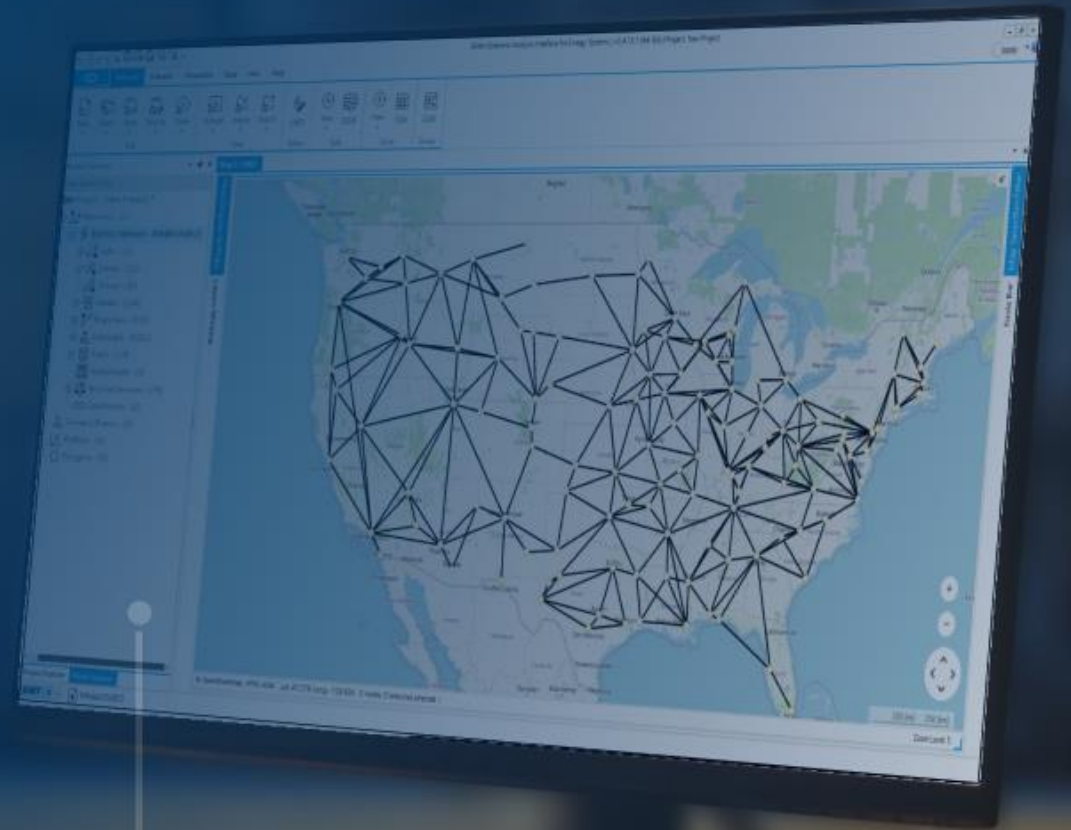




Insights, Consensus, and Disagreement in the Power Systems Community

About Dynamic Simulation Tools Necessary for Stability

Jacob Kravits, October 23, 2024



Estimate the Expertise at This Workshop

$$300 \text{ experts} * \frac{15 \text{ years}}{\text{expert}} * \frac{2000 \text{ hours}}{\text{year}} = \mathbf{9,000,000} \text{ expert hours}$$

41 Interviewees From Diverse Roles and Backgrounds

As part of our ongoing NSF Small Business Innovation Research Grant, we interviewed 41 people:

- How are you assessing reliability *today*?
- How about *in 5-10 years*?

Diversity in roles and expertise

Methods of qualitative analysis

- 45 min. – 1 hr. interviews with each person
- Each interview followed a set of guiding topics/questions
- Detailed notes taken of points mentioned
- Notes were tagged for themes

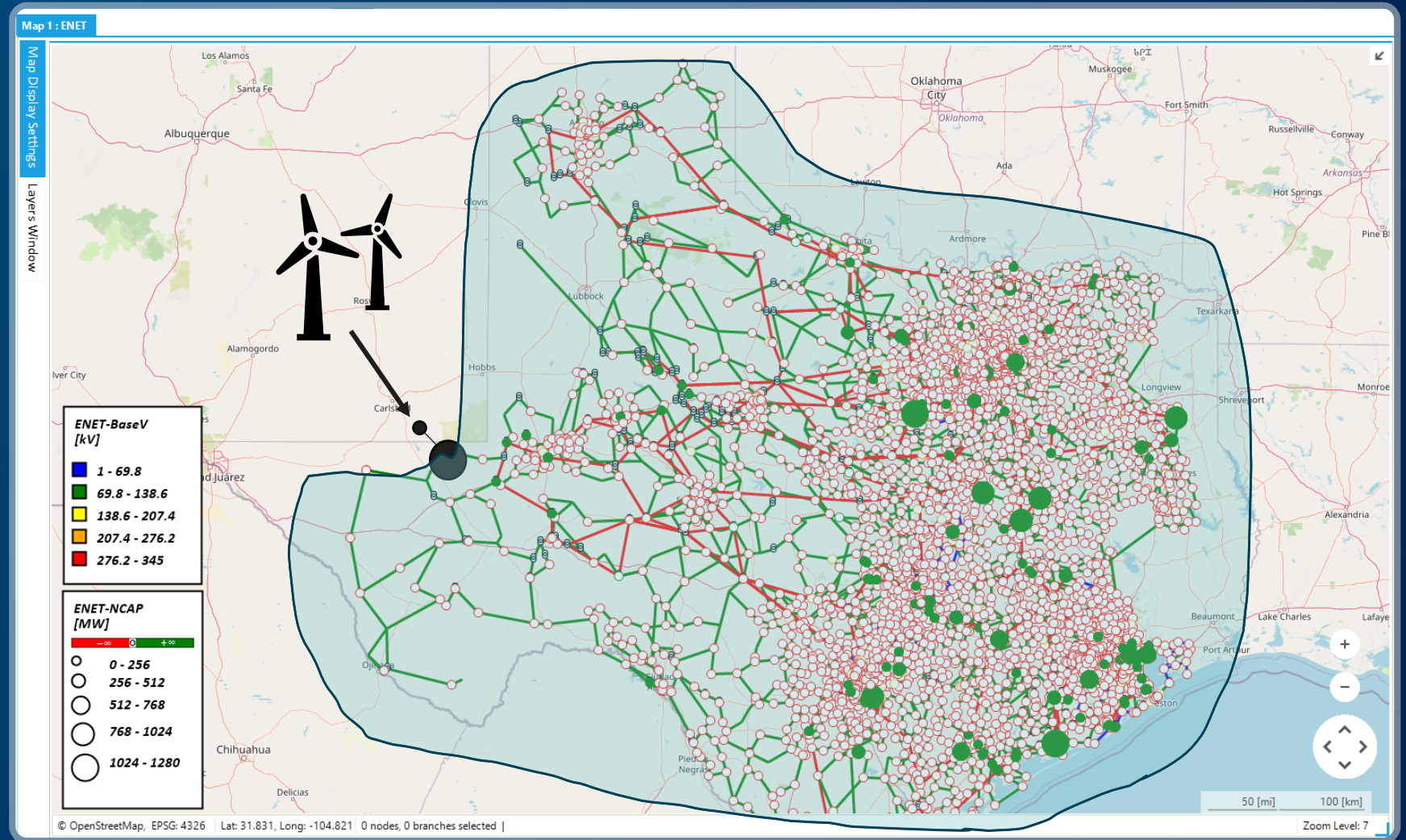
Role	Titles	Interviews
End User	Researcher, Planner, Consultant	15
Decision Maker	Center Director, Manager of Transmission Planning, Senior Technical Leader	13
Non-purchase Decision Maker	Inverter-based Resource Specialist, Senior Technical Leader, Chief Engineer	4
Other	Professor, Founder, High Performance Computing Engineer	9

IBR Interconnection: A Key Challenge From Interviews

Infinite Bus Method

Phasor Domain
Model

Electro-Magnetic
Transient (EMT)
Domain Model



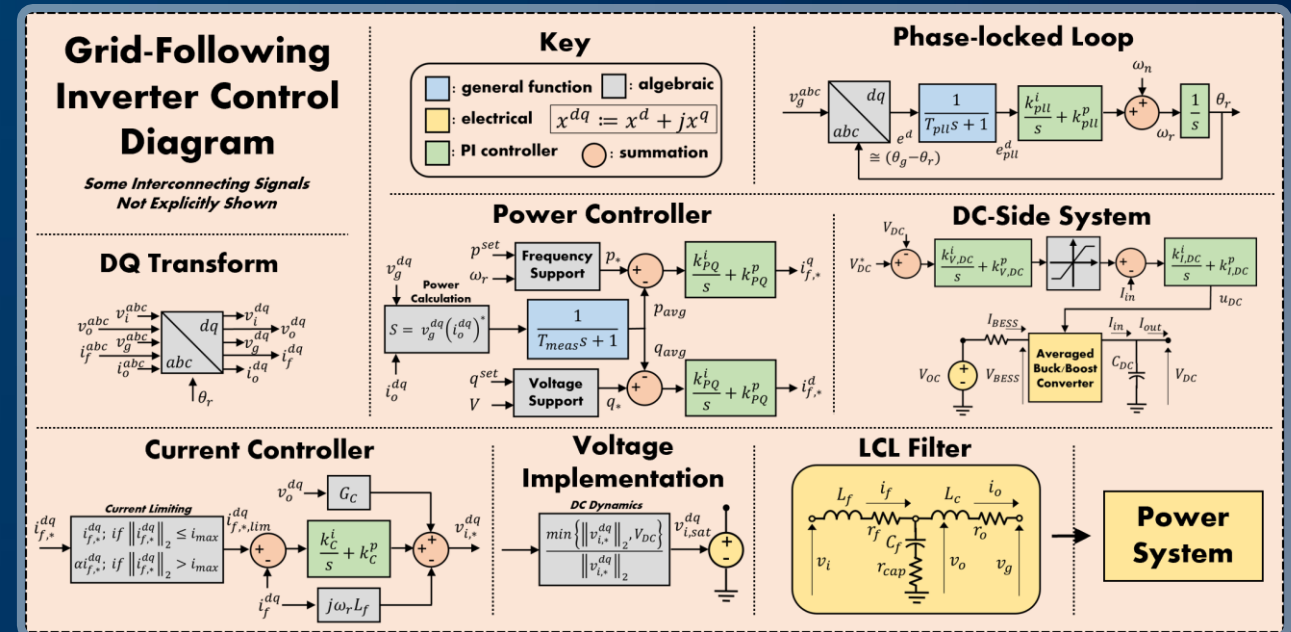
70% of participants - Input Data Barriers

Network Information:

- Amount of high-quality data required to run meaningful simulations
- Validation of these high-fidelity simulations is particularly onerous

Dynamic Models:

- The physics of inverter-based resources permit a wide range of design
- Proprietary nature of devices

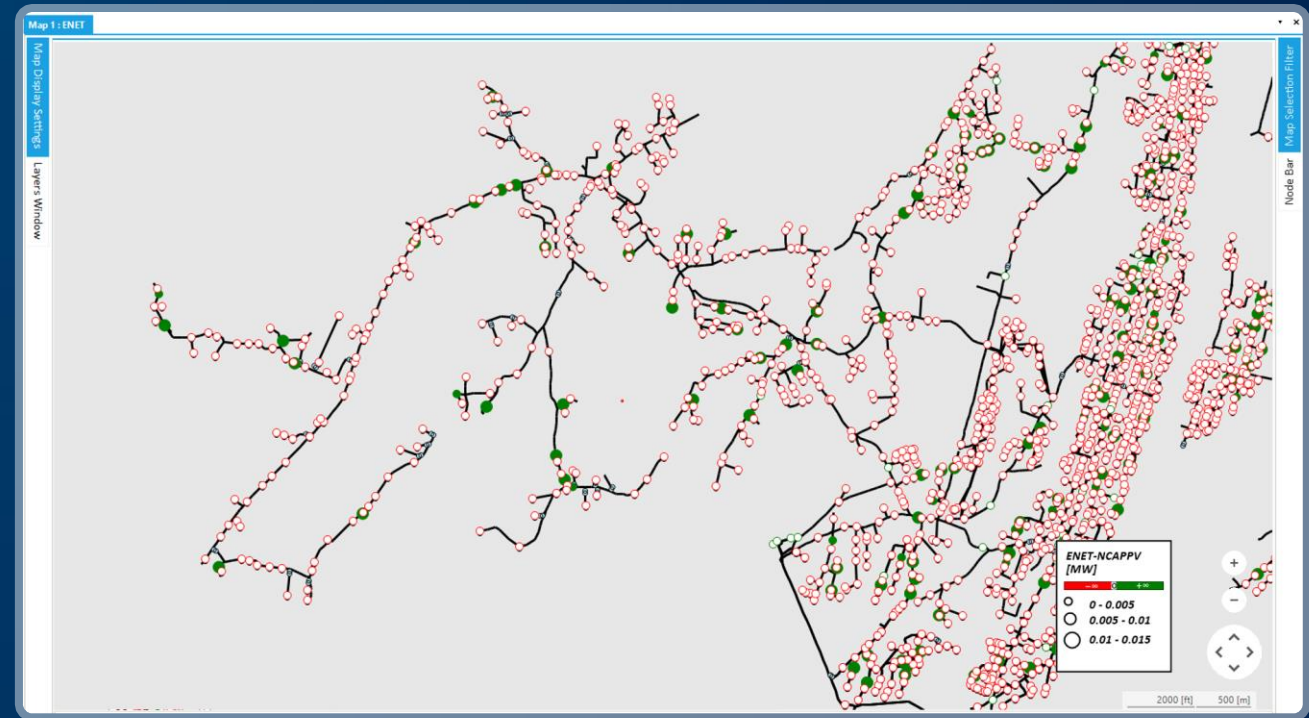
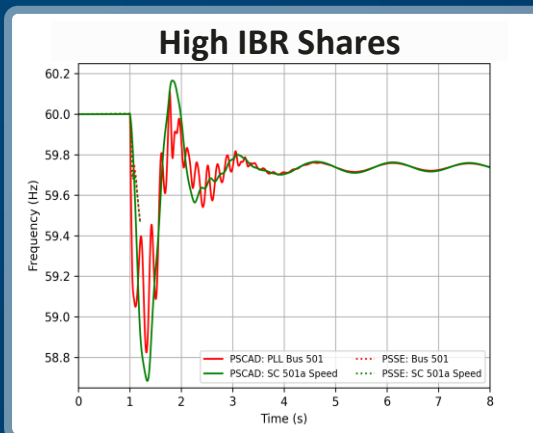
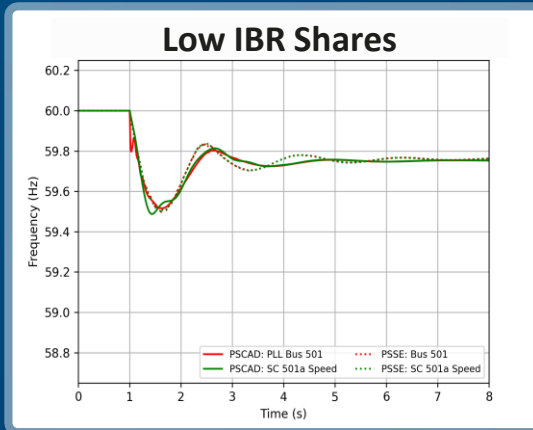


R. W. Kenyon, A. Sajadi, A. Hoke, and B.-M. Hodge, "Open-Source PSCAD Grid-Following and Grid-Forming Inverters and A Benchmark for Zero-Inertia Power System Simulations," in 2021 IEEE Kansas Power and Energy Conference (KPEC), Apr. 2021, pp. 1–6. doi: [10.1109/KPEC51835.2021.9446243](https://doi.org/10.1109/KPEC51835.2021.9446243)

50% of Participants - More Detail Needed... *during certain conditions and space*

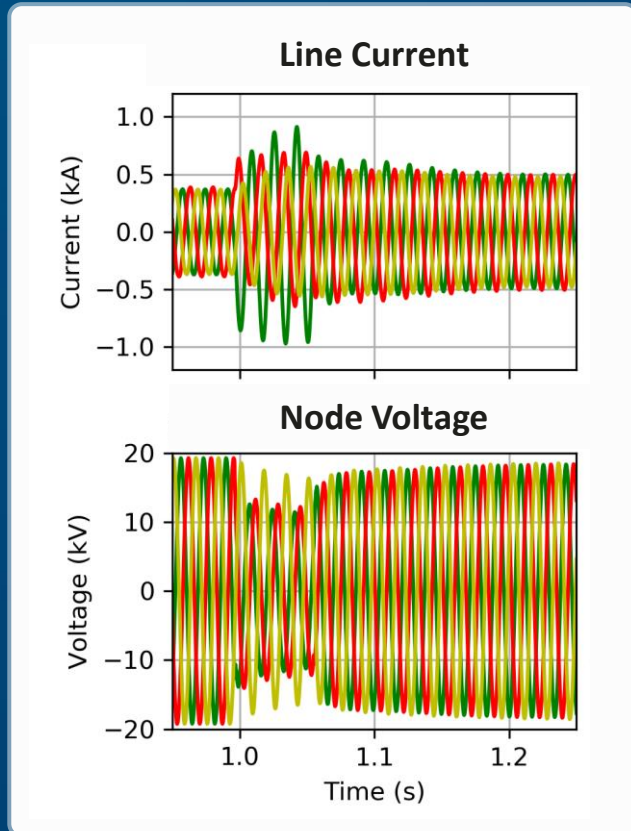
Operating Conditions
May Be Indicators

Spatial Diversity



60% of participants - Cognitive Burden: Part 1

EMT Simulations Generate a Huge Amount of Data



100 Node System x 1 second Simulation -> Gigabytes

100,000 Node System x 1 second Simulation -> Terabytes

For one simulation run (1 contingency)

R. W. Kenyon, B. Wang, A. Hoke, J. Tan, C. Antonio, and B.-M. Hodge, "Validation of Maui PSCAD Model: Motivation, Methodology, and Lessons Learned," in *2020 52nd North American Power Symposium (NAPS)*, Apr. 2021, pp. 1–6. doi: [10.1109/NAPS50074.2021.9449773](https://doi.org/10.1109/NAPS50074.2021.9449773)

60% of participants - Cognitive Burden: Part 2

What Is the Analyst Looking For?

Often some sort of anomalous behavior which can be hard because...

Numerical Noise vs Results

In certain cases, it can be difficult to distinguish numerical error from important response characteristics

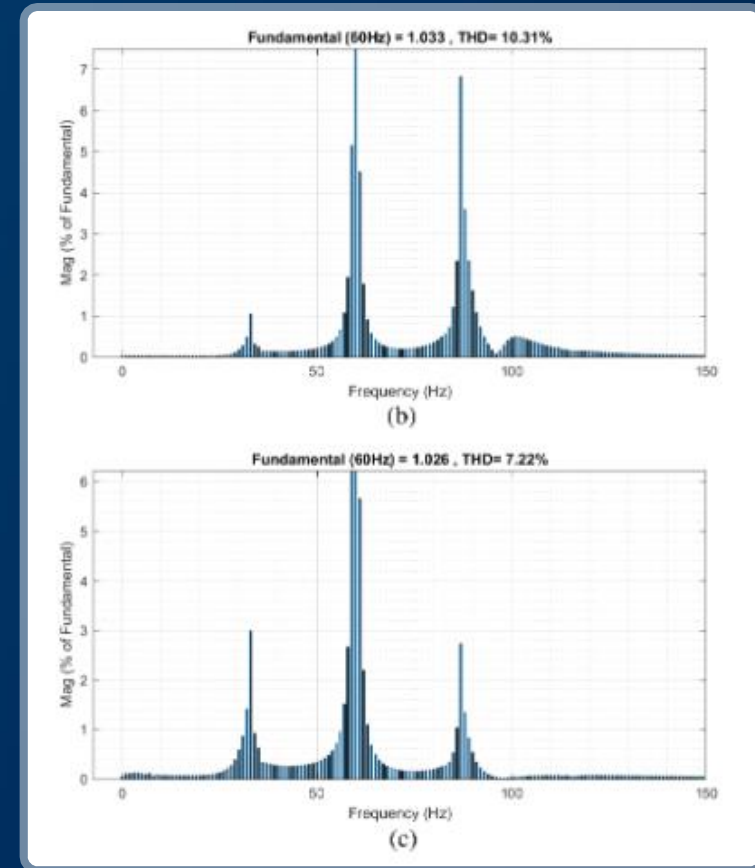
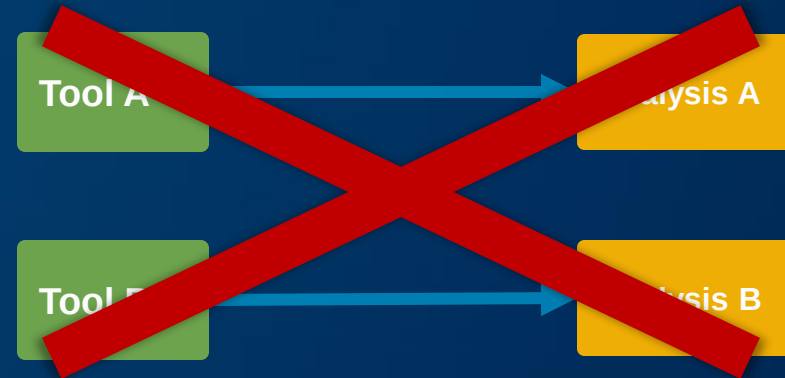


Fig 12 from - L. Fan *et al.*, "Real-World 20-Hz IBR Subsynchronous Oscillations: Signatures and Mechanism Analysis," *IEEE Transactions on Energy Conversion*, vol. 37, no. 4, pp. 2863–2873, Dec. 2022, doi: [10.1109/TEC.2022.3206795](https://doi.org/10.1109/TEC.2022.3206795).

50% of participants - High "Inertia" Industry

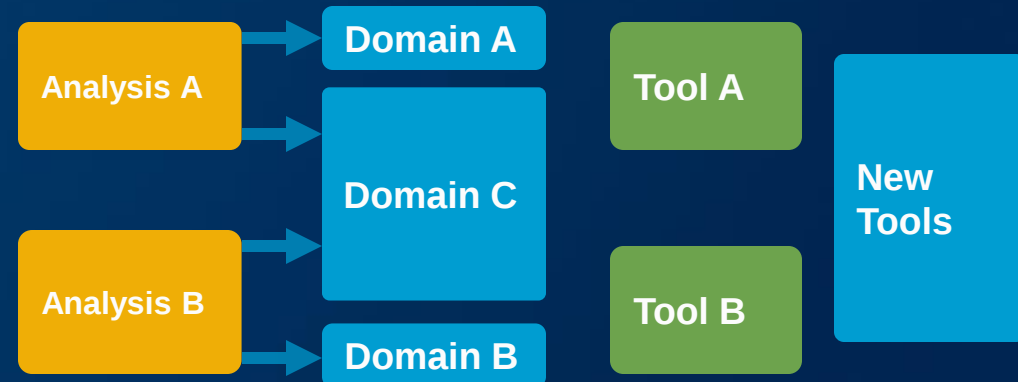
Expertise in Tools

9,000,000 expert-hours have been put into a handful of tools



Separate Domains from Tools:

Domains, not specific tools, should guide analysis



Other Viewpoints

Device/Model Standardization:

Test-driven practices can standardize certain device behavior

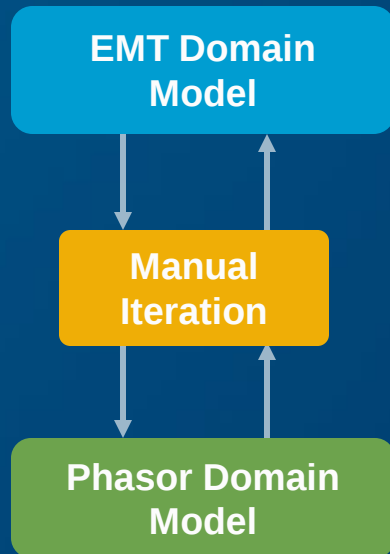


Grid-Forming Inverters May Absolve Need for EMT-level Detail:

Assumptions may no be valid for all system stressors

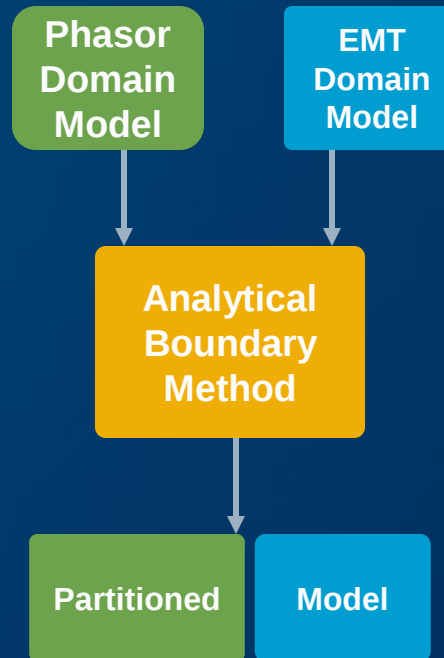
Approaches Mentioned To Speedup Stability Analysis

Iterate using Rules of Thumb



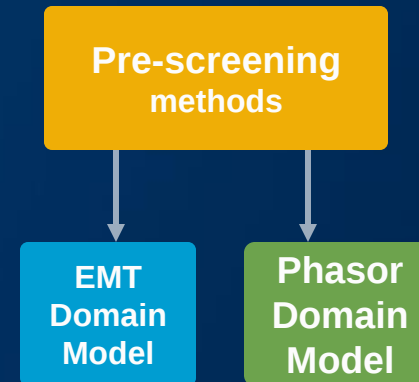
- Mentioned Pro: Engineers to use judgement
- Mentioned Con: Commercial tools weren't created for iteration

Analytical Boundary Tools



- Mentioned Pro: Get a single answer
- Mentioned Con: Are you confident in your analytical method?

Pre-screening Methods



- Mentioned Pro: Fast way to arrive as trusted-domains
- Mentioned Con: Mainly in-house tools

Other Domains

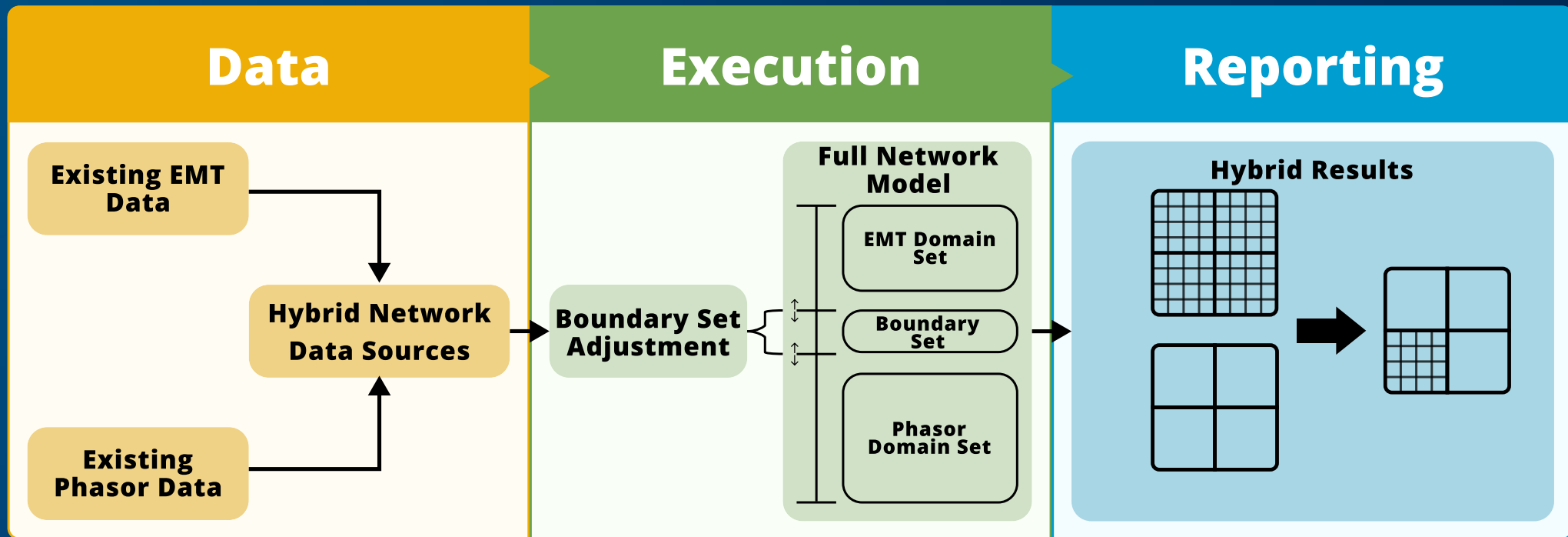
- Impedance Spectroscopy
- Frequency Analysis

Other Viewpoints – Scalability

Contemporary Approaches Are Unsustainable:

Today's method of speeding up EMT, or create hybrid phasor/EMT models by linking existing software is exceedingly difficult (impossible?) to scale

Our Perspective: Hybrid Phasor/EMT



Alleviates the need for system-wide high fidelity data

Autoadaptively determines when phasor or EMT is needed

Targeted insights reduces need to sift through big data



We are finalizing our proof of concept as part of our NSF SBIR Phase I initiative!

Conclusion

Consensus:

Input data is a barrier

Difficult to know when more detail is needed

Avoid cognitive overload

Change is hard

Selected Views:

Model standardization

Role of grid-forming inverters

Unsustainable contemporary approaches

“May you live in interesting times”

encoord

Plan the Energy Future



encoord.com



info@encoord.com

Learn More

