SAND2015-4627C

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NMSPE – June 2015

National Infrastructure Simulation & Analysis Center

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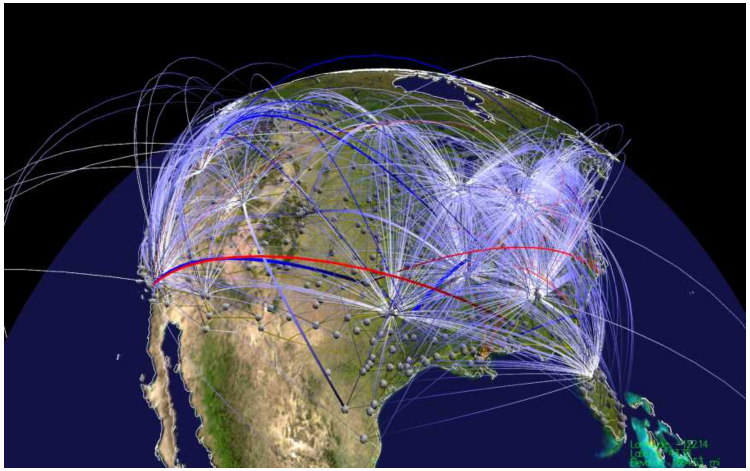
Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

- **Patriot Act identified NISAC as the center for Critical Infrastructure Interdependency Modeling, Simulation, and Analysis.**
- **Provide a common, comprehensive view of U.S. infrastructure and its response to disruptions.**
- **Operationally-tested DHS rapid-response capability.**
  - 24/7 crisis action analysis
- **Devolution site for DHS/O-CIA**

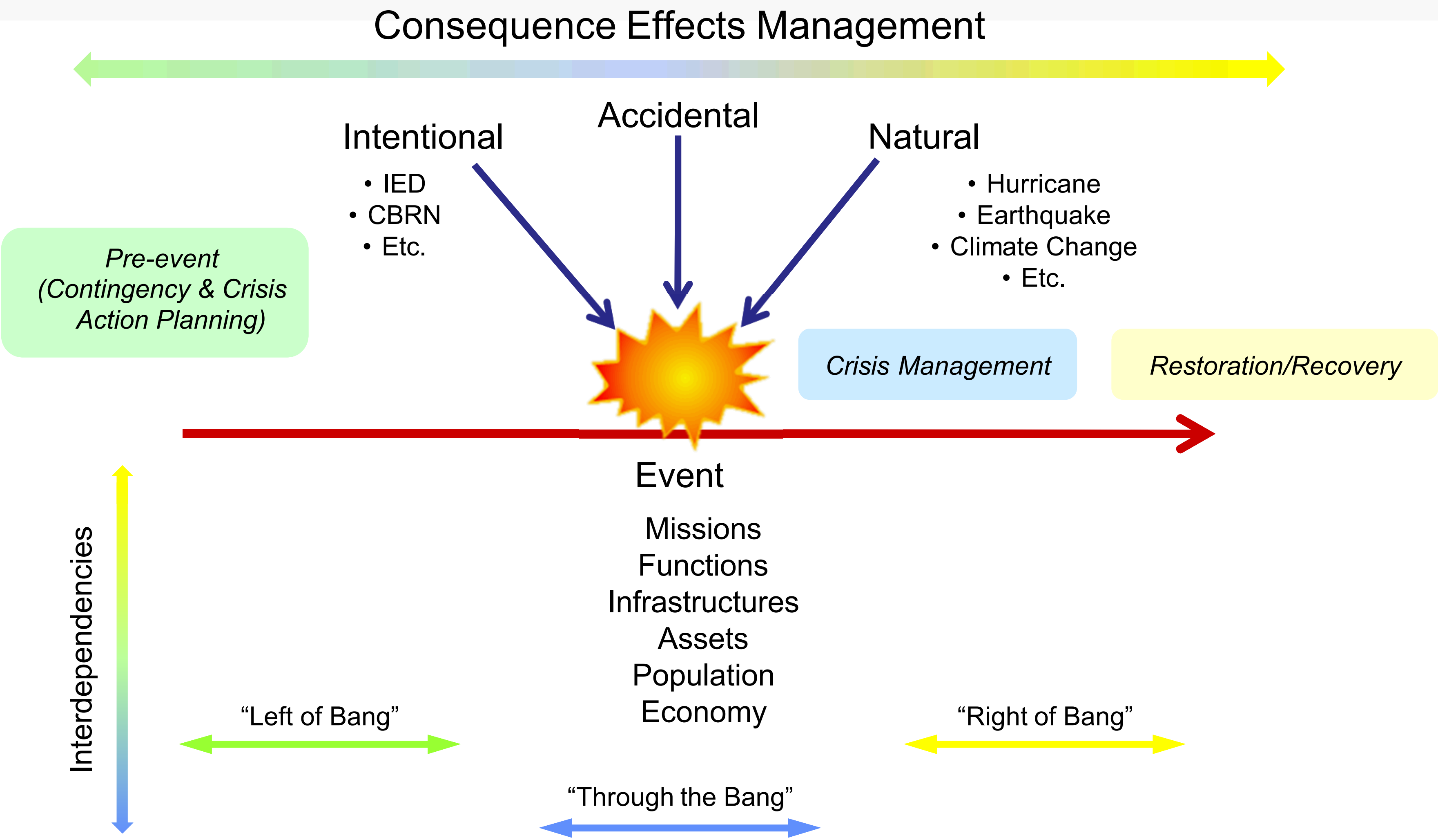


NISAC is a critical component in DHS/NPPD/O-CIA's analytical capability

NISAC Structure

- Department of Homeland Security Program, jointly executed by Sandia and Los Alamos National Laboratories
- Draws upon the expertise of 40-50 individuals located across the two sites
- Uses the unequalled and extensive reachback capabilities of Sandia and Los Alamos National Laboratories as premier United States National Security Laboratories

The Disruptive Event Lifecycle



Critical Infrastructures are Massively Interconnected

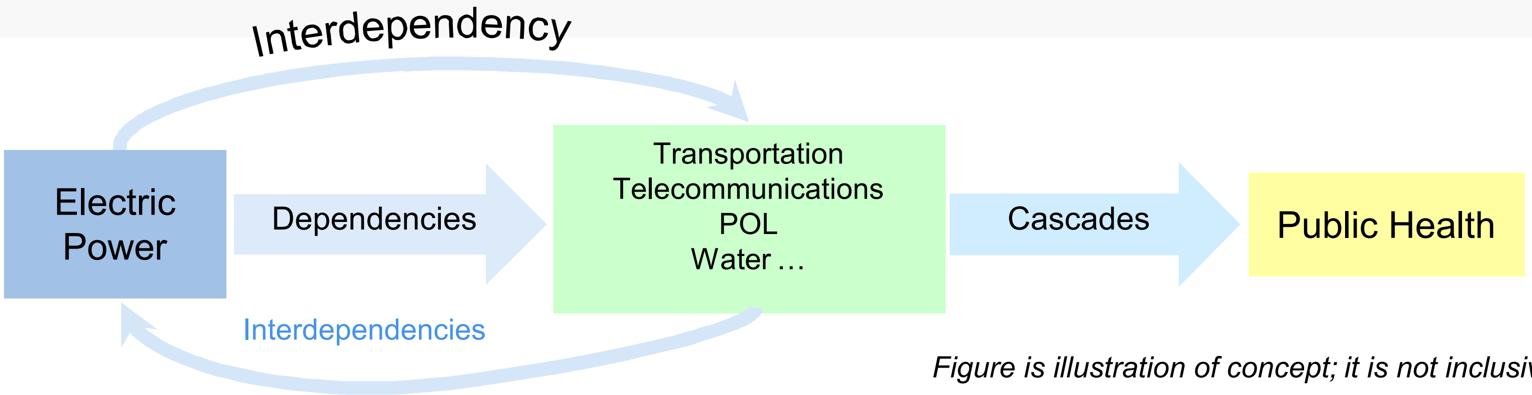


Figure is illustration of concept; it is not inclusive

- **Dependency**: Each infrastructure, while important on its own, is also dependent on other infrastructures to function successfully. Transportation, Telecommunications, Petroleum, Water (and others) require electric power to function.
- **Interdependency**: The dynamic of being mutually dependent upon each other. For example, transportation is dependent upon electric power to pump fuel and electric power is dependent on transportation and petroleum to deliver fuel for power generating plants. Such dynamic feedback loops can exist within a single infrastructure or among multiple infrastructures.
- **Cascade**: A series of infrastructure dependencies in which a disruption in one sector causes disruption in the next. In the example above, loss of electric power causes the loss of wastewater treatment which causes a public health emergency.

What We Want to Know About Infrastructures and Their Interdependencies

- **Are certain systems, networks, supply chains, 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?

This is a Hard Problem – Requires National Laboratory Capabilities

- Need to enhance preparedness, protection, response, recovery, and mitigation activities
- Quantifying / Qualifying interactions of political, health, social, economic and technical systems including uncertainties
- Coupling socio-systems (power networks, societies, etc.) to physical systems (climate, weather, CBRNE, …)
- Empirically-based computational social science does not exist
- Large, complex data; data poor environments
- Calibration, Verification, Validation
- Multiple simultaneous scales and resolutions
- Attribute-based assessments cannot capture non-local, non-intuitive or interdependency effects
- Operationalize confidence and trust in decision support

Why we model

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

August 14, 2003 Northeast Power Outage

- **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

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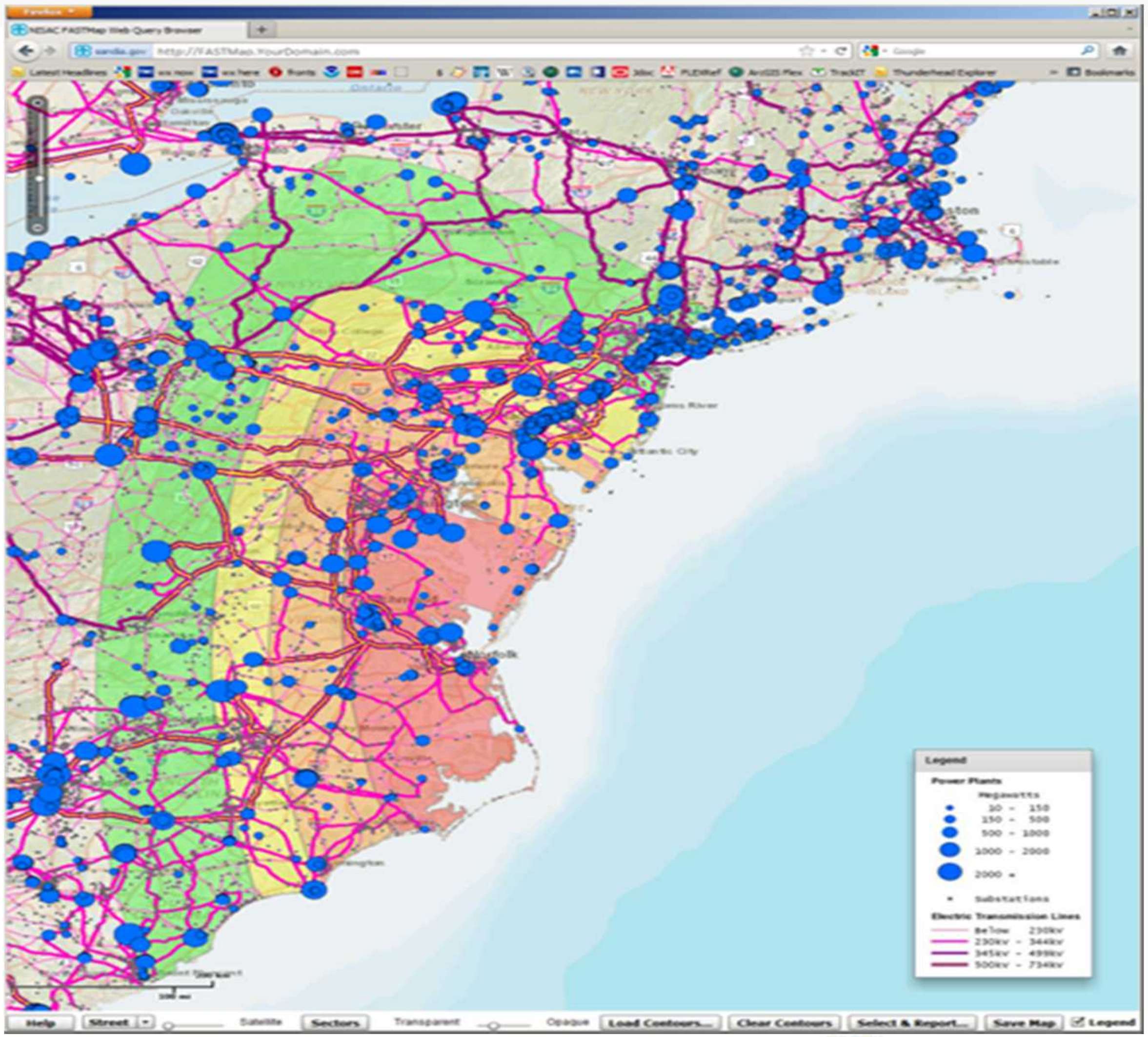
A Multitude of Models/Simulations Are Needed to Inform Decisions

Realistic → Decreasing detail, computation and development time → Abstract

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	Detailed simulation of changes in conditions or behaviors	Effects of conditions and limitations on system operation	Simulation and identification of vulnerabilities of different network topologies to disruptions
For existing systems only	For complex systems and detailed phenomenology	For trade-studies and planned systems	For quick-turnaround answers

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



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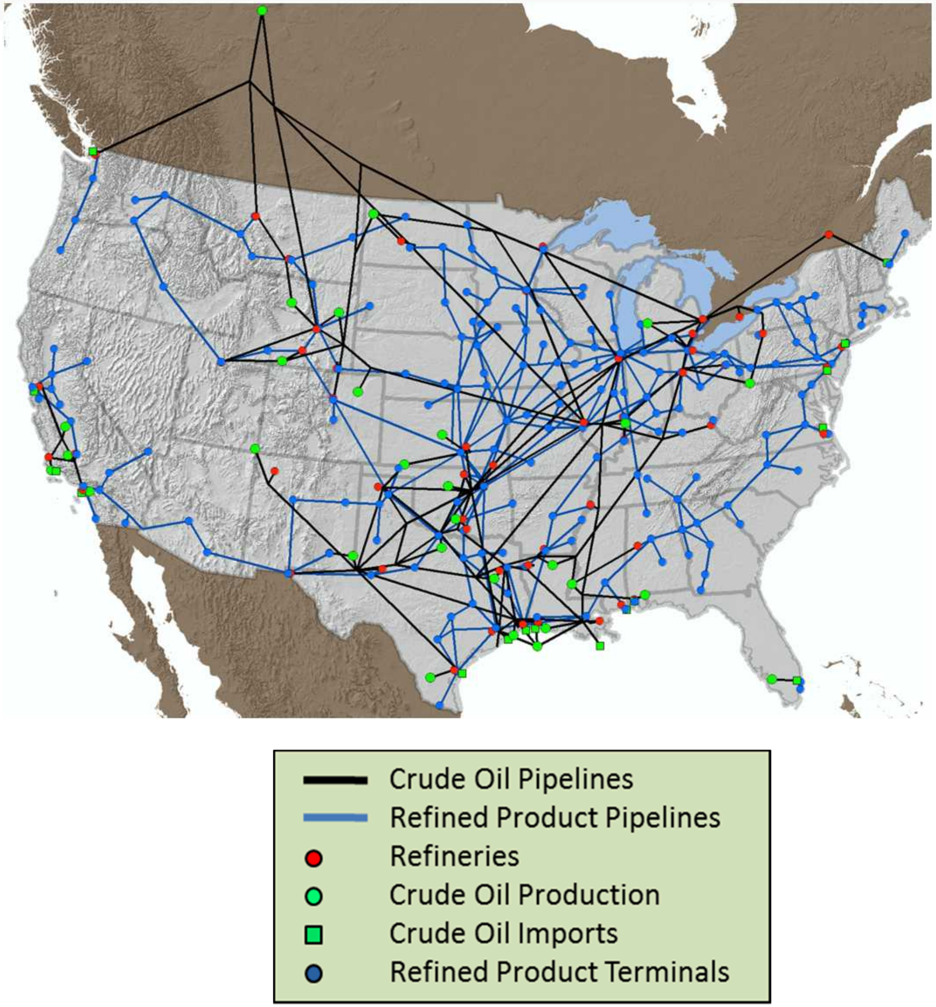
Example Model: National Transportation Fuels Model

- **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?



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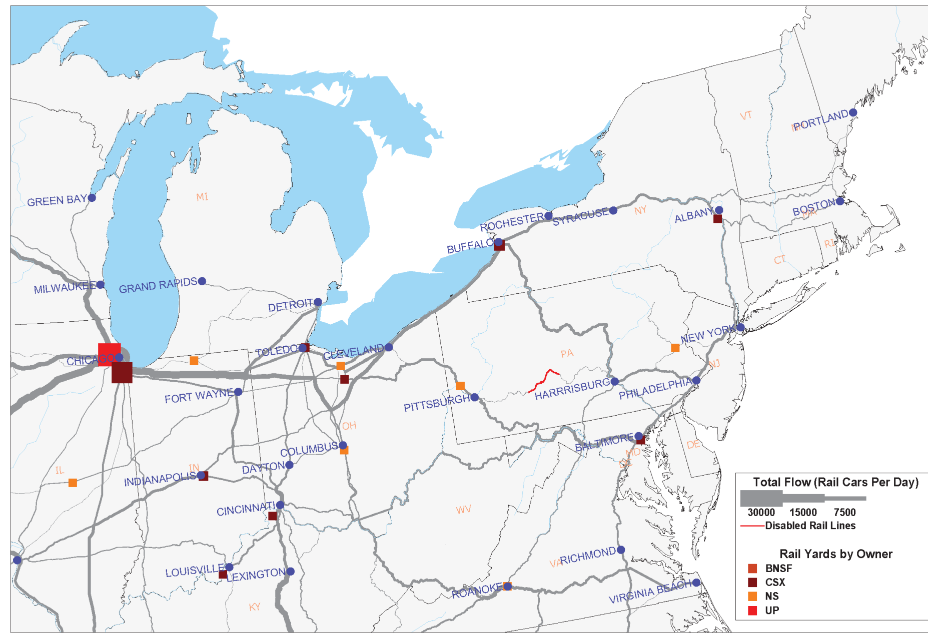
Example Model: Rail-Network Analysis System (R-NAS)

- **Model includes:**
  - National-level perspective
  - Best available commodity data
  - Optimization model for commodity flow prediction
- **Designed to answer questions of the form:**
  - How would the loss of one or more major assets in the rail network affect its ability to maintain service?
  - Which commodities (and in what quantity) could not be shipped or received?
  - How would transportation costs increase if rerouting rail traffic were required?
  - Could the rail system support additional demand if another transportation mode were disrupted (i.e., water shipping)?



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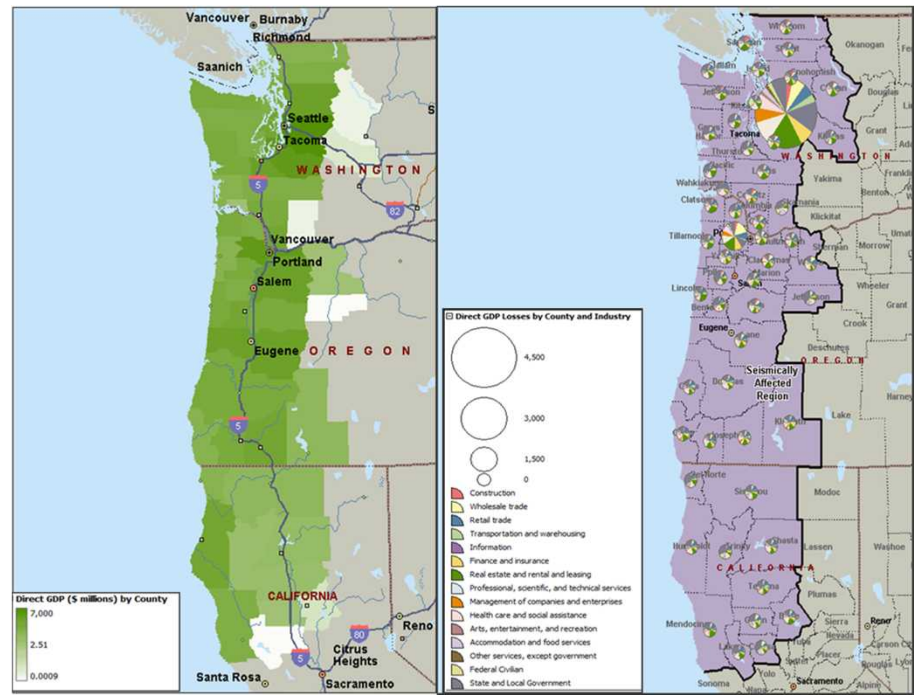
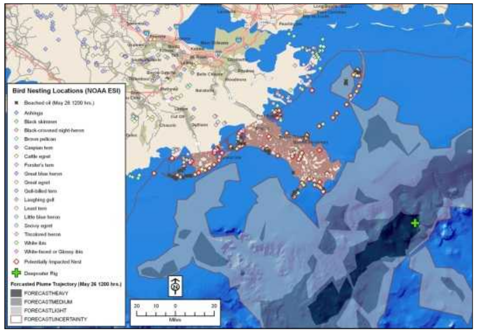
- **Model includes:**
  - Economic data permitting the identification of geographical impact zones, allowing for differential magnitude and duration estimates to be specified for regions affected by a simulated or actual event
  - Uses public data from Department of Commerce and Census Bureau
- **Designed to answer questions of the form:**
  - Due to reported or modeled disruptions, which regions could have larger economic losses?
  - Which industries or counties are estimated to be most affected by an infrastructure disruption?
  - What are the estimated impacts to firms that are directly affected by the change to baseline conditions?

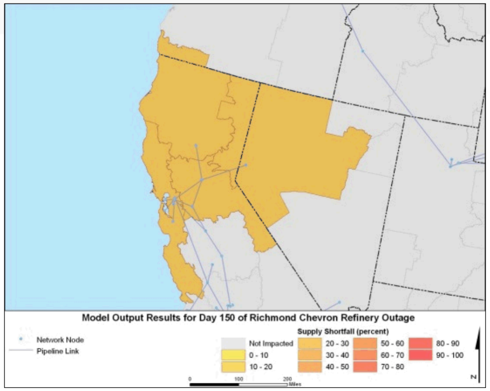


Fast-Turnaround Examples

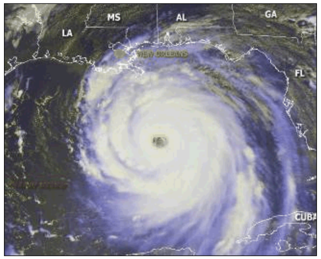
- 2015
  - Bakken Crude Rail Accidents
- 2014
  - Ebola
- 2013
  - CA Drought
- 2012
  - Hurricane Sandy
- 2011
  - Morganza Spillway Flooding
- 2010
  - Deepwater Horizon
- 2009
  - H1N1 response support
- 2008
  - Midwest flooding



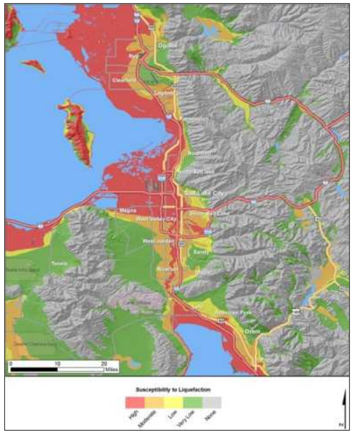
Well Explosion



Refinery Outage



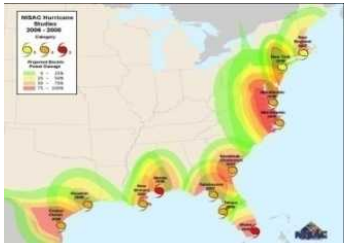
Hurricane



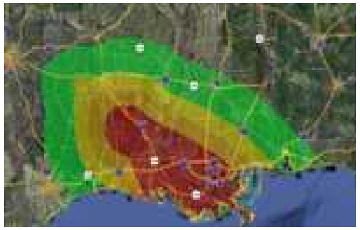
Earthquake

Example Types of NISAC Analysis - Hurricanes

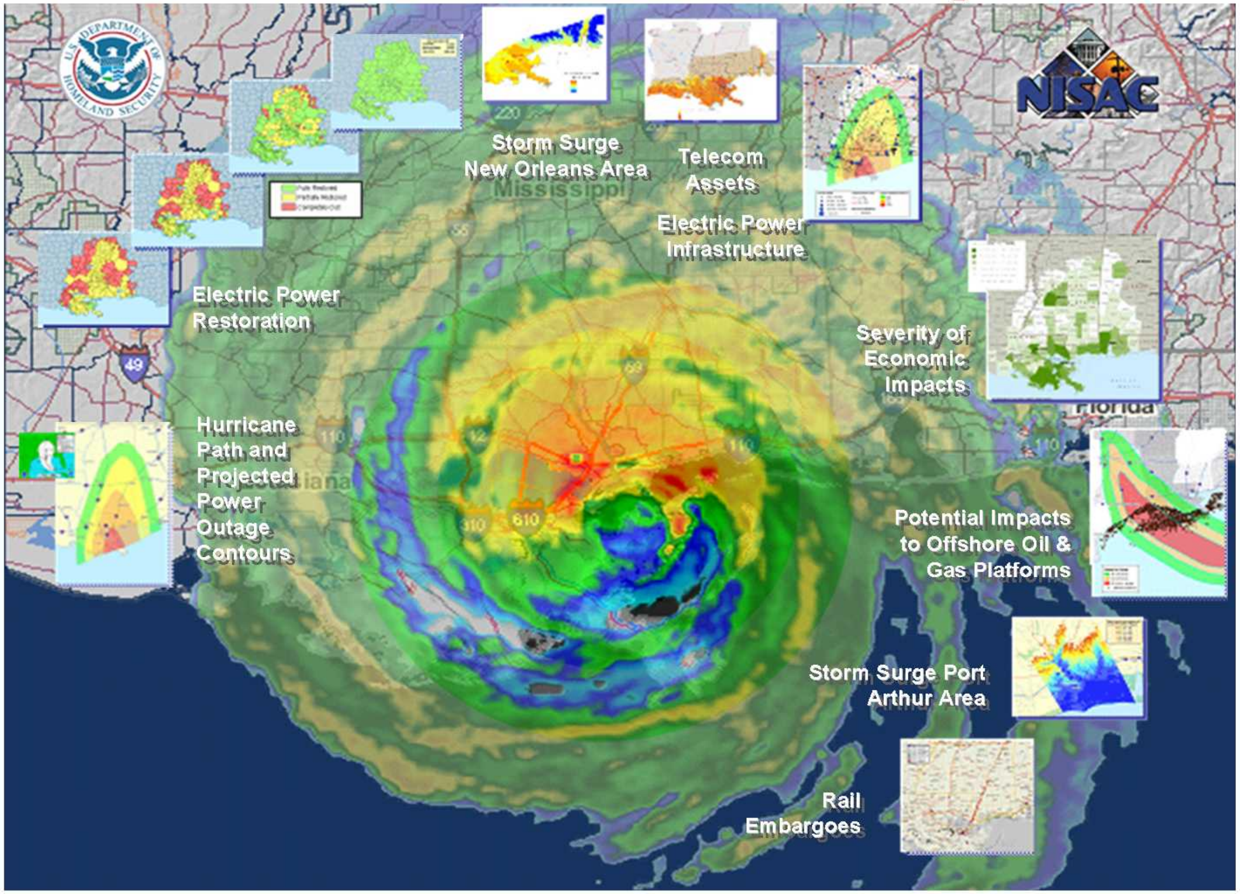
- Planning Scenarios



- Pre-Landfall Infrastructure & Population Impacts



- Post-Landfall Response & Recovery Issues



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Fast-Analysis Process: Hurricane Impact Analysis

Data

- National Hurricane Center: Storm data
  - Wind
  - Surge
- Flood maps
- Infrastructure Information (asset locations, capacities, etc.)
- Regional/temporal specific conditions and issues

Infrastructure Modeling, Simulation, and Analyses

Infrastructure outage/restoration

- Assets/capacity outaged
- Economic Impacts
- Sector-specific impacts

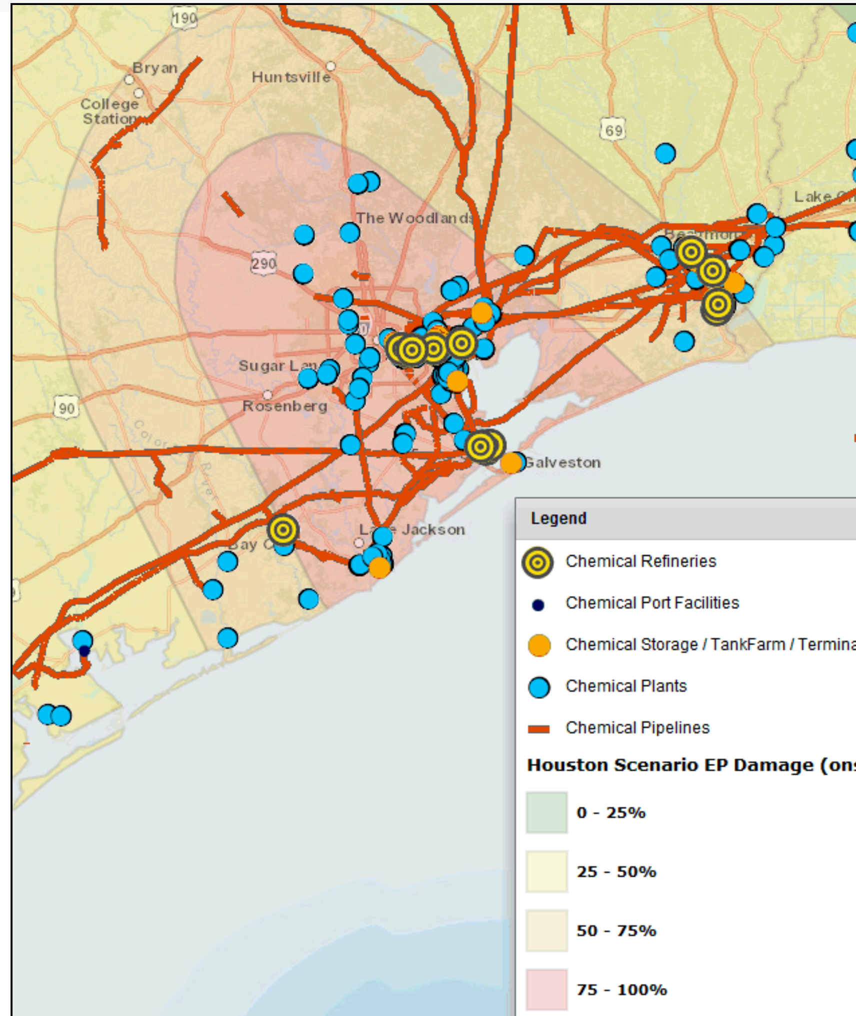
Dependency and Interdependency Analyses

Consequence Assessment

- National, regional, local impacts
- Short and Long term impacts
- Impacts of infrastructure disruptions
- Commodity flow / supply chains

Example Swath: Potential Houston Hurricane

- Category 5 hurricane.
- Maximum wind intensity: 137 nautical miles per hour (kt)
- Forward speed: 13 kt
- Landfall:
  29.2177° north latitude
  94.9111° west longitude
- Radius of 50-knot winds: 136 kt
- Radius of 34-knot winds: 200 kt
- Radius of maximum winds: 12.5 kt



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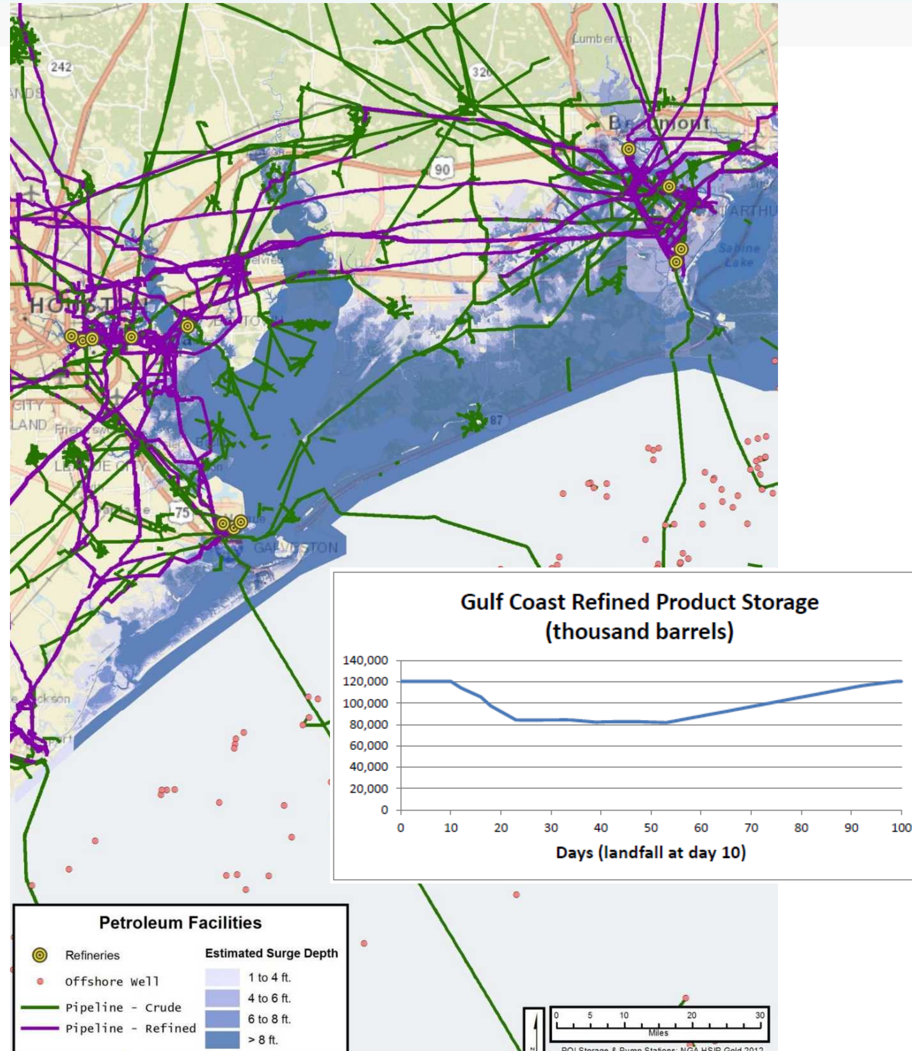
Petroleum Impacts in a Potential Houston Hurricane

- Gulf Coast hurricanes affect fuel supplies by shutting down offshore production, refineries, ports, and transmission pipelines for durations that depend on the level of damage they suffer and the availability of electric power
- Shortages of refined products could occur locally in the Houston area because local fuel deliveries depend on terminals associated with the shut-in refineries
- No widespread fuel or crude oil shortages are expected



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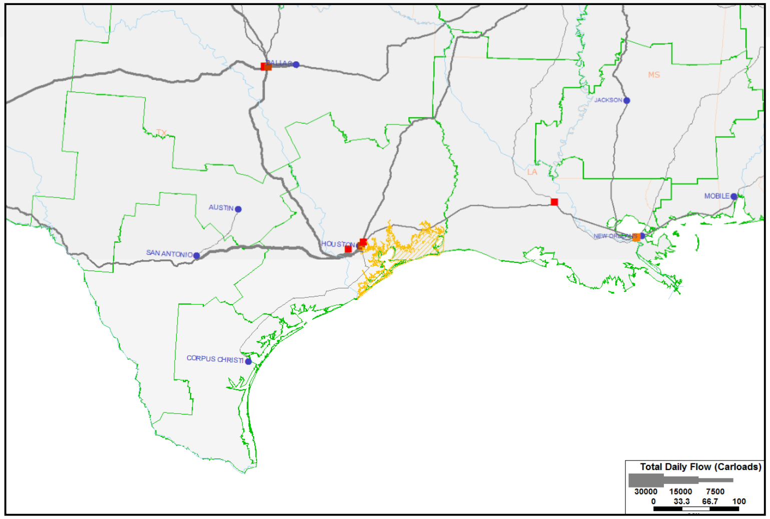
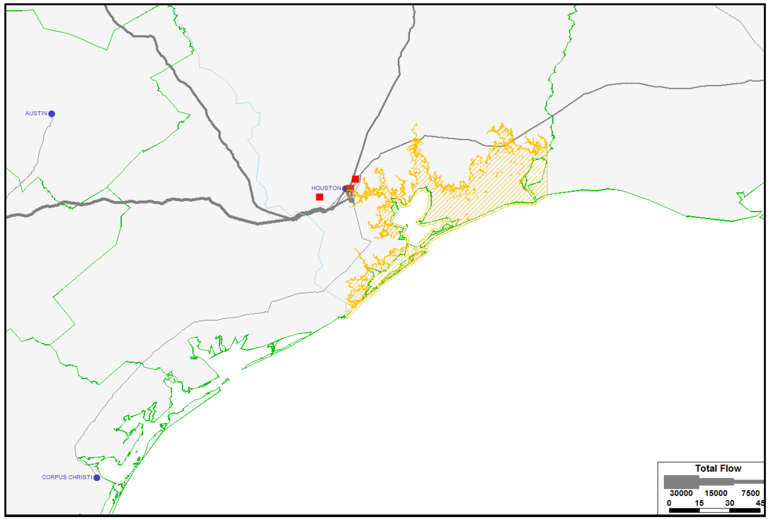
Rail Impacts in a Potential Houston Hurricane

- Eastern rail line between Houston and New Orleans will be in the surge zone
- More than 10 percent of the total U.S. rail volume for petroleum/natural gas products, chemical, minerals, hazardous waste, farm products, and motor vehicles originates or terminates in the Houston region
- Overall impact to the national rail transportation network should be minimal





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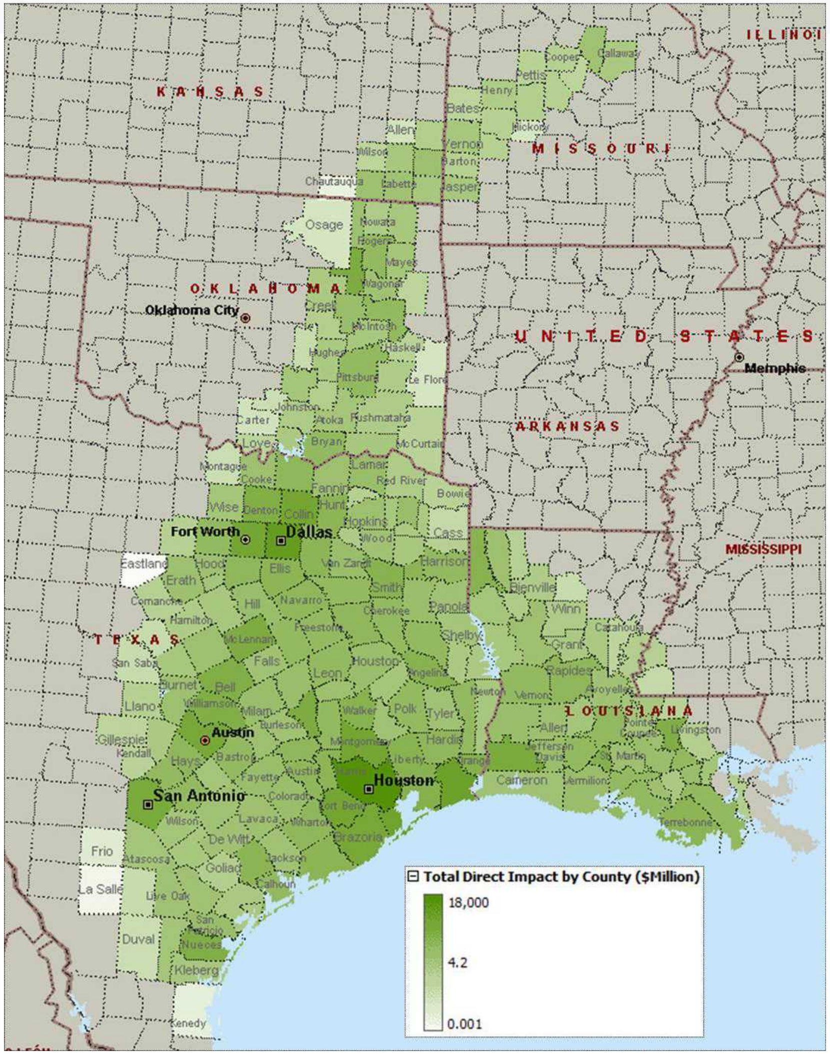
Economic Impacts in a Potential Houston Hurricane

- Estimated total reduction in GDP is in the range of $54 to $88 billion
- Direct GDP reductions of $21 to $35 billion experienced by entities directly affected by the hurricane's damage
- Counties with largest impacts: Harris, Dallas, Jefferson, Galveston, and Montgomery



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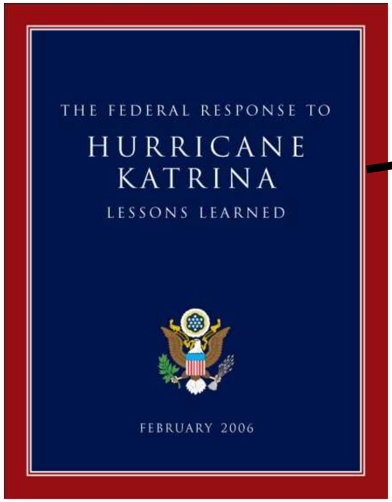
Collaborations

University of Minnesota
USC – CREATE
University of Maryland
Cornell
Columbia
UC Berkeley
UC Santa Barbara
UCLA
UC Riverside
University of Washington
Rice University
University of Illinois
University of Utah
Carnegie-Mellon University
University of Texas at Austin
University of Washington
Virginia Tech
University of New Mexico
University of Arizona
MIT
Duke University
SUNY Albany
University of Nebraska
Illinois Institute of Technology
Ohio State
Georgia Tech

CERA
NSTAC
Goodyear
AON
RMS
SRI-C
Veterans Administration
AIR
Lucent/Alcatel (Bell Labs)
Microsoft Research
SAMSI
Scalable Networks
Motorola
Metatech
Telcordia
Pacific Northwest Economic Region
Port of Portland
Port of Seattle
Portland METRO
Central European Bank
Bank of Finland
ETH Zurich
Nankai University
University of Vienna
DSO Singapore

NISAC's Impact is Nationally Recognized

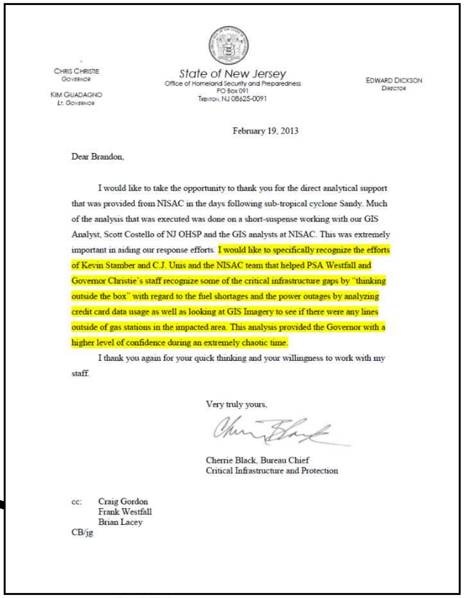


Hurricane Katrina Lessons Learned Recommendations:

78. DHS should revise the National Response Plan…optional actions will be based on reports from…the National Infrastructure Simulation and Analysis Center (NISAC)…
82. DHS should expand the National Infrastructure Simulation and Analysis Center's (NISAC) Modeling and Analysis capability to allow more robust and accurate systems modeling.
83. The National Economic Council should form an Impact Assessment Working Group to provide an overall economic impact assessment of major disasters, including the Departments of Homeland Security, Treasury, Commerce, Energy (Energy Information Administration) and Labor as well as the President's Council of Economic Advisers…The various economic modeling expertise of the members of the Impact Assessment Working Group should be incorporated into the NISAC models.

From Cherrie Black, Bureau Chief, NJ Critical Infrastructure Protection
On NISAC's support during SuperStorm Sandy:

I would like to specifically recognize the efforts of Kevin Stamber and C.J. Unis and the NISAC team that helped PSA Westfall and Governor Christie's staff recognize some of the critical infrastructure gaps by "thinking outside the box" with regard to the fuel shortages and the power outages by analyzing credit card data usage as well as looking at GIS Imagery to see if there were any lines outside of gas stations in the impacted area. This analysis provided the Governor with a higher level of confidence during an extremely chaotic time.



CHRIS CHRISTIE
GOVERNOR

KIM GUADAGNO
LT. GOVERNOR

State of New Jersey
Office of Homeland Security and Preparedness
PO Box 091
TRENTON, NJ 08625-0091

EDWARD DICKSON
DIRECTOR

February 19, 2013

Dear Brandon,

I would like to take the opportunity to thank you for the direct analytical support that was provided from NISAC in the days following sub-tropical cyclone Sandy. Much of the analysis that was executed was done on a short-suspense working with our GIS Analyst, Scott Costello of NJ OHSP and the GIS analysts at NISAC. This was extremely important in aiding our response efforts. I would like to specifically recognize the efforts of Kevin Stamber and C.J. Unis and the NISAC team that helped PSA Westfall and Governor Christie's staff recognize some of the critical infrastructure gaps by "thinking outside the box" with regard to the fuel shortages and the power outages by analyzing credit card data usage as well as looking at GIS Imagery to see if there were any lines outside of gas stations in the impacted area. This analysis provided the Governor with a higher level of confidence during an extremely chaotic time.

I thank you again for your quick thinking and your willingness to work with my staff.

Very truly yours,

Cherrie Black, Bureau Chief
Critical Infrastructure and Protection

cc: Craig Gordon
Frank Westfall
Brian Lacey

CB/jg

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