GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Overview of GMLC Planning Tools Research and the North American Resilience Model

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February 3, 2020
Irvine, CA

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DOE is driving development of new planning and design tools to meet future grid needs

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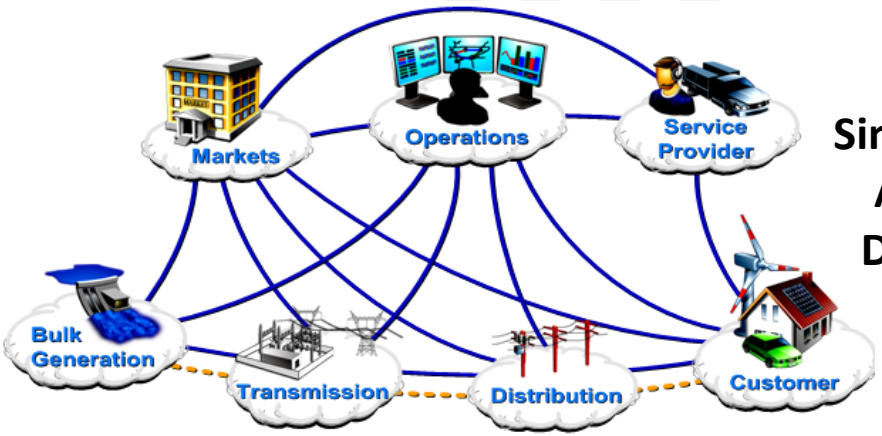
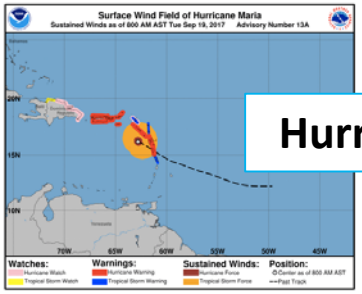
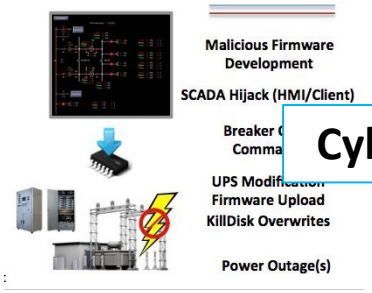


Simulating Across Domain



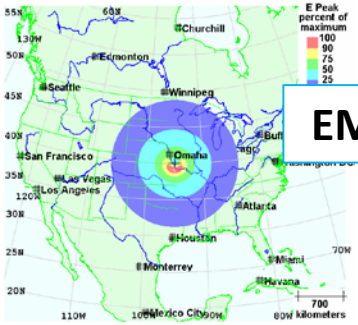
Hurricanes



Cyber

Predicting Impact and Mitigations for National Threats and Hazards

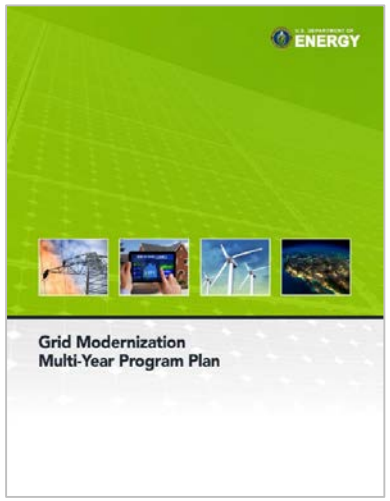
Reducing Time to Solution



EMP

Grid Modernization Initiative Approach

- Devices and Integrated Systems
- Sensing and Measurement
- System Operations and Control
- Design and Planning Tools
- Security and Resilience
- Institutional Support



Design and Planning Tools
Summary

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Objective

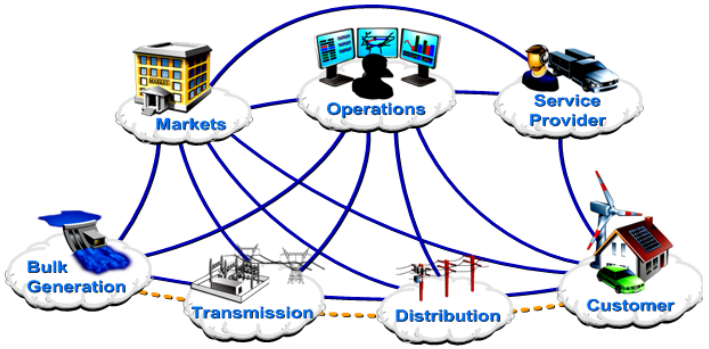
- Drive development of next- generation tools that address evolving grid needs

Expected Outcomes

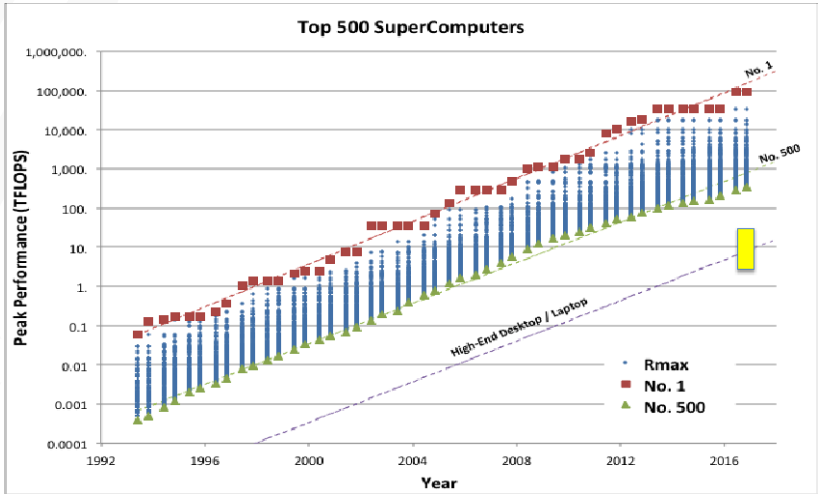
- Software framework to couple grid transmission, distribution, and communications models to understand cross-domain effects
- Incorporate uncertainty and system dynamics into planning tools to accurately model renewables, extreme events, etc.
- Computational tools, methods and libraries that enable 1000x improvements in performance

Federal Role

- Attack strategic gaps in tools capabilities
- Partner with industry to demonstrate value
- Work with vendors to transition to practice



Coupling grid simulations software



Exploiting Advances in Computing

Activities and Technical Achievements

MYPP Activity Description

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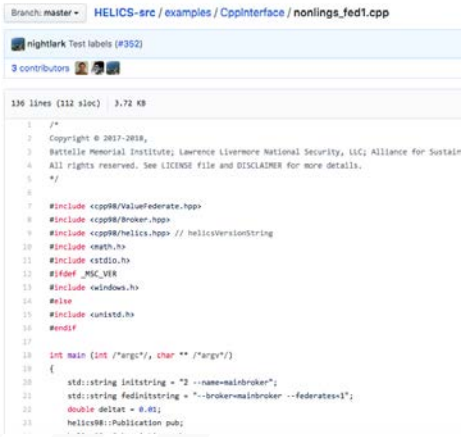
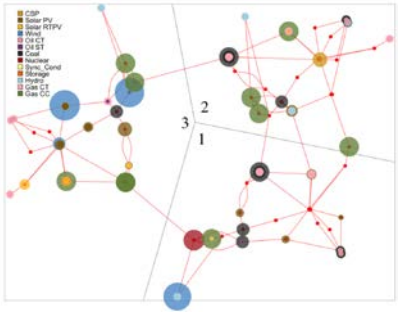
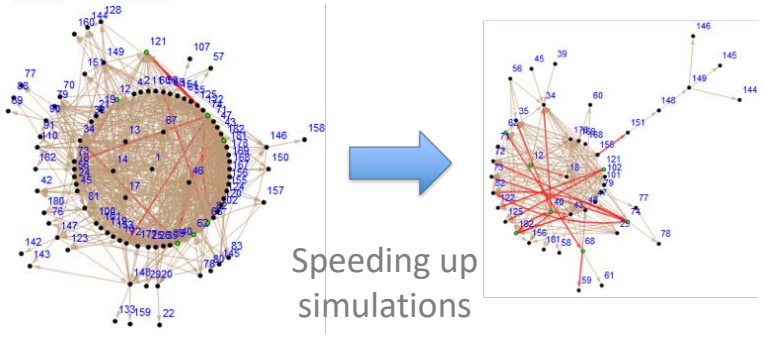
Activity	Technical Achievements by 2020
1. Scaling Tools for Comprehensive **Economic Assessment**	• Enhance performance of stochastic production cost modeling from 100 to 10,000 transmission nodes; expand to include distribution system.
2. Developing and Adapting Tools for Improving **Reliability and Resilience**	• Scalable simulation framework that couples transmission, distribution, and communications systems for integrated modeling at regional scale.
3. Building **Computational Technologies** and High Performance Computing (**HPC**) Capabilities to Speed up Analyses	• Scalable math libraries and tools for enhanced analysis; co-simulation frameworks to support coupling of tools and models, uncertainty quantification, and systems optimization.



Software

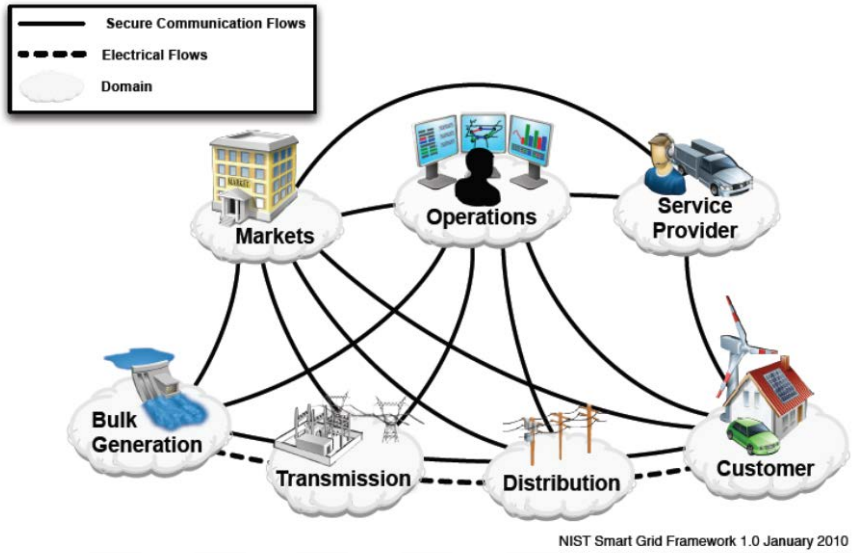


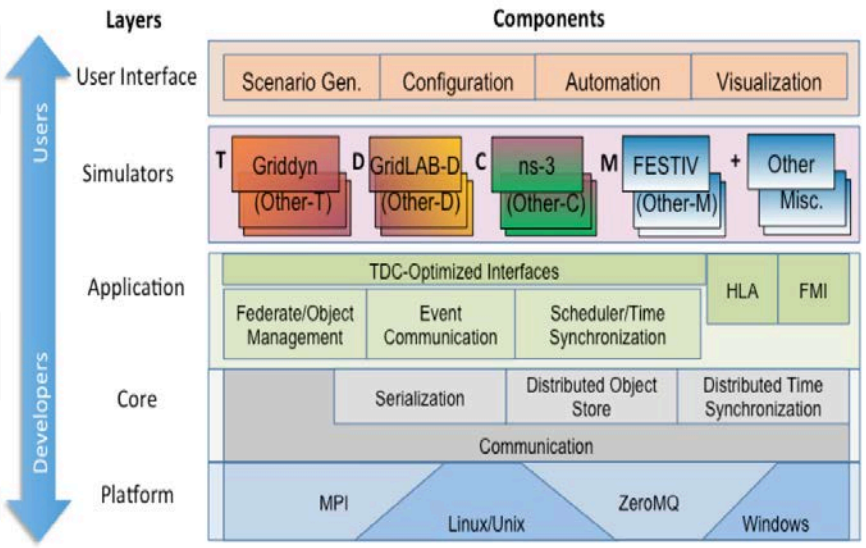
Datasets



Algorithms

GMLC developed co-simulation framework enables federation of grid and infrastructure modeling simulation and analysis software





Create HELICS™, an **open-source co-simulation platform**, enabling interactions between leading commercial & lab developed simulators on a wide range of computing environments (HPC to laptop).

GMLC Multi-scale PCM project developed scalable algorithms used for deterministic and stochastic production cost modeling

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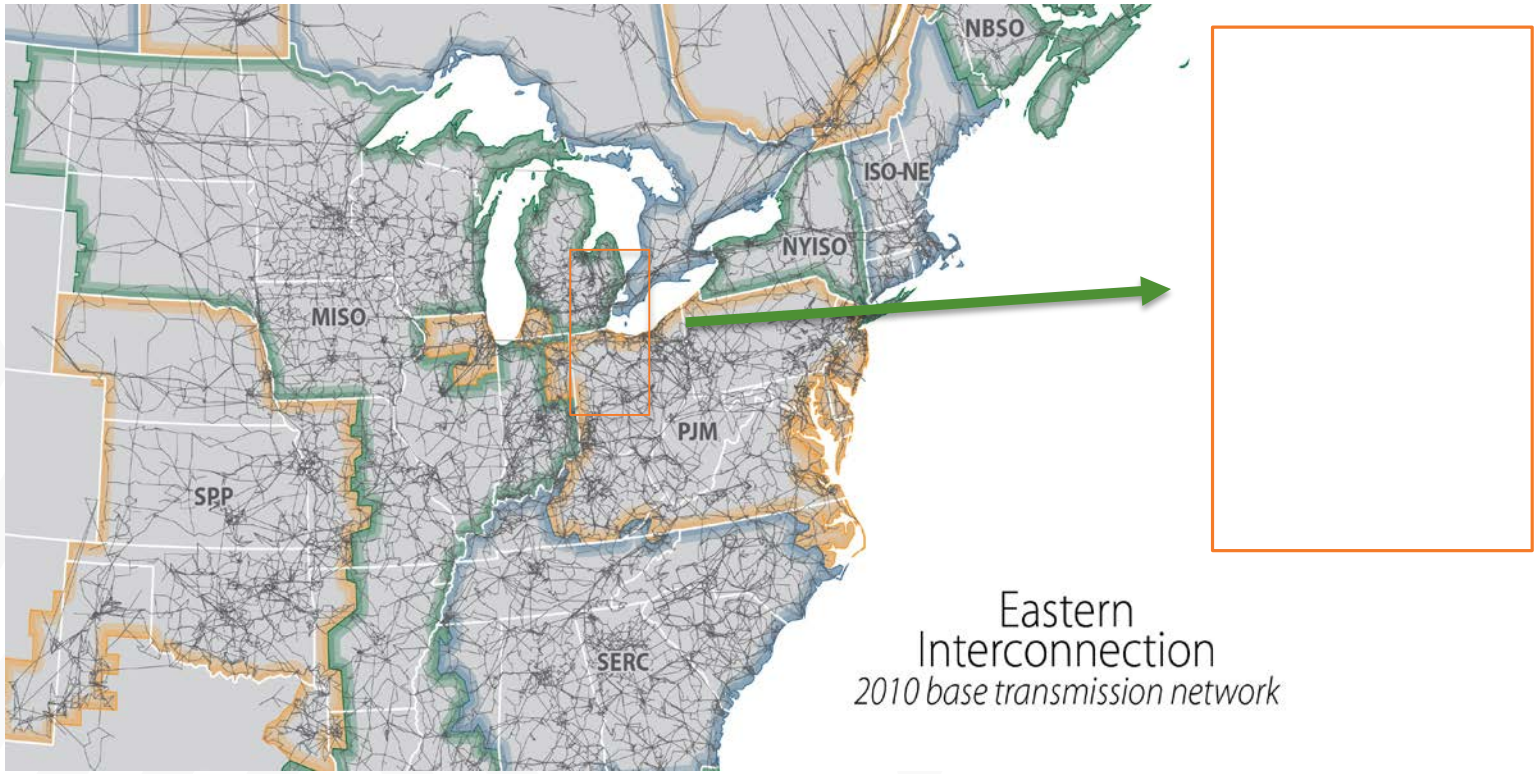
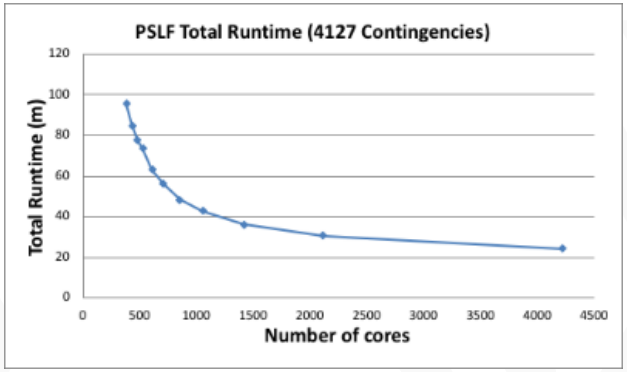


Deterministic PCM calculation time reduced from one year to about one week on an HPC

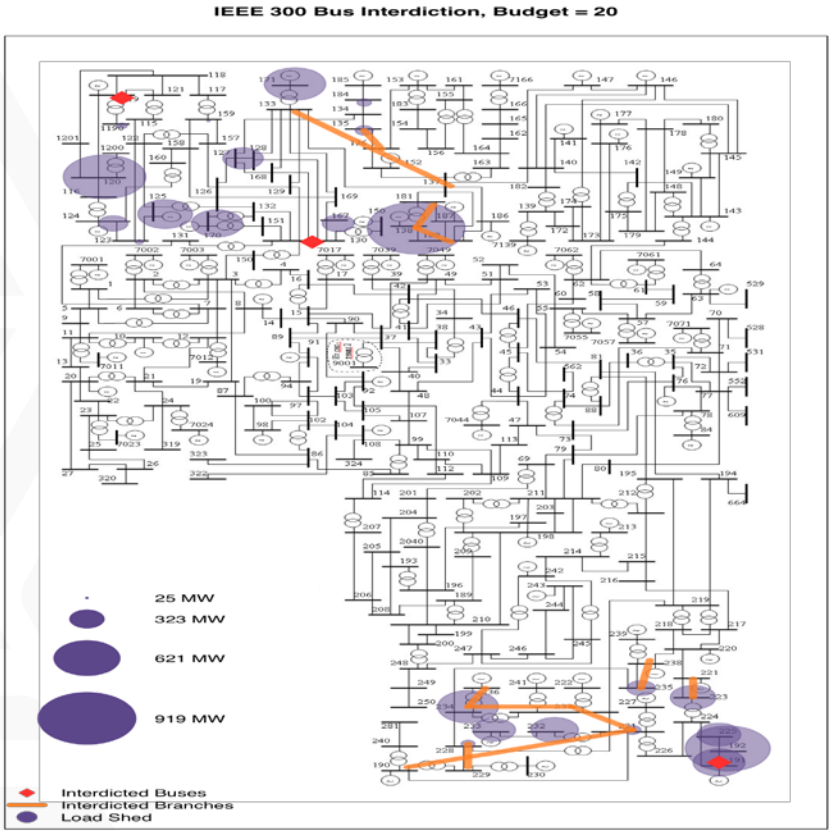
Developed stochastic PCM as an open source tool (i.e., Prescient)

GMLC Extreme Events project developed new methods for modeling of cascading events and contingency analysis



Reduced runtime from 23.5 days to 23 min

Using HPC to Accelerate Contingency Analysis



Model Attacker and Defender Actions

GMLC Computational Science for Grid Management project developed new math libraries for grid modeling

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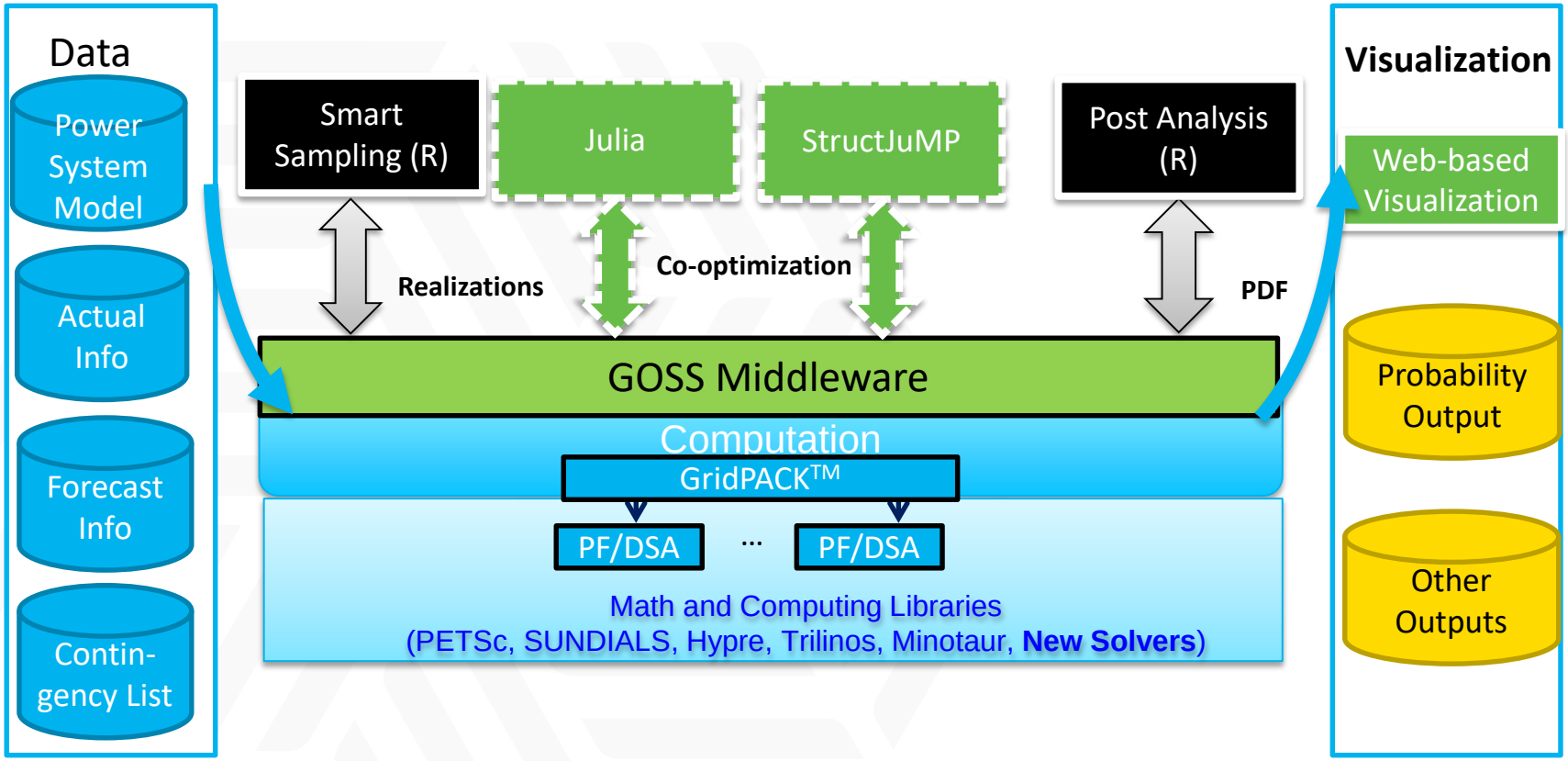

Apply DOE innovations in computational science to develop unified grid math library optimization, dynamics, and uncertainty

Program-Specific Projects

Transmission

- GM0111 - Protection and Dynamic Modeling, Simulation, Analysis, and Visualization of **Cascading Failures** (Lead: ANL)
- GM0074 - Models and methods for assessing the value of **HVDC and MVDC technologies** in modern power grids (Lead: PNNL)
- WGRID-38: North American Renewable **Integration Study** (NARIS) (Lead: NREL)
- SI-1631: Assessing the Value and Impact of **Dispatchable Concentrating Solar** Power in a SunShot Future (Lead: NREL)

Distribution

- GM0057 - LPNORM: A LANL, PNNL, and NRECA Optimal **Resiliency Model** (Lead: LANL)
- SI-1545 - **Rapid QSTS** Simulations for High-Resolution Comprehensive Assessment of Distributed **PV Impacts** (Lead: SNL)
- SI-1756 - **Visualization and Analytics** of Distribution Systems with Deep Penetration of **Distributed Energy Resources** (VADER) (Lead: SLAC)
- SI-1639: System Advisor Model (Lead: NREL)

Multiple Domains

- SI-1625 - CyDER: A Cyber Physical **Co-simulation** Platform for **Distributed Energy Resources** in Smart Grids (Lead: LBNL)
- GM0229 - Integrated Systems Modeling of the Interactions between **Stationary Hydrogen, Vehicle and Grid Resources** (Lead: LBNL)

Load Modeling

- GM0094 - Measurement-Based Hierarchical Framework for Time-Varying **Stochastic Load Modeling** (Lead: ANL)
- GM0064 - Open-Source High-Fidelity Aggregate Composite Load Models of **Emerging Load Behaviors** for large-Sale Analysis (Lead: PNNL)

DOE is developing the North American Energy Resilience Model (NAERM)

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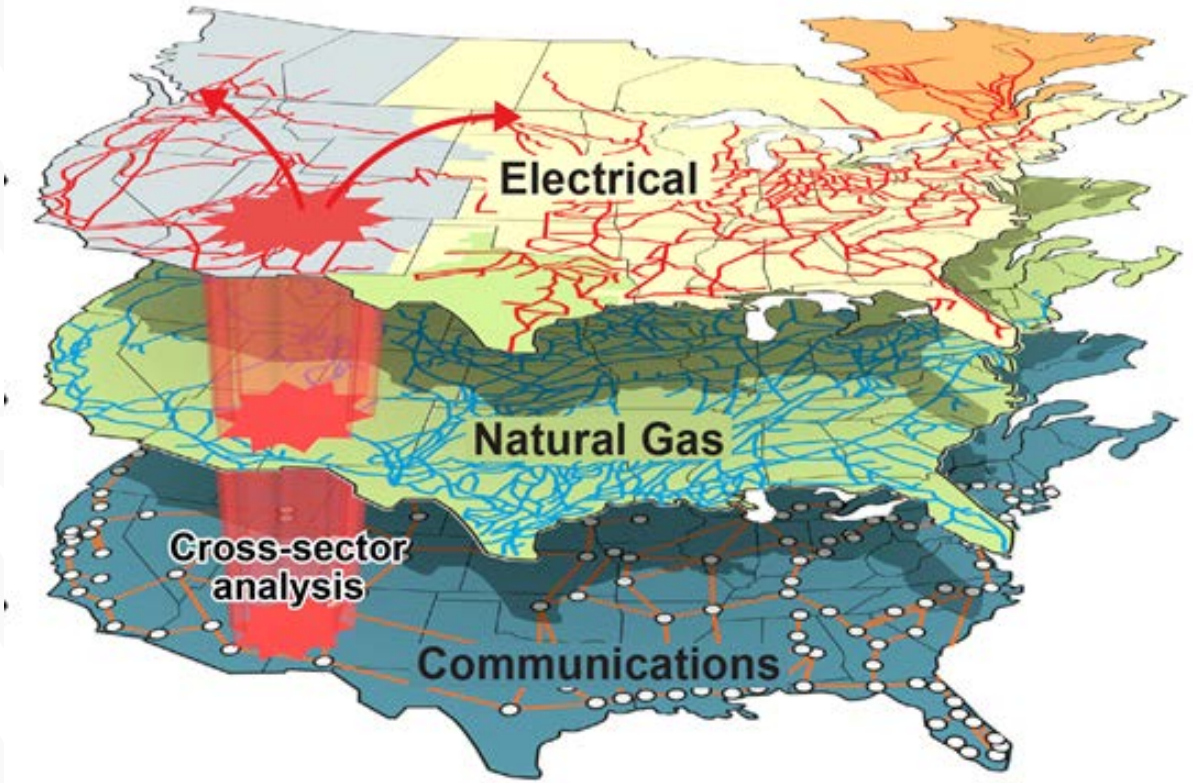
Vision - Rapidly predict energy system interdependencies, consequences and responses to extreme events at a national scale

Mission - Develop and deploy engineering-class modeling system for planning and real-time resilience analysis



Workflow for NAERM enables analyst to understand impact of threats/hazards

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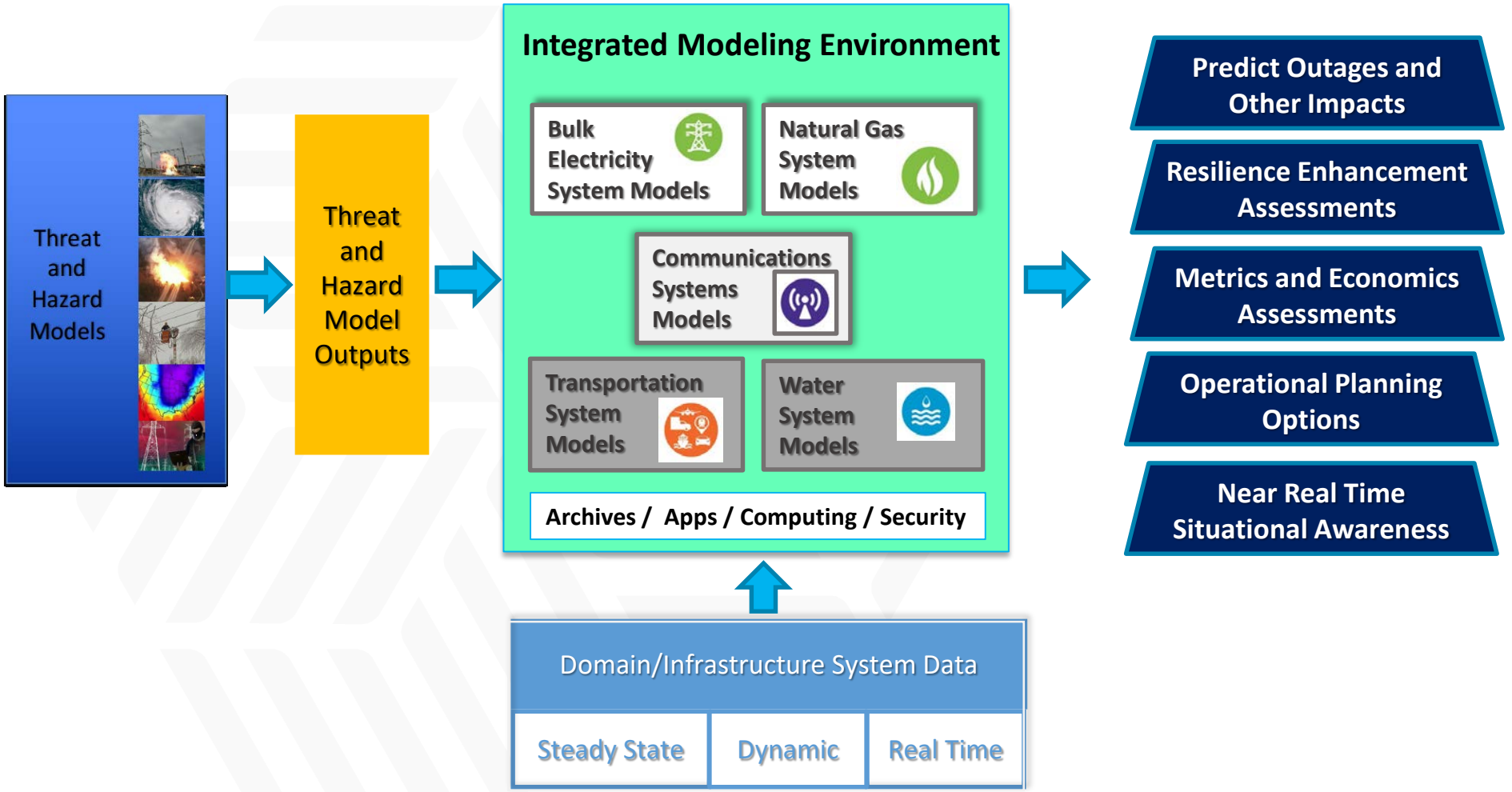

NAERM is a “toolbox” of interactive, modular software elements

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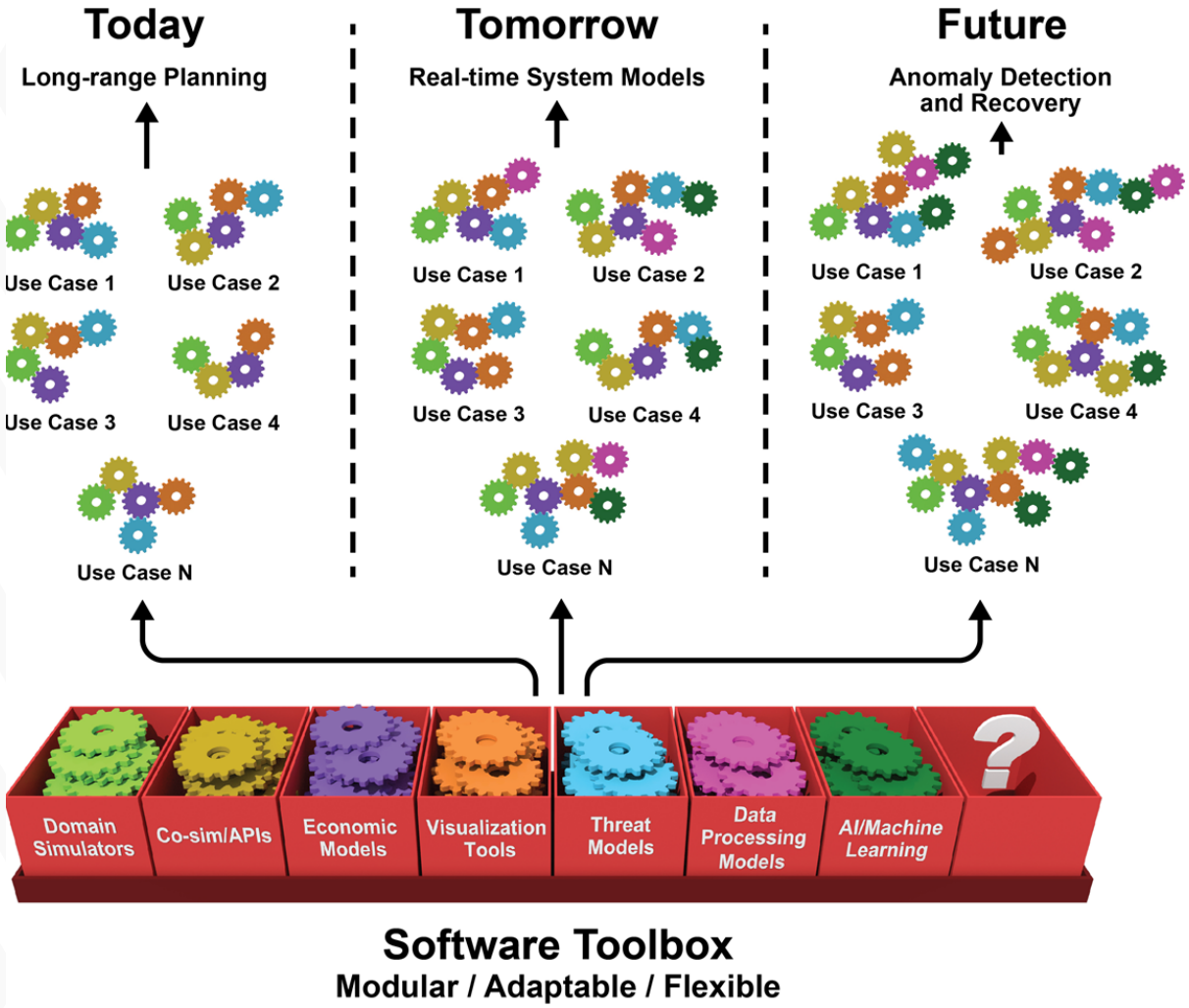
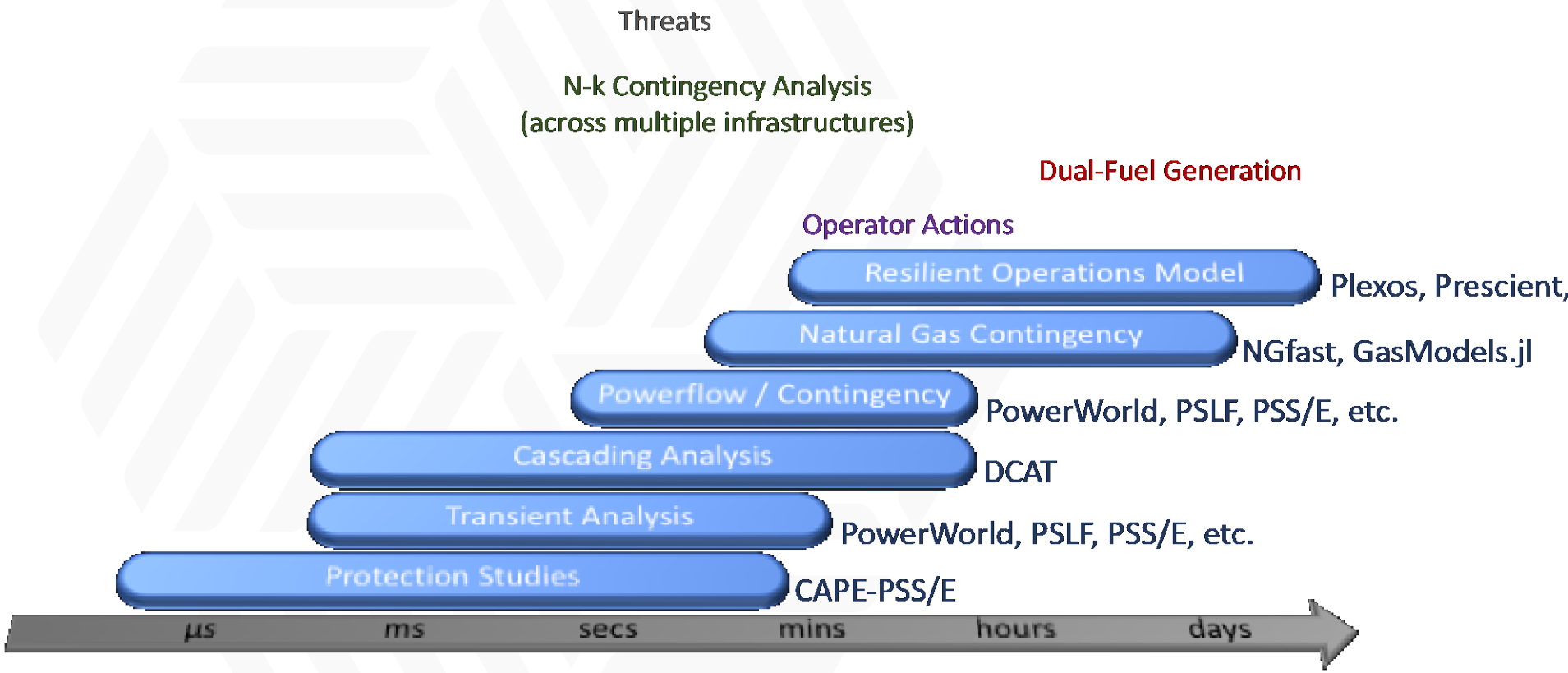
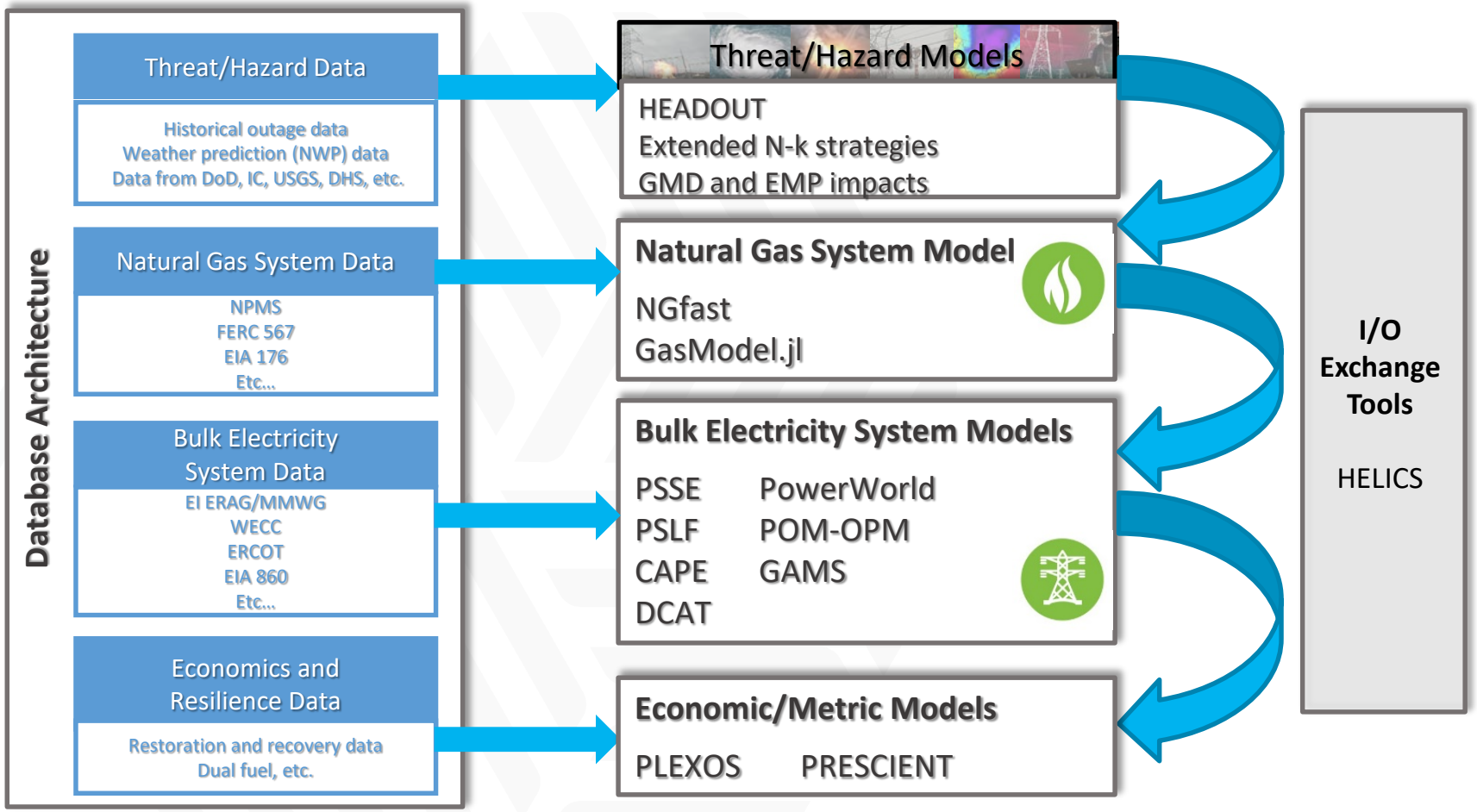
The different elements are assembled in relation to the threat and hazard scenarios being addressed



NAERM is federating a suite of tools and data to analyze a wide range of time scales and model fidelity



NAERM models will host range datasets to drive the models



Natural gas – bulk electricity system use case demonstration as a starting-point for integrating multiple models

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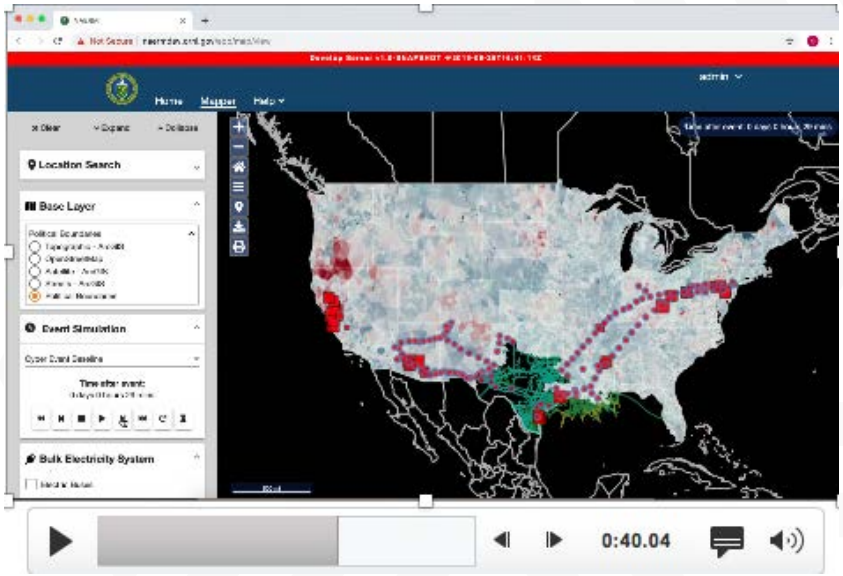


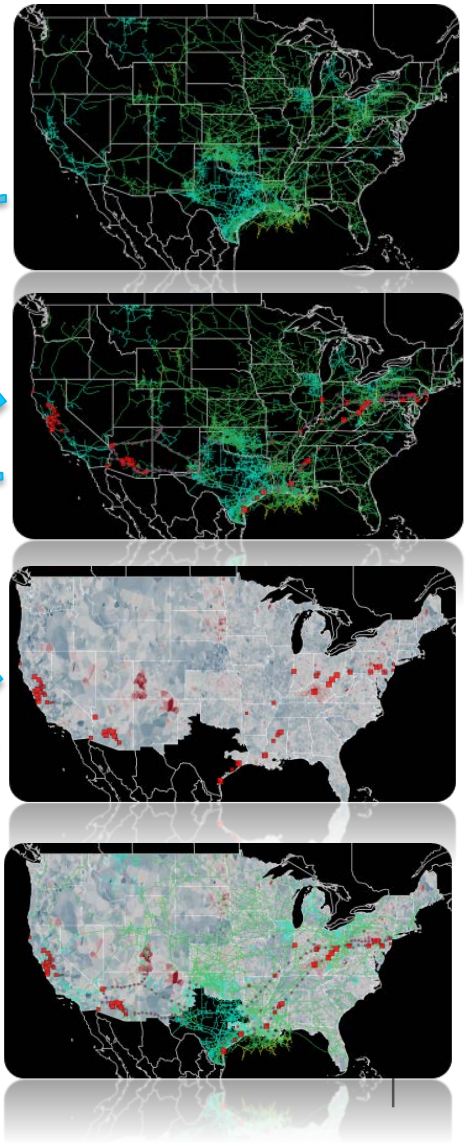
Visualization interface

Natural Gas Pipelines

Power Plant & Compressor Outages

Electricity Impact

Gas + Electric Impact



Images represent demonstration of capability, not fully validated scenarios

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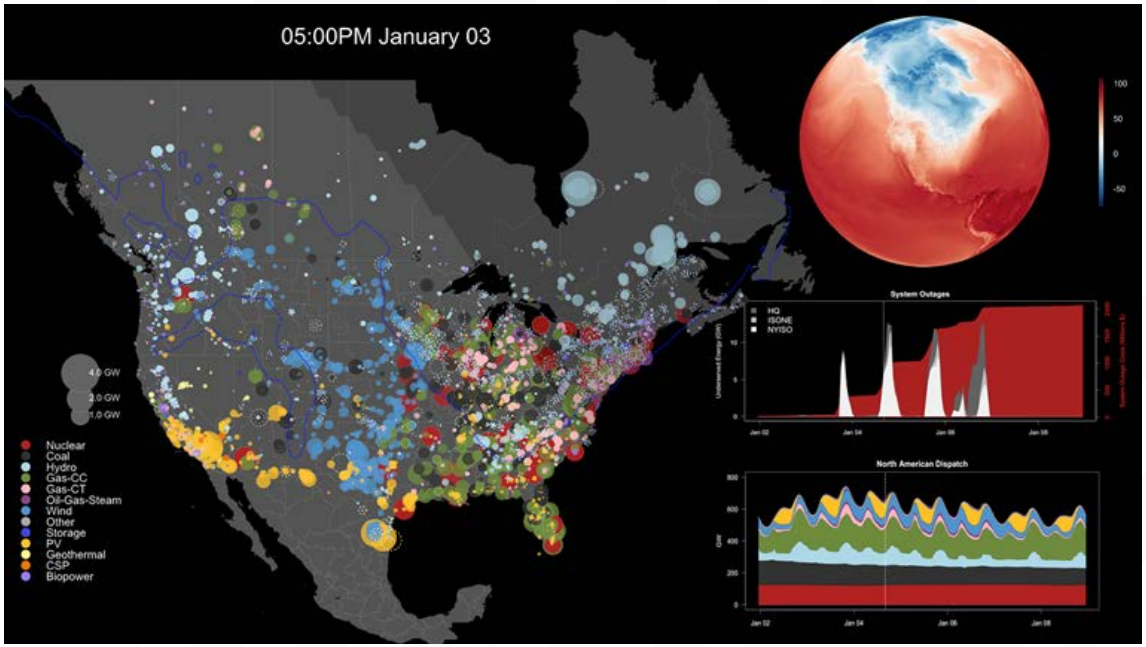
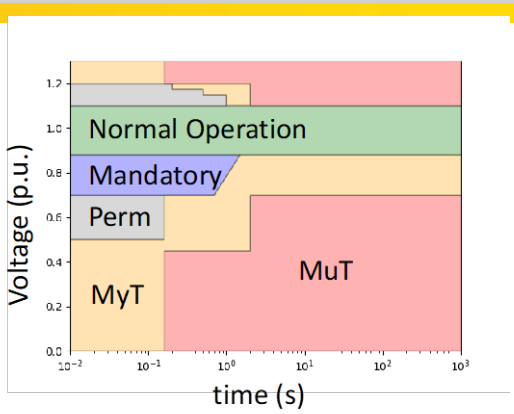
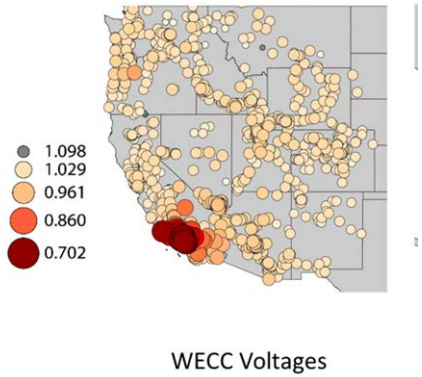
NAERM is developing additional use cases and demos to inform development



Polar Vortex Scenario

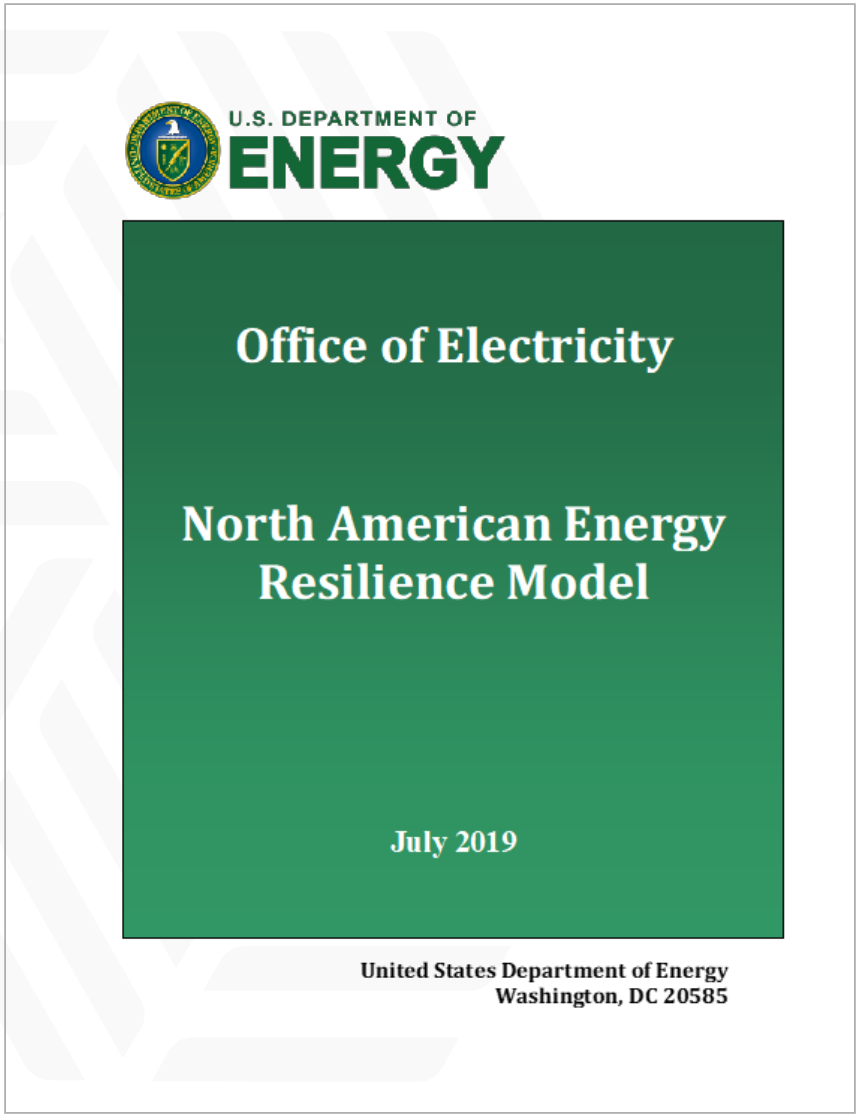




WECC Voltages

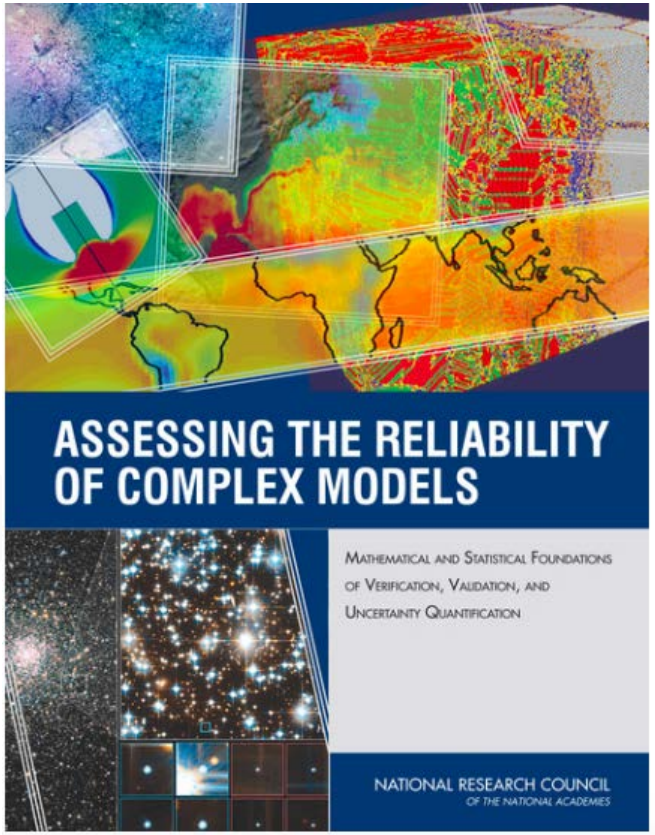
Impact of Solar Inverter Setting on Transmission

DOE submitted report to Congress provided the high-level strategy for NAERM



Final thoughts for the panel

- Validation, verification, and uncertainty quantification is a key challenge
- Need a conference strategy for bringing vendors, users, and R&D together
- Realizable strategies for access of data
- Software engineering for building multi-disciplinary teams is critical



2012, National Research Council: Washington, DC.