Synchrophasor technology and human performance in the control room

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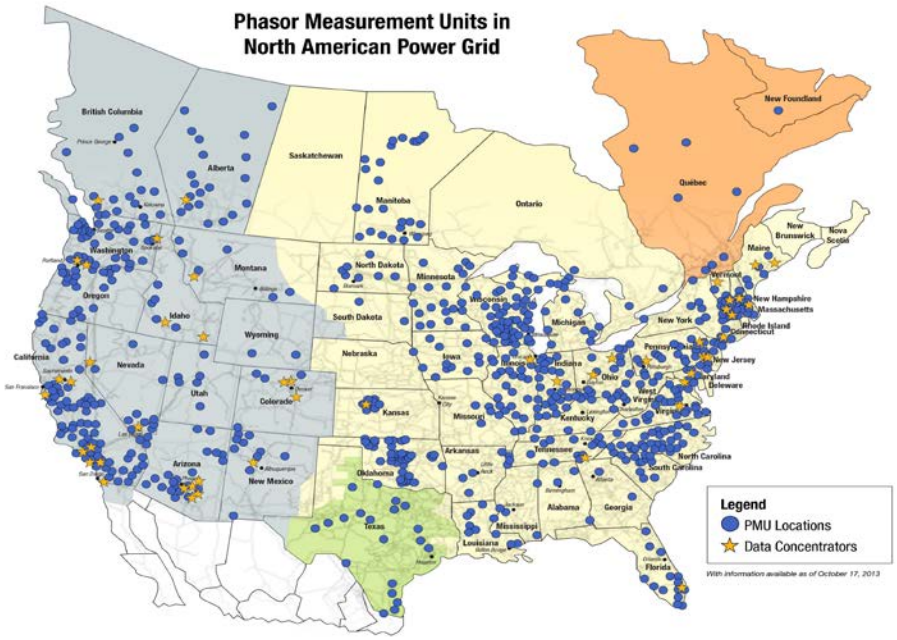
Overview

- What is synchrophasor technology?
- What operator tools will it enable?
- How synchrophasor tools could change control room operations (and two digressions)
- How do we move synchrophasor data smoothly into the control room?

What is synchrophasor technology?

Synchrophasor = time-synchronized number that represents both the magnitude and phase angle of the sine waves found in electricity.

- Phasor measurement units (PMUs)
- Phasor data concentrator (time alignment & archive)
- High-speed communications networks & secure IT infrastructure
- Applications
  - Real-time (operations)
  - Off-line (engineering)
  - Forensic event analysis



Almost 1,700 PMUs, most networked, most funded by $328 million in federal ARRA Smart Grid funds and matching private sector funds

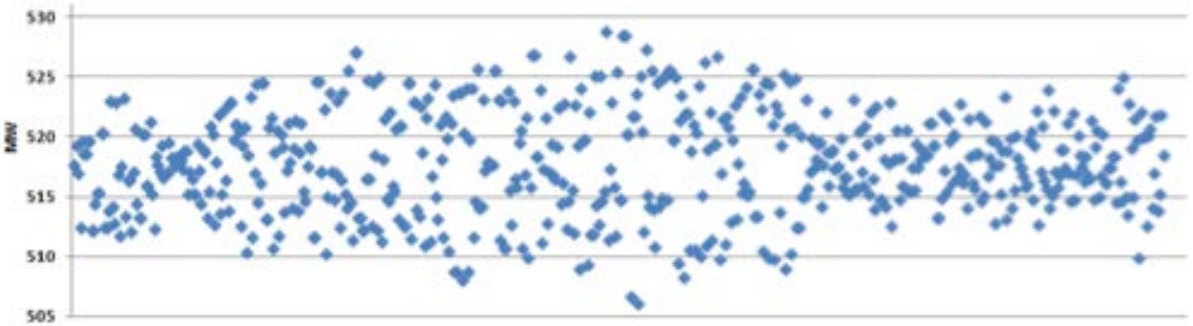
Synchrophasor data v. current control room data

- Wide-area -- data measured and delivered across most or all of the interconnection (eventually)
- 100x faster – 30-60 samples/second v. every 4-6 seconds (SCADA)
- Time-synchronized -- all samples time-synchronized to one micro-second accuracy
- Real-time data delivery into applications

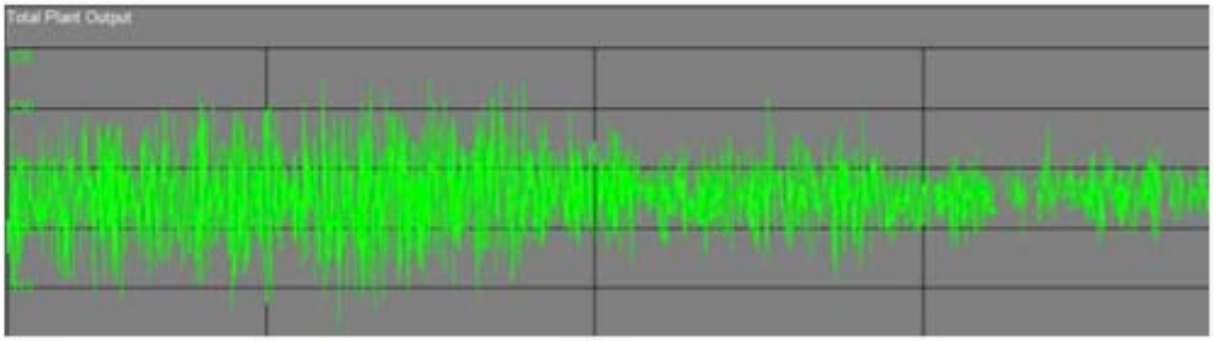
Much different data density and periodicity

New England – sustained oscillations for 1 hr

SCADA DATA – no obvious pattern or relationships



POWER PLANT PMU DATA – clear pattern



What could synchrophasor data do for the control room?

Leveraging advances in graphics, computing and high-speed communications, synchrophasor data will enable:

- More intuitive and informative visualizations
- Better grid condition situational awareness
- Smart, integrated alarms and alerts
- Sophisticated decision support tools (e.g., N-x studies based on better data) to help deal with real-time operations needs
- Automate and distribute some less important activities to let operators work on high-value activities and challenges

Operational uses for synchrophasor data

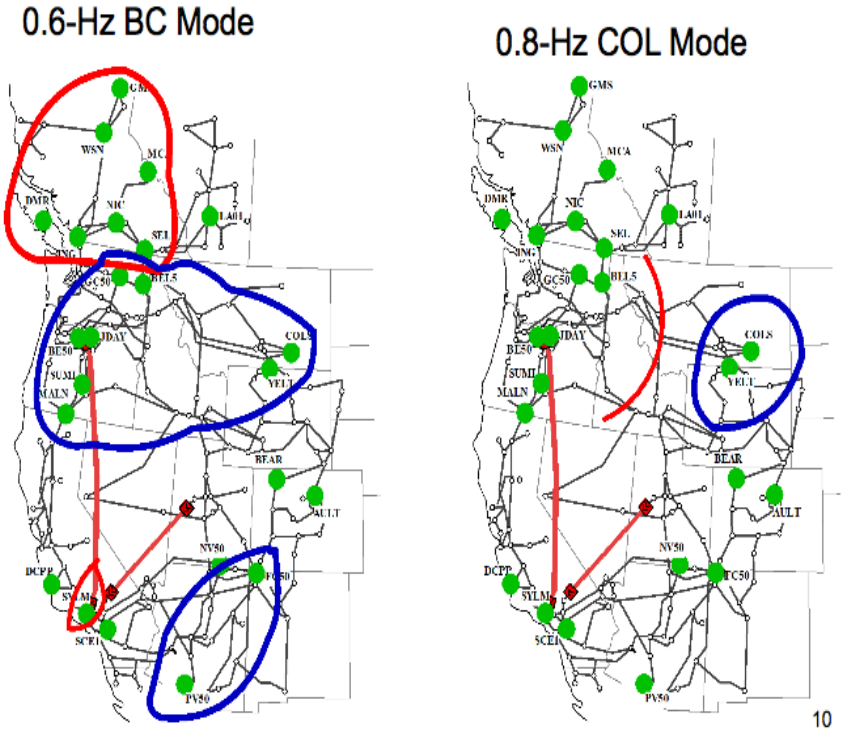
- Wide-area visualization
- Oscillation detection & analysis
- Event detection, analysis & response & event replay
- Angle difference monitoring & post-contingency phase angle alarming
- Voltage monitoring
- Island detection and black-start assistance
- Fault location analysis
- Verify load response to DR event calls
- Better state estimation
- Distributed automated controls for grid assets
- Back-up to EMS and AGC
- Operator training

Engineering uses for synchrophasor data

- Model validation
  - Power plant validation under MOD standards
  - Wind plant models
  - State estimator validation
  - System model improvements
- Frequency analysis – BAL standards
- Set alarms and alerts based on baselining
- Manage transmission throughput & limits
- Disturbance analysis
- Create an event library of synchrophasor data (WECC)
- Replay grid events for operator training
- Create operator decision support tools

Challenges of synchrophasor data

- Unprecedented volumes of data coming into the control room
- Still working on assurance of high-quality data and how to distinguish between real events and bad data
- Unprecedented insights into grid events means that we don't always know what we're seeing and how to respond
- Poor introduction and management of phasor data information and tools could overload or turn off operators



WECC is using synchrophasor data to identify previously unknown oscillatory modes – but they don't yet know how to deal with these oscillations….

Digression 1 – consider the evolution of video games

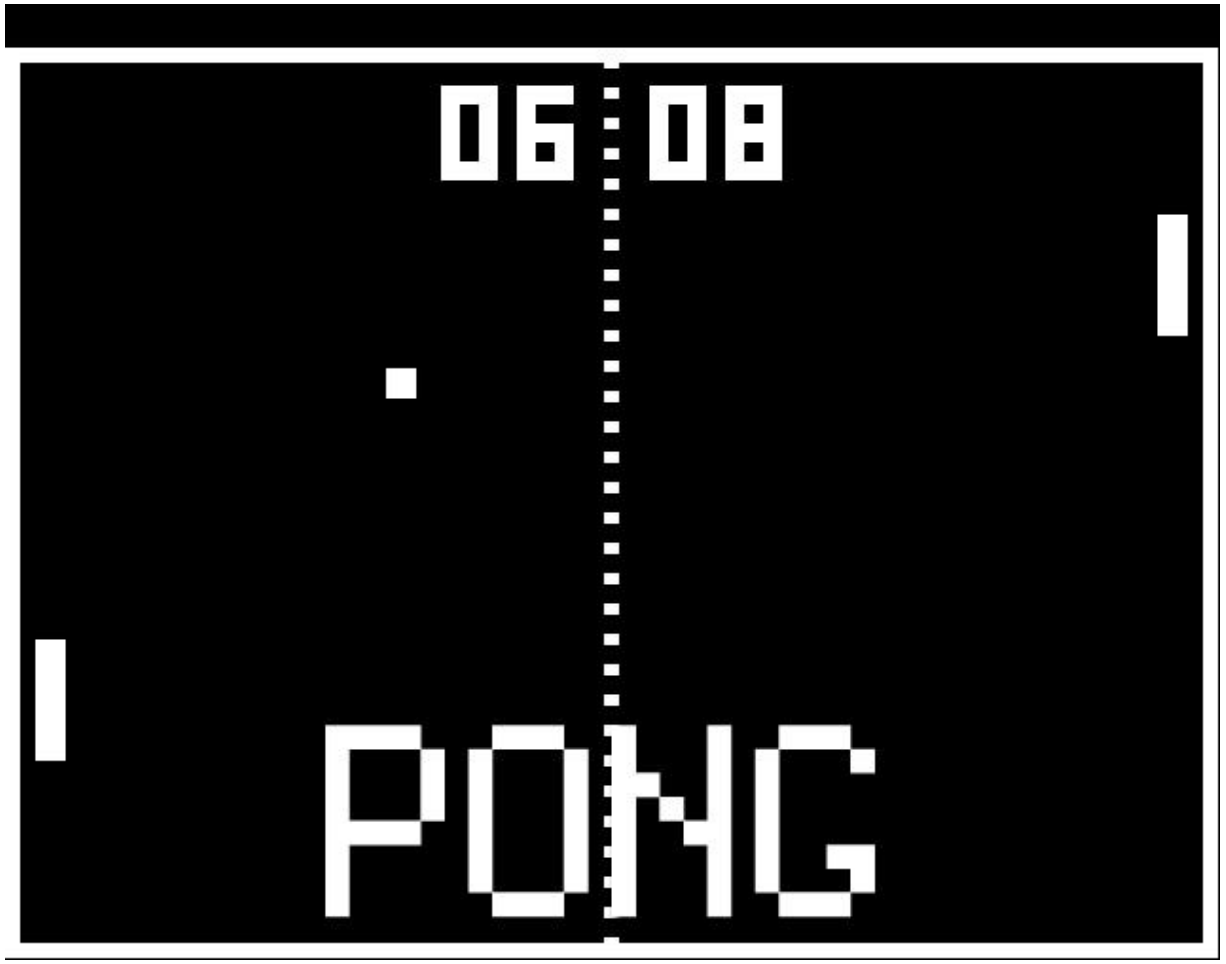
Factors to consider from the player's perspective:

- Information density
- Quality of graphics
- Variety of screens and data displayed
- Number of players
- Perspectives available to each player
- Reaction and screen refresh speed
- Speed, quality and sophistication of analytics and options available

All affect the quality, enjoyment and learning from the gaming experience

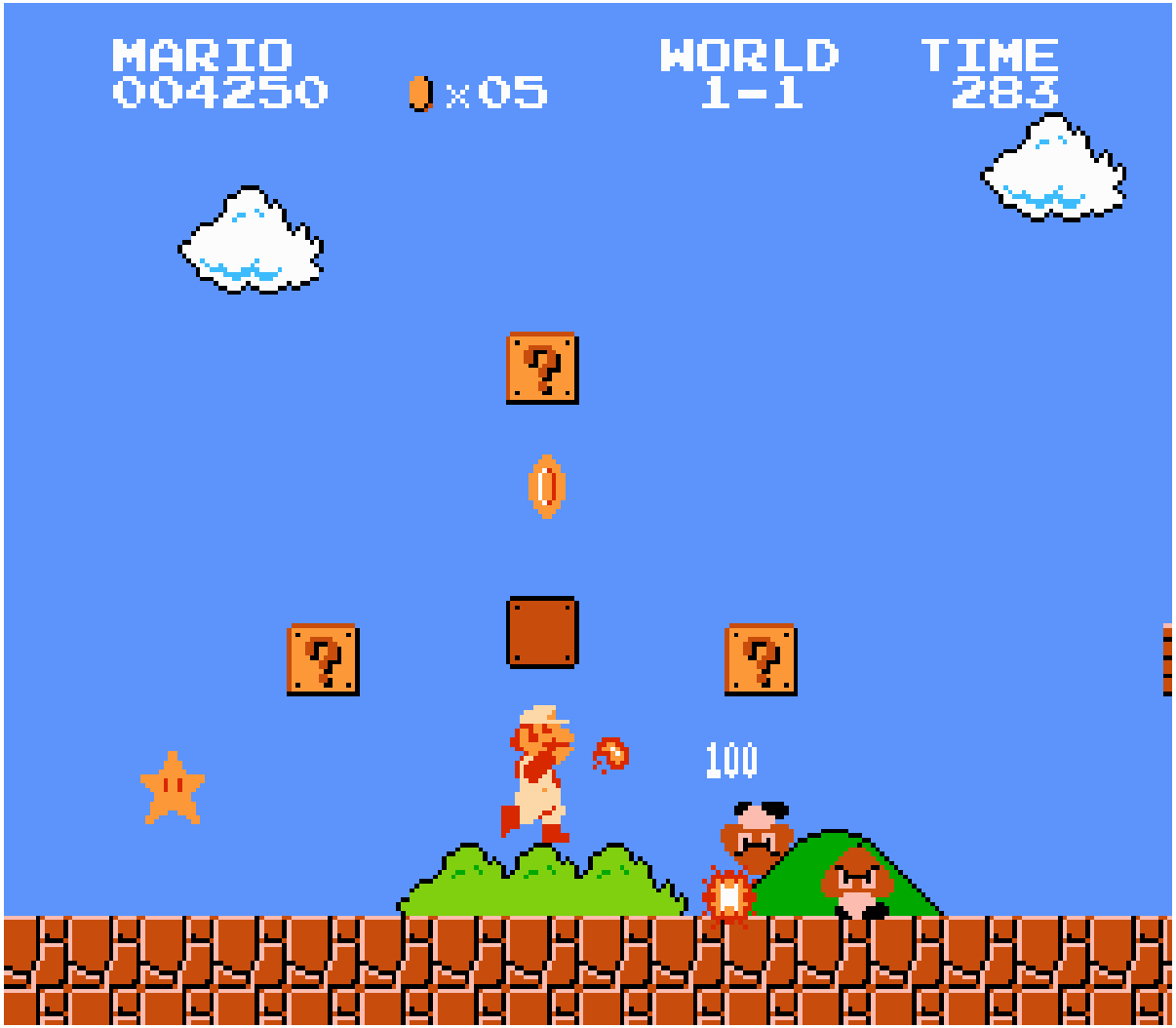
In the beginning there was PONG

First video games – minimal graphics, single player or two-player, minimal processing



Then there was Mario…

Rudimentary graphics, one-player, stripped environment, limited tools and perspectives, lives inside the host computer



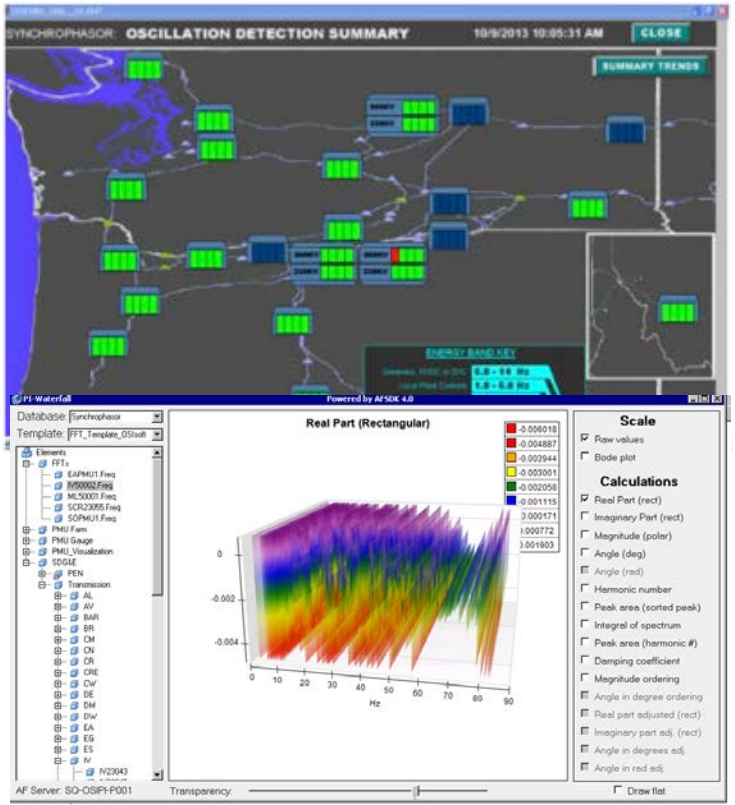
Now there are MMOs in the cloud…

Massive multi-player on-line games – sophisticated graphics, huge community of players in real-time, all making independent but inter-dependent decisions and actions; multiple information display options, multiple player tools, communication methods and player perspectives, all hosted in the cloud.

Sample World of Warcraft screen

From games to the control room

Now suppose you're the control room operator – are your tools today more like Mario or World of Warcraft? Which would you rather have? How can we use better data, better computational capabilities and human factors insights to enrich control room tools to make operators more effective?



Digression 2 – smart diagnostics and automated actions

Human operators don't have to do everything….

- Here are some of the things that cars are doing for their operators today
  - Parallel parking
  - Traffic lane "maintenance"
  - Dynamic cruise control managed by radar-informed proximity and braking
  - Manage engine, brakes and battery for system fuel efficiency
  - "Active" headrest and seatbelt management to protect passengers
  - Operator voice commands for communications and entertainment
- So what kinds of automated activities could phasor data make possible, to address fast-occurring grid events and free up grid operator attention for high-priority decisions? Is this a JTA opportunity?

Synchrophasor technology can change operators' roles and tasks

- Better wide-area situational awareness and visualization tools and better asset models give operators better information and decision support tools
  - State recognition and better state estimation
  - Faster contingency analysis
  - Pattern recognition and libraries of past grid events enable faster event identification (e.g., oscillations) and appropriate reaction
- More automated actions out on the grid with synchrophasor-driven decision-making and switching, including:
  - Dynamic stability management -- synchrophasor data feed local, in-field state estimation and distributed decision-making
  - Voltage management at generators, capacitors, SVCs
  - Automated reclosing decisions informed by phase angles

How can we move synchrophasor data into the control room more effectively?

- Don’t make it about synchrophasor data, but treat it for now as “fast SCADA”. Integrate the phasor data into existing tools and enrich their ease of navigation and usability (trending, visualization, drill-downs).
- Develop smart alarms that analyze and integrate multiple data sources and link multiple causes and symptoms to identify mis-operations and problematic developments and alert multiple actors.
- Show the value of each tool and make them easy to use – but don’t push a tool into the control room before it, or the operators, are ready.
- Enrich the tools and displays over time as analytical and visualization capabilities improve.
- BUT -- when we’re ready to do flash-cut changes in tools, leverage high-speed synchrophasor data and fast analytics and graphics to give younger operators tools that look and feel more like what they’re used to and already good at outside the control room….

October 22 am – NASPI Technical Workshop
Oscillation Detection & Voltage Stability Tools
Analysis and Usability Comparison

PLEASE BRING YOUR OPERATORS!

CIGRE & NASPI meeting together in Houston
Integrated tutorials, workshop and programs
CIGRE – October 19-21, 2014
NASPI – October 22-23, 2014

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Questions?

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