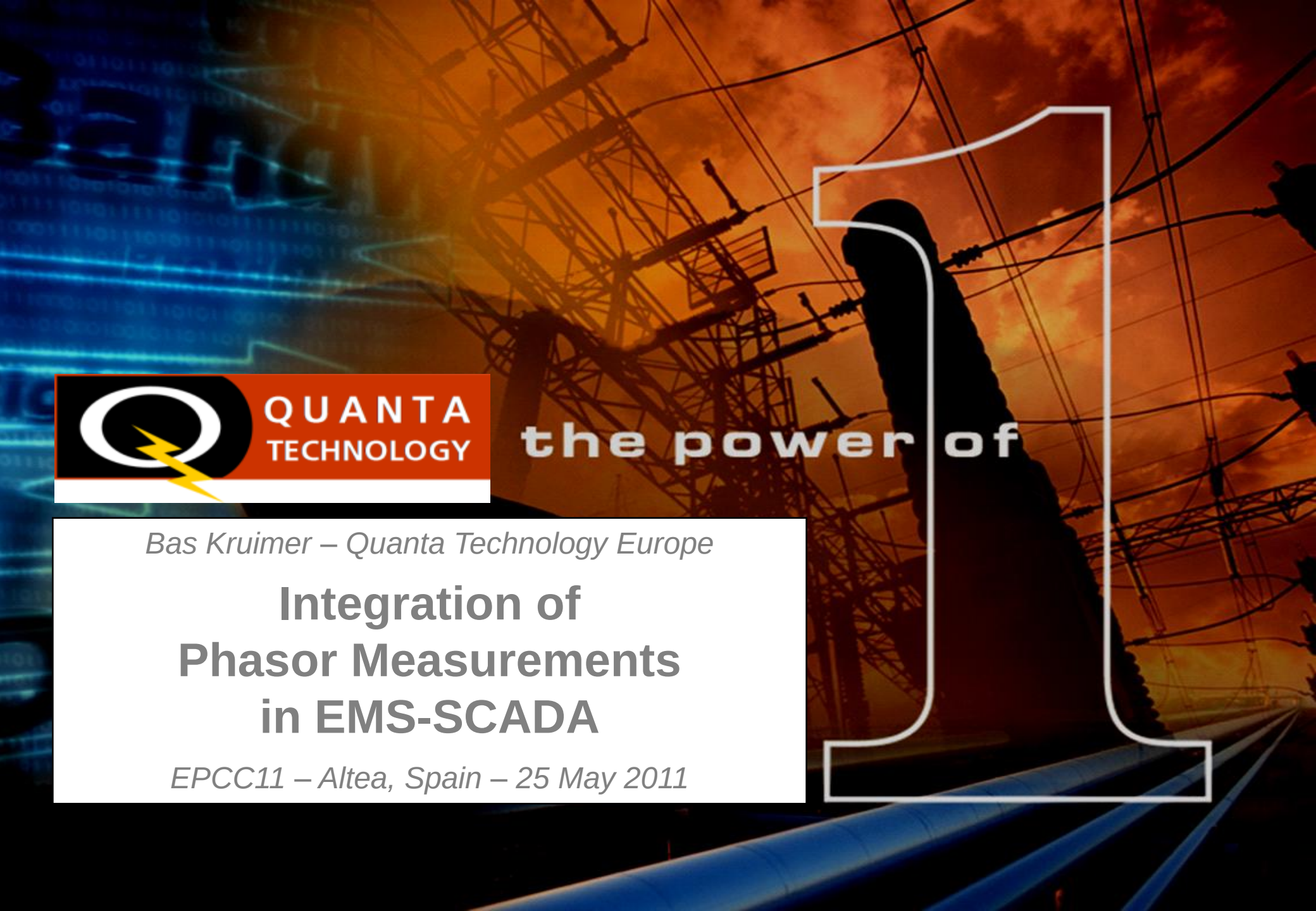

Bas Kruimer – Quanta Technology Europe

Integration of Phasor Measurements in EMS-SCADA

EPCC11 – Altea, Spain – 25 May 2011

Introduction

Bas Kruimer

- ABB
- KEMA
- ENECO / Joulz – Service Provider
- Quanta Technology – Europe

- *Power Systems*
- *Substation Automation*
- *Protection, Control, Communication*
- *SCADA – Network Control*
- *IEC 61850*
- *Substation / Grid Design & Engineering*
- *Quality Management Systems*

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Smart T&D

Renewables Integration

Strategy

Roadmaps

Modeling

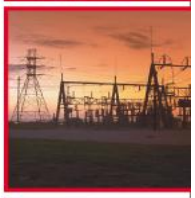
Planning

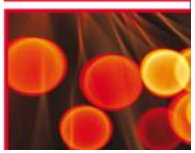
Design

Deployment

Training

Knowledge





QUANTA ENERGIZED SERVICES

Live Work:

- Upgrading
- Maintenance
- Reconductoring
- Emergency Response

Robotic Arm

QTE Focus Areas

Dealing with New Technologies:

- Application & Technology Roadmapping
- Technology & Operations Consulting
- Integration of Innovations into utility systems

Smart T&D Applications RD&D:

- Synchro-phasor Network and WAM
- Automation, Protection, Control, Comm.
- Substation Autom. – IEC 61850 – ProcessBus
- Distribution Automation – DSM – EMS/DMS
- SCADA EMS / CC – Applications Integration

Modeling & Impact Studies – Testing:

- Dynamic Models & Transient System Studies
- Impact analysis of PEV Charging
- Impact analysis of Self-healing grids on CML
- RTDS – Real Time Digital Simulation / Testing

Renewables Integration:

- Wind farm integration on/off-shore
- Long term grid developments
- Solar integration in T&D grids
- Interconnections & Advanced Prot. Coord.
- T&D Storage – Large Scale / Distributed

Energized Services: Live Work in Transmission Grids

- OH Lines & Towers
- Substations & Equipment
- Power Plant Switch Yard & Grid Connection
- Consultancy & Business Case
- Upgrading/uprating, reconductoring, maintenance, repairs
- Bare hand – Hot stick – Robot Arm

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Phasor Measurement System (to be) integrated with Energy Management

Pacific Gas and Electric Co.

Vahid Madani

Quanta Technology

Gerry Sheblé / Damir Novosel / Tom Gentile

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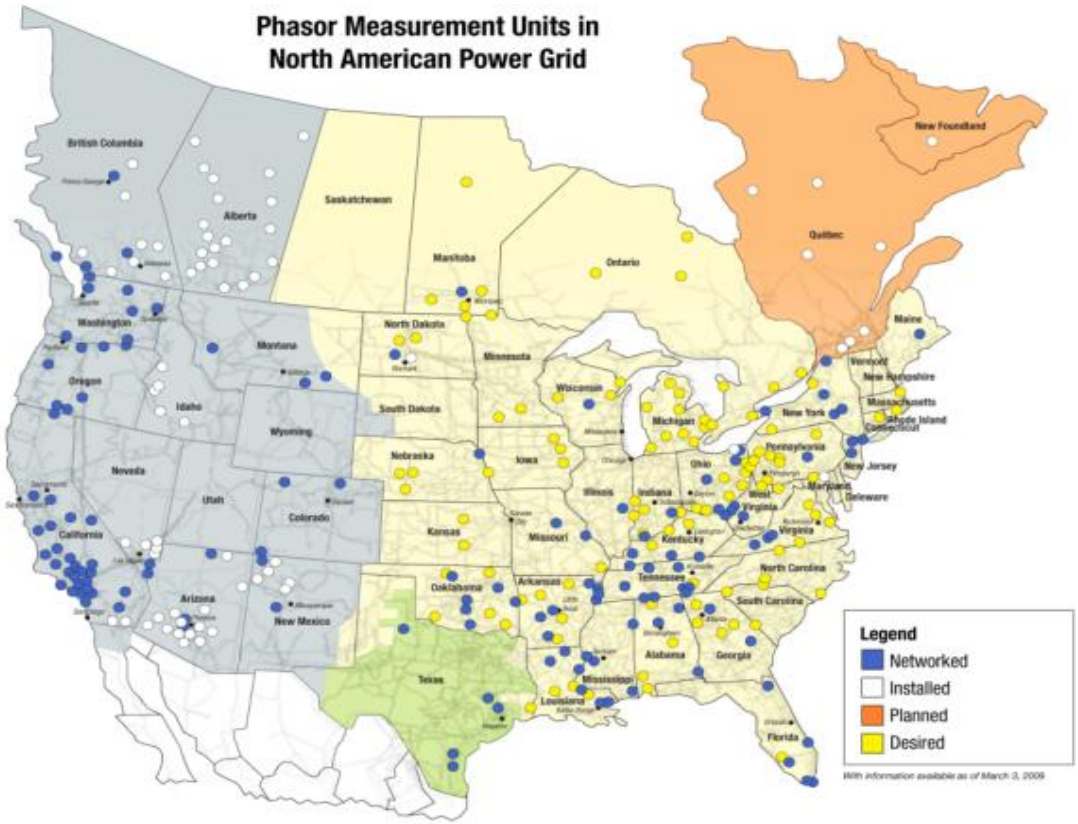
Transmission Smart Grid DOE Stimulus Funding

- **WECC*:** 250 PMUs ($108 M)
  PG&E ($50 M); BPA; SCE
- **NYISO:** 35 PMUs ($76 M)
- **PJM:** 90 PMUs ($28 M)
- **Midwest ISO:** 150 PMUs ($35M)
- **ATC: 5 PMUs** ($28 M)
- **Entergy: 18 PMUs** ($10 M)
- **ISO New England:** 30 PMUs ($9M)
- **Duke Energy:** 45 PMUs ($8M)
- **Midwest Energy:** 1 subst. ($1.5M)



*WECC – Western Energy Coordinating Council

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Pacific Gas & Electric Company Overview

Encompasses 70,000 square miles in Northern and Central CA

Population served – 16 million

- More than 139,000 circuit miles of T&D electric lines
- More than 45,800 miles of natural gas pipelines
- 5 million electric and 4 million gas customer accounts
- 20,835 schools
- 3,250 hospitals
- 20,700 high-tech companies
- 770 military facilities

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PG&E WAMS Project Overview

- *Objectives:*
  - Integrate Synchro-phasor technology into electrical grid
  - Applications to improve performance and customer service
  - Improve coordination with ISO and neighboring systems
- *Overall scope*:
  - Identify PMU number and location
  - Communication infrastructure
  - Applications deployment as a part of the overall ***Roadmap*****:** *Operational, Engineering, Protection and Control, etc.*
  - Training, standards, testing and maintenance
  - Cyber security / CIP – Critical Infrastructure Protection
  - POC – Proof of Concept – stage may drive some adjustment
- *Schedule:* 3 years

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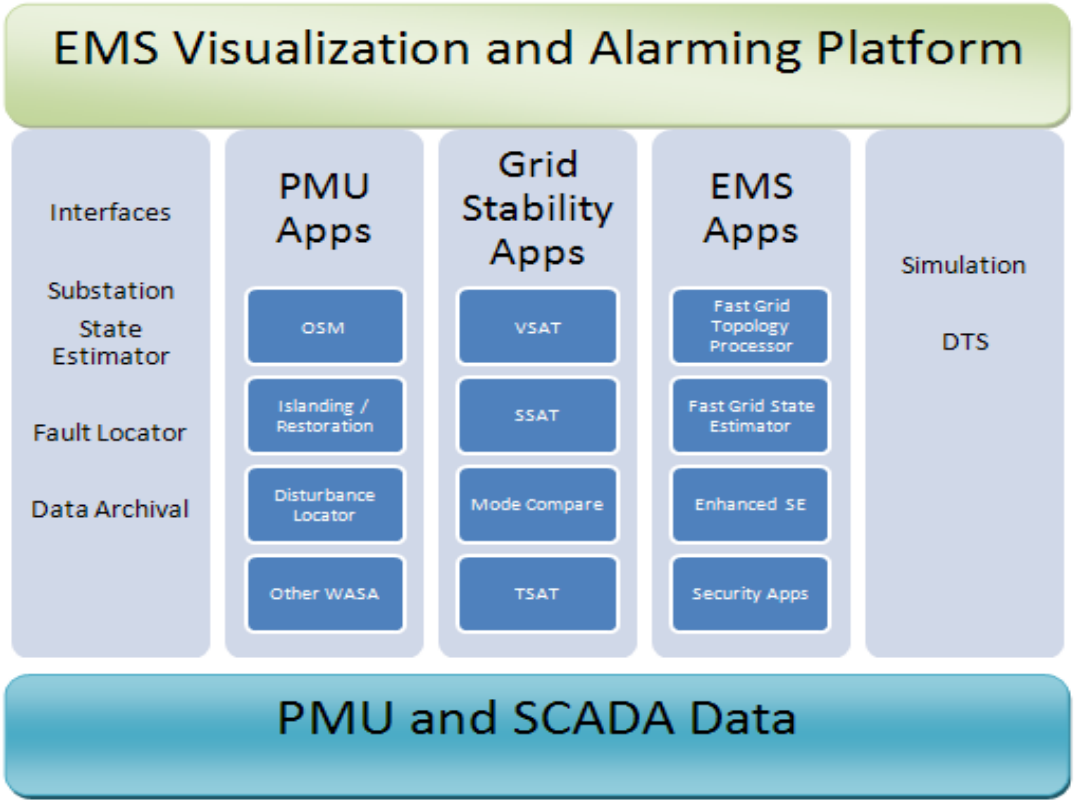
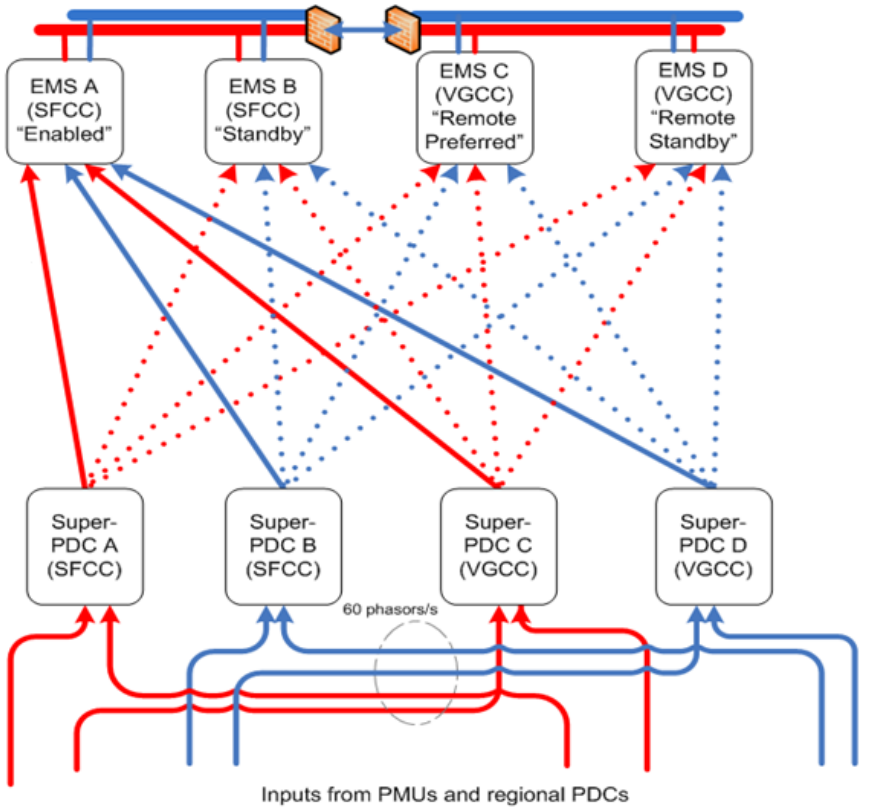
PG&E WAMS / Synchro-phasor Project Team

Strategic Team:	*PG&E, ALSTOM, GE, Mississippi State University, Quanta Technology*
Academic & Testing:	*GeorgiaTech, OMICRON / RTDS / Virginia Tech., Washington State Univ.*



Synchro-Phasor Applications for the Control Center



Multi-host Redundancy (ISD Link)

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Benefits of Integrating Phasors into EMS

- High resolution + more accurate grid measurements
- Improvements in off-line and real-time models
- ***Helps operator*** with ***improved visibility*** of the fast, dynamic grid conditions and disturbances
- Evaluating true limits for on-line EMS applications supporting State Estimation improvements and dynamic line rating
- Accurately identify system constraints *(voltage, system instability, thermal)* and 'true' operational limits, minimizing congestion
- Prompt identification of un-damped grid oscillations
- Quicker post-event re-creation of actual disturbance scenarios
- More cohesive system restoration among transmission owners and reliability coordinators

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Infrastructure Considerations

- Existing digital connectivity
  - Links between substations, substations & control centers, control centers.
  - Bandwidth and network capacity
    - Data sets/second; Considerations for use of unfiltered data
    - Accountability for corporate growth
- Redundant Ethernet connectivity and ease of upgrade
- Aggregate site (includes complete redundant network)
- Multifunction devices with PMU capabilities
  - Ease of upgrade to meet application needs
- NERC compliance
  - CIP (003 through 009) of the devices and solutions
  - PRC

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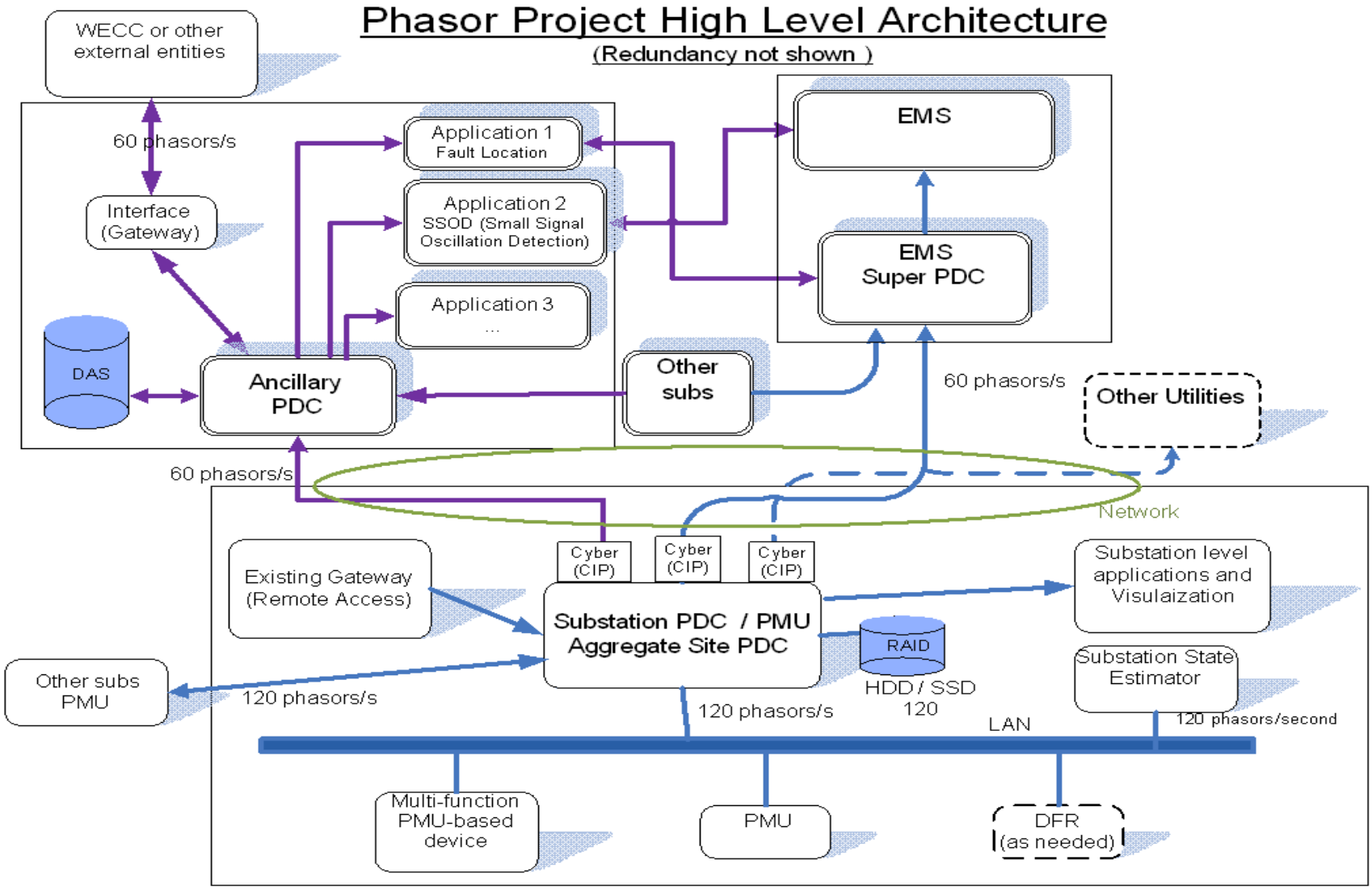
Project Architecture



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Optimal PMU Placement

- Maximize benefit for multiple applications
- Least cost solution: *i.e. leverage existing or planned infrastructure, PMU placement in neighboring systems*
- ***Applications' criteria:***
  - Situational Awareness
    - *Improving State Estimation (observability, critical measurements)*
    - *Monitoring Critical Paths (tie-lines, WECC paths, congestion, cut-planes)*
    - *Monitor major generation and loads*
    - *Oscillation Monitoring (Local and Inter-area)*
  - Critical Substation Locations
    - *Renewable Generation*
    - *Islanding Separation & Restoration*
    - *Remedial Action Schemes, Adaptive Protection*
    - *FACTS, SVC and HVDC Controls*
- Other:
  - Upgradable HW, existing communications, etc.

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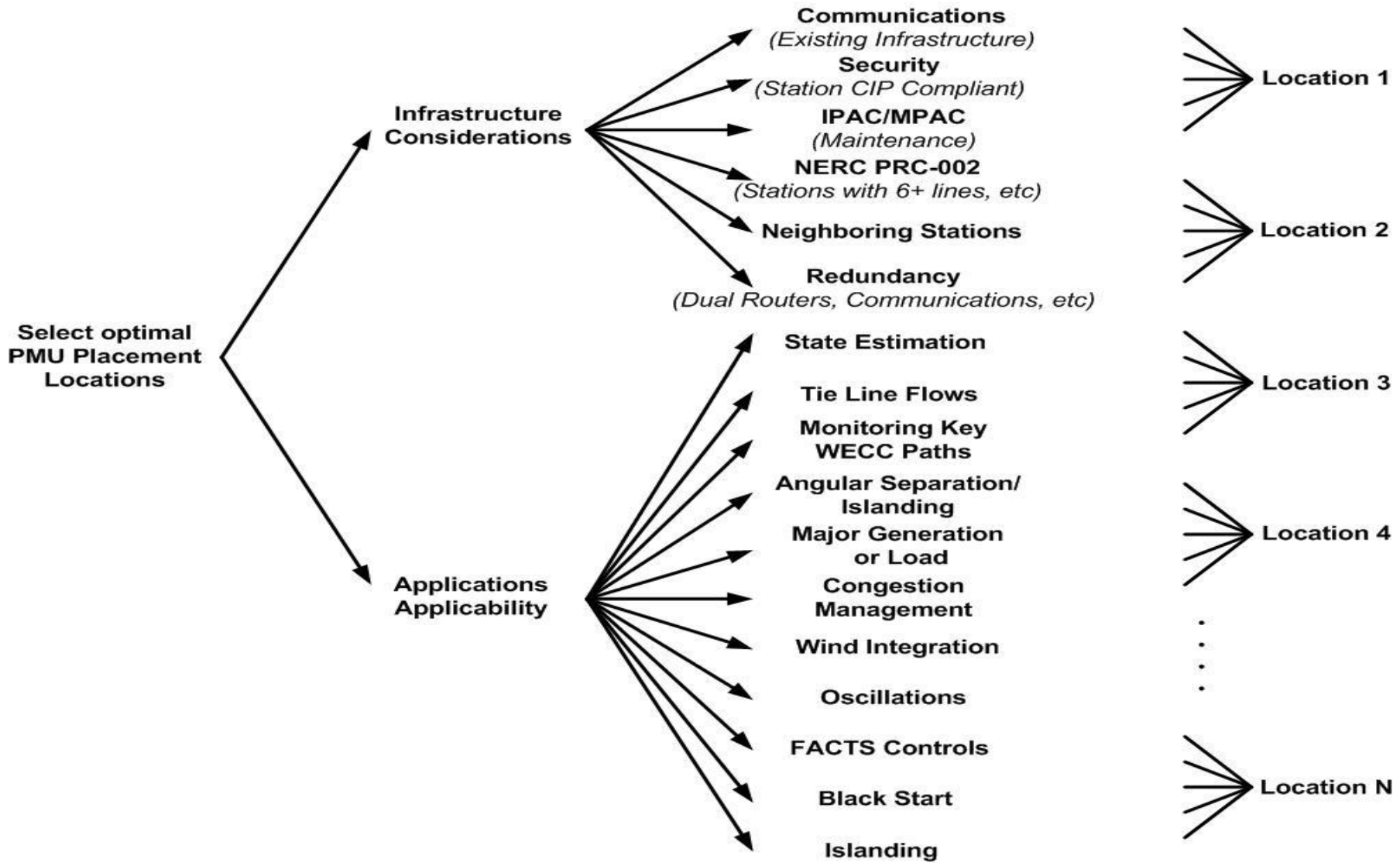
Hierarchy Structure for PMU Placement Decision Criteria



GOAL *DECISION CRITERIA* *ALTERNATIVES*

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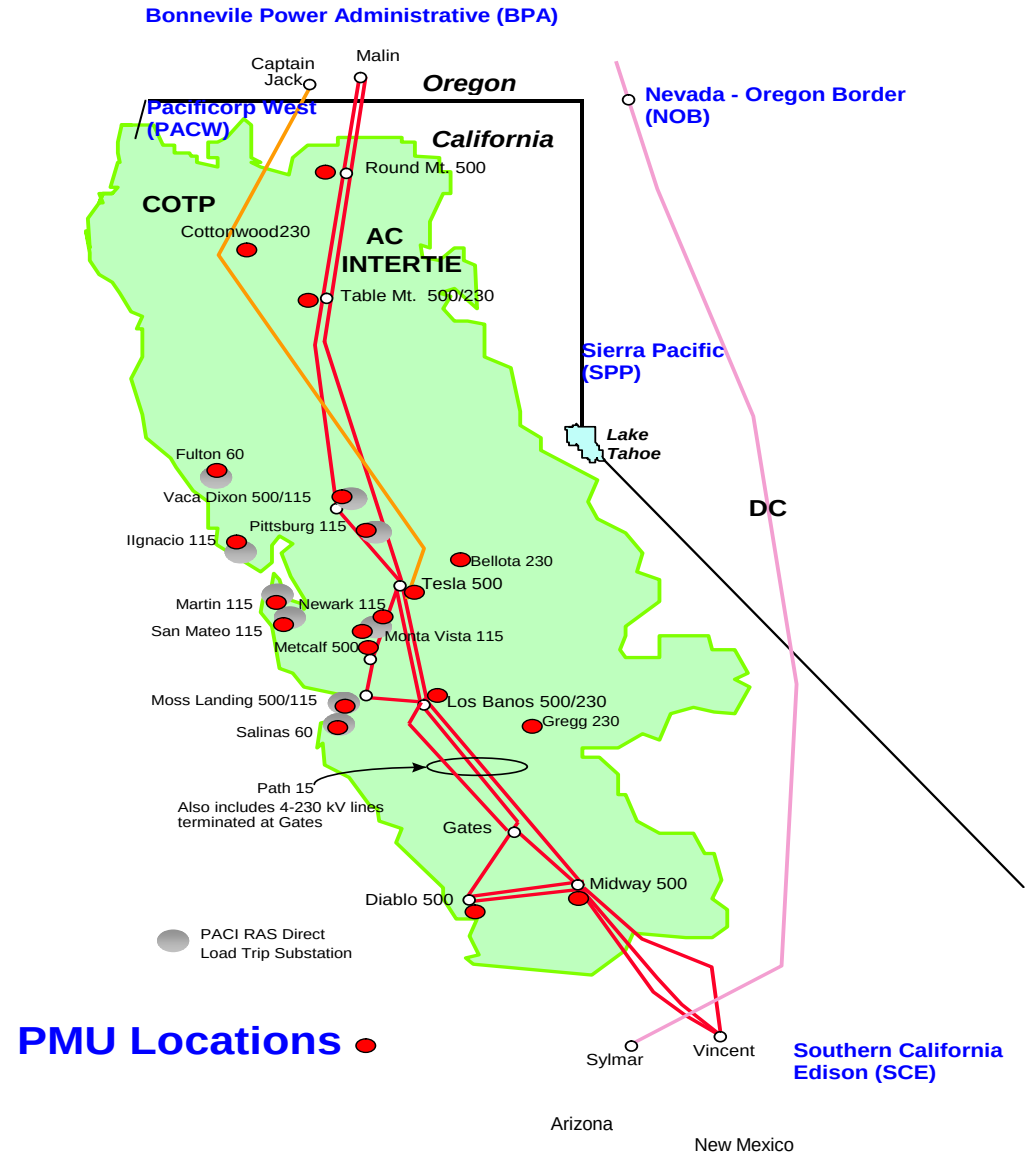
Summary Methodology and Locations

- Decision process which typically involves choosing among *Alternatives* based on multiple *Criteria* to satisfy a *Goal*
- For each PMU location evaluate its '*applicability/need*' for the decision '*Criteria*' under consideration (e.g. application, networking cost, etc)
- Assign '*weights*' to each of the decision criterion based on:
  - *Criterion importance*
  - *Feasibility / likelihood – Infrastructure support*
  - *Maintenance over life cycle*
- Prioritize locations based on the '*aggregated weighted score*'



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Proof of Concept (POC) Stage

- POC is a smaller scale synchro-phasor system:
  - Test, validate, and demonstrate various functions before field deployment
  - Trouble shooting platform throughout the project
- POC system includes:
  - Minimum of 8 PMUs, 2 Aggregate PDCs, 2 Super PDCs (+ EMS systems)
  - Real Time Digital Simulation (RTDS) system
  - COMTRADE file playback system
  - Other test equipment generating time-sync signals
  - Capability to introduce noise impairment
  - Communication routers, switches, delay line, as well as test equipment (e.g., traffic and error bit generators)
- Early testing is well underway with significant results!

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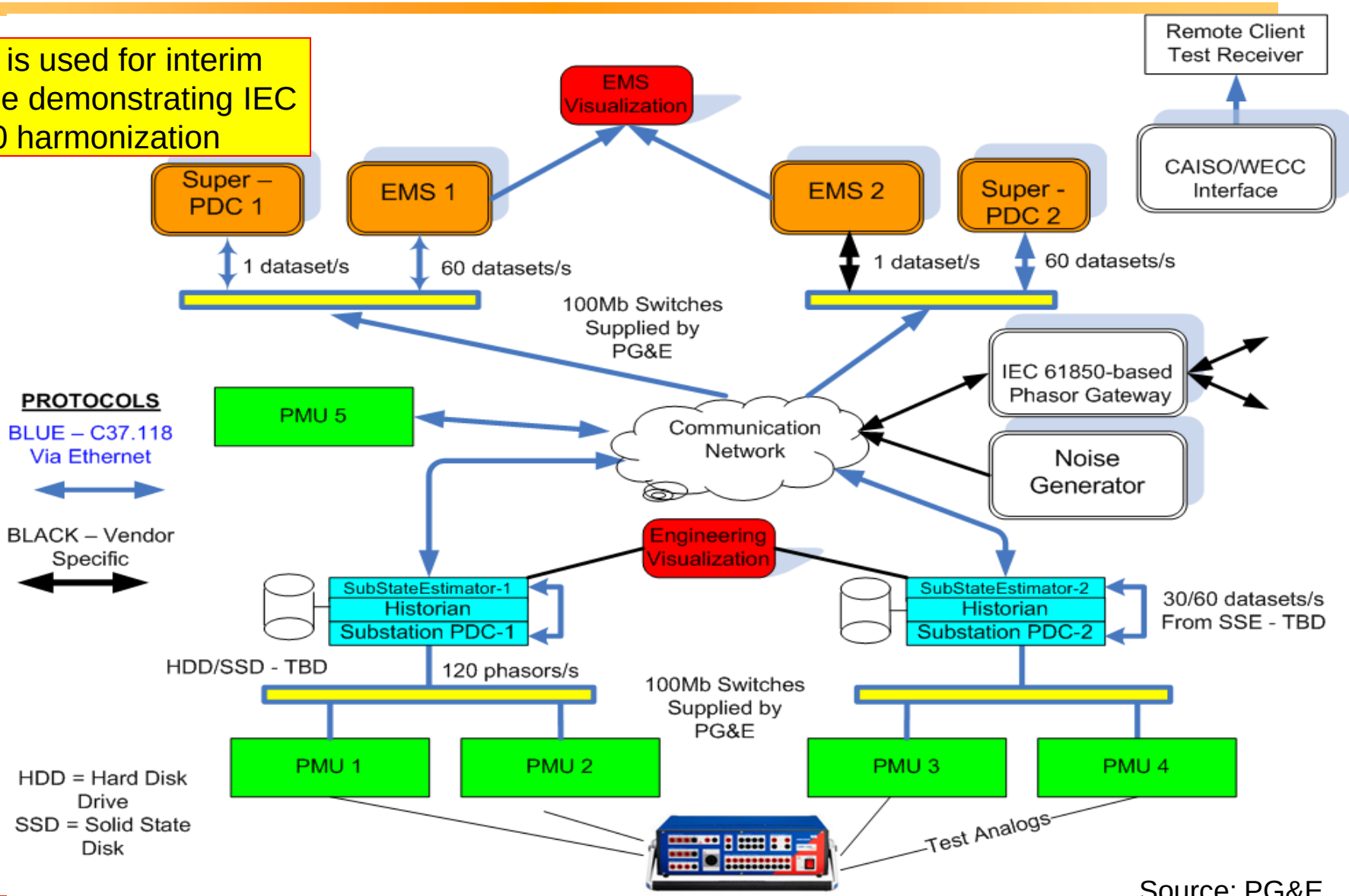
Example: Proof of Concept Architecture

C37.118 is used for interim testing while demonstrating IEC 61850 harmonization



Source: PG&E

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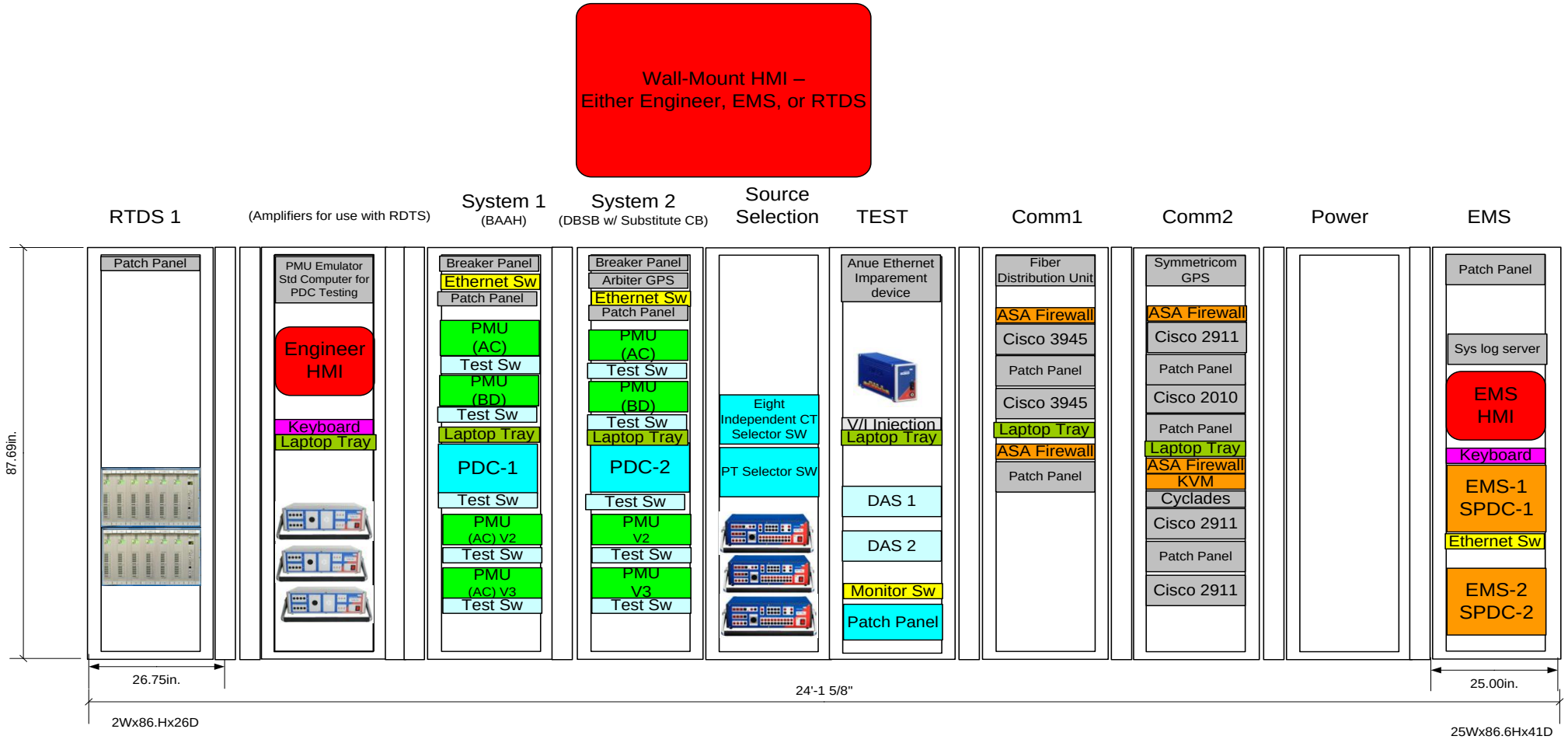
Proof of Concept Testing: Rack-Layout



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POC Initial Testing *(Interoperability Considerations)*

- Sample findings w/ reporting rates of 30, 60, 120 samples (frames)/s
  - *For certain PMUs, when reporting rate is set to 60, PMU recording / streaming rates seem to be ~ 30 Phasors/s*
  - *For other PMUs, when the rate is set to 60, transmit ~75 Phasors/s*
  - *Certain PMUs missing a number of output frames sporadically*
  - *Certain PDCs when they receive invalid status, do not pass on data or flag*
- When using TCP/IP multiple phasors may be combined into one TCP packet causing significant delay in getting some phasors to the destination (not comm. delay)
  - *May be PMU design in packaging data*
- UDP/IP seems to address data Packet broadcast – With UDP/IP every packet is sent out as soon as it is available, on a regular time interval
- Have observed packets missing in bunches
- P and M class related observations

PMU / PMN Standardization + Certification

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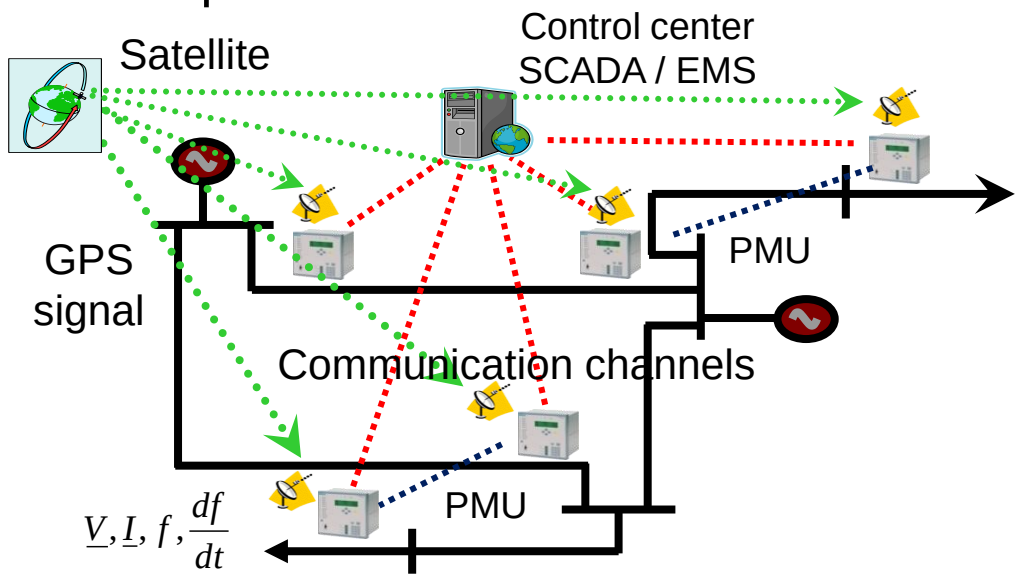
Large Scale Deployment of Synchro-phasor Systems

- Stringent and varied requirements
  - High reliability and availability
  - Accommodate all participants
- Address both short and long term needs
  - System expandability ➔ Number of measurements will grow over time including both synchro-phasor and non-phasor data
  - System flexibility and adaptability ➔ Start with small number of applications and add new in the future
- Technology advancements and product development
  - Standards development continues to evolve: NERC CIP; synchro-phasor (IEC 37-118); cyber security; IEC 61850, etc.
- ***System integration with other enterprise systems, such as EMS/SCADA, DMS, GIS***



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“New” approach to system control

- Process automation
- Electricity supply grids – T + D
- High speed
- High accuracy
- Wide area

→ *Work closer to the limit – use ALL capacity*

→ *Checking the heart beat of the system*

→ *Early warning system*

→ *Entirely new approach to E-system control*

→ *Important to turn (vast amounts of) data into information*

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When Will You . . .

Deploy

Synchro-Phasor

Measurements ?!

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Thank you !

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