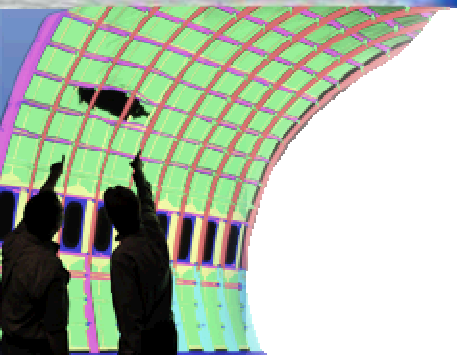
SAND2012-0154P

Sandia National Laboratories

11/30/2011

Critical Infrastructure Simulation & Analysis

Angie Kelic
Sandia National Laboratories

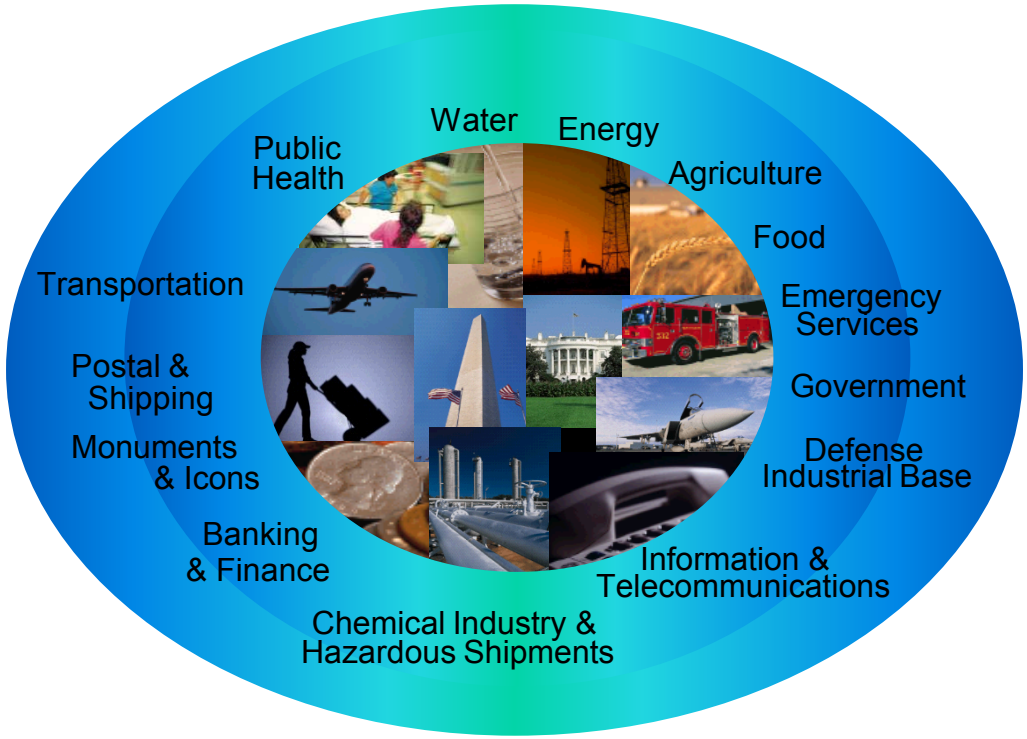


Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Goal

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

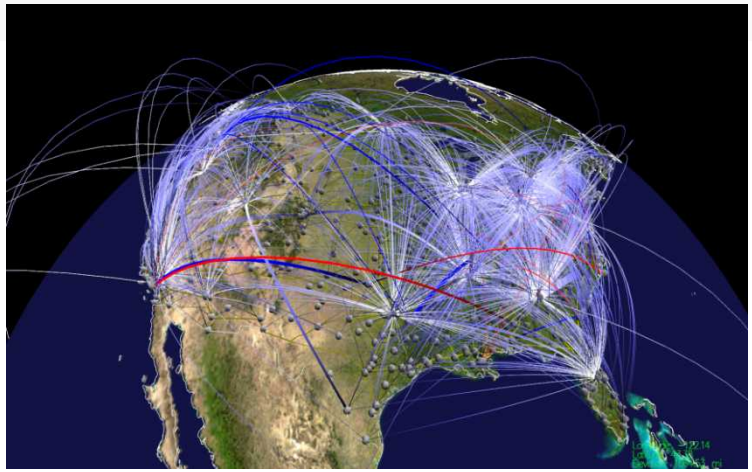
These advanced capabilities improve the robustness of our Nation's critical infrastructures by aiding decision makers in the areas of policy assessment, mitigation planning, education, training, and near real-time assistance to crisis response organizations.



Sandia National Laboratories

Why We Model

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



Agent based supply chain disruption model

- **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

Sandia National Laboratories

Models/Simulations to Inform Decisions

Realistic → Abstract

Decreasing detail, computation and development time

Data on system elements	High-fidelity models - individual infrastructure elements	Systems models of aggregate supply - demand dynamics	Generic, highly abstracted network models
Only know what is measured or monitored - limited to specific set of conditions **For existing systems only**	Detailed simulation of changes in conditions or behaviors **For complex systems and detailed phenomenology**	Effects of conditions and limitations on system operation **For trade-studies and planned systems**	Simulation and identification of vulnerabilities of different network topologies to disruptions **For quick-turnaround answers**

Sandia National Laboratories

What We Want to Know About Critical Infrastructures

- **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?

Capturing Complex Interdependencies

Sandia National Laboratories

National Infrastructure Simulation & Analysis Center (NISAC) Mission

- **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**

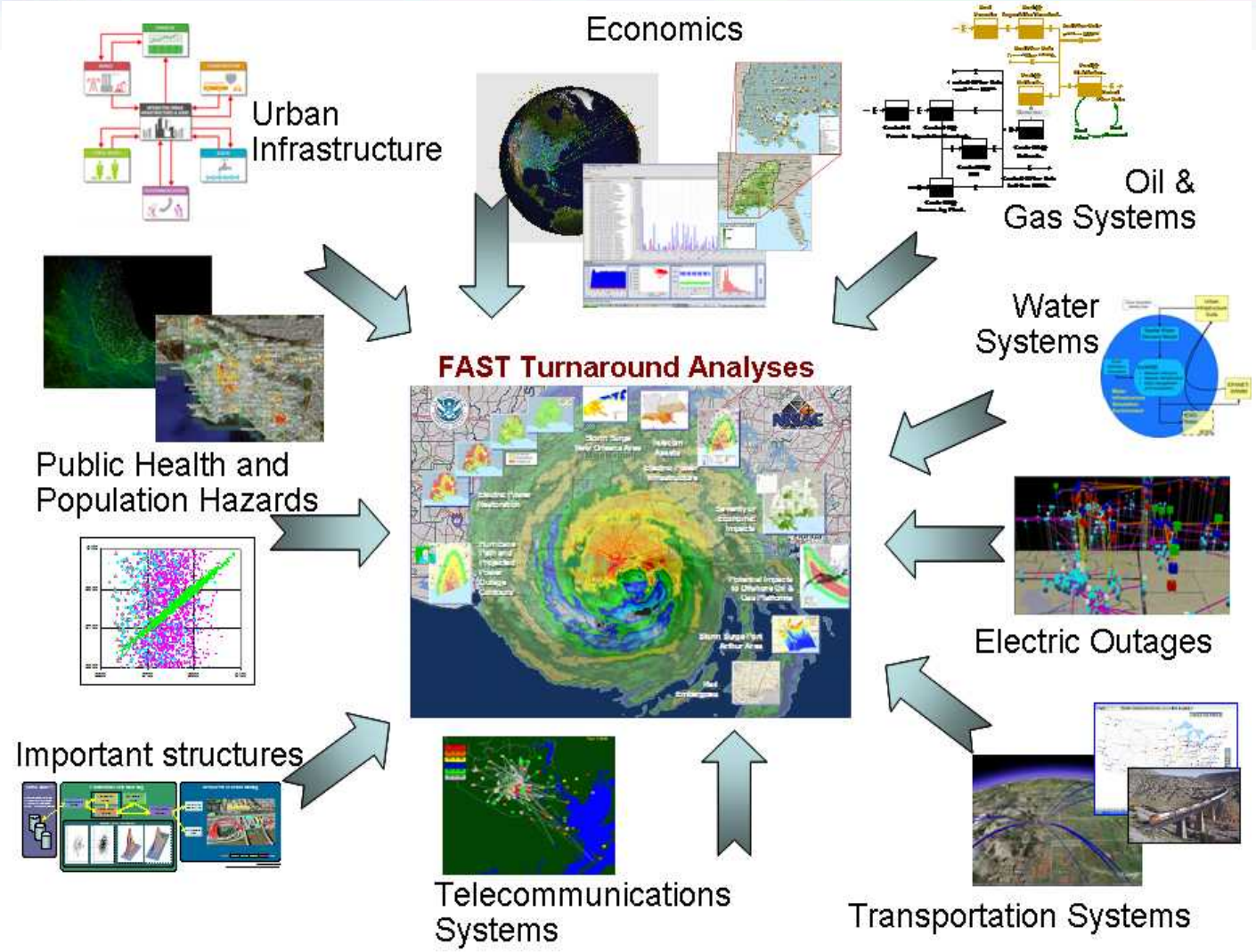
NISAC provides comprehensive, quantitative analyses of the nation's infrastructures and their interdependencies against all threats (e.g., natural, accidental and malevolent) in support of homeland security concerns for DHS

Sandia National Laboratories

Program Capabilities

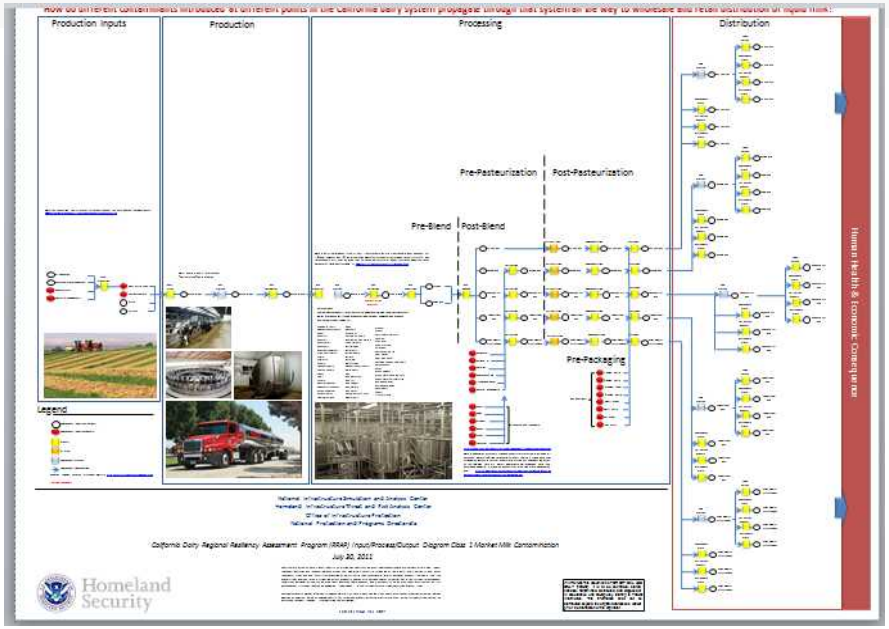
- **Interdependencies and System Modeling**
  - The interdependencies and system modeling capability provides the foundation for all products including asset prioritization, earthquake planning scenario, and other impact analyses.
- **Economic and Human Consequences**
  - A mixture of proprietary commercial software and in-house modeling and simulation capability to provide first-in-class estimates of population and economic impacts.
- **Asset and Facility Operations Modeling**
  - Infrastructure operators interact with infrastructure systems by making decisions based on constraints and opportunities. Modeling these interactions allows prediction of likely infrastructure operator responses to external events and the possible infrastructure impacts caused by those decisions.
- **Fast Integrated Hazards Analysis**
  - A common integrated simulation environment to provide consistent consequence estimates across event analyses and to expand event scenarios to multiple cascading events. This capability significantly improves NISAC's ability to provide timely and cost-effective analysis of event implications during a real event.
- **Integrating Architecture**
  - Integrating architecture supports systems analyses, fast turnaround analyses for events of national concern, and exercise support. Integrating architecture also improves coordination with other stakeholders in infrastructure protection including sector-specific agencies, FEMA, and state agencies.

Integration of Multidisciplinary Skill Sets & Expertise

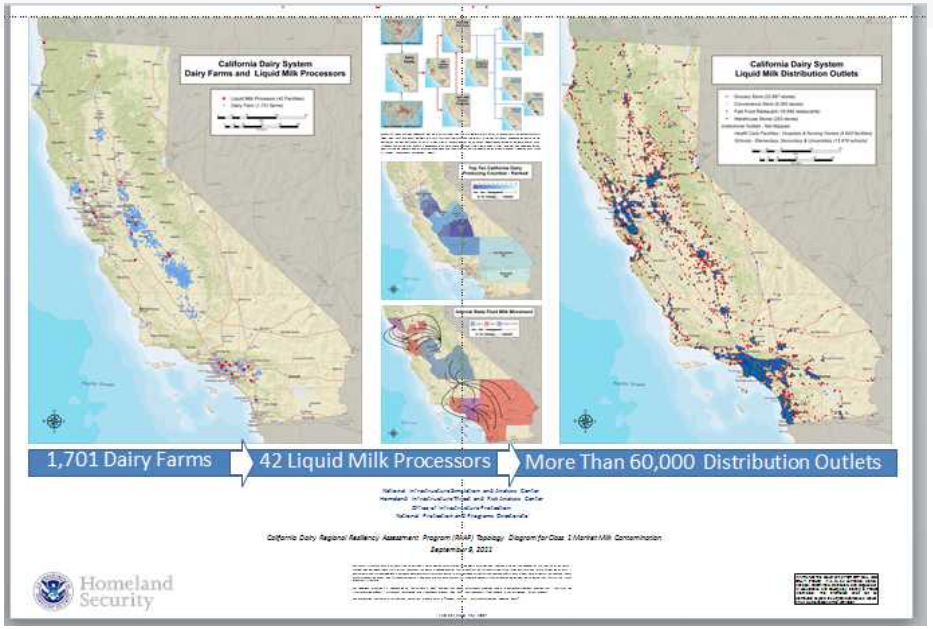


Sandia National Laboratories

System-Scale Food & Ag Risk-Assessment & Communication



Context specific process diagrams



Context specific supply & distribution diagrams

- Emphasize system-scale risks
- Visualize the linkages
- Identify vulnerabilities
- Understand the potential for consequence

Sandia National Laboratories

Conclusions

- **Model development and tools allow analysts to**
  - develop a better understanding of the system
  - focus on tasks that require their skill, like complex interactions
  - think about the system at multiple levels (system -> component)
- **In order to**
  - provide more detailed answers in a more timely fashion in a way that can be useful to decision makers