# 2nd Workshop on Challenges in Next-Generation Analytics for the Future Power Grid: Operational Decision Support Presentation


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# Power System Operations

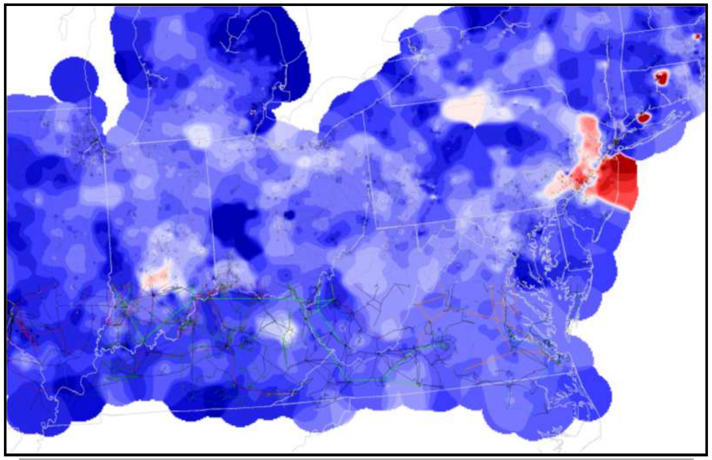
- Tremendous respect for the people who plan and operate the grid!
  - Often a thankless job, that only gets noticed during the rare blackout
- Society is more and more dependent on a reliable grid, so we need even better reliability
  - Avoiding the large "black swan" type events is crucial
- Power grid operation are becoming more and more complex

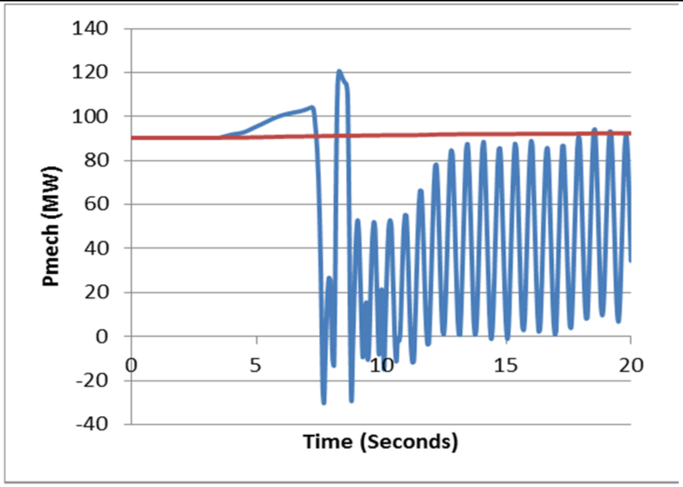
# Visualization and Data Analytics

- Visualizations are ultimately used as an input to human decision making
  - Application dependent: What are the needed decisions? What are the time frame for making the decisions? Who makes them? How important are the decisions? Etc…
- The visualizations that are shown on a screen are the end result of a potentially quite detailed process that usually begins with large amounts of data, and potentially underlying models
  - The dividing line between visualization, data analytics and traditional power system analysis applications is fuzzy

# Decision Support: Minding the Analytics

- As the grid gets more complex, a key challenge is to make sure the underlying analytics and models are behaving as expected, and certainly not having glaring errors that can often go unmissed
- Verification and validation are key!

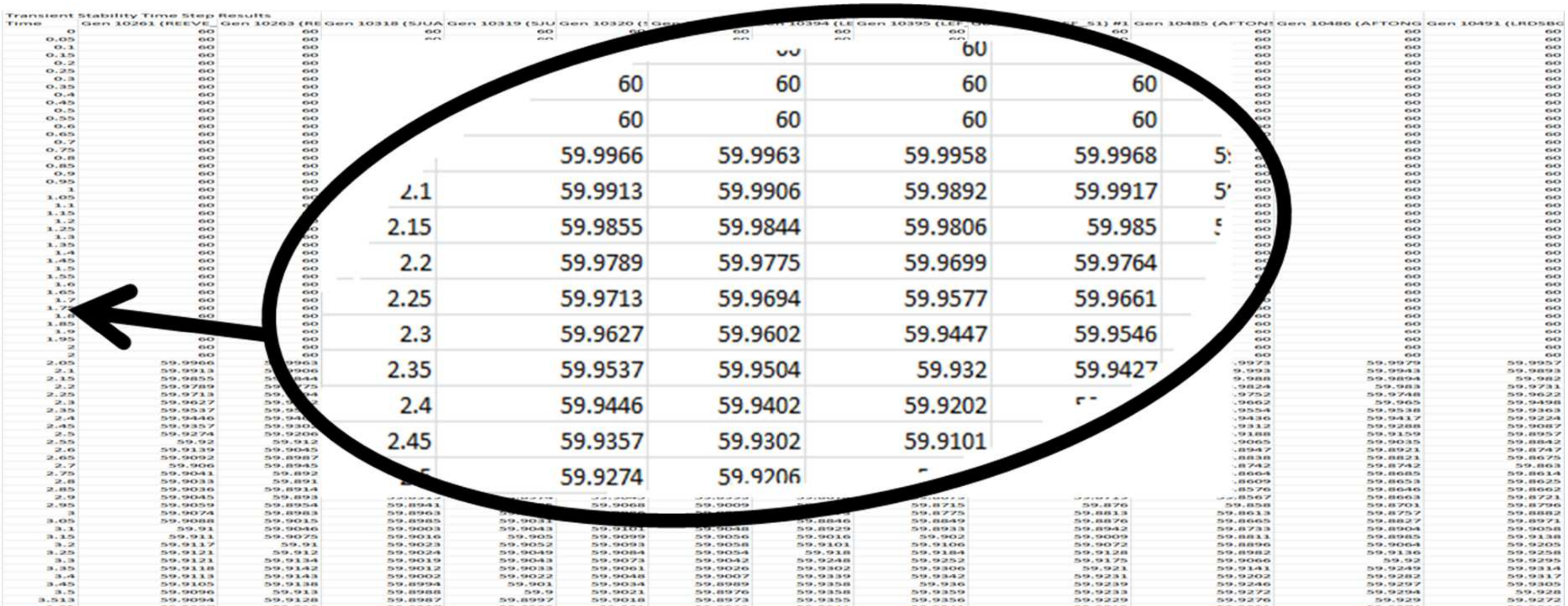




# Transient Stability Example

- A single transient stability solution can generate large amounts of results data
- Operationally thousands of runs may be done for different contingencies
- How much this data needs to be considered is application dependent
  - In operations the concern may just be OK or Not OK
  - In planning more detailed analysis may be required.  Issue is how to determine if the results are “correct”?

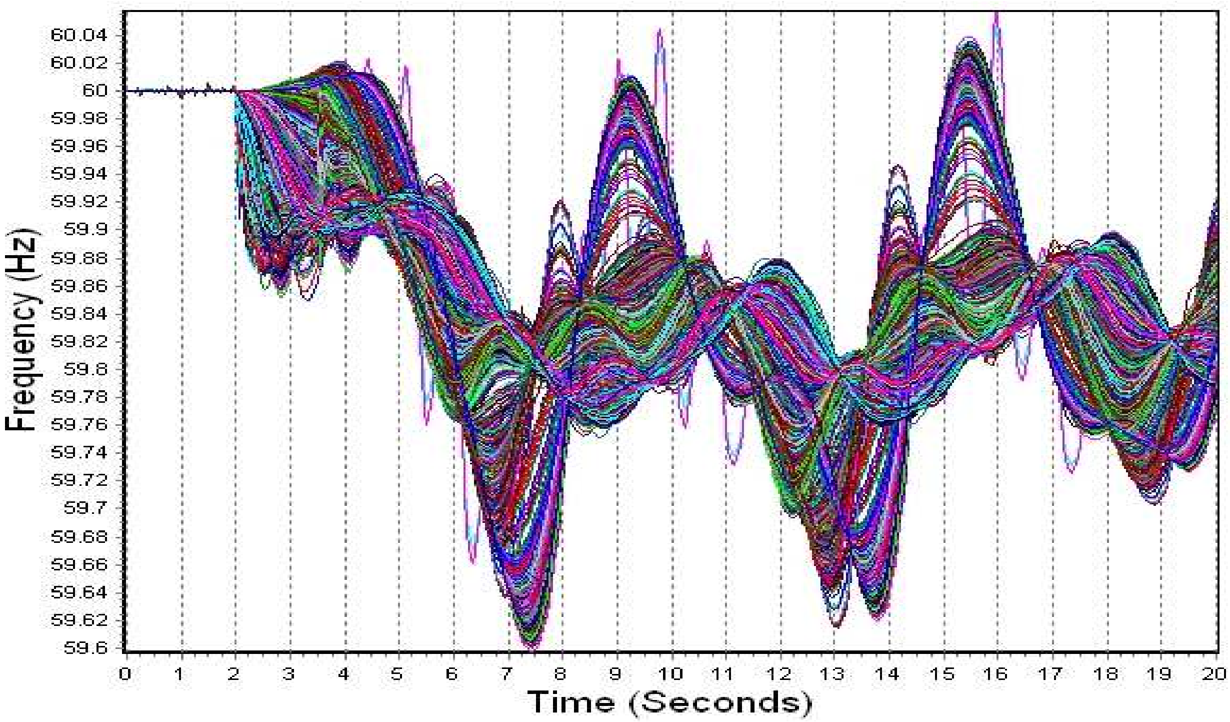
# Example of Time-Varying Data: Tabular Displays Do Not Work Well




**Transient stability results**

- System with 16000 buses, 2400 generators
- Fault occurs at simulation time 2s
- Triggers a frequency disturbance
- Frequencies across system generators over simulation time of 20s (time step 0.05s)

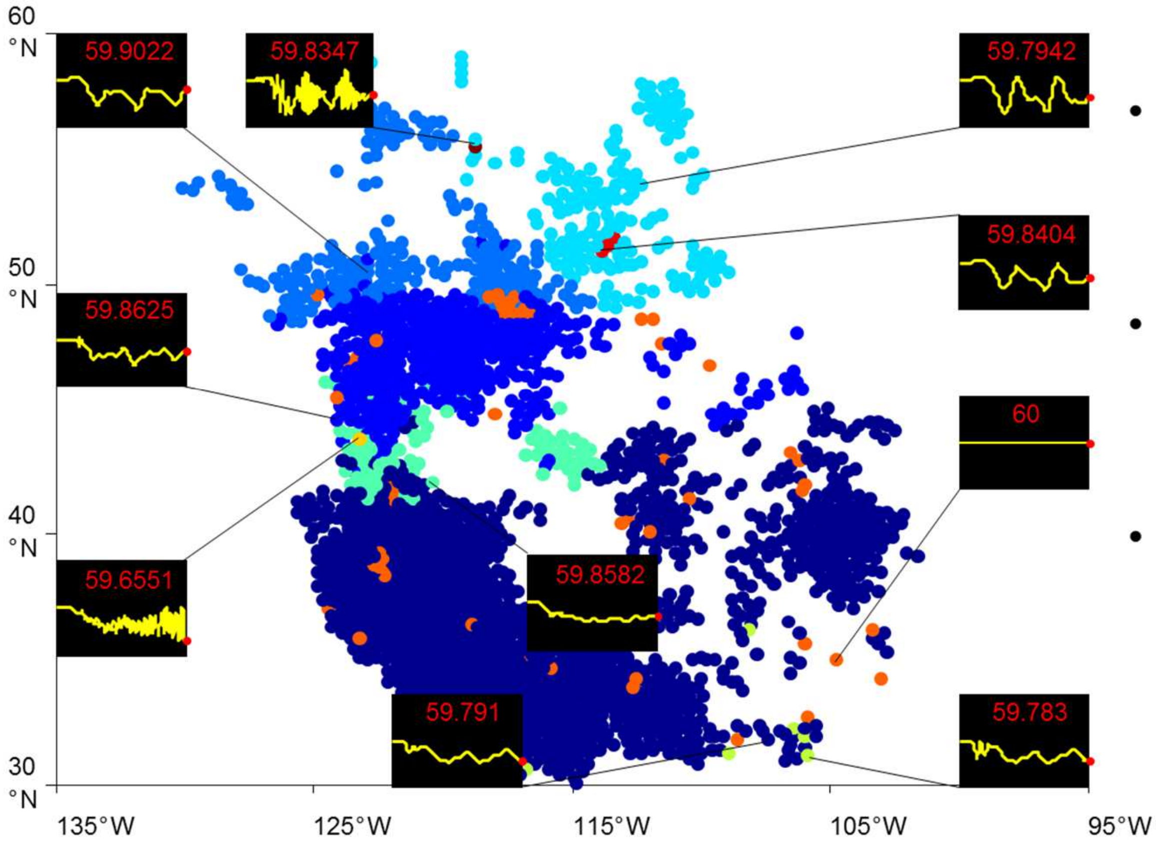
# Frequency Graph of Data for 2400 Generators




**Questions:**

- Is the system responding as expected?
- How to separate out the patterns?
- How to incorporate geographic information in the visualization?

# 2400 Generator Results Visualized in a Geographic Context




- 10 distinct frequency responses identified
- Visualized on actual geographic location with “spark-lines”
- Different color dots = generators of a cluster

# Blackout Prevention and Decision Support

- Many large-scale blackouts have time scales of several minutes to a few dozen minutes
  - this time scale allows for operator intervention, but it must occur quickly to be effective (extreme emergency control)
- Operators can't respond effectively if they do not know what is going on– they need "situational awareness"
- Decision support tools need to be designed (at least in part) to meet the needs for the small about of time when making quick, accurate decisions could be crucial!

# Extreme Emergency Support

- The control room environment during such an event might be quite different
  - Advanced analysis tools not working, unfamiliar system state, high level of stress, many decision makers
- Designing software for extreme conditions is challenging since users seldom encounter these conditions.
- August 14th, 2003 Example: Because of the stressed system conditions, the contingency analysis result displays had many entries
  - Many phone calls were coming in

# A Few Topics for Discussion

- What are we getting right?
- Where do we need to improve?
- How much to we consider the extreme situations?
- How much do we rely on models? When to go modelless?
- How do we validate approaches?
- How do we leverage all the new data that may be available?
- What existing work to leverage? How do we work together?