The Office of Infrastructure Protection

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National Protection and Programs Directorate
Department of Homeland Security

Infrastructure Interdependencies Simulation and Analysis

NSTC Infrastructure Subcommittee Meeting
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Overview

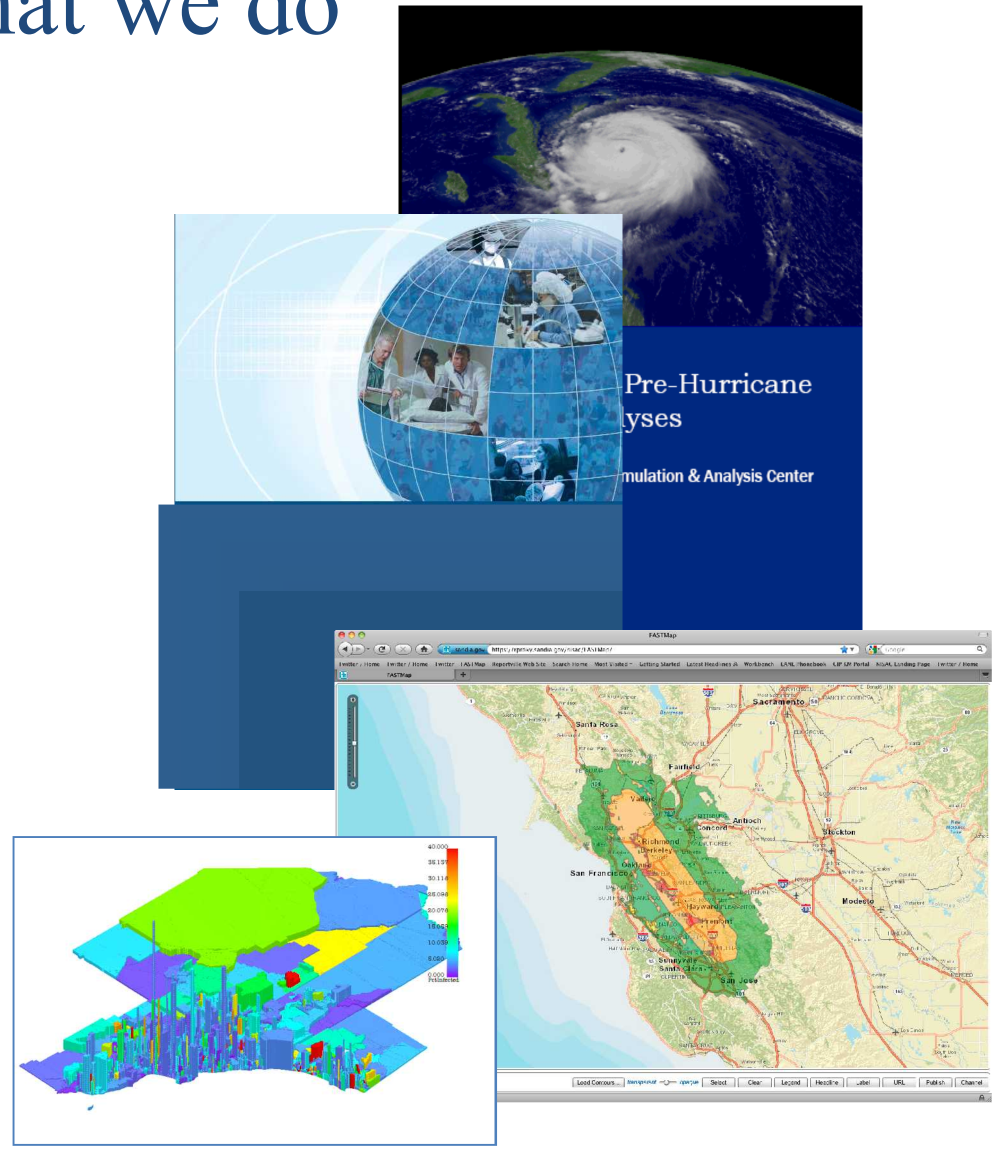
- NISAC Overview
- Constraints on Modeling and on Model Sharing
- Lessons Learned

NISAC Overview: Who we are

- The National Infrastructure Simulation and Analysis Center (NISAC) is
  - A program of the Office of Infrastructure Protection
  - With researchers and analysts at
    - Sandia National Laboratories, Albuquerque NM
    - Los Alamos National Laboratory, Los Alamos, NM
  - Began as a collaboration between the two laboratories in 1999
    - Built on top of years of prior modeling and simulation of infrastructures and systems
  - Established under §1016 of The USA PATRIOT Act of 2001
  - Transferred to DHS under §201 (g) (4) of The Homeland Security Act of 2002

NISAC Overview: What we do

- NISAC performs a range of infrastructure simulation and analysis tasks for and through DHS
  - Conducts incident consequence analyses
    - Planned analyses
    - Ad-hoc analyses
  - Provides support for national and regional exercises
  - Conducts capability development to support analysis



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NISAC Overview: What we do

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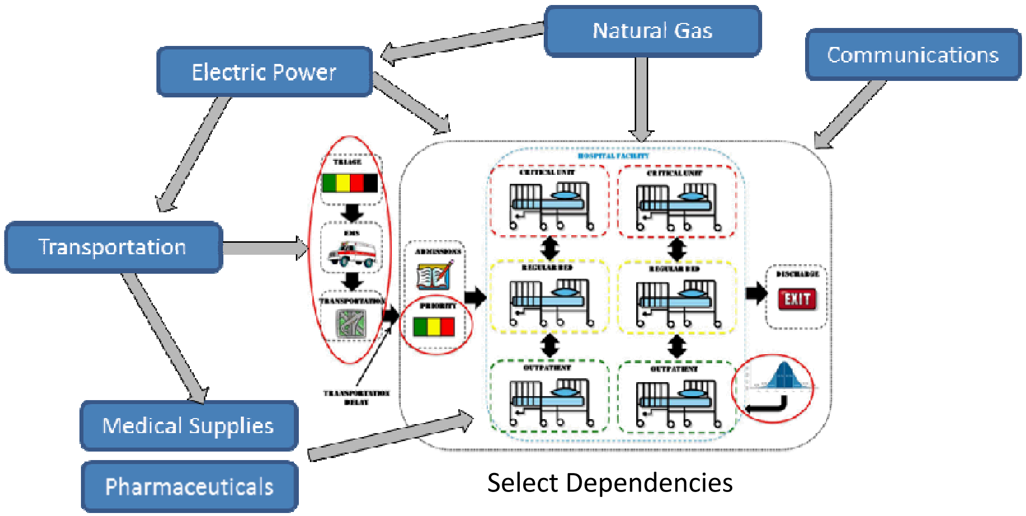
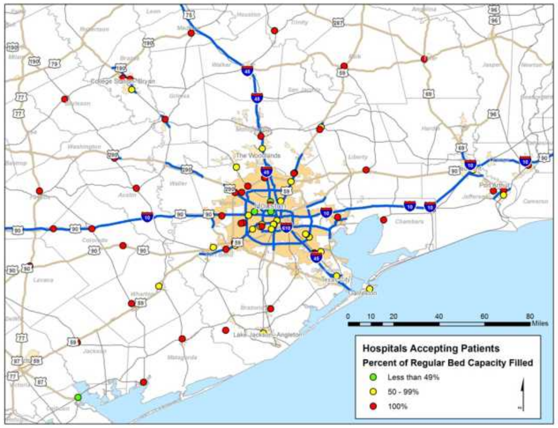
NISAC Overview: What we do

Example: Healthcare Dependencies

- Determine Critical Dependencies
  - Natural gas may only be used for backup generation and cooking so it is only critical if electric power supply is lost
  - Without electric power, the hospital may not run operating rooms even with backup generators
- Mitigation Options
  - How and where can patients be relocated?
  - Did the event cause higher demand on hospitals?
  - Analyze the effect of existing patient demand on healthcare resources and infrastructure
  - Assess how the quality of care and patient prognoses may be altered by a lack of resources
  - Assess the impact of allowing resources and patients to be redistributed between healthcare providers
  - Determine how resources and patients can be shifted to maximize treatment outcomes and minimize response costs



Select Dependencies



Regional Impacts

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NISAC Overview: What we do

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

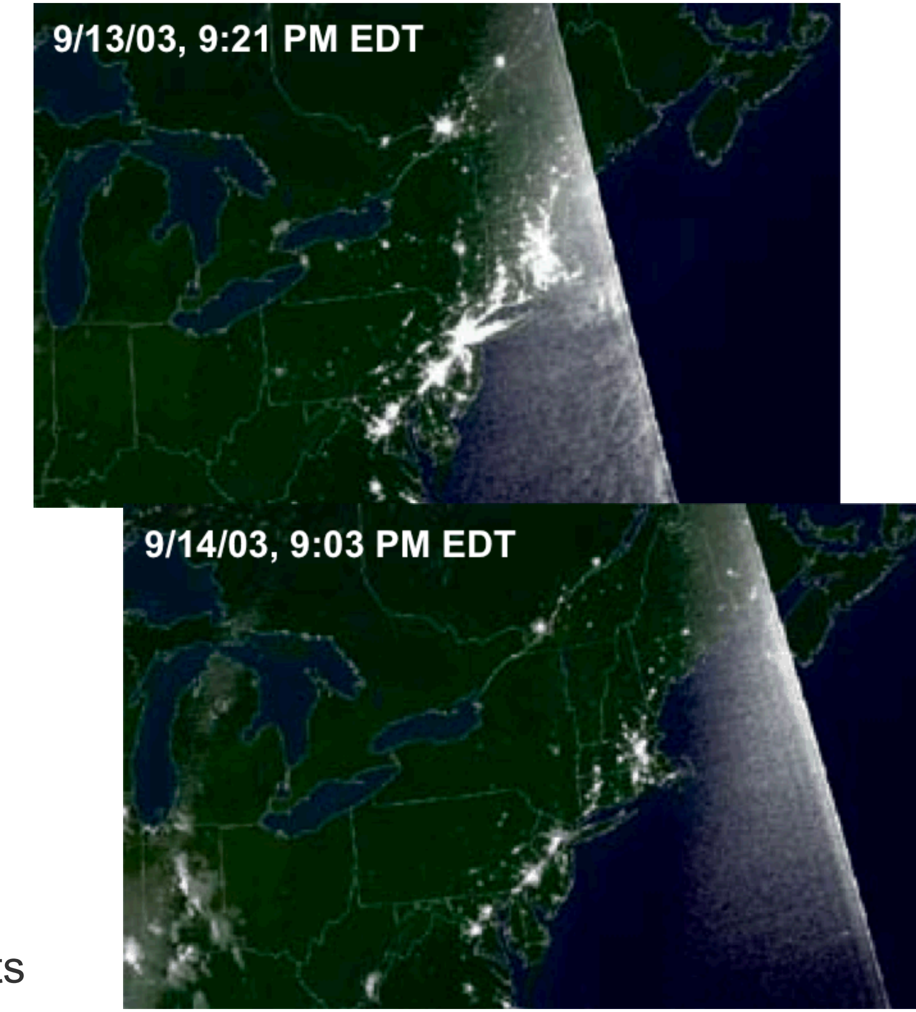
These domains are

- Large
- Complex
- Dynamic
- Adaptive
- Nonlinear
- Behavioral

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.

NISAC Overview:
Critical Infrastructures are 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



Images: NOAA

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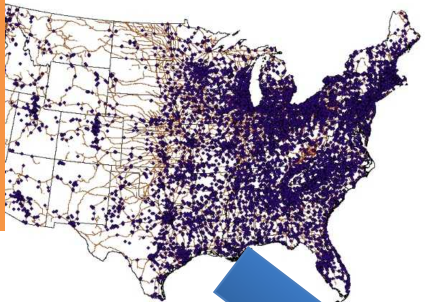
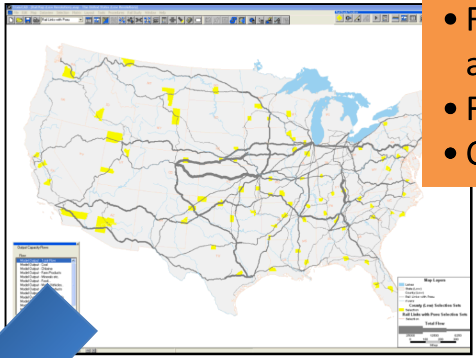
Too complex for mental models to be effective decision tools.

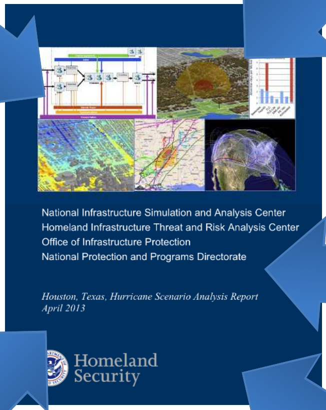
NISAC Overview: Perspective Drives Process

Spatial/Physical
- Location of key infrastructure assets
- Asset Characteristics
- Co-location

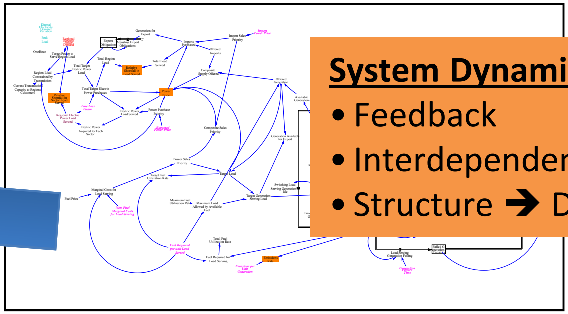


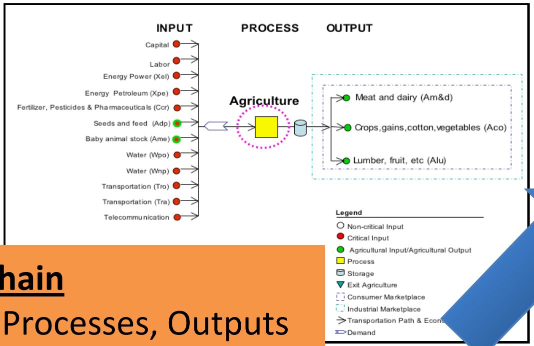
Network
- Flow of resources and goods
- Flow Capacity
- Critical Nodes



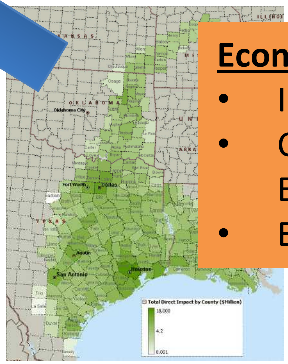


System Dynamics
- Feedback
- Interdependencies
- Structure ➔ Dynamics





Supply Chain
- Inputs, Processes, Outputs
- Process ➔ Infrastructure
- Dependencies



Economics/Human Behavior
- Input-Output modeling
- Computable General Equilibrium modeling
- Evacuation

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Constraints on Modeling and Model Sharing

- Temporal constraints
  - On the timing needed to reflect certain system elements
  - On the time needed to deliver analytic products
- System uniqueness
  - Generalizing systems can result in a model of infrastructure systems that doesn't respond to hazards/dependencies accurately
- Variation across the risk landscape
  - Failure mechanism can greatly influence cascading impacts across infrastructure systems
- Information constraints
  - Data
- The Human in the Loop
  - Within the model
  - Using the model
    - Properly defining the use case(s) for which the model was designed and applying the model to the appropriate use case(s)

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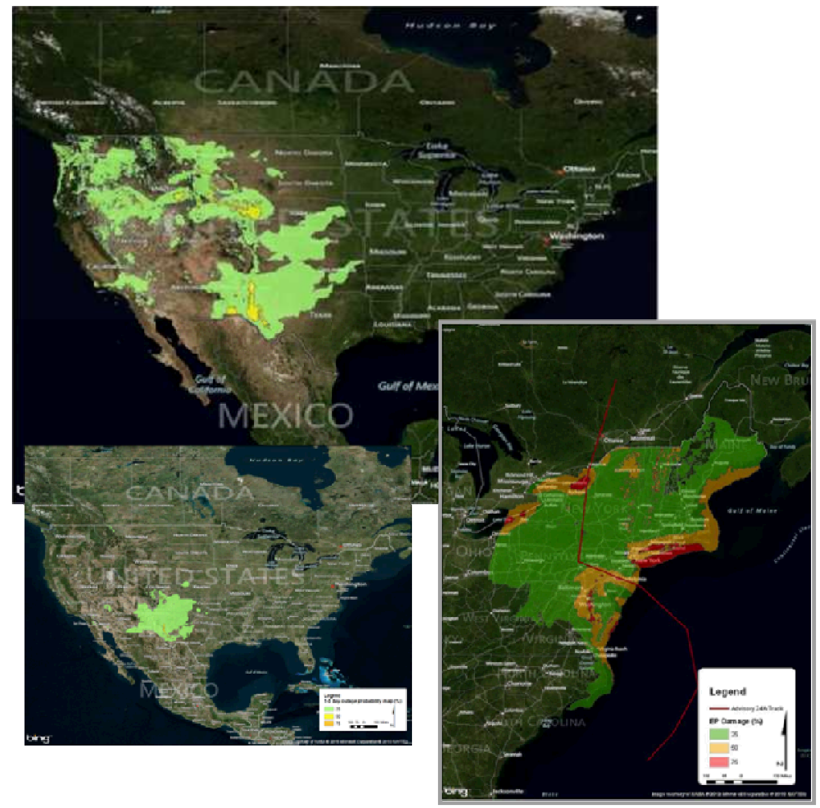
Constraints: Variation Across the Risk Landscape

- Understanding how infrastructure components become damaged
  - What components are susceptible to different hazards
  - May differ by location
  - Will vary by infrastructure system
- Large-scale versus local event
  - Damage to many infrastructure systems within a region
  - Regional differences (earthquakes act differently in different regions)



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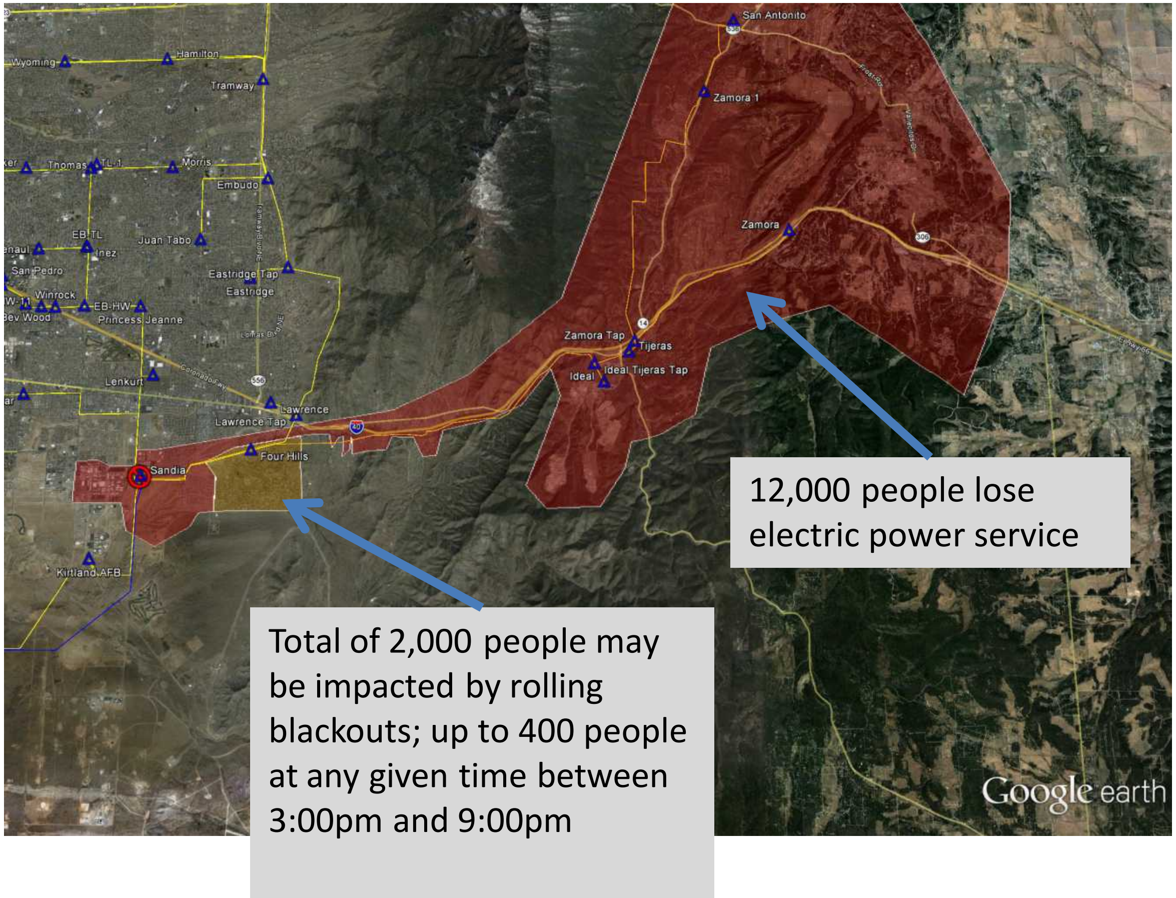
Constraints: System Uniqueness

- Geographic distribution
  - What areas will be directly impacted
    - How many people are affected
    - What other infrastructure systems are in disruption area
- Components that are damaged
  - More components, the longer restoration/recovery times
  - Severity of damage impact repair times



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Lessons Learned

- Common metrics beneficial and useful in comparing alternatives and discussing differences within and across sectors
  - Economic consequence
  - Resilience metrics
- Identifying the 'next problem' is important – identifying the right way to address it is equally important
  - Flexibility to deal with variants to the 'next problem' is desired
- Validation is important and hard
  - Especially for low probability, high consequence system disruptions
- Modeling is a constant balance of the tradeoff between breadth and depth
- The scope of unaddressed problems within sectors, especially those that involve cross-border concerns, is still large

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For more information visit:
www.dhs.gov/criticalinfrastructure

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