Modernizing the US Electric Grid – Transmission's Role and SGIG's Impact

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DOE's Electricity Advisory Committee
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Premise – This Isn't Your Mother's Power System Anymore

Previous Operating Environment:

- Central plant
- Stable, predictable commercial arrangements that changed only seasonally
- Generation with lots of mass and therefore inertia
- Voltage dependent load that gave you a break if the power system was in trouble
- Pretty good conditions for system operators

Premise – This Isn't Your Mother's Power System Anymore

Today's Complex Operating Environment:

- Smaller, more distributed generation and demand-side measures for which the grid was not designed
- Many more transactions that change in increments of 5-10 minutes
- The generation fleet's characteristics have changed – a greater percentage of intermittent, low mass machines – less inertial response to help arrest frequency decline
- Finally, the load has changed – less industrial, voltage dependent load, and more computer and air conditioning service…and will dynamically participate in the market

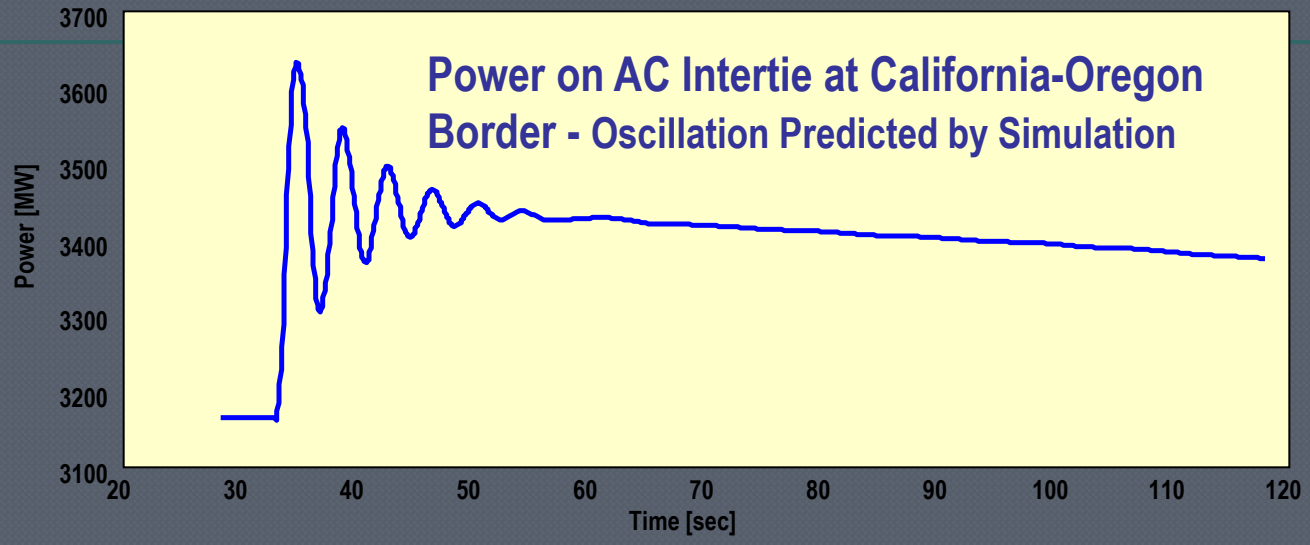
So What Does That Mean?

- A grid that is more complex and harder to operate…and demands better modeling and visibility.
- No matter how carefully operators, operating engineers, and planning engineers study the system….if the models aren't right…,
- ….the results they get and the limits they set aren't right either.
- And if they can't see what's happening, they can't fix it.

Yikes – Poor Modeling

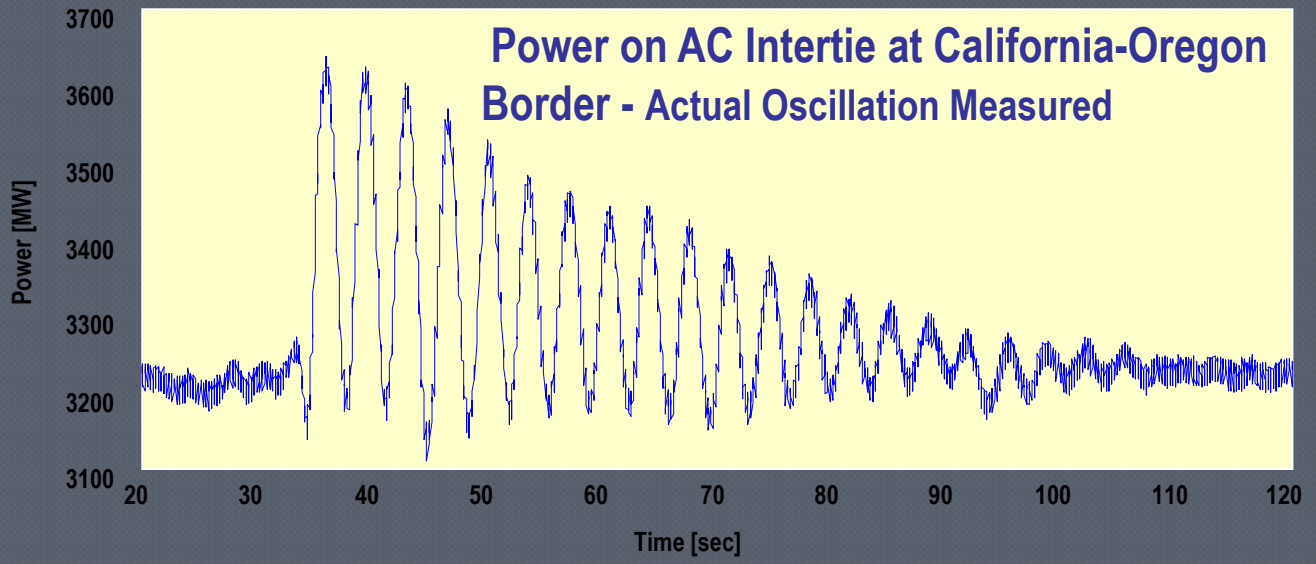
This Is What We Thought Would Happen

(Simulation)



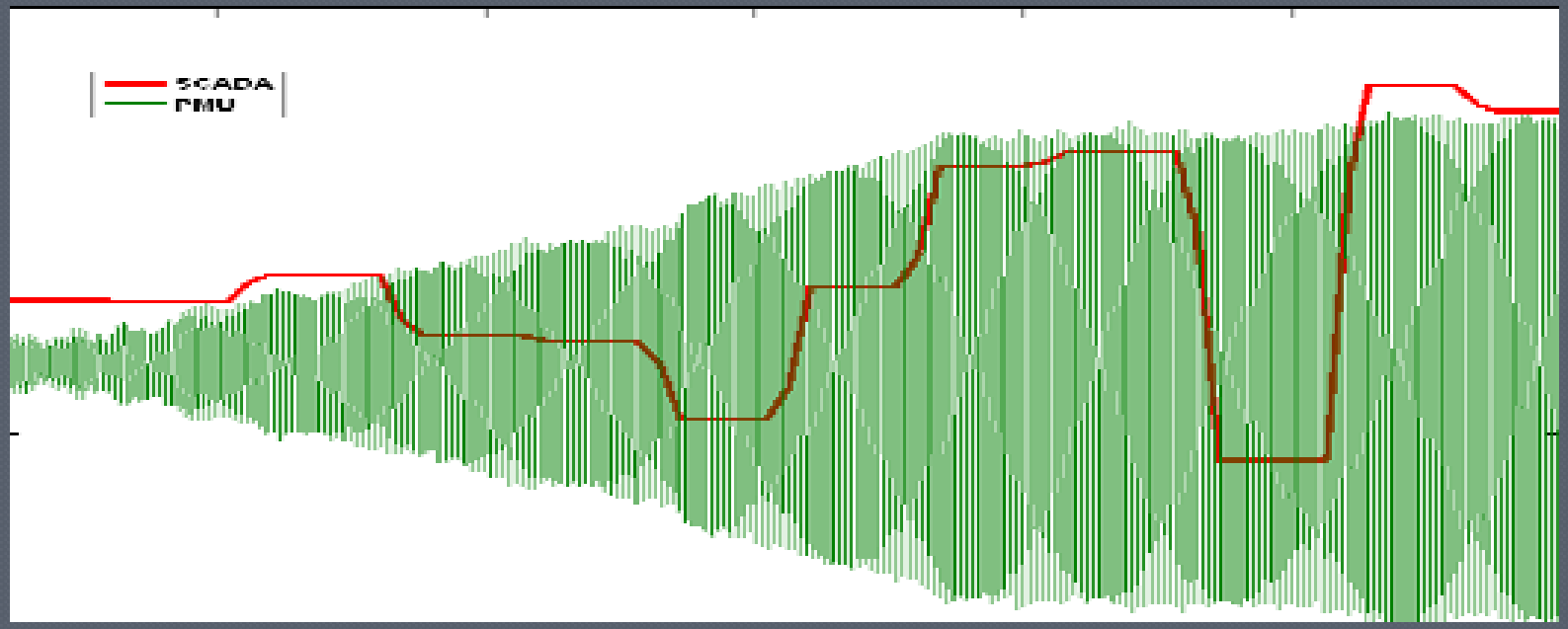
This Is What Actually Happened

August 4, 2000 Oscillation - Alberta Separation



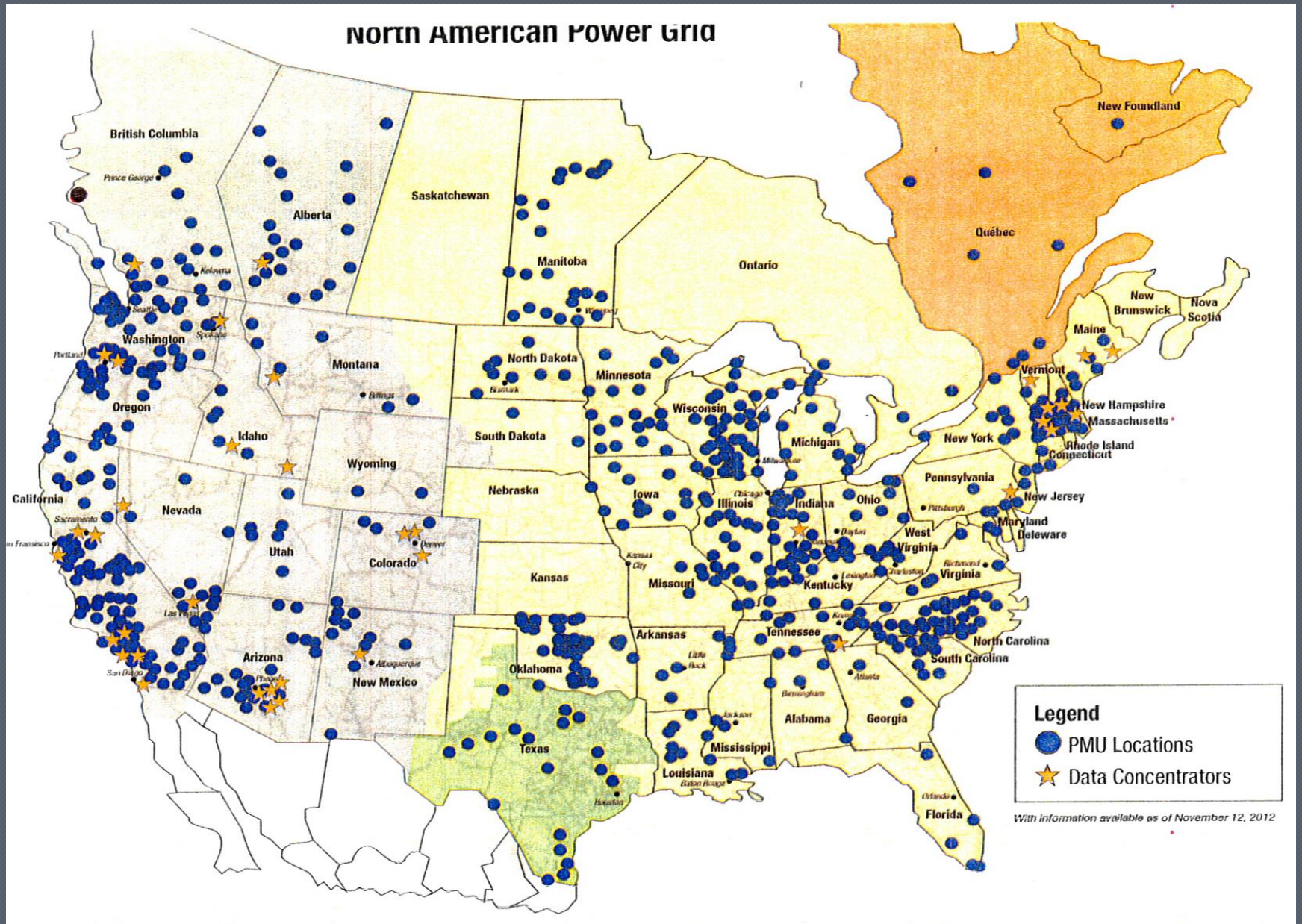
Yikes - Poor Visualization

- …and if power system phenomena can't be seen, operators aren't aware of vulnerabilities and can't take mitigating action



Modeling and Visualization?

- SCADA can't help much with this effort
- More frequent and time-synchronized measurements are necessary to get this model improvement and situational awareness done
- We just happen to have some of those as a result of the SGIG investments…..


North American Power Grid
British Columbia
Alberta
Saskatchewan
Manitoba
Ontario
Québec
New Foundland
New Brunswick
Nova Scotia
Maine
Vermont
New Hampshire
Massachusetts
Rhode Island
Connecticut
New York
Pennsylvania
New Jersey
Maryland
Delaware
Virginia
West Virginia
Kentucky
Ohio
Michigan
Indiana
Illinois
Wisconsin
Minnesota
Iowa
Missouri
North Dakota
South Dakota
Nebraska
Kansas
Oklahoma
Texas
Montana
Wyoming
Colorado
New Mexico
Arizona
Utah
Nevada
California
Oregon
Washington
Idaho
Tennessee
North Carolina
South Carolina
Georgia
Alabama
Mississippi
Louisiana
Arkansas
Florida
Legend
PMU Locations
Data Concentrators
With information available as of November 12, 2012

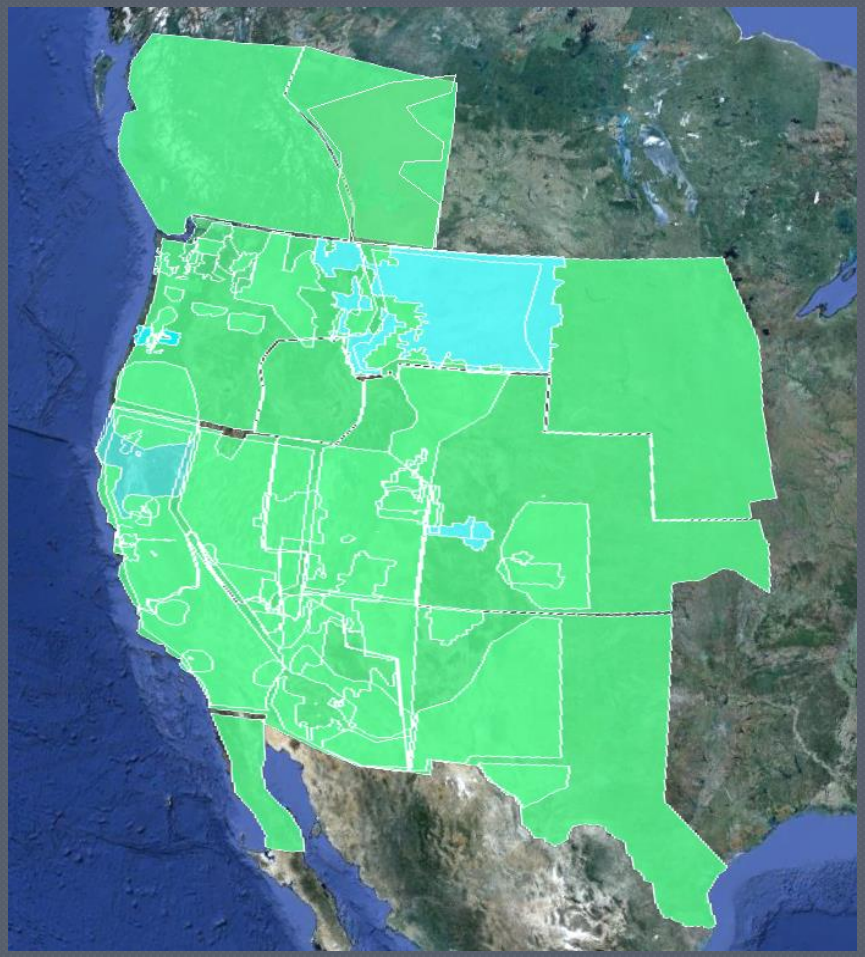
Data Sharing Agreement Coverage

Green = NDA

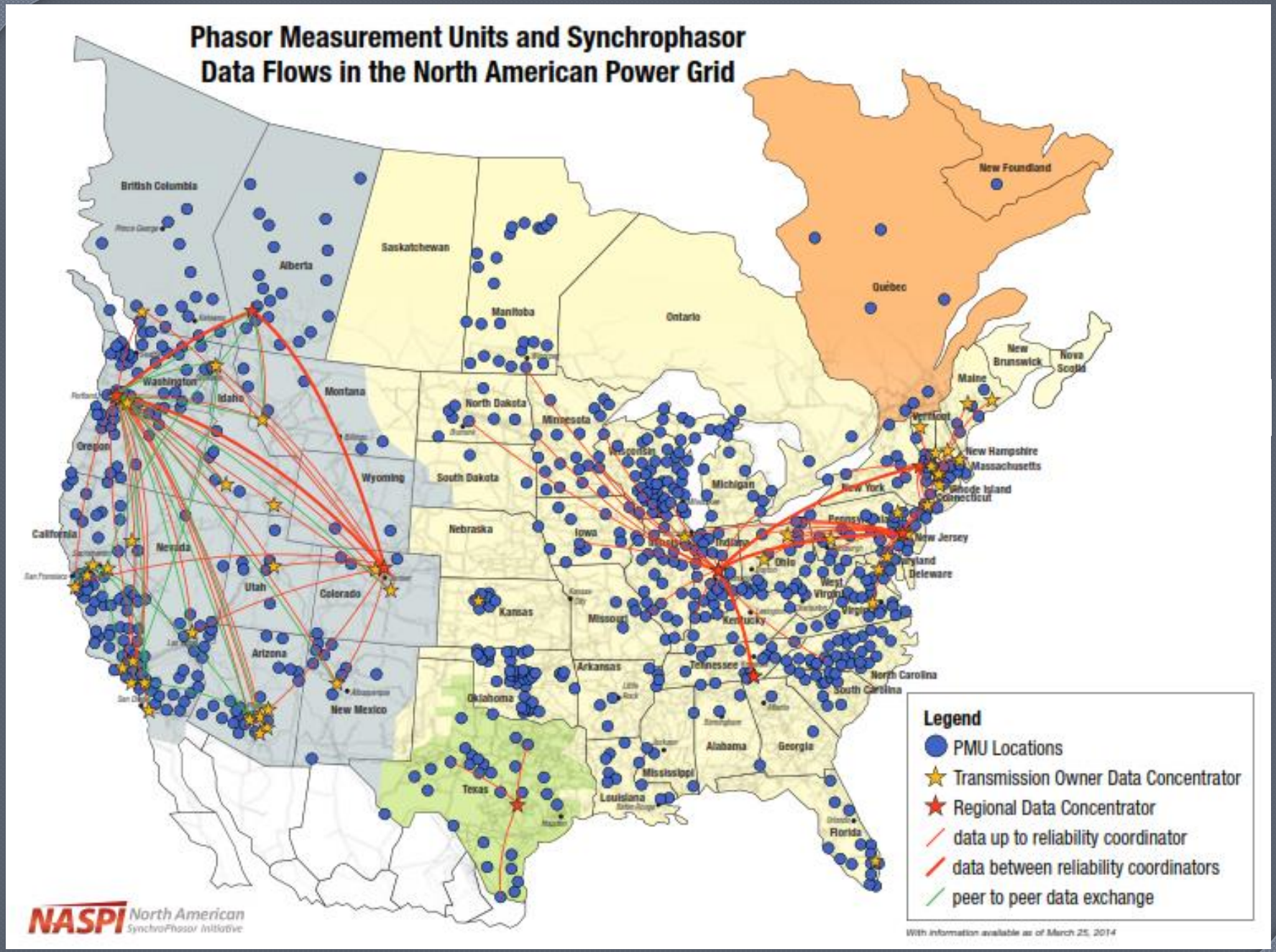
Signatory

Blue = Waiver

Signatory



100% Participation of Western TOs, TOPs,


Phasor Measurement Units and Synchrophasor Data Flows in the North American Power Grid
British Columbia
Alberta
Saskatchewan
Manitoba
Ontario
Québec
New Foundland
New Brunswick
Nova Scotia
Maine
Vermont
New Hampshire
Massachusetts
Rhode Island
Connecticut
New York
New Jersey
Pennsylvania
Maryland
Delaware
Washington
Oregon
California
Idaho
Nevada
Montana
Wyoming
Utah
Colorado
Arizona
New Mexico
North Dakota
South Dakota
Nebraska
Kansas
Oklahoma
Texas
Minnesota
Iowa
Missouri
Arkansas
Louisiana
Wisconsin
Michigan
Illinois
Indiana
Ohio
West Virginia
Kentucky
Tennessee
Mississippi
Alabama
Georgia
Florida
North Carolina
South Carolina
Virginia
Legend
PMU Locations
Transmission Owner Data Concentrator
Regional Data Concentrator
data up to reliability coordinator
data between reliability coordinators
peer to peer data exchange
NASPI North American SynchroPhasor Initiative
With information available as of March 25, 2014

Modeling?

- Of the three components:
  - Transmission
  - Generation
  - Loads
- Transmission is pretty good
- Generation is improving, but more to go
- Loads need the most work

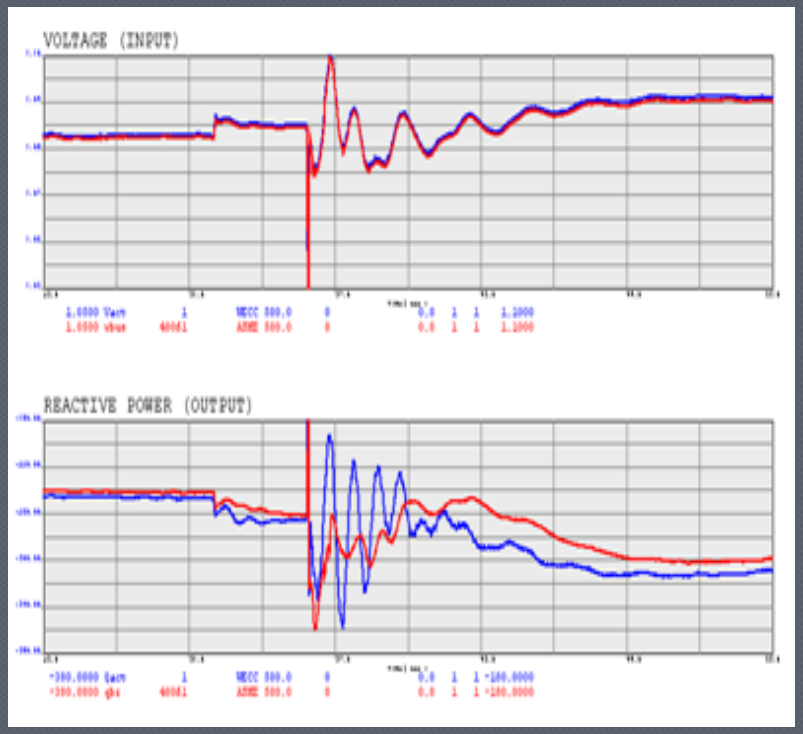
Generator Model Validation

(for 1100MW Nuclear Plant)

Before Calibration

Blue = Actual Response

Red = Simulated Response



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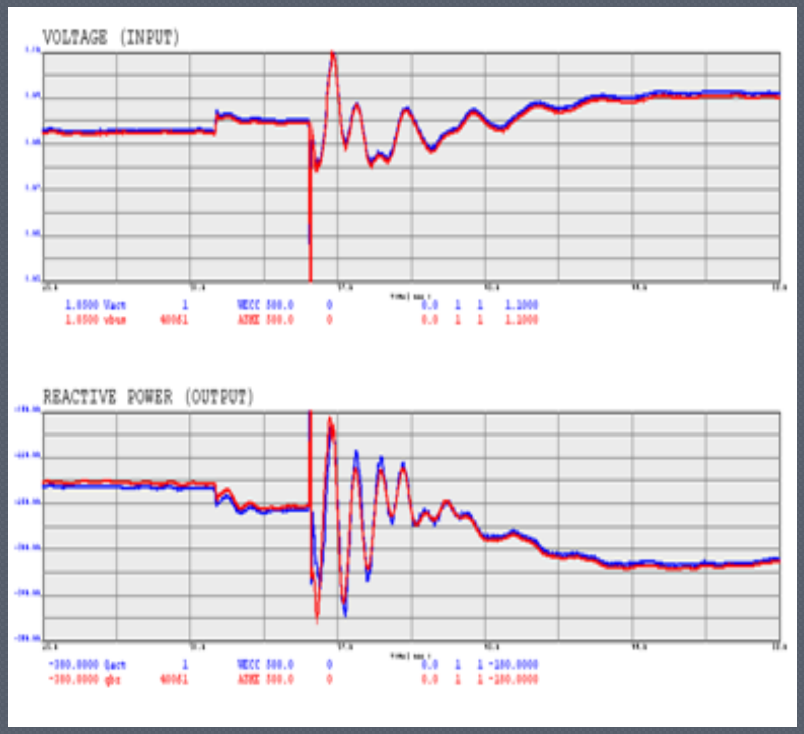

Why WISP was unique

- Interconnection-wide in scope;
- Largest of the Smart Grid Investment Grant projects in the Electric Transmission Category (10 total);
- Both public and private participants;
- Deployed a dedicated, secure high-speed, wide-area network for synchrophasors
- Visualization of power system oscillations (a particular vulnerability in the West) provided along with decision support for mitigation;
- Will deploy two automated, regional control schemes.

What's Next

Qualifying the Data

- PMU/PDC Data Quality
  - Bad Data Detection and Management
- Interconnection Baseline Correlation (Angle, Modal Damping, Oscillation Energy, etc.)
- Calibrating and Validating the Models

What's Next

Decision Criteria

- Dynamic Simultaneous Limits (Nomograms) for Major Western Transmission Transfer Paths
- Determine Corrective Actions for Stressed Power System States (Operating Procedures)
  - Coping with Loss of Inertia, Low Damping Conditions, High Angle Separation
  - Some Actions will be Automatic