Why You Need a 'Nathan'

Or How to Avoid the Pitfalls of Synchrophasor Integration

2016 IEEE PES General Meeting Tutorial

"Use of Synchrophasors in Grid Operations"

Tuesday, July 19, 2016

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Outline

- 4 Lessons for Control Room Integration
  - Planting Synchrophasor Trees
  - The Many Roles in the Control Room
  - Closing the Loop
  - Why You Need a ‘Nathan’

Lesson 1

PLANTING SYNCHROPHASOR TREES

OR HOW TO DEPLOY PMUs

Deploying PMUs

- Why Standardize? – More Synchrophasors!
  - Appears obvious but can be said again
    - Value in PMU footprints of all sizes but…
    - Small footprints yield niche applications while large footprints yield applications which are *widespread, interoperable, prolific*
  - How to champion sustainable continued deployment?
    - Dedicated projects can be resource intensive
    - Dominion now utilizes substation construction standards which dictate PMU/PDC installations for any control house visited or created during normal project work.

Substation Standards for PMUs

- Four Affected Standards
  - Transmission Line Relays
    - Add satellite coaxial cable, Ethernet connection, PMU settings
  - Transmission level Transformer Relays
    - Add satellite coaxial cable, Ethernet connection, PMU settings
  - Stand-alone PMU Panels
    - Installed when additional signals are desired (V, I, Digital, etc) or when line or transformer relays aren't installed
  - Substation PDCs
    - Install 1 per control house on a communication panel or stand-alone PMU panel

Impacts to Synchrophasor Footprint

- Original Grant Deployment
  - 80 PMUs, 39 PDCs, 21 Control Houses
- Present Day
  - 141 PDCs
- 5 Year Projection
  - ~300 Control Houses in total
- Approximately 0.01% of total capital expenditure on PMUs/PDCs over next 5 years

Key Takeaways

- More PMUs open up the door to more and better observability and applications.
- Standardization is an extremely efficient, effective, and affordable way to deploy PMUs across a service territory.
- Standardization was easier after deploying the first round of PMUs over several years.
- There are many existing processes that can be utilized for integrating synchrophasor technology in a sustainable way with minimal organizational impact.
- However, don’t allow standardization to trump progress during the initial phases.

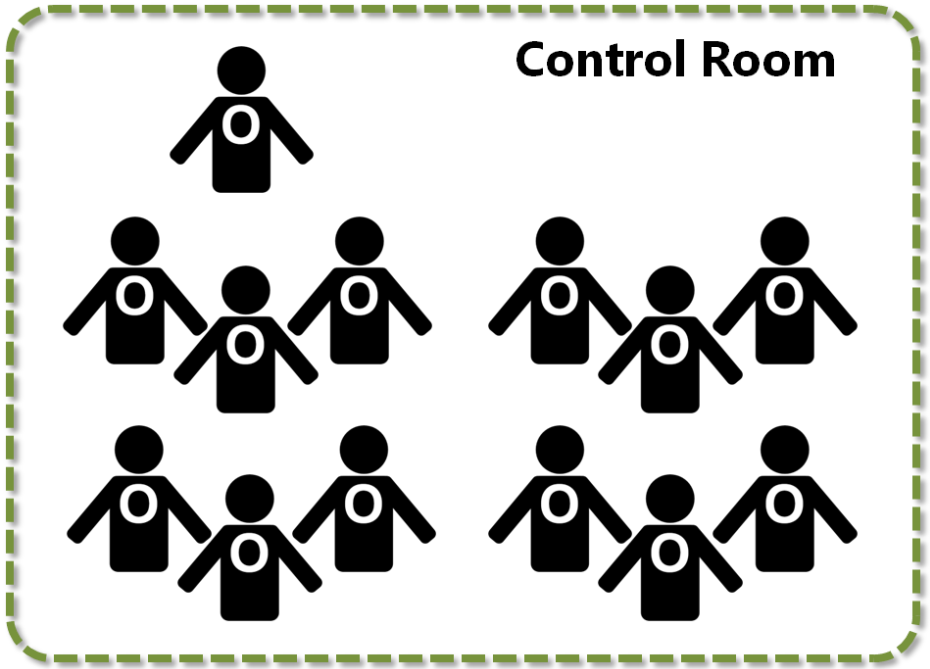
Lesson 2

THE MANY ROLES IN THE CONTROL ROOM

THE NON-OPERATOR-CENTRIC APPROACH

Flaws with the Operator-Centric Approach

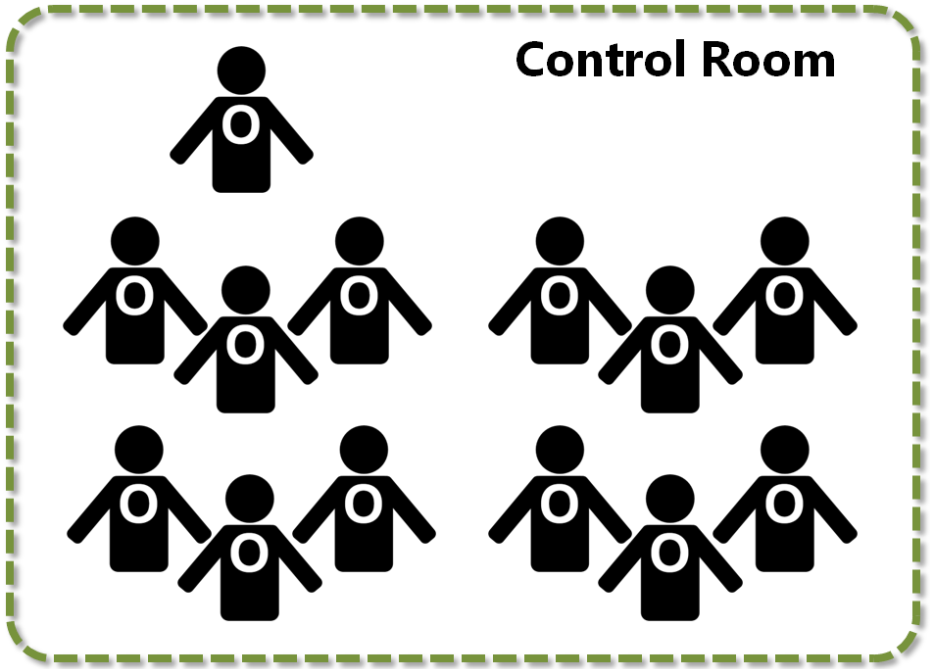
- Conversations regarding control room integration of synchrophasors often center around the ‘operator’.
- Colloquially, the ‘operator’ role tends to get over generalized and dilutes our ability to envision control room applications



What role is then responsible for situational awareness?

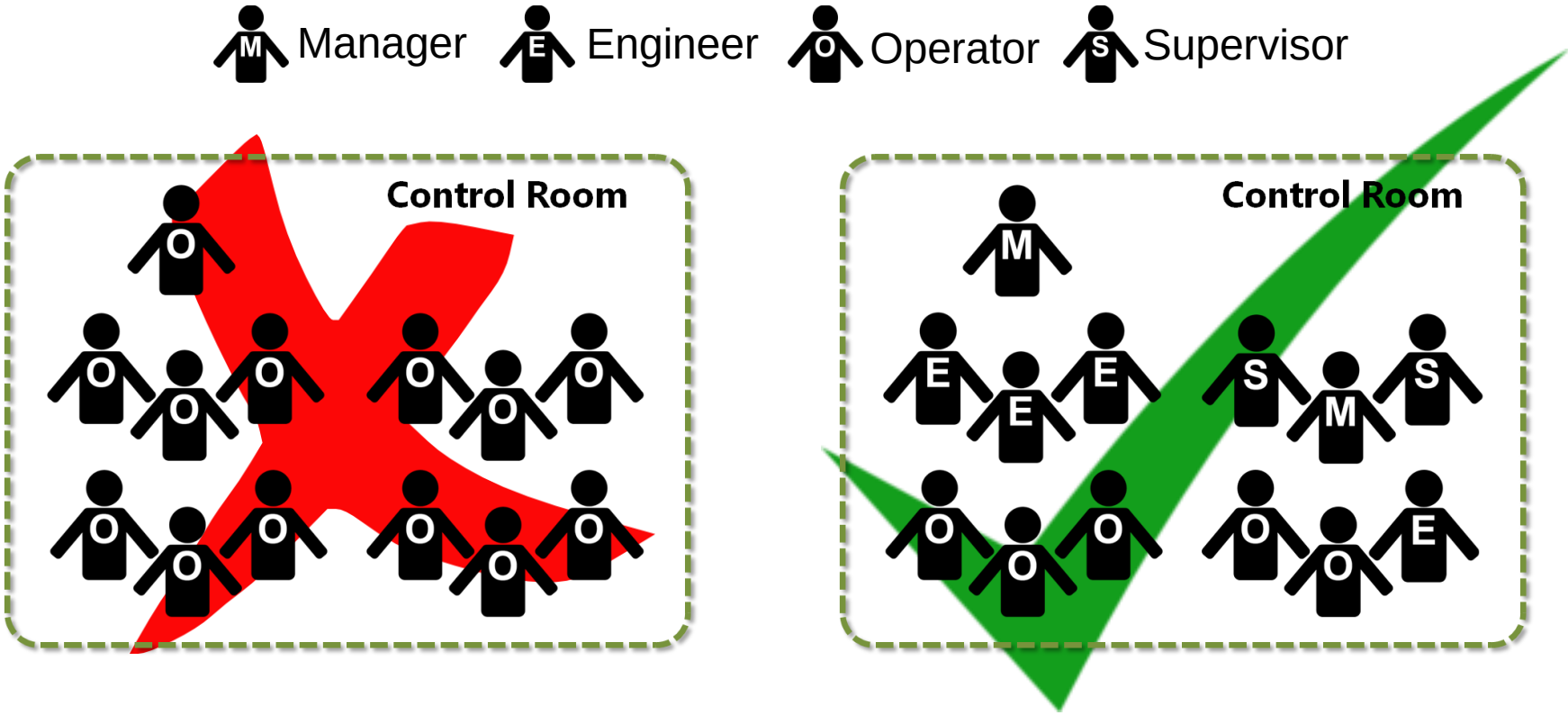
Flaws with the Operator-Centric Approach

- This is particularly isolating when the primary role of the ‘operator’ is switching.
- Furthermore, the ‘operator’, due to the criticality and specificity of the role, may be the last to adopt new technologies, regardless of the importance to overall operation.



What role is then responsible for situational awareness?

It takes more than the 'operator' role to run an effective control room.



What role is then responsible for situational awareness?

Everyone in the control room in the way that makes sense for their role.

Key Takeaways

- The roles in a control room are many and varied, particularly amongst different organizations.
- Focusing on the generic operator role in defining key applications and use cases is limiting in many ways.
- Leverage the engineering and technical roles to increase functionality and responsibility of the control room without overburdening the operator role.
- Leverage leadership in the control room to set appropriate goals rather than depending on only the operator to define requirements.

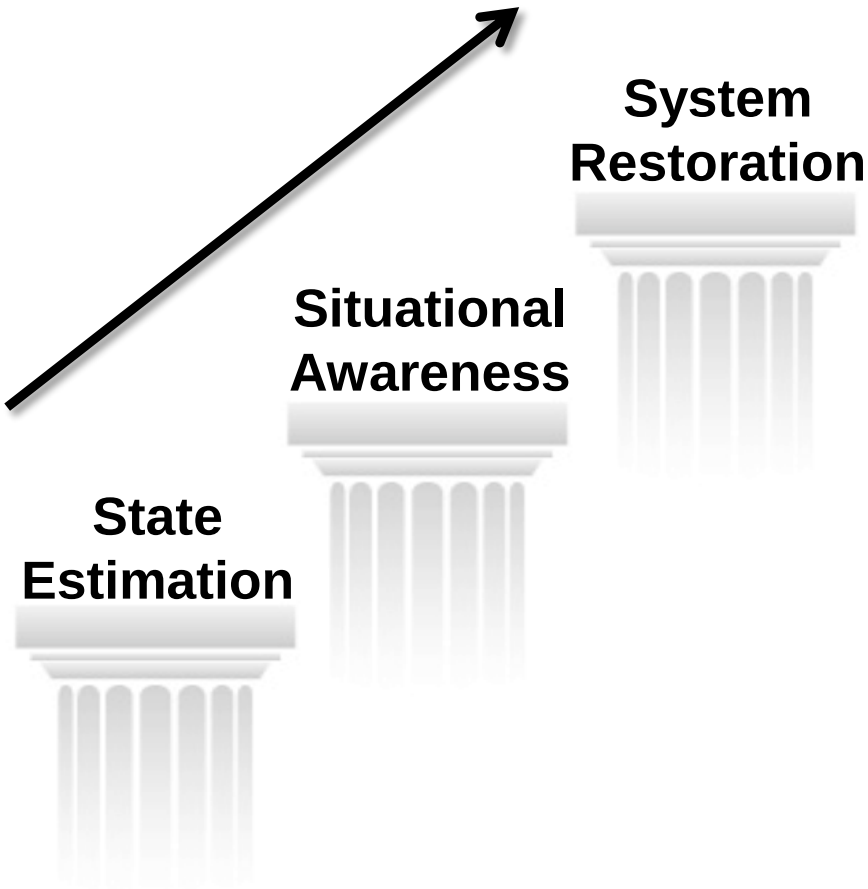
Lesson 3

CLOSING THE LOOP

OR HOW TO SET THE RIGHT GOALS

The Pathway for PMUs into a TO Control Center

- Align synchrophasor goals with key functions and values of DVP as Transmission Owner (TO)
- *Limitation of scope:* synchrophasors can do so many things, but pick a small number of use cases to champion
- *Closing the Loop:* find ways to create progress in incrementally realizable ways.



State Estimation with PMUs

Why is State Estimation key?

- Integration of PMU measurements into traditional state estimators
  - Cross validation of data and model
    - PMU data validates SCADA data and network model
    - SCADA data and model validate PMU data
- Linear state estimation for synchrophasor-only network applications
- PMU integration into SE is a known solution (low risk value add)
  - We can pattern after others
  - We can expect a workable result

Challenges to SE Integration

- At DVP, the supporting infrastructure is in place
  - Central PDC
  - Translation adapter to EMS
- Human/time resource is needed to ramp up
  - Integrate existing PMUs
  - SCADA modeling
  - SE testing
- Need a sustainable process to maintain, troubleshoot, and grow synchrophasor footprint in traditional SE

Situational Awareness with PMUs

- Polar Chart
- Early Warning System for Blackouts
- Community Watch - everyone should do their part!
- NE Blackout of 2003
- Angle Walkout

Situational Awareness with PMUs

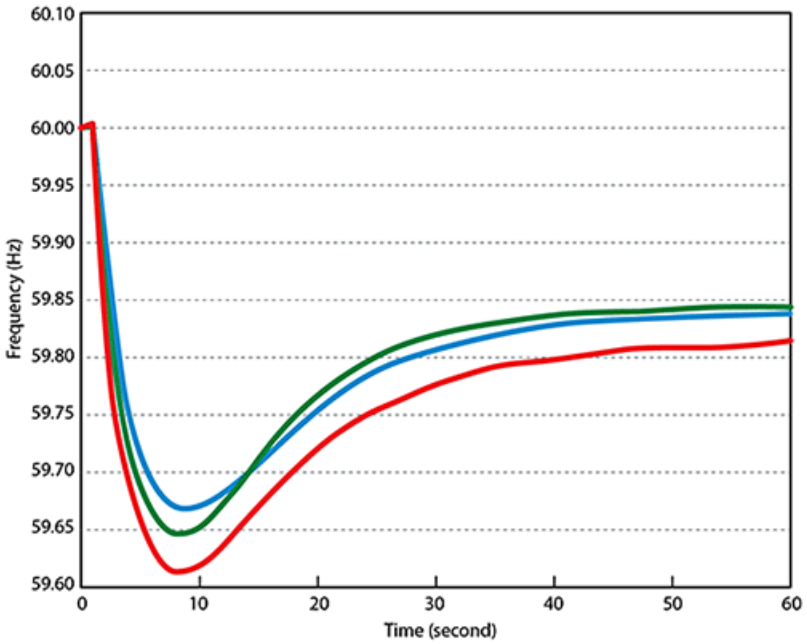
- How to keep operators informed of *"What just happened??"*
- ***Event Detection*** – Success stories of FNET demonstrate the ability of time synchronized measurements to detect and locate events
- ***Near Real Time Event Analysis*** – Post event analysis just after an event to provide operators with event narrative

System Restoration with PMUs

- During system restoration activities, especially black start scenarios, Dominion is not just a TO anymore
  - During black start conditions, TO is likely to be its own BA, RC, etc.

Frequency Monitoring

- Low system inertia
- It will be important to know the affect operator switching decisions will have on frequency.
  - So that we don't try to pick up too much load
  - So that we don't waste time picking up loads that are very small



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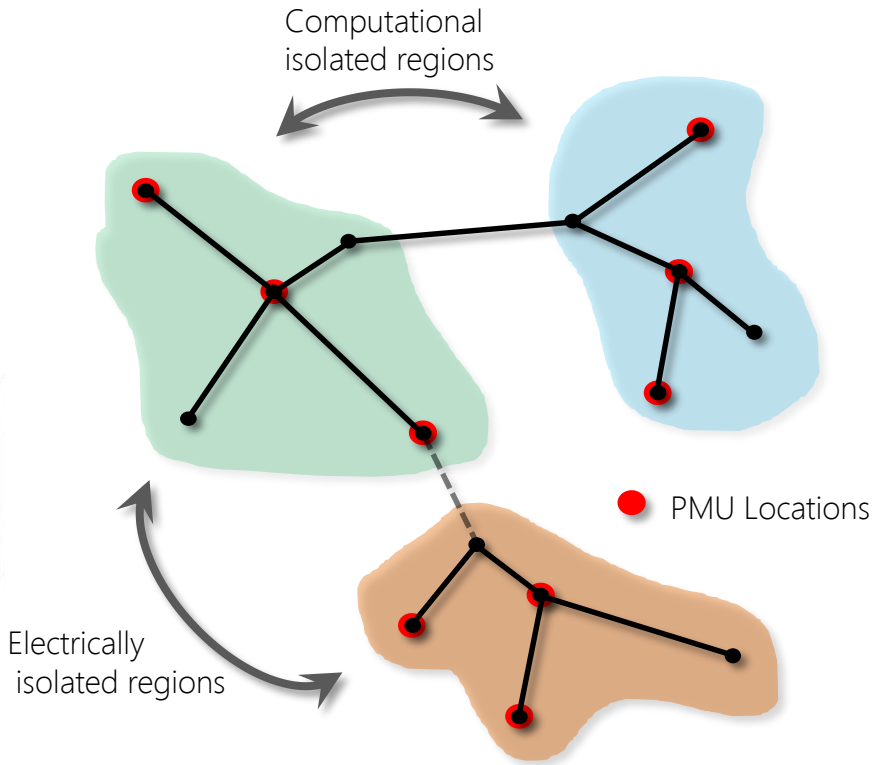
Island Synchronization

- LSE can handle computational and physical islands
- Synchronized monitoring of islands
  - Voltage
  - Frequency
  - Angle across breaker



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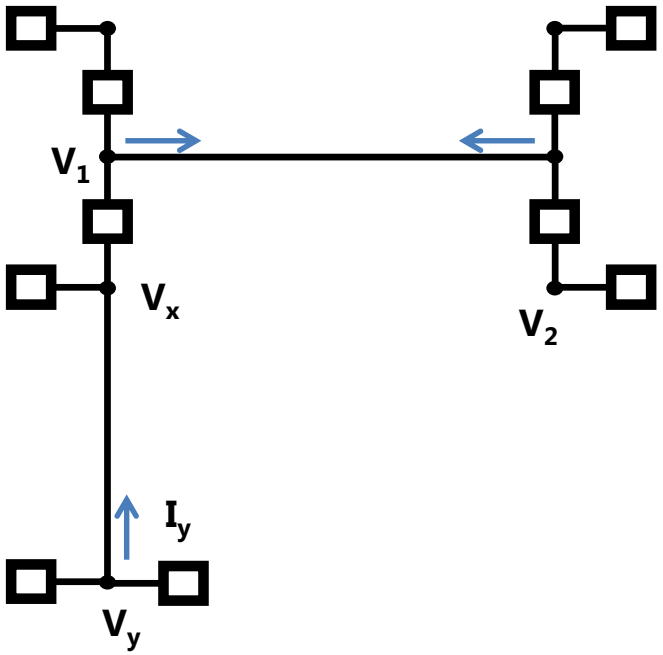
Breaker Closing Angle

- Thin application layer over LSE
- If **Line$_{1\text{-}2}$** is open, how to tell breaker closing angle?
  - Substitute $\mathbf{V_1}$ with $\mathbf{V_x}$
  - Compute $\mathbf{V_x}$ with $\mathbf{V_y}$ & $\mathbf{I_y}$



System Restoration with PMUs

- During system restoration activities, especially black start scenarios, Dominion is not just a TO anymore
  - During black start conditions, TO is likely to be its own BA, RC, etc.
  - Applications which may not seem relevant for day-to-day operations can become much more valuable under stressed or outaged system conditions
- Network applications developed for system restoration conditions could have ‘blue sky’ analogues where the application can be adapted to provide value day-to-day

Key Takeaways

- Goals for control room applications are not one size fits all.
- There isn't necessarily a 'killer app'.
- Look for ways to incrementally deploy and integrate applications. Don't wait for the all-in scenario to build out your system.
- Consider abnormal operating conditions (low-probability-high-consequence) when deciding what is valuable and what isn't and what the role of the control room becomes under those scenarios.

Lesson 4

WHY YOU NEED A ‘NATHAN’

OR THE POWER OF THE RIGHT BUY-IN

Bringing Synchrophasors into DVPs Control Room

- As part of the DOE Technology Demonstration
  - Trending, strip-charting
  - Polar charts
- RTDMS Platform
- Displays eventually repurposed.
- Attempted to bring back RTDMS displays into control room for years.

Why You Need a Nathan

- Who is Nathan?
  - Nathan is a transmission system operator at DVP with a background in electrical engineering who is also under 30.
- What is Nathan's story?
  - Nathan and I have discussed PMUs many times 1-on-1.
  - Nathan visited an operator training seminar where he got to see several synchrophasor visualizations used by the RTO hosting the seminar.
  - Upon returning home, Nathan's request to bring synchrophasor displays into our control room **was green-lit in 2 days**.

Key Takeaways

- Nathan's youth and engineering background immediately saw the value of the displays to situational awareness and did not see their presence as a hindrance to core business.
- Spending time discussing technology with younger, more technically oriented operators is a worthwhile investment.
- While it is important to focus on all roles, in an operator-centric environment, the voice of the operator is a powerful ally for creating alignment in goals.
- Getting operators exposure to state-of-the-art technology in the form of external events and seminars is extremely valuable for perspective.

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QUESTIONS?