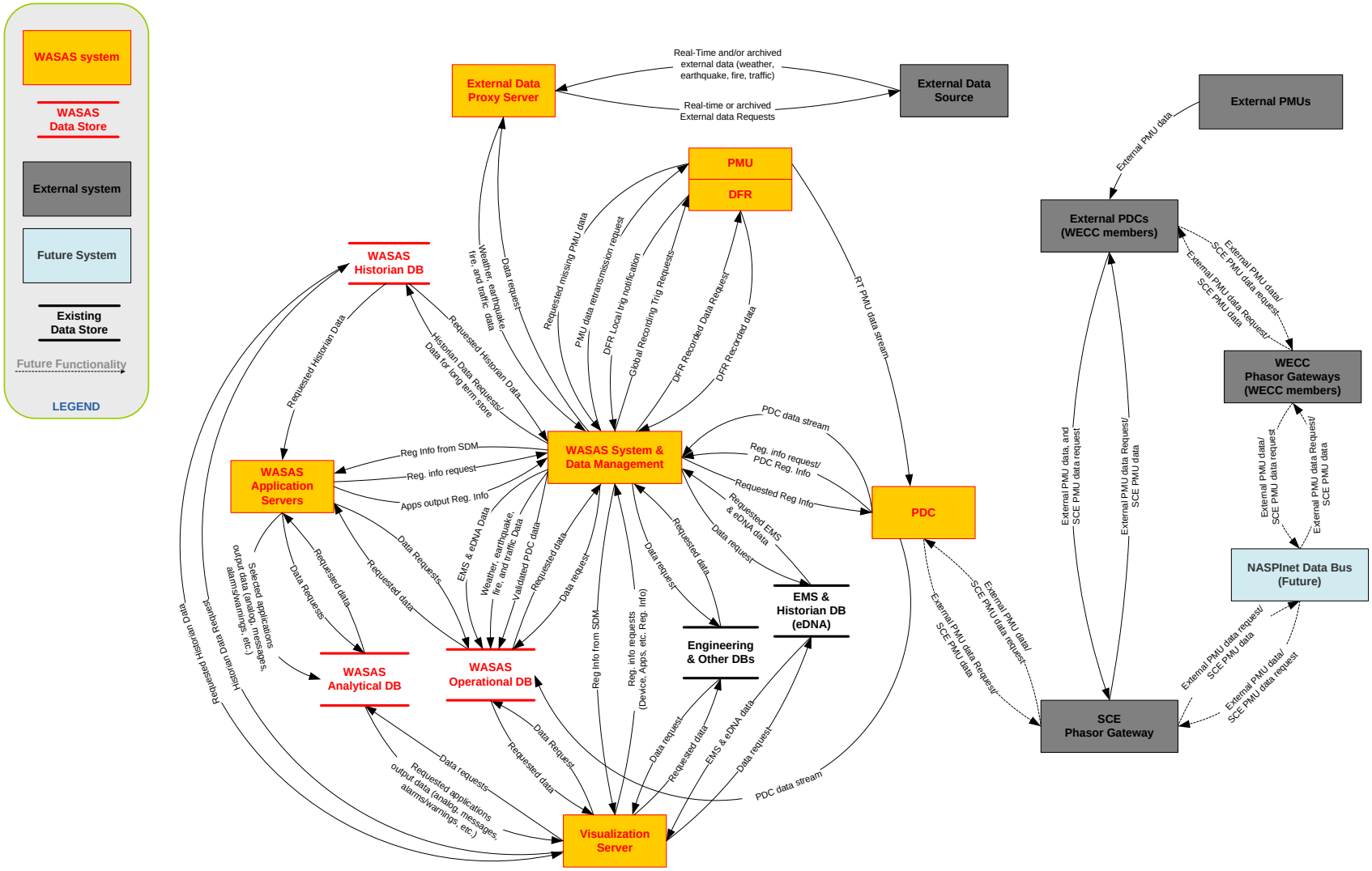
SCEnet2 Conceptual Architecture



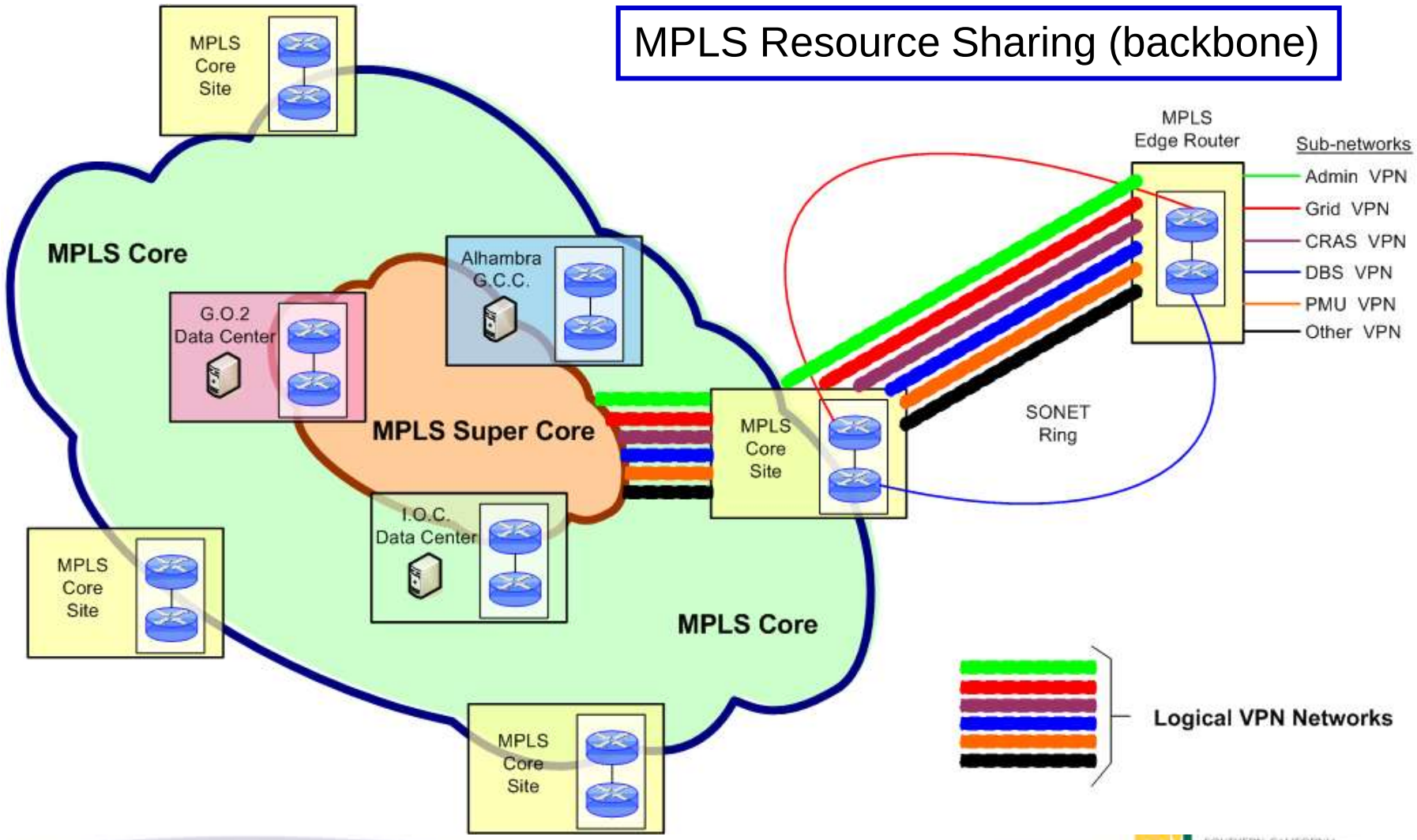
WASAS System Design Views – logical



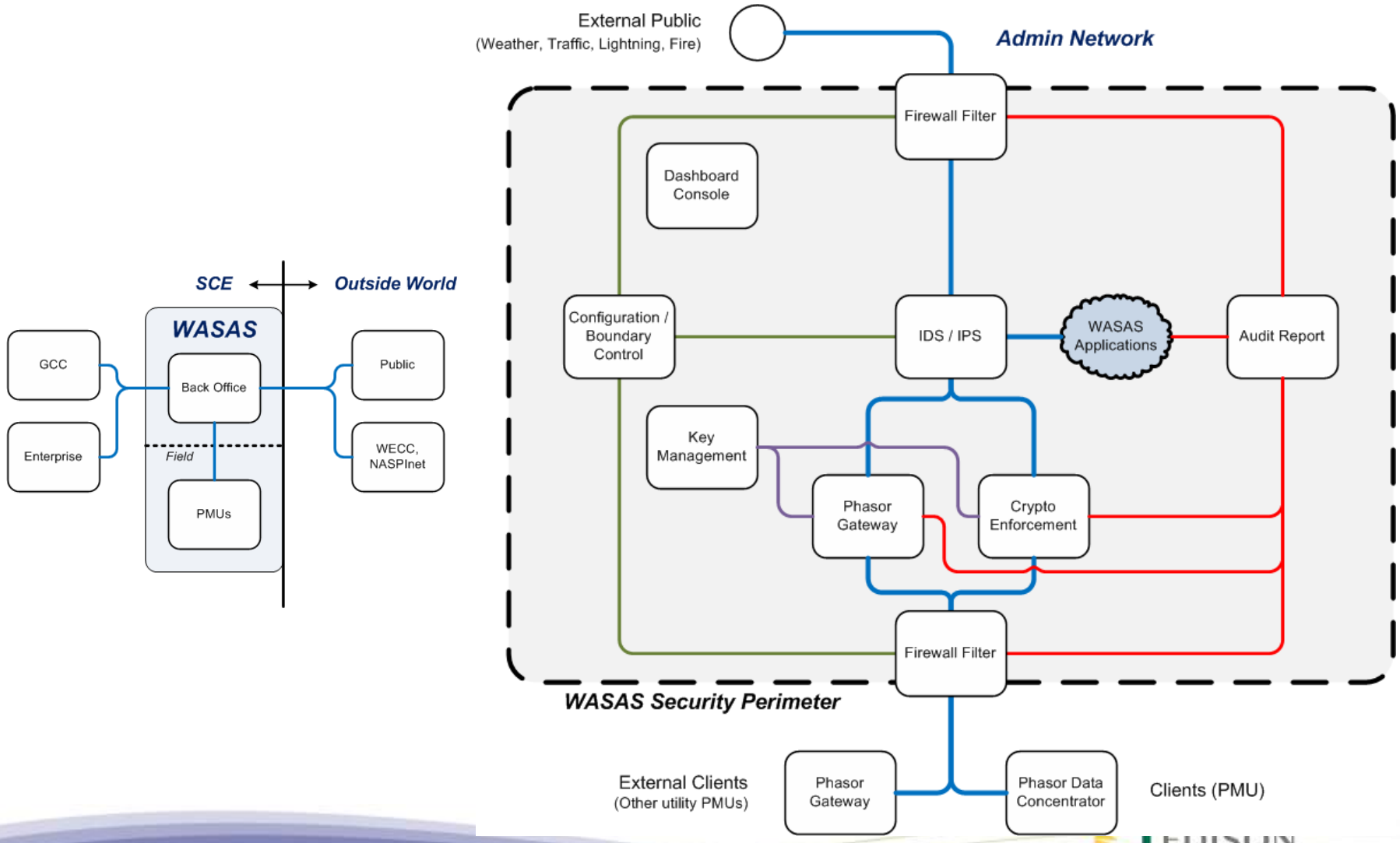
WASAS System Design Views – Data Flow



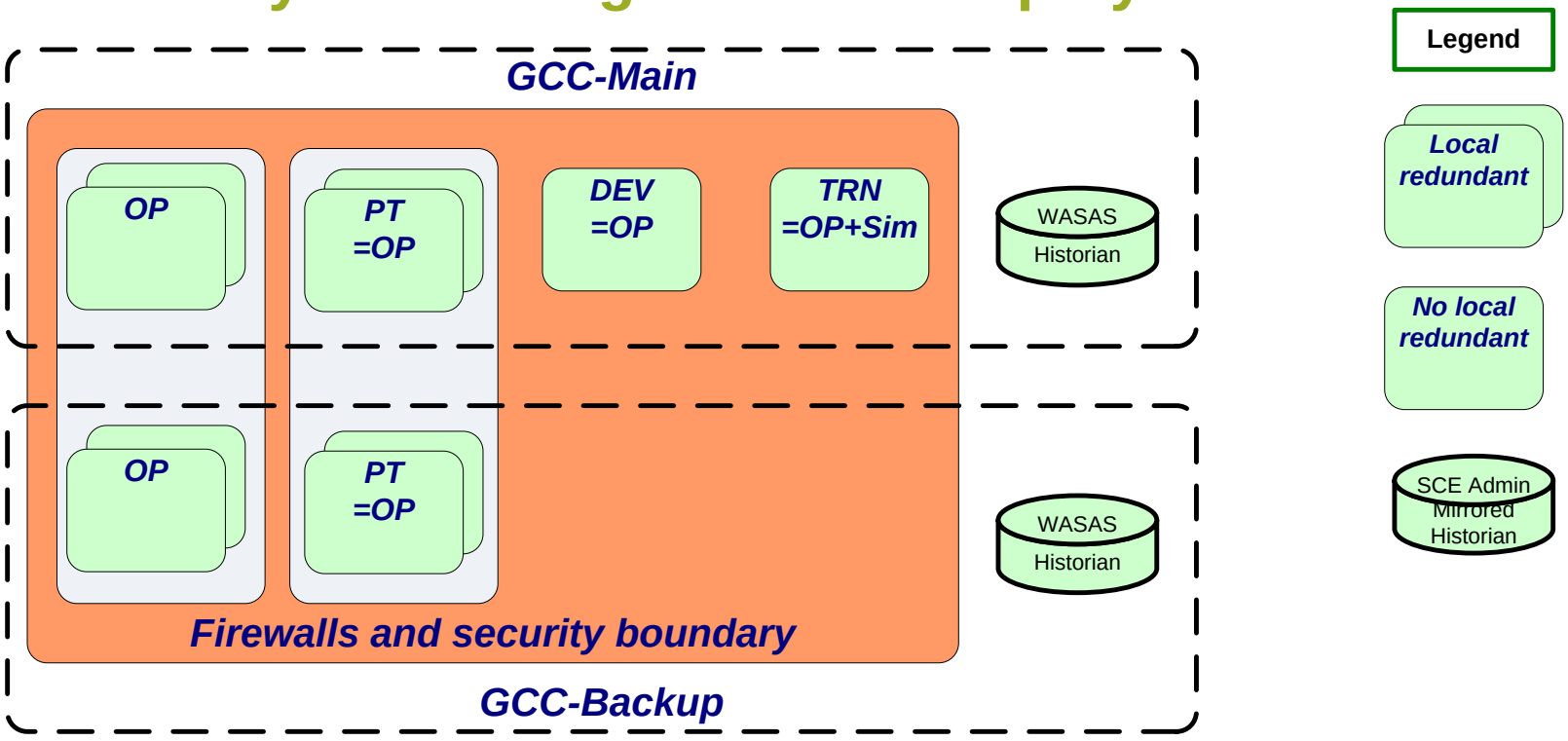
WASAS System Design Views – Network/Comm (cont.)



WASAS System Design Views – Security



WASAS System Design Views – Deployment



- 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

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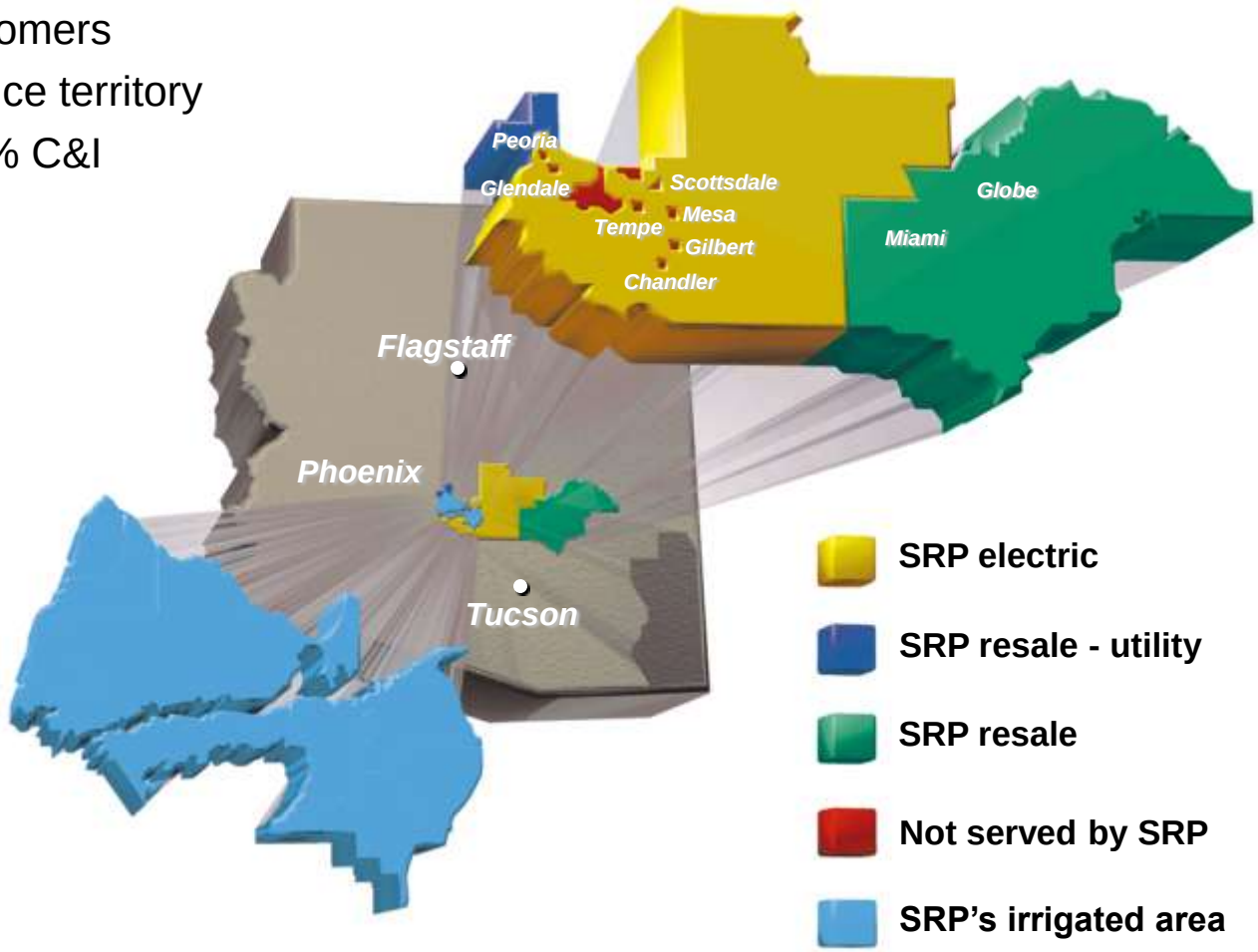
SRP
Synchrophasor Activities

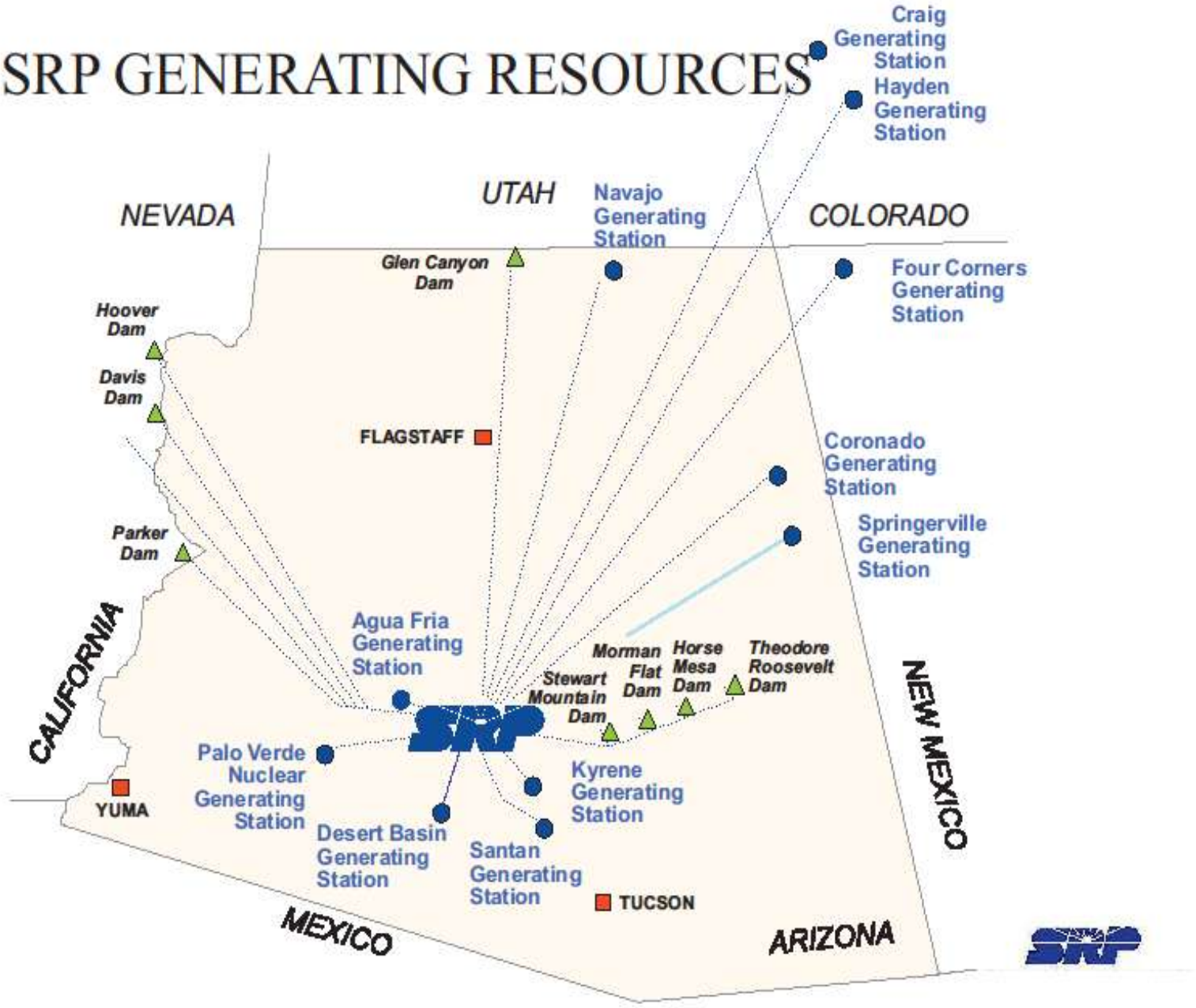
Jeff Younger
SRP Electronic Systems

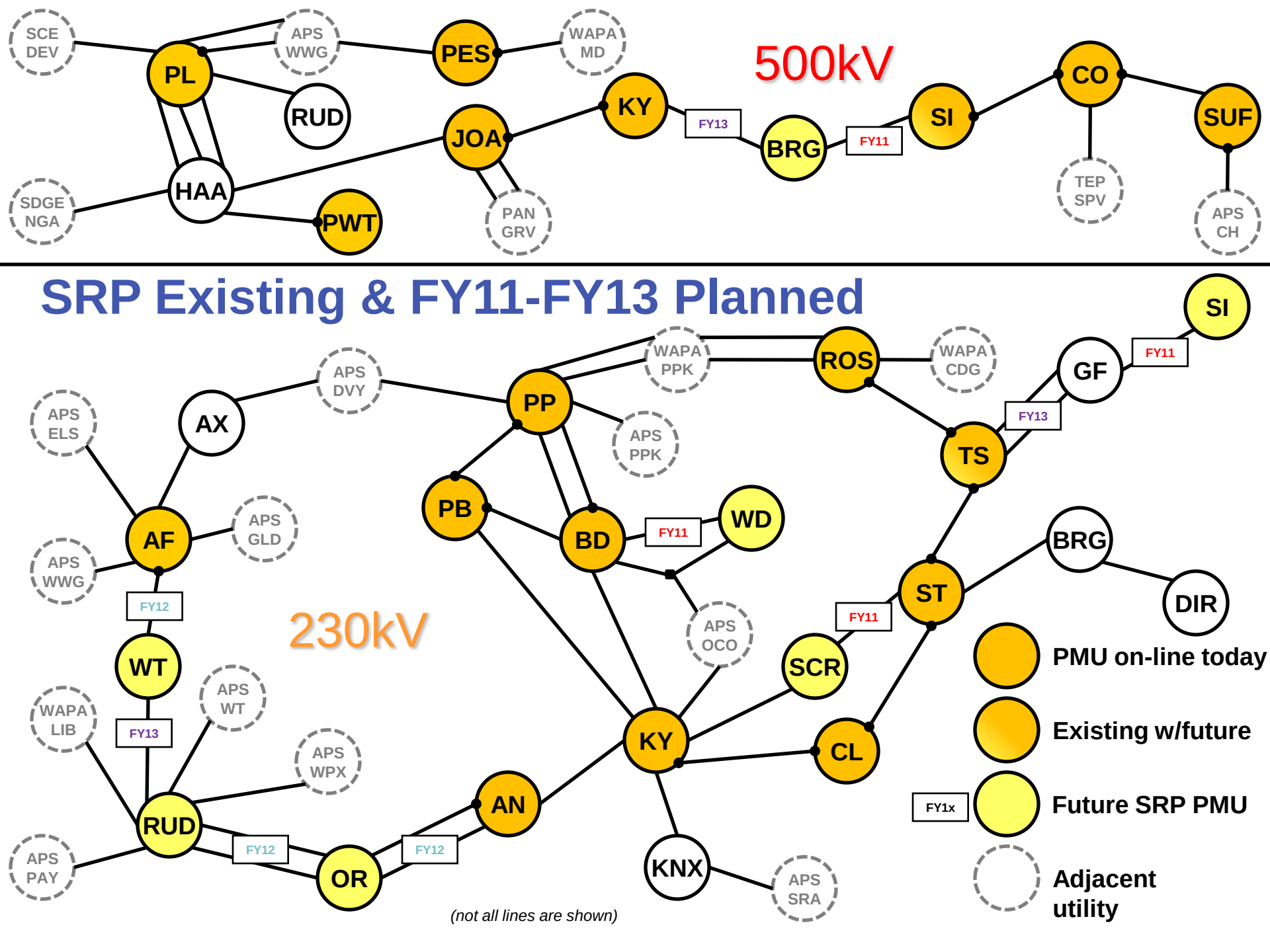
Salt River Project (SRP)

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



SRP GENERATING RESOURCES




SRP Existing & FY11-FY13 Planned
500kV
230kV
SCE DEV
APS WWG
PES
WAPA MD
PL
RUD
JOA
KY
FY13
BRG
FY11
SI
CO
SUF
HAA
SDGE NGA
PWT
PAN GRV
TEP SPV
APS CH
WAPA PPK
ROS
WAPA CDG
GF
FY11
SI
APS DVY
PP
FY13
APS ELS
AX
APS PPK
TS
PB
BD
FY11
WD
BRG
AF
APS GLD
APS WWG
ST
DIR
FY12
FY11
APS OCO
WT
SCR
WAPA LIB
APS WT
FY13
KY
CL
APS WPX
AN
RUD
FY12
FY12
KNX
APS PAY
OR
APS SRA
(not all lines are shown)
PMU on-line today
Existing w/future
FY1x
Future SRP PMU
Adjacent utility

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

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
  - Can brand G ***really*** talk to brand S? Reliably?
- Security
  - Data sharing among utilities can be difficult
  - More hooks into substation, relays
- Operator acceptance
  - Must turn ***data*** into ***information***
  - Efficient visualization is key
- Cohesion among utilities
  - Need for a common forum & standards
- Catch-22 application cycle
  - Developer needs installed PMU base
  - 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
  - Computer Applications – EMS, SE
  - Communications Engineering – network
  - Communications C&M – field installation
  - Transmission Planning – model validation & disturbance analysis
  - System Protection – PMU design, settings
  - System Operations – visualization
  - Control Engineering – EMS, SE integration
  - 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

SRP Future Efforts

- Hardware
  - 230kV & 500kV expansion plan is underway
  - Evaluating Arbiter 1133A PMU device
  - Hathaway DFR upgrades
- Software
  - State Estimator & EMS integration
  - Evaluating visualization packages (RTDMS)
- Industry Involvement
  - Increased WECC WISP & JSIS involvement

SRP Synchrophasor Contact

For Additional Information:

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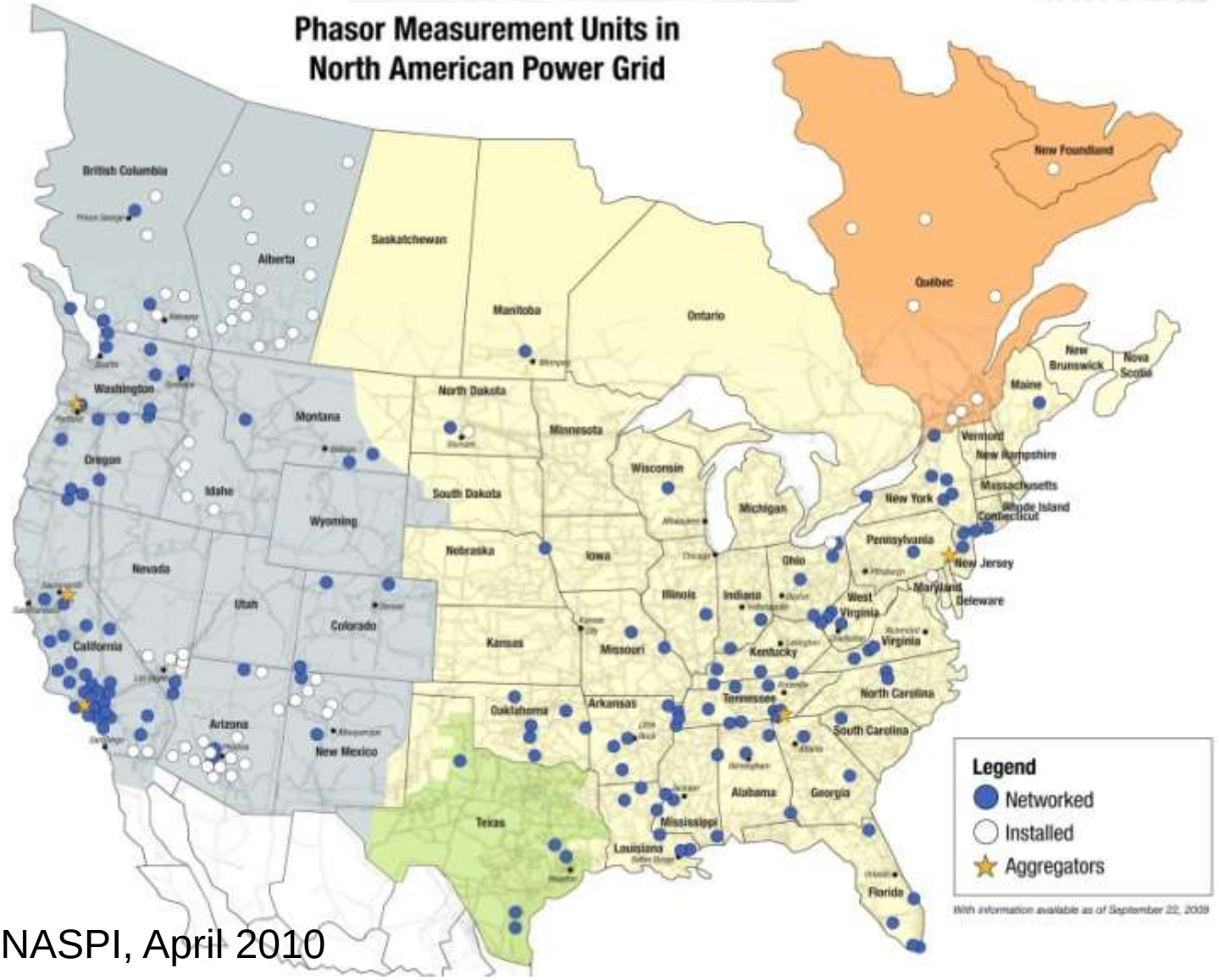
PJM SynchroPhasor Technology Deployment

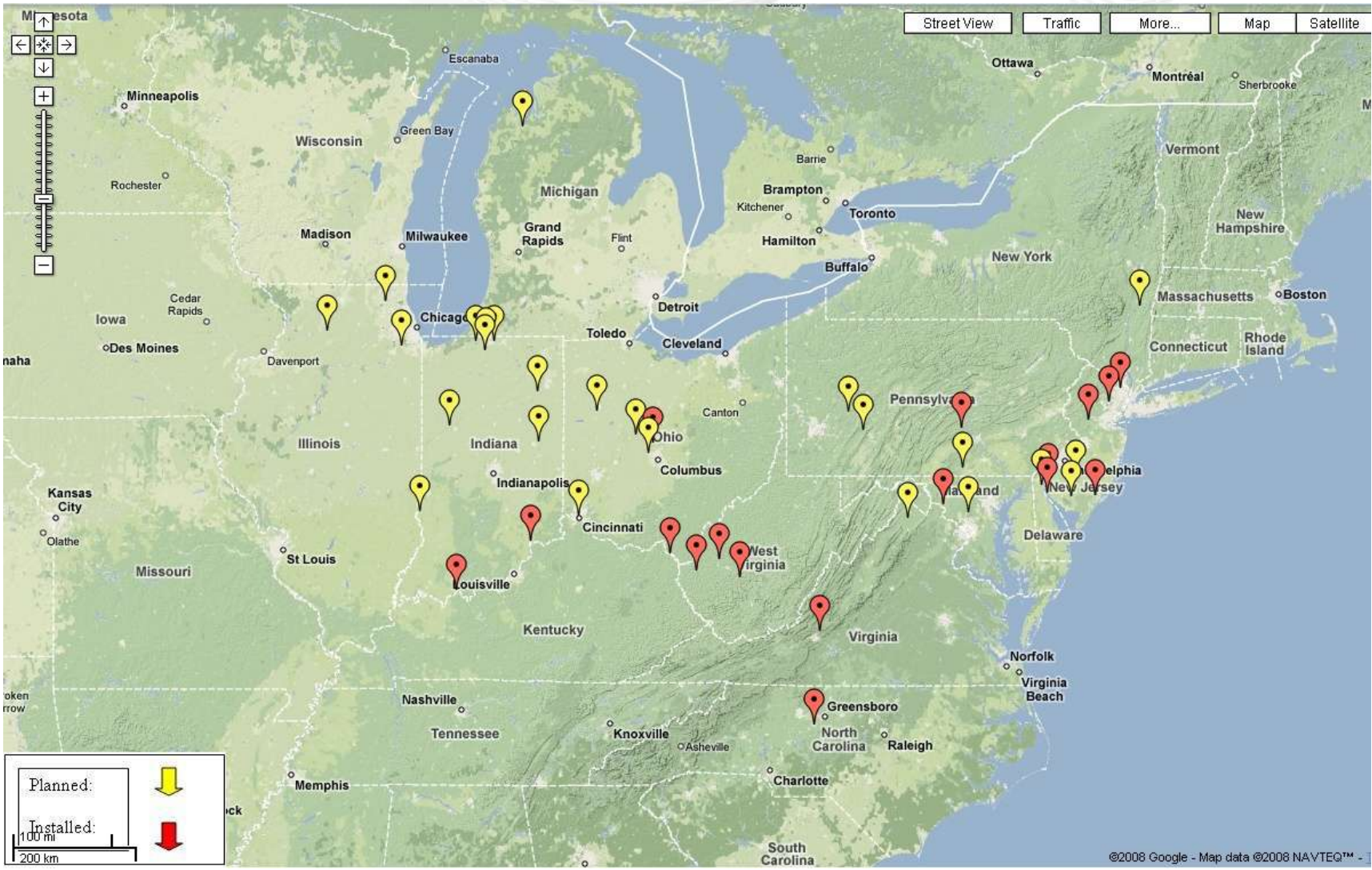
Chantal Hendrzak
General Manager – Applied Solutions
PJM Interconnection

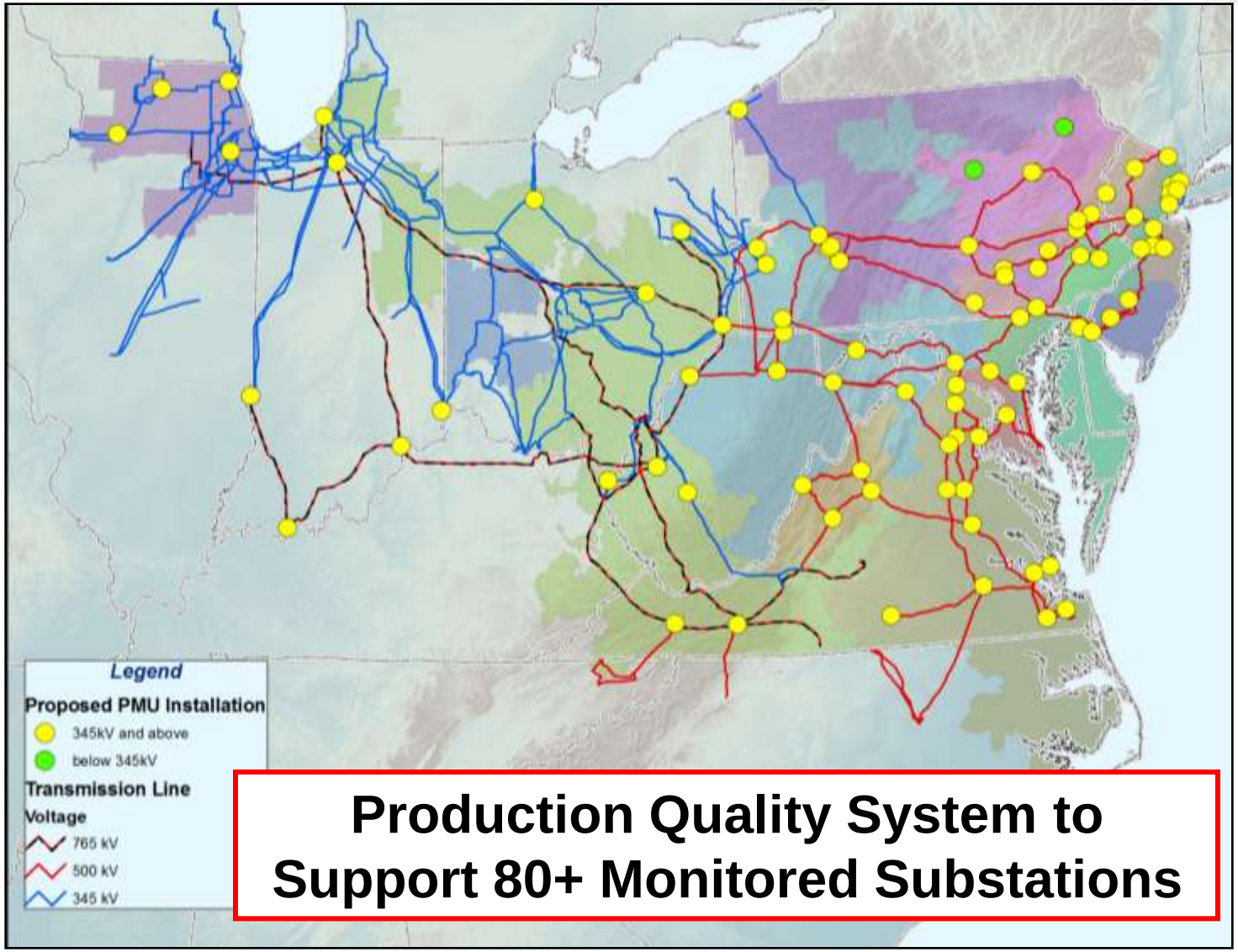
PMU Installations in the U.S.



Source: NASPI, April 2010

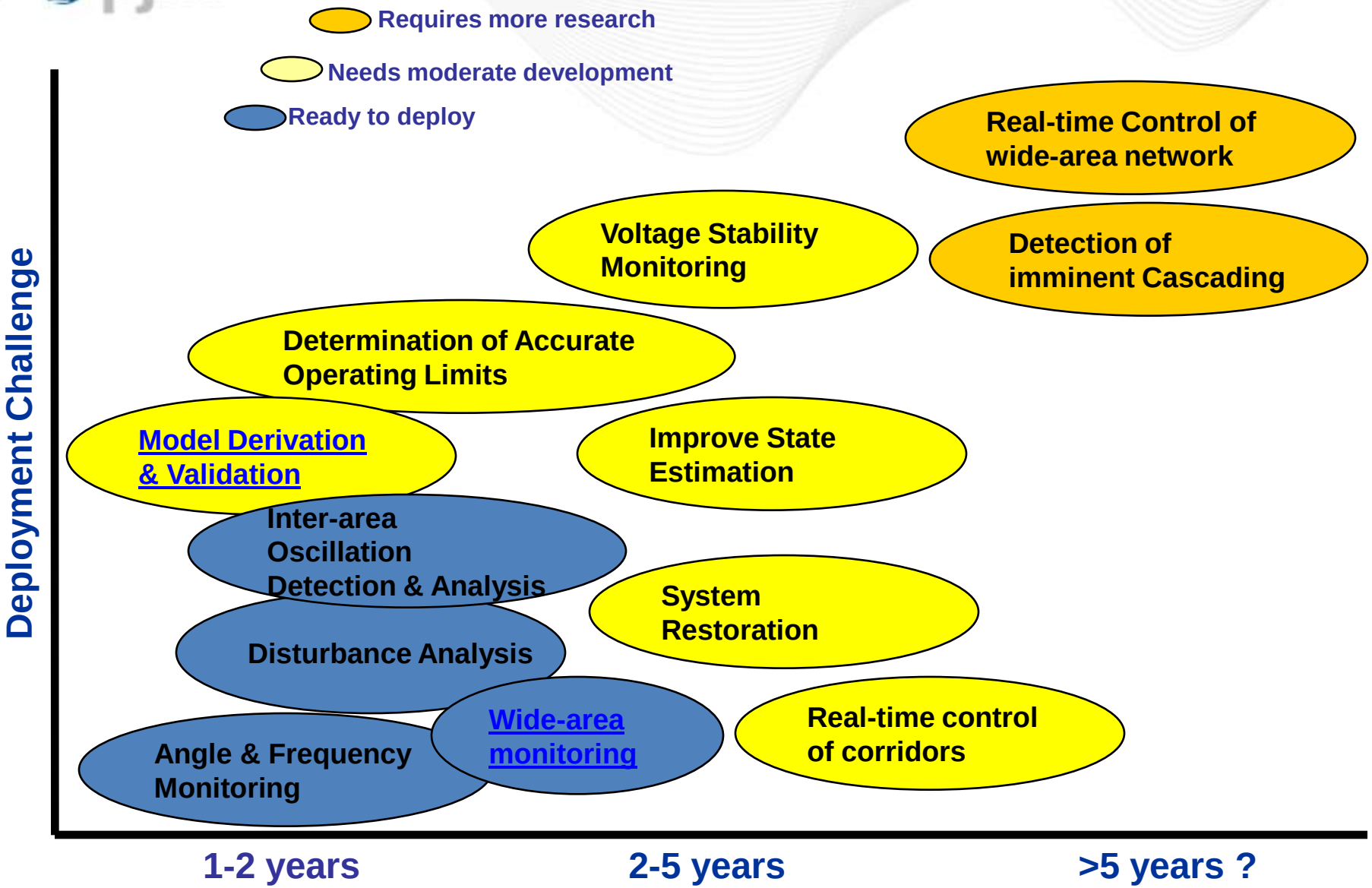
Pre-Grant SynchroPhasor Deployment

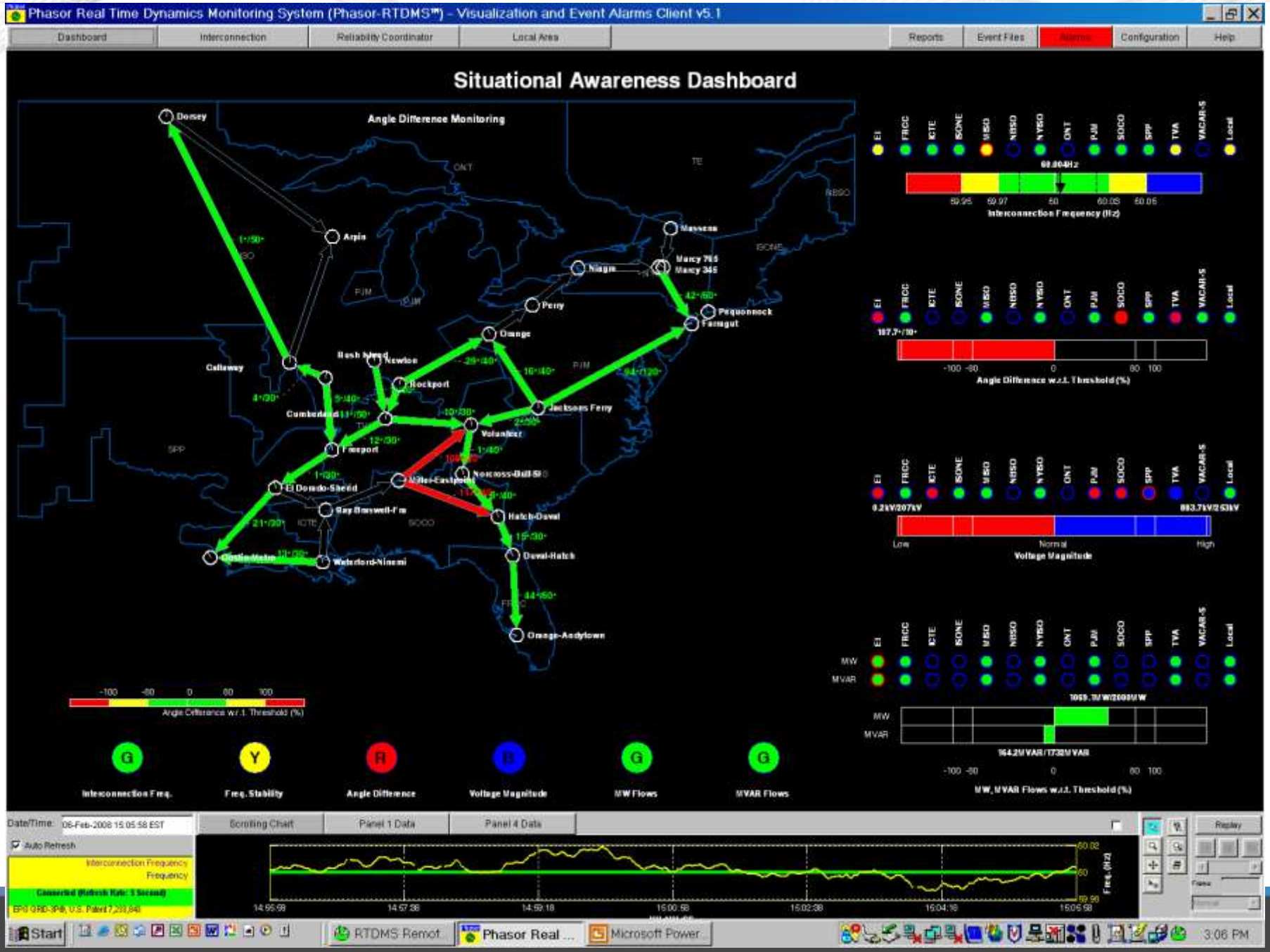




Production Quality System to Support 80+ Monitored Substations

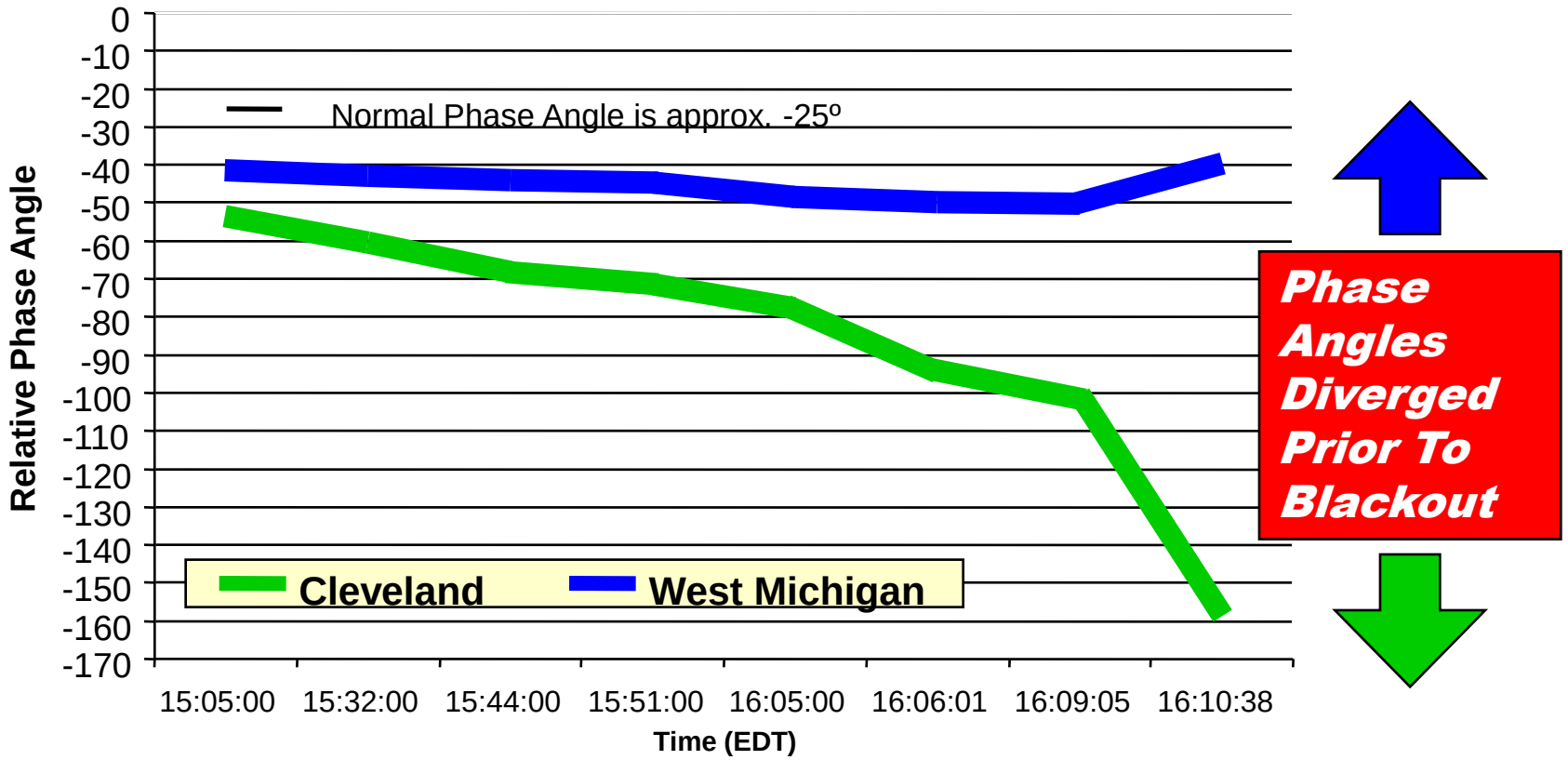
SynchroPhasor Applications



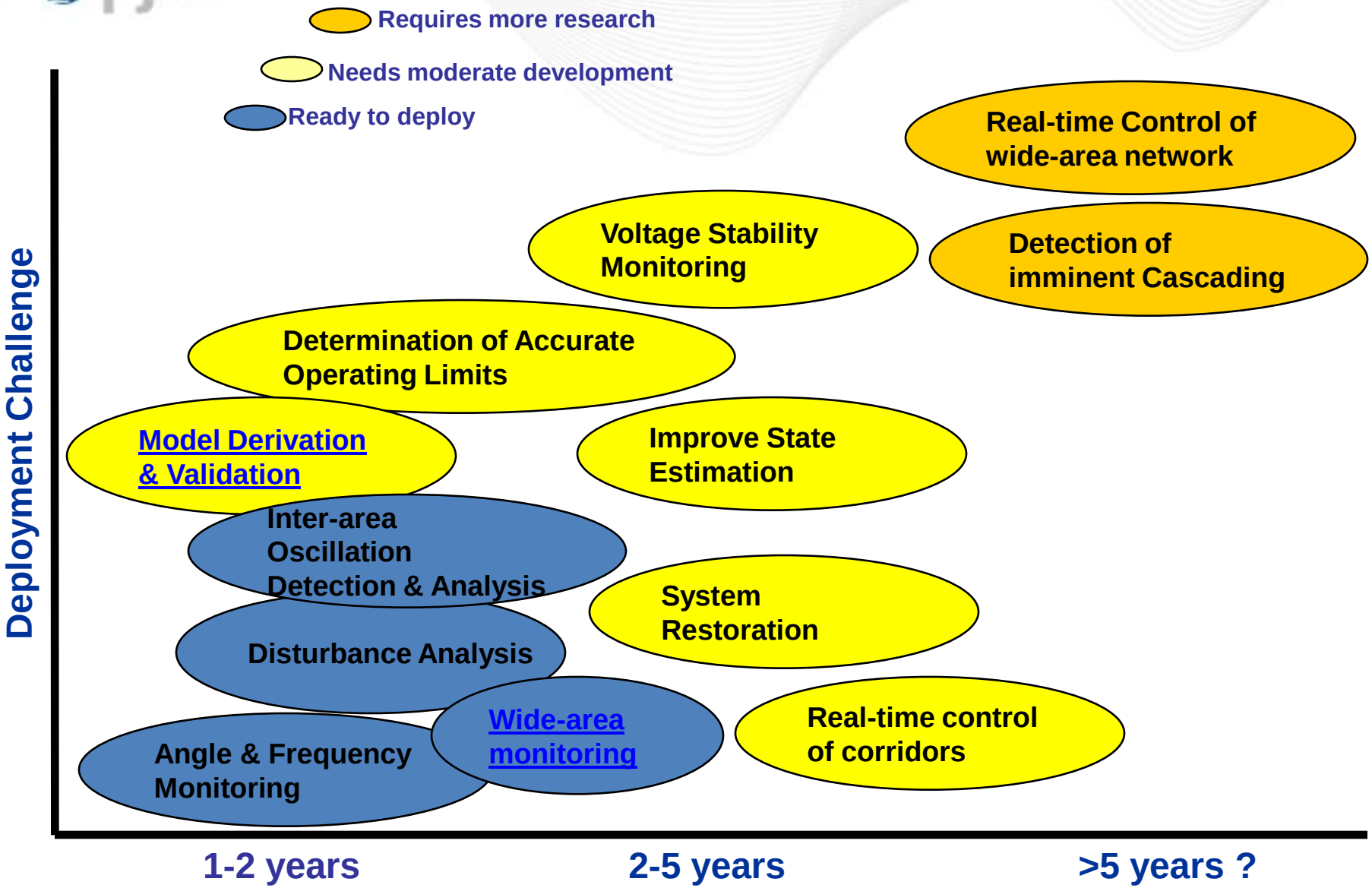

Phasor Real Time Dynamics Monitoring System (Phasor-RTDMS™) – Visualization and Event Alarms Client v5.1
Dashboard
Interconnection
Reliability Coordinator
Local Area
Reports
Event Files
Alarms
Configuration
Help
Situational Awareness Dashboard
Angle Difference Monitoring
Dorsey
Argia
Massena
Marcy 765
Marcy 345
Niagra
Perry
Pequonnock
Farragut
Orange
Bush Street
Newton
Rockport
Jacksons Ferry
Callaway
Cumberland
Volunteer
Freeport
Norcross-Bull Sl
El Dorado-Shield
Ray Braswell-Fm
Hatch-Duval
Duval-Hatch
Waterford-Nineml
Orange-Andytown
ONT
TE
NBSO
ISONE
PJM
SPP
ICTE
SOCO
FRCC
EI
FRCC
ICTE
ISONE
MISO
NBSO
NYISO
ONT
PJM
SOCO
SPP
TVA
VACAR-S
Local
60.004Hz
59.95
59.97
60
60.03
60.05
Interconnection Frequency (Hz)
187.7°/30°
-100
-80
0
80
100
Angle Difference w.r.t. Threshold (%)
0.2kV/207kV
883.7kV/253kV
Low
Normal
High
Voltage Magnitude
MW
MVAR
1059.3MW/2600MW
164.2MVAR/1738MVAR
MW, MVAR Flows w.r.t. Threshold (%)
Angle Difference w.r.t. Threshold (%)
G
Interconnection Freq.
Y
Freq. Stability
R
Angle Difference
B
Voltage Magnitude
G
MW Flows
G
MVAR Flows
Date/Time: 06-Feb-2008 15:05:58 EST
Auto Refresh
Interconnection Frequency
Frequency
Scrolling Chart
Panel 1 Data
Panel 4 Data
Replay
14:55:58
14:57:38
14:59:18
15:00:58
15:02:38
15:04:18
15:05:58
Start
RTDMS Remot...
Phasor Real ...
Microsoft Power...
3:06 PM

When Visibility is Lacking

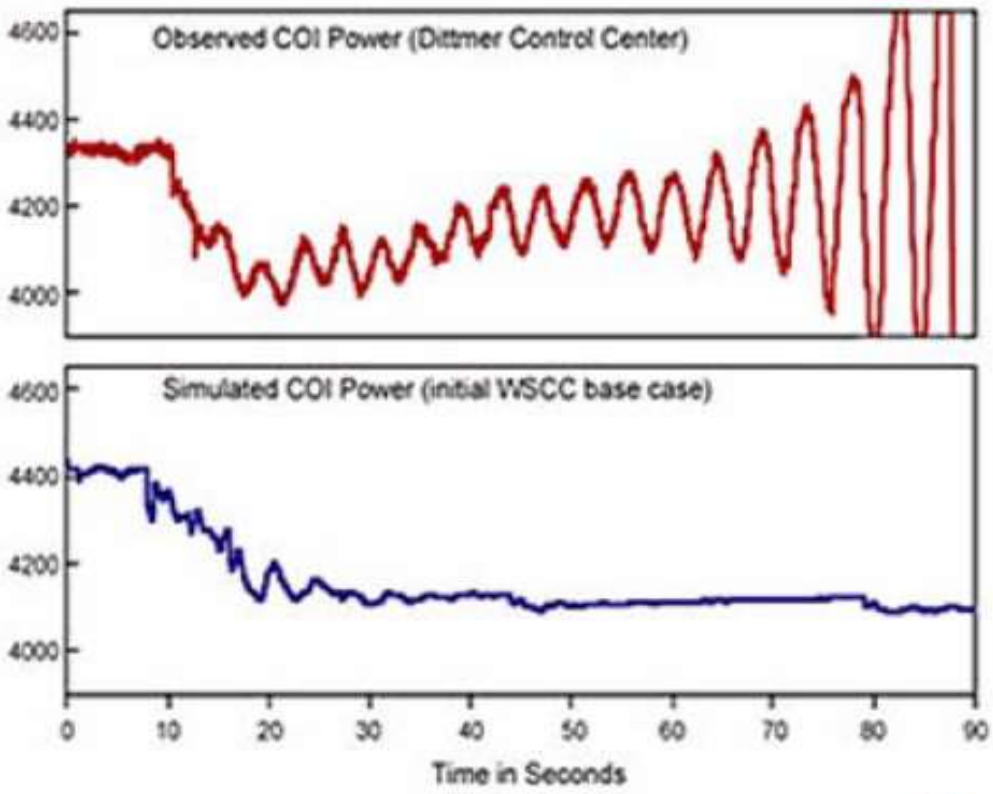
August 14, 2003 Blackout



SynchroPhasor Applications

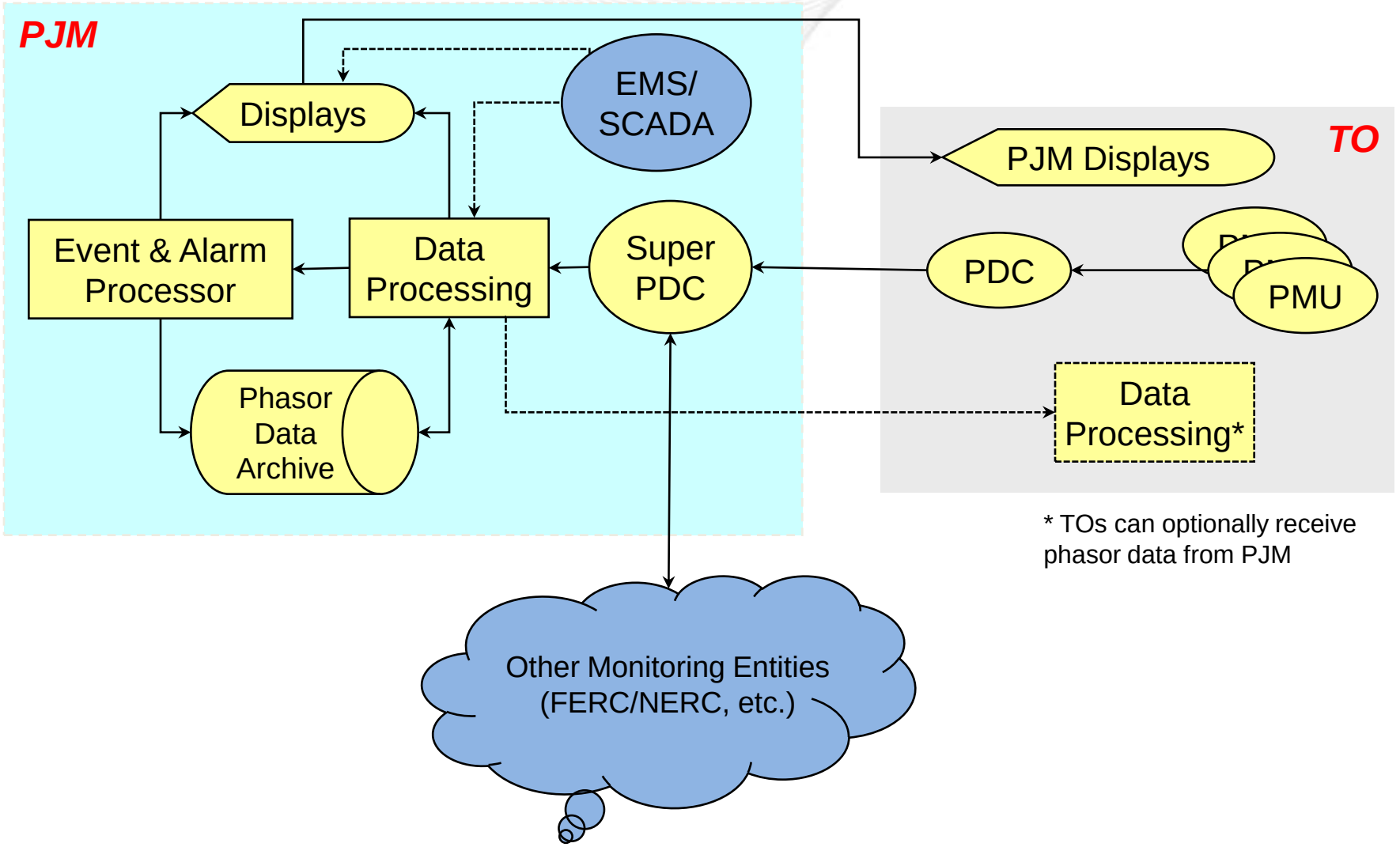


Actual System Performance
- unstable system behavior observed.

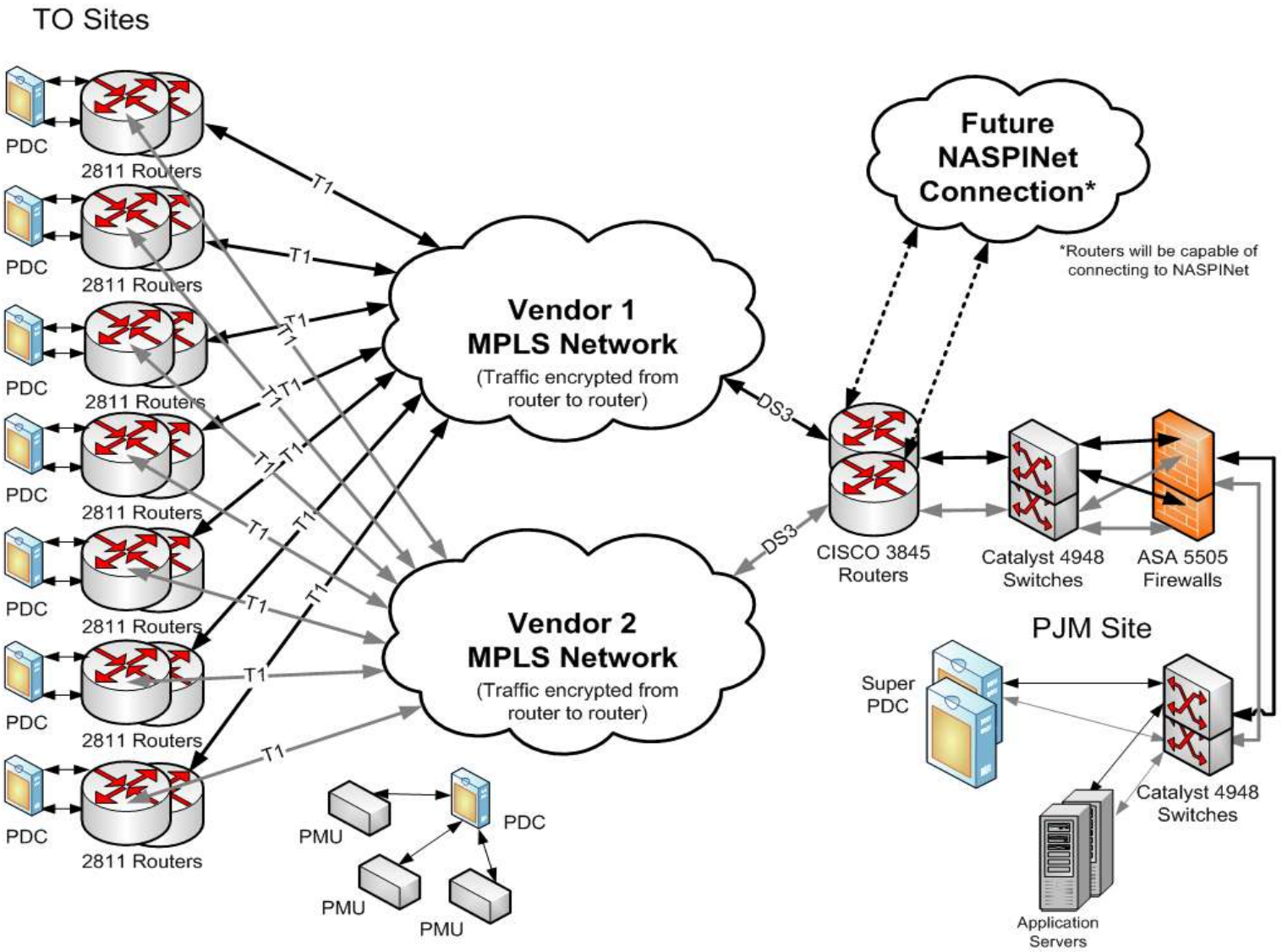


Model Simulation
- predicted stable system performance.

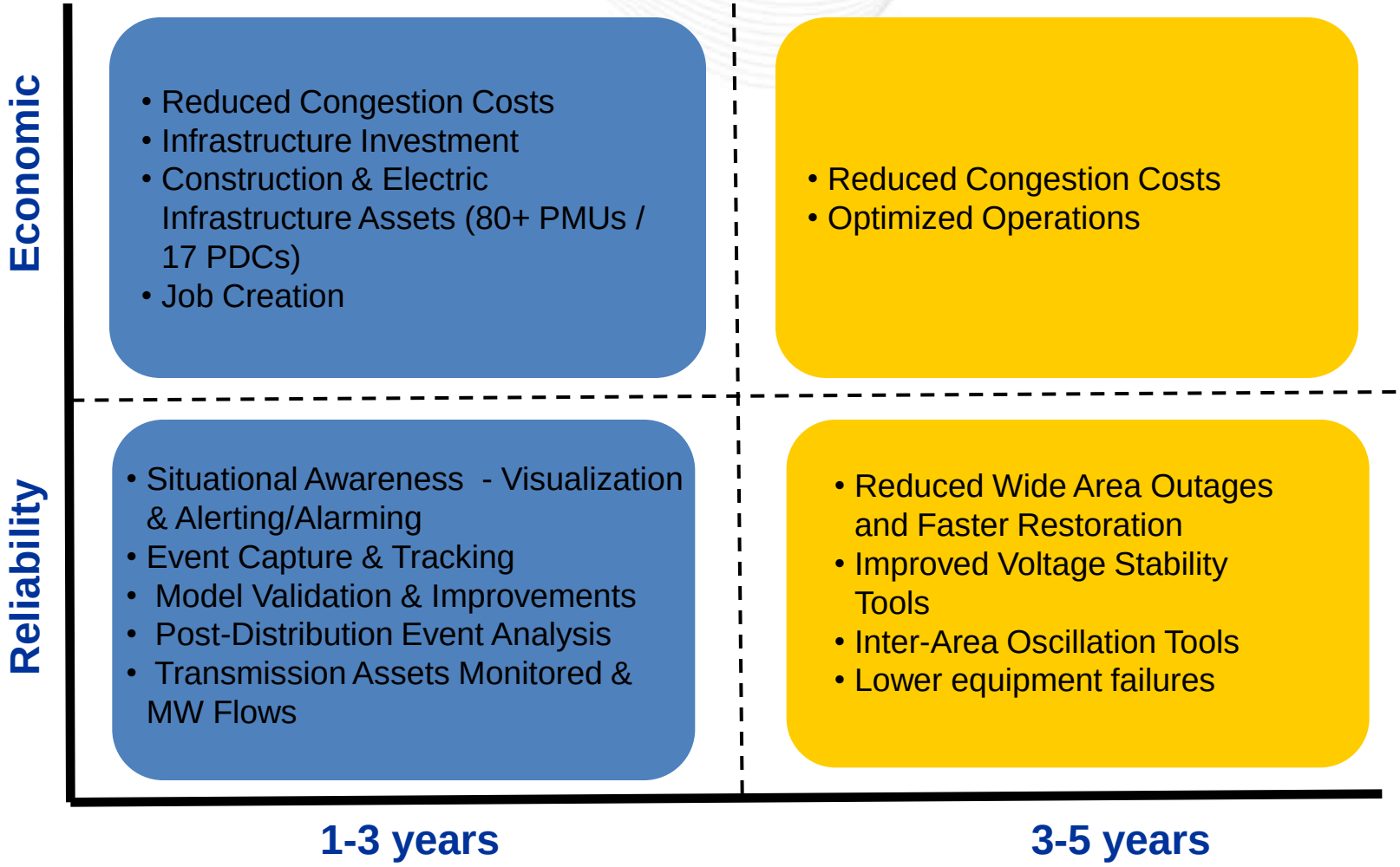
PJM SynchroPhasor Deployment: System Overview



SynchroPhasor Redundant Network



Metrics / Benefits



For Additional Information on PJM's SynchroPhasor Deployment

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Q&A

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to the right of your screen.

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Closing Remarks

Phil Carson
Editor-in-Chief
Intelligent Utility Daily

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INTELLIGENT UTILITY EXECUTIVE SUMMIT

November 8-10, 2010 – Scottsdale, AZ

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