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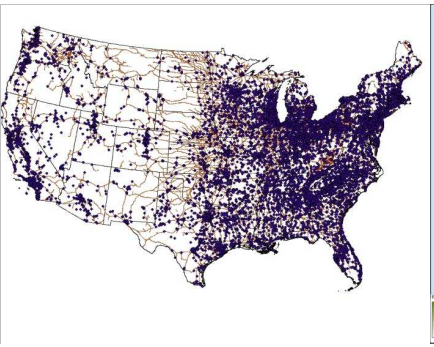
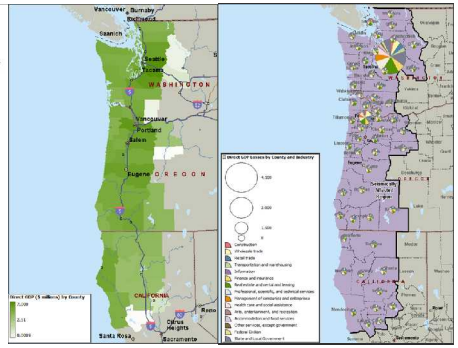
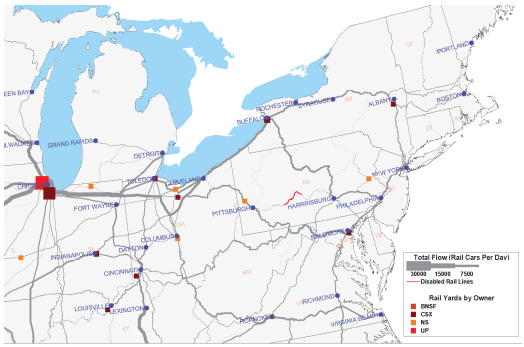
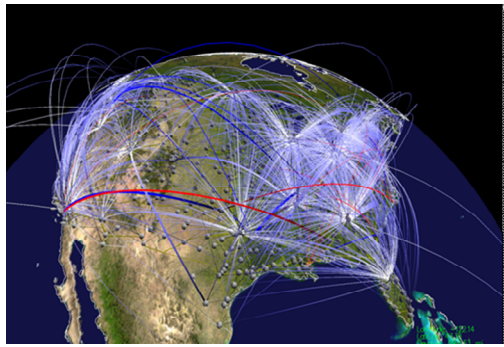

Critical Infrastructure Simulation & Analysis

Angie Kelic

Sandia National Laboratories

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Goal of Infrastructure Simulation and Analysis

Provide fundamentally new modeling and simulation capabilities for the analysis of critical infrastructures, their interdependencies, vulnerabilities, and complexities.

These advanced capabilities improve the robustness of our Nation's critical infrastructures by aiding decision makers in

- *Policy assessment,*
- *Mitigation planning,*
- *Education and training, and*
- *Near real-time assistance to crisis response organizations.*

Critical Infrastructure Systems Face an Array of Threats

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Natural

- Drought
- Earthquake
- Flood
- Heat Wave
- Hurricane
- Ice Storm
- Landslide
- Pandemic
- Space Weather
- Tsunami
- Wildfire

Terrorist

- Biological
- Chemical
- Cyber
- Explosive
- IED
- VBIED
- Aircraft
- Insider
- Nuclear
- Physical Assault
- Radiological

Hurricane Flooding

Terrorist Attacks

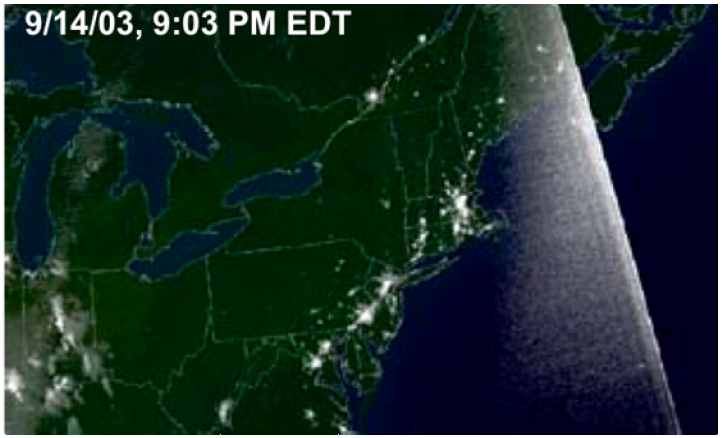
Wildfire

Pandemic Flu

Critical Infrastructures are Massively Interconnected

- **Interconnections exist**
  - Within an infrastructure sector
  - Across infrastructure sectors
- **This includes**
  - Dependencies
  - Interdependencies
- **These dependencies and interdependencies include**
  - Humans in the loop
  - Rules and other constraints
    - Functionally specific
    - Geographically specific
    - Treaties, regulations, etc.
- **Dependencies and interdependencies can result in**
  - Unexpected consequences
  - Cascading failures and impacts
- **History is increasingly full of long-tail events**

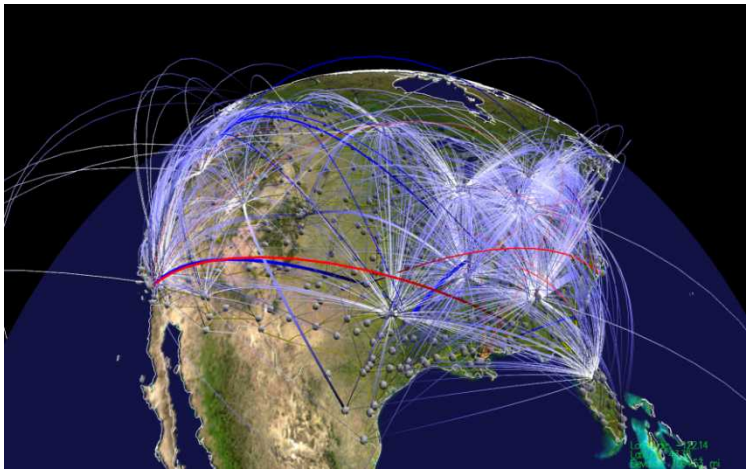
Sandy 10 days post-landfall



Northeast blackout image courtesy of NOAA

Why We Model

- **The domains in which we work are:**
  - Large
  - Complex
  - Dynamic
  - Adaptive
  - Nonlinear
  - Behavioral



Agent based supply chain disruption m

- **Too complex for mental models to be effective decision tools**
- **Identify when/where things break, and any cascading effects**
- **Quantifying consequences of disruptions in very complex systems**
  - Loss of a single asset or node within a particular system due to a directed attack
  - Regional disruptions due to a natural disasters or large scale attacks
- **The rational choice is to…**

  Experiment with models, *not* the system

  Gain expert operational insight through modeling

What We Want to Know About Critical Infrastructures

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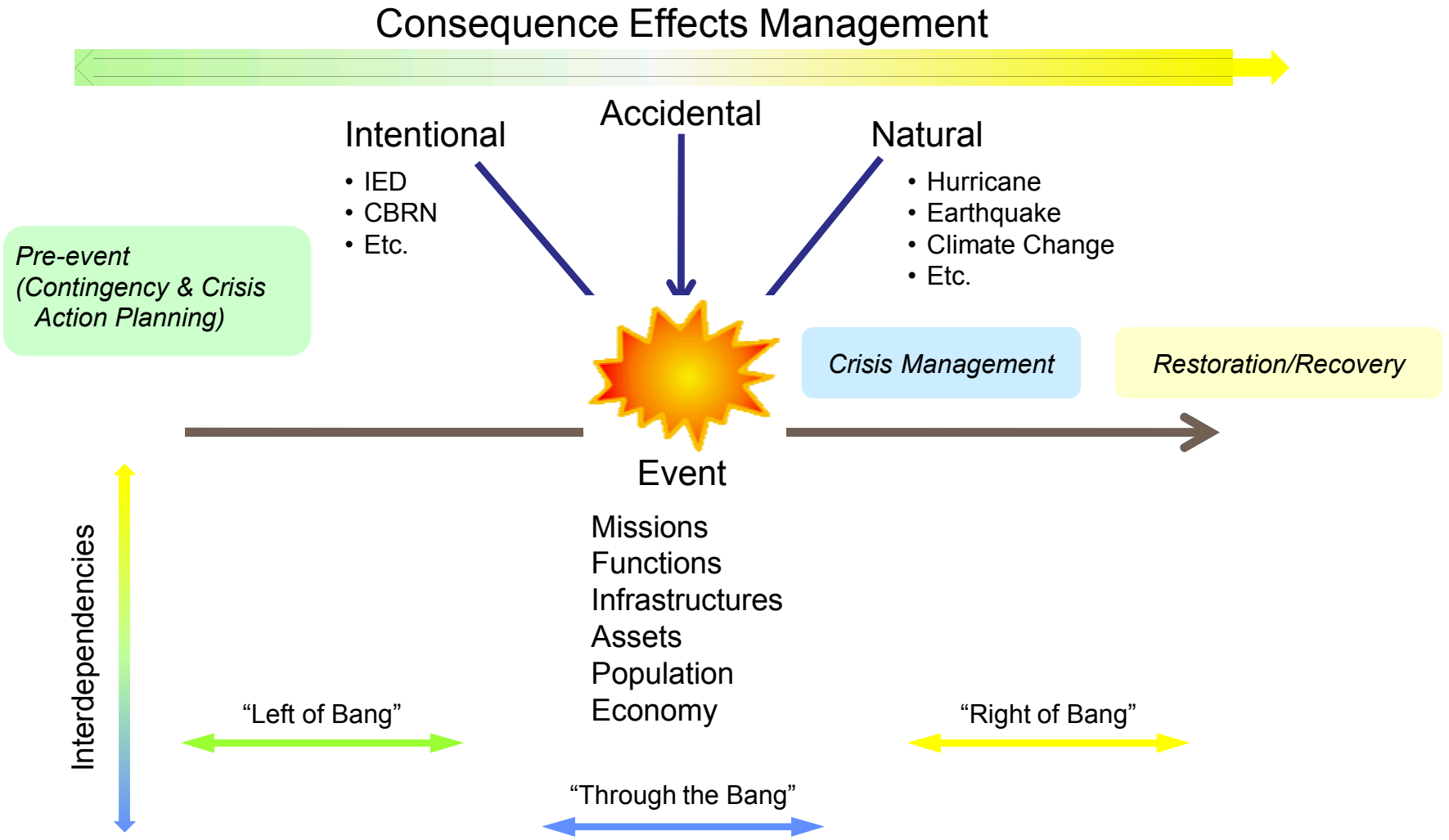
- **Are certain systems, networks, parts of the country more at risk than others? Why?**
- **Have interdependencies increased the risks or have they changed them?**
  - What conditions have to exist to cause cascading failures?
  - What size of event has to occur to initiate cascading failures?
- **Are there trends in the evolution of the infrastructures toward more vulnerable conditions or configurations?**
- **Are we repeating any mistakes from the past or have we really learned from them?**
- **How do the risks to infrastructures impact national security?**
- **How can we reduce the risks to infrastructures?**
  - Can we afford to reduce those risks?
  - Over what timeframe?

The Disruptive Event Lifecycle



National Infrastructure Simulation & Analysis Center (NISAC) Mission

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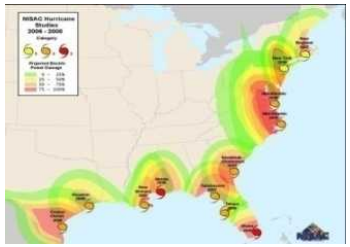
- Improve the understanding, preparation, and mitigation of the consequences of infrastructure disruption.
- Provide a common, comprehensive view of U.S. infrastructure and its response to disruptions.
  - Scale & resolution appropriate to the issues
  - All threats
- Built an operations-tested DHS capability to respond quickly to urgent infrastructure protection issues.
  - 24/7 when needed
- Use the unequalled and extensive reachback capabilities of Sandia and Los Alamos National Laboratories as premier United States National Security Laboratories

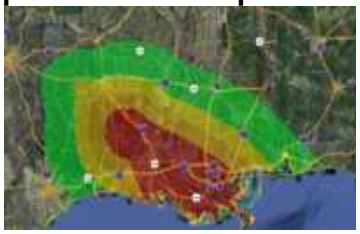
NISAC provides comprehensive, quantitative analyses of the nation's infrastructures and their interdependencies against all threats (e.g., natural, accidental and malevolent) in support of homeland security concerns for DHS

Example Types of NISAC Analysis - Hurricanes

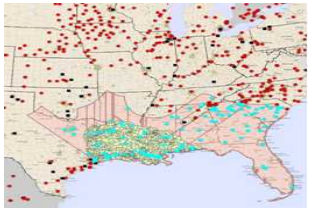
- Planning Scenarios

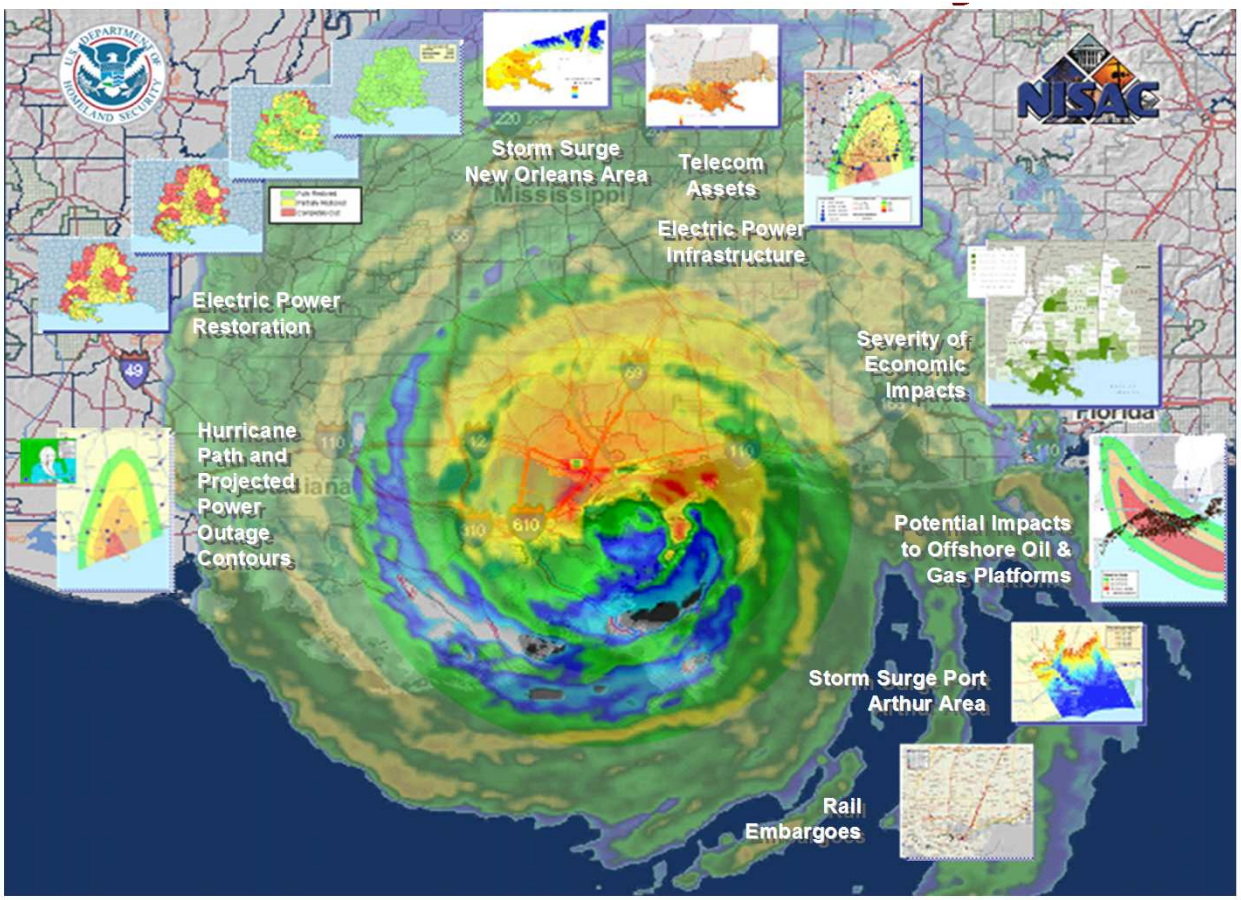


- Pre-Landfall Infrastructure & Population Impacts



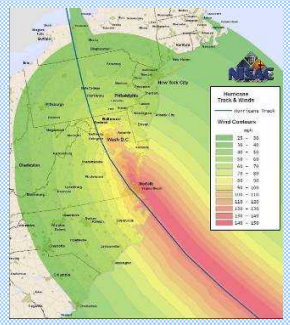
- Post-Landfall Response & Recovery Issues



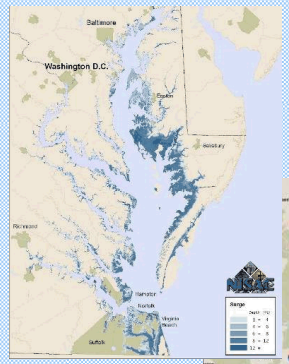


Hurricane Analysis Sequence

Mid-Atlantic Scenario



Projected Wind Contours

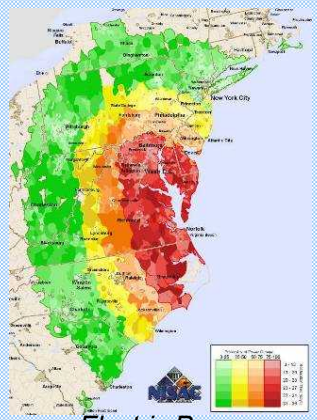


Storm Surge and Flooding

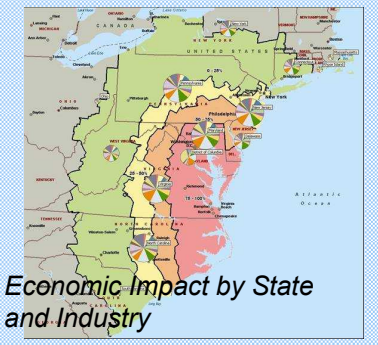
Data	Infrastructure Modeling, Simulation, and Analysis	Consequence Assessment

• National Hurricane Center: storm data
  • Wind
  • Surge
• Flood maps
• Infrastructure information (asset locations, capacities, and so forth)
• Regional-/temporal-specific conditions and issues
	Infrastructure outage/ restoration
	• Assets/capacity outaged
	• Economic impacts
	• Sector-specific impacts
	Dependency and interdependency analyses
		• National, regional, and local impacts
		• Short- and long-term impacts
		• Impacts of infrastructure disruptions
		• Commodity flow/supply chains

Electric Power Outage Areas



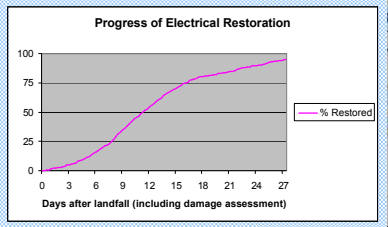
Electric Power Restoration



Economic Impact by State and Industry

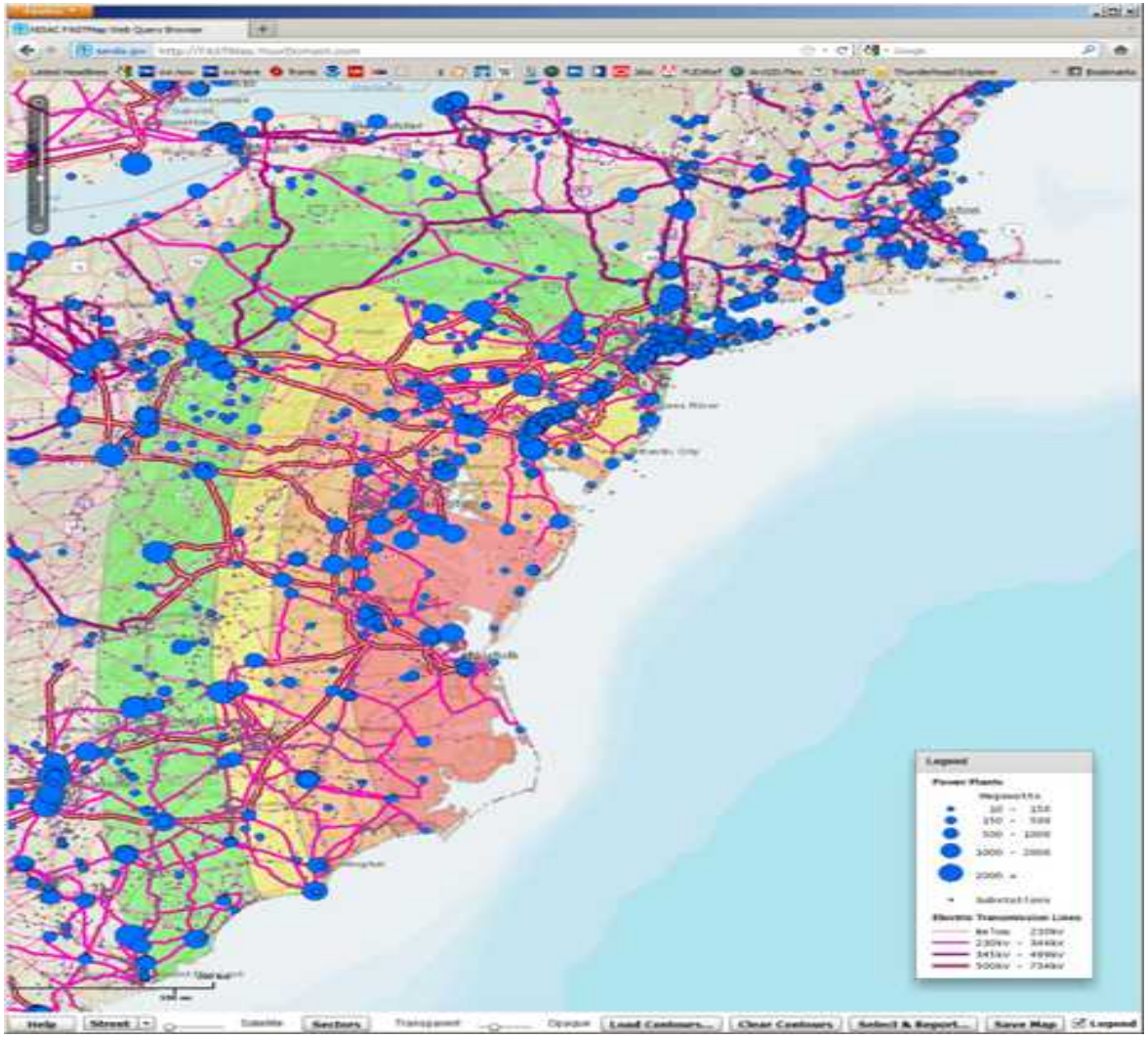
Affected Petrochemical Facilities

Telecommunications Assets in Surge



Example Tool: FASTMap

- Seamless nationwide data
- Mobile platforms (iOS and Android)
- Infrastructure and assets depicted on an inter-active map in context with any area of disruption or analysis area
- Channel technology allows instant broadcast of dynamic maps as well as collaborative exchange
- Geospatial reports containing lists and statistics on assets at risk



Example Model: National Transportation Fuels Model

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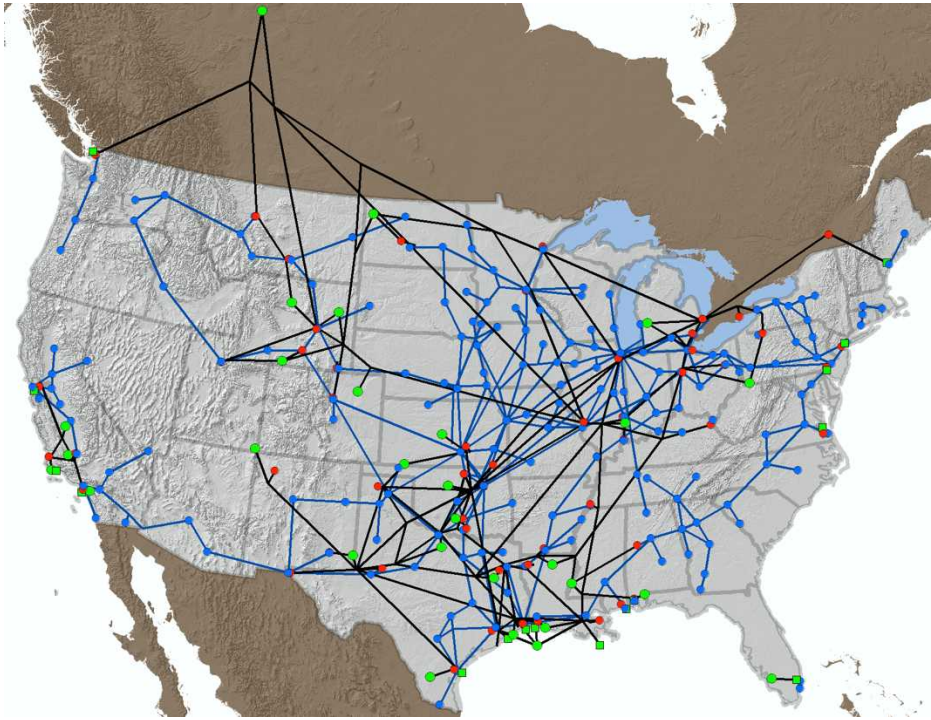
- Model includes:
  - Crude production
  - refining nodes,
  - pipeline linkages
  - Terminals
  - ports
- Designed to answer questions of the form:
  - Which regions of the United States would experience shortages of transportation fuel after a specified disruption to one or more components of the fuel infrastructure?
  - What would be the duration and magnitude of the shortages?



Challenges or What's Next?

- Answers are expected to be provided
  - Faster
  - With more fidelity
  - To a broader audience
    - Who in turn expect a series of area specific answers
  - At lower cost
- Understanding and helping decision makers anticipate the evolution of infrastructure and options they have to increase resiliency before the fact (as opposed to addressing vulnerabilities identified afterward)
- Identifying and modeling global dynamics in infrastructures and their impacts on US infrastructures (energy, climate, finance, food, etc)
- Increasing our ability to support nonfederal stakeholders (regional, state, or local entities)