NISAC

NATIONAL INFRASTRUCTURE SIMULATION & ANALYSIS CENTER

SAND2008-5939P

Overview and Impact Analysis Examples Hurricanes and Earthquakes

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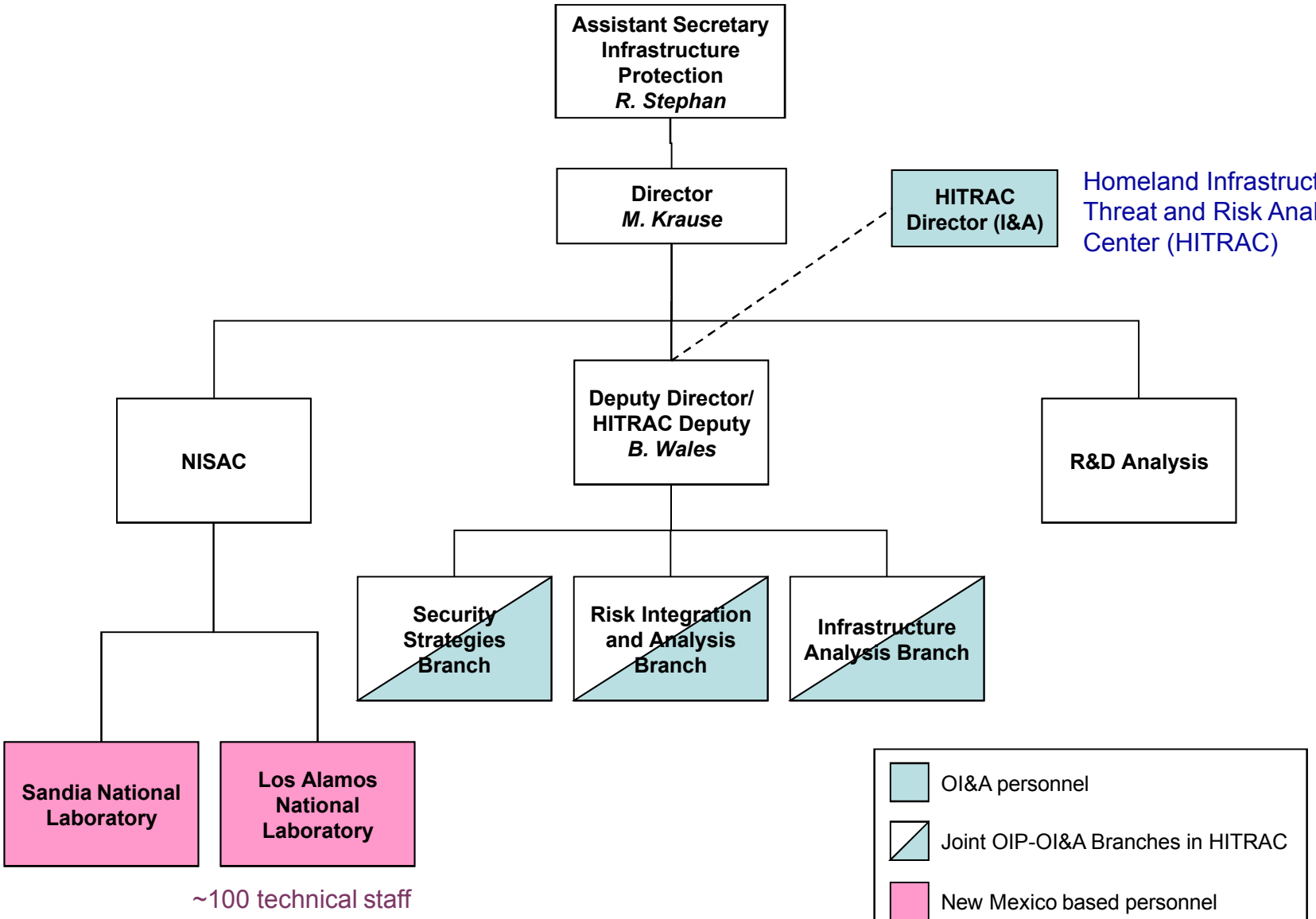
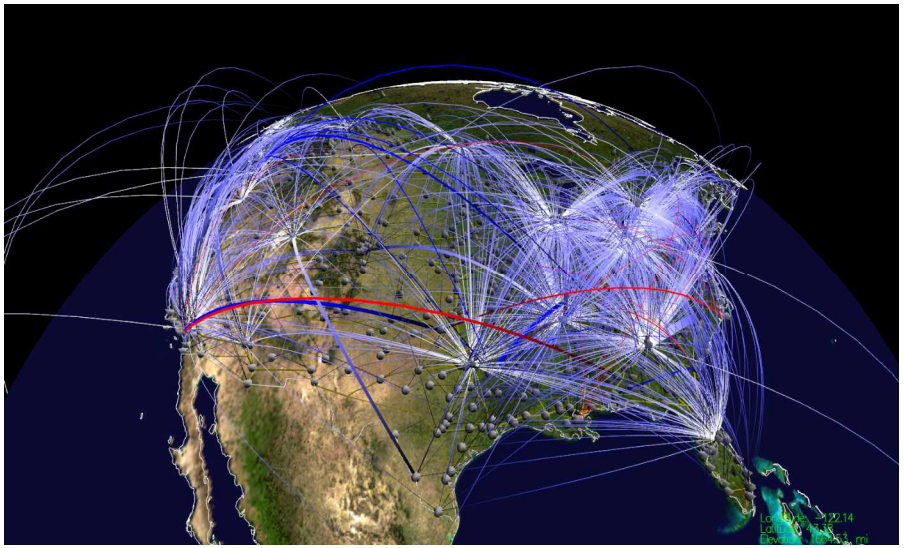


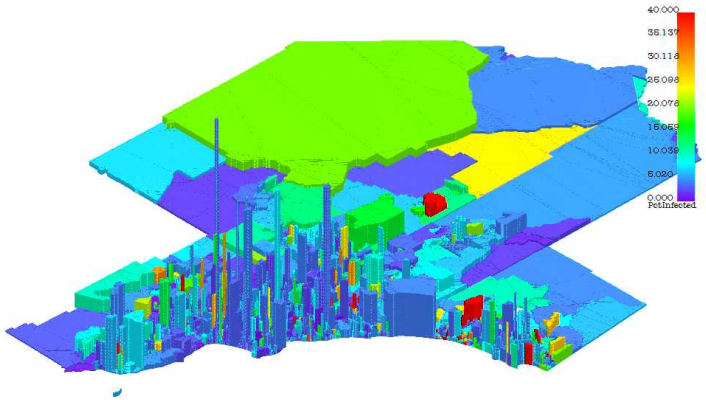
Who We Are and Our Mission

- 90 scientists & researchers from Sandia & Los Alamos National Laboratories; joint project; building on Kirtland AFB, New Mexico
- 2001 Patriot Act formally established NISAC, but around since 90s
- 2007 Homeland Security Approp. Act expanded NISAC mission
  - "**source of national expertise** to address **critical infrastructure protection…"**
  - … **counterterrorism, threat assessment, and risk mitigation**
  - … **natural disaster, act of terrorism, or other manmade disaster**
  - …**modeling, simulation, and analysis** … to **enhance preparedness, protection, response, recovery, and mitigation activities**."
  - Directs NISAC share with Federal agencies with departments with critical infrastructure responsibilities under HSPD-7 – NIPP partners

NISAC's goal – understand, prepare for, and mitigate the consequences of infrastructure disruptions

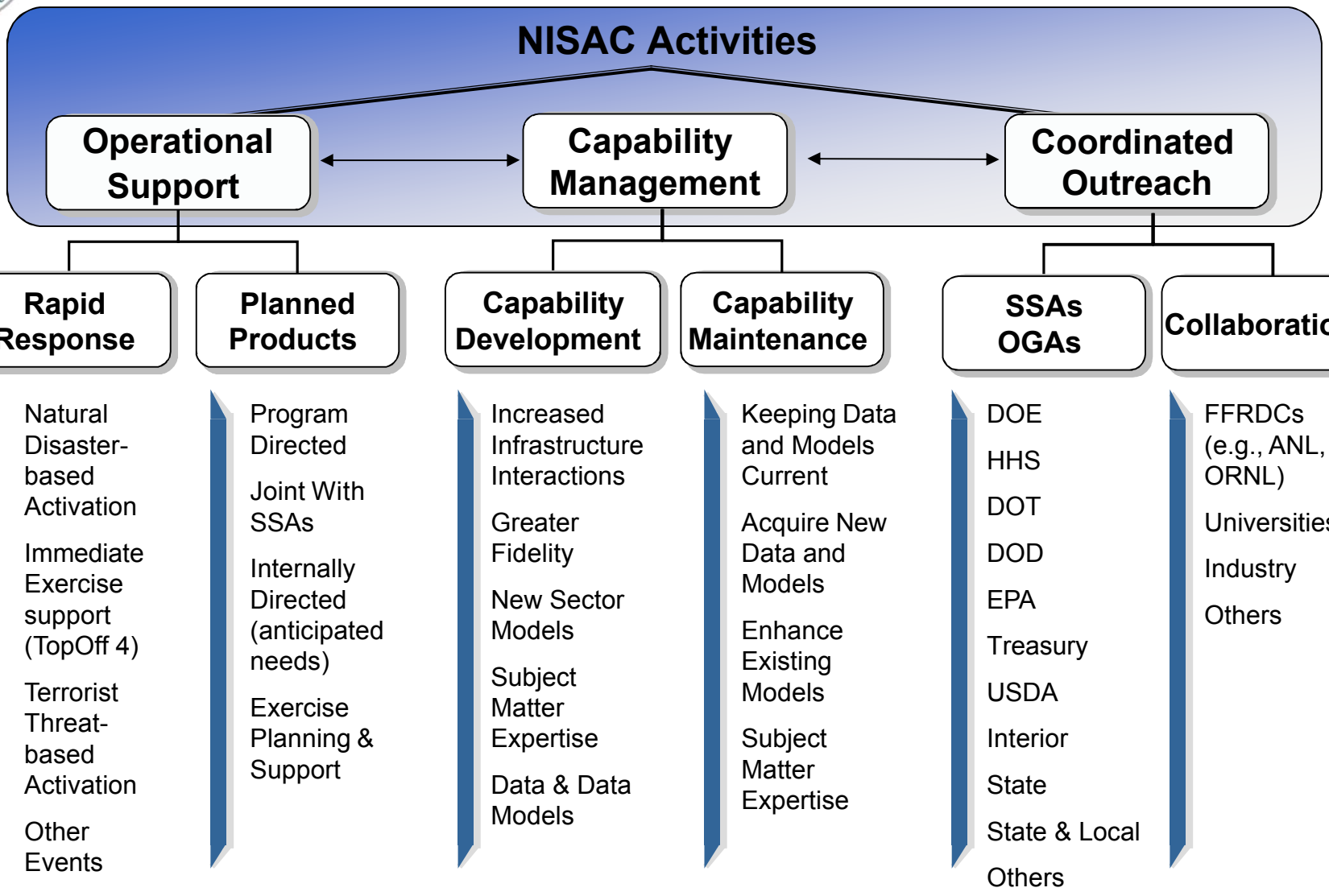
- Provide a common, comprehensive view of U.S. infrastructure in response to disruptions
  - Scale & resolution appropriate to the issues
- Build DHS capability to respond quickly to urgent infrastructure protection issues





What we want to know about infrastructures and their interdependencies is…

- Are there any time bombs?
- Are there any weak points we don't know about?
- 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?


NISAC Activities
Operational Support
Capability Management
Coordinated Outreach
Rapid Response
Planned Products
Capability Development
Capability Maintenance
SSAs OGAs
Collaborations
Natural Disaster-based Activation
Immediate Exercise support (TopOff 4)
Terrorist Threat-based Activation
Other Events
Program Directed
Joint With SSAs
Internally Directed (anticipated needs)
Exercise Planning & Support
Increased Infrastructure Interactions
Greater Fidelity
New Sector Models
Subject Matter Expertise
Data & Data Models
Keeping Data and Models Current
Acquire New Data and Models
Enhance Existing Models
Subject Matter Expertise
DOE
HHS
DOT
DOD
EPA
Treasury
USDA
Interior
State
State & Local
Others
FFRDCs (e.g., ANL, ORNL)
Universities
Industry
Others

Collaborations Throughout Government, Private Sector and Academia

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 at Urbana-Champaign
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

NSTAC
Goodyear
Florida Power and Light
AON
RMS
SRI-C
Veterans Administration
AIR
Lucent/Alcatel
Microsoft Research
SAMSI
Bell Labs
Scalable Networks
Motorola
ERCOT
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

Capability Development Strategy

Highly Connected and Interdependent Infrastructures	Essential and Highly Dependent Infrastructures	Economic Sectors	Assets
• Energy • Banking & Finance • Telecommunications • Transportation	• Health Care • Ag & Food • Water • Government • Chemical	• Residential • Commercial • Industrial	•Power lines •Banks •Central offices • Bridges •Many more…
Commerce and national economic security depend on these infrastructures	Human health and safety depend on these infrastructures	Source of demand and labor for infrastructures	Potential targets

Fast-Turn Analysis Examples

2008
- National Level Exercise 2 - 08
- Transportation corridors analysis
- International asset analyses

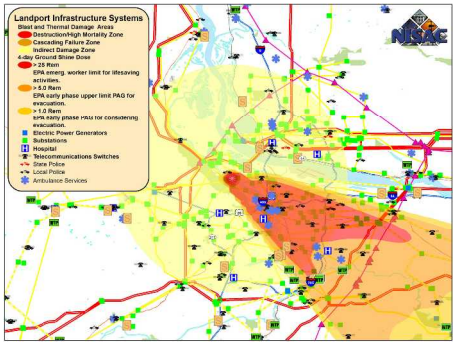
2007
- Minnesota oil pipeline explosion
- California wildfires
- TOPOFF IV
- I-35W Bridge Collapse
- Rail car TIH release scenario
- Ardent Sentry exercise support

2006
- Pre-Hurricane scenario analyses
- Detroit MSA chemical analysis
- International Energy impact analysis

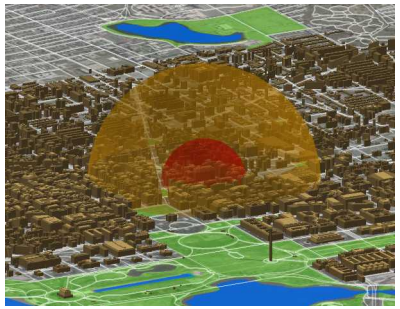
2005
- Hurricane Damage and Recovery (Dennis, Emily, Katrina, Rita, Wilma)
- Avian Influenza CATF Exercise Support
- Urban Area Security Initiative IV
- Transit tunnel analyses - London bombing
- Hazardous Chemical Transportation Policy

2004
- Hurricane Damage & Recovery (Frances, Ivan)
- Economic Impacts of 2003 BSE discovery

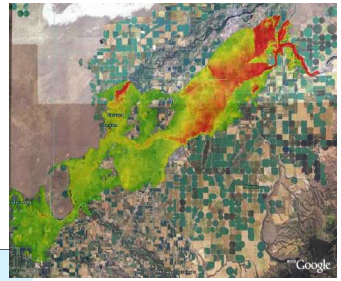
2003
- Hurricane Isabel Damage and Recovery
- Holiday Threat



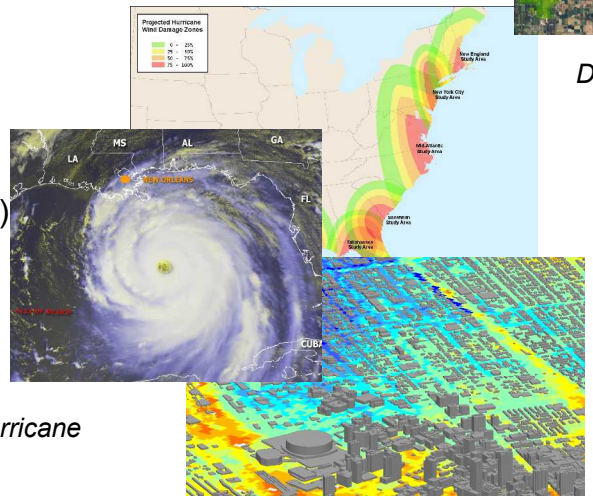
Infrastructure and Population Impacts



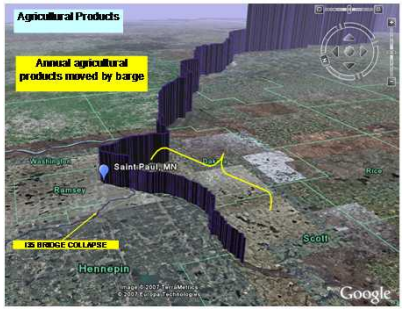
Improvised Nuclear Device



Dam Break



Hurricane



Example Planned Analysis Products

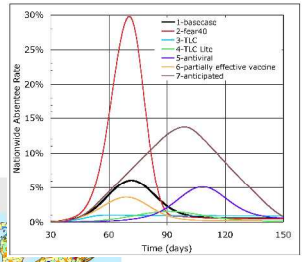
2007
- Earthquake Impacts (California, New Madrid Seismic Zone)
- Petrochemical global supply-chain disruption impacts
- Long-term economic impacts of Hurricane Katrina
- Dam failure impacts – case studies

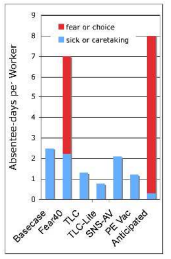
2006
- Pandemic Influenza Impacts and Mitigation Design
- National Hazards Mitigation
- Regional Economic Impacts
- Air Transportation disruption impacts

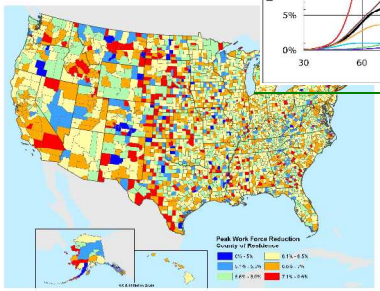
2003- 2005
- Gulf Coast infrastructure disruption impacts
- Pacific NW port security impacts
- National rail system asset disruption
- Chlorine transportation disruption
- Risk-based asset prioritization

Key Results – Workforce

- Analysis quantified absenteeism impacts on infrastructures and economic sectors nationally by county



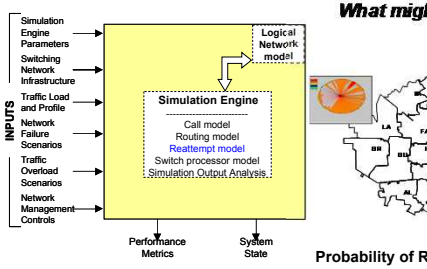




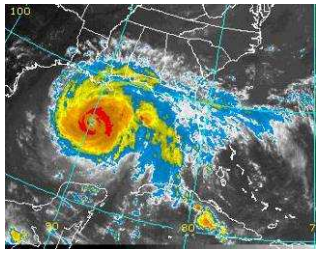
- Counties are impacted by absenteeism differently due to demographic differences (e.g., household size)

N-SMART Voice Simulation Architecture

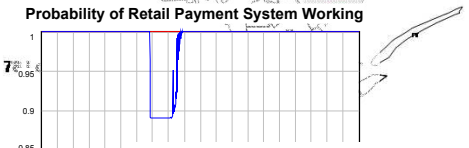
Network-wide model that includes trunks and switch processor resources, network management controls, and customer behavior in a single model.
➔ models the interaction between wireline and mobile networks.



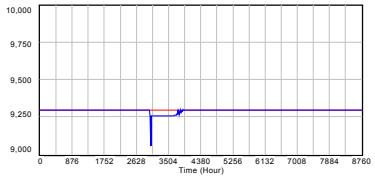
What might have been the impacts to telecom had Hurricane Rita directly hit Houston?



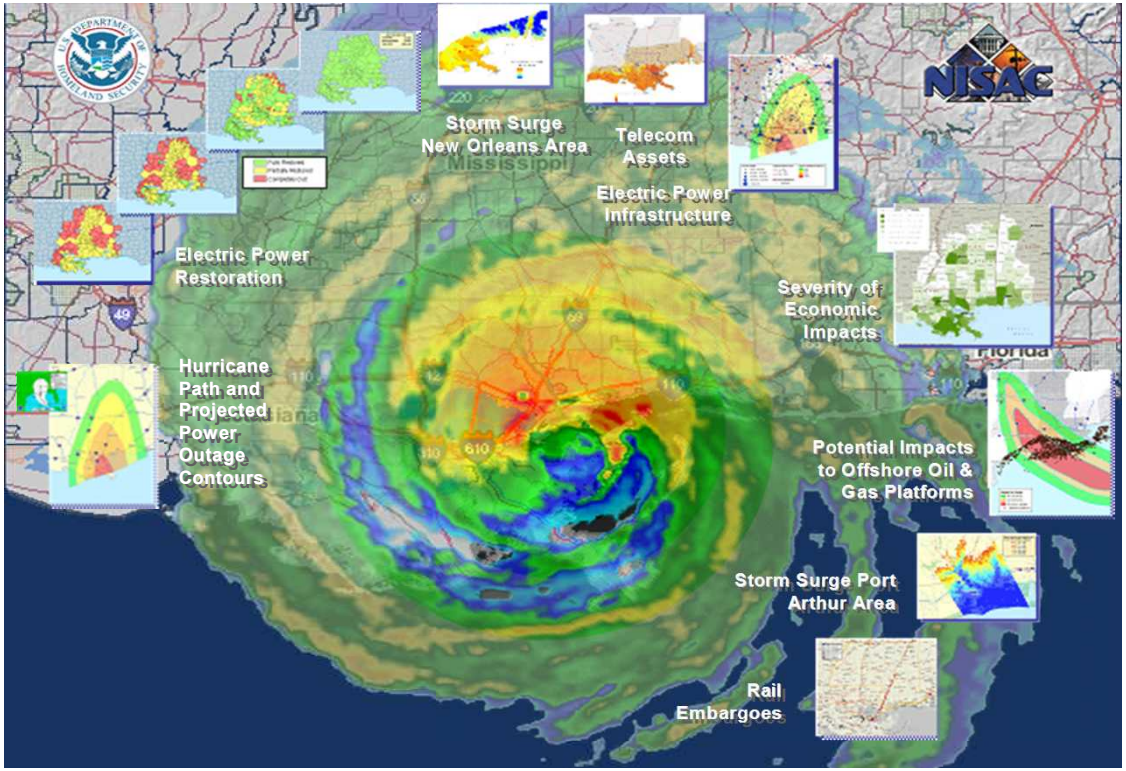
Probability of Retail Payment System Working



Total Product Transfer Capacity from Exporters



Hurricane Impacts
Pre-Season Analyses and Real-Time Response



2007

Flossie

Dean

2003

Isabel

2004

Frances

2006

Ernesto

Ivan

2005

Dennis

Wilma

2005

Ophelia

Rita

Katrina

Emily

Evolution of Hurricane Analyses

2003

Populations, outage, concerns for infrastructures, cost

2004

More systematic approach, refined interlaboratory cooperation, integrated capability development and responsibilities

2005

Expanded scope. Population details, more infrastructures covered. Identified needs for tools and automation

2006

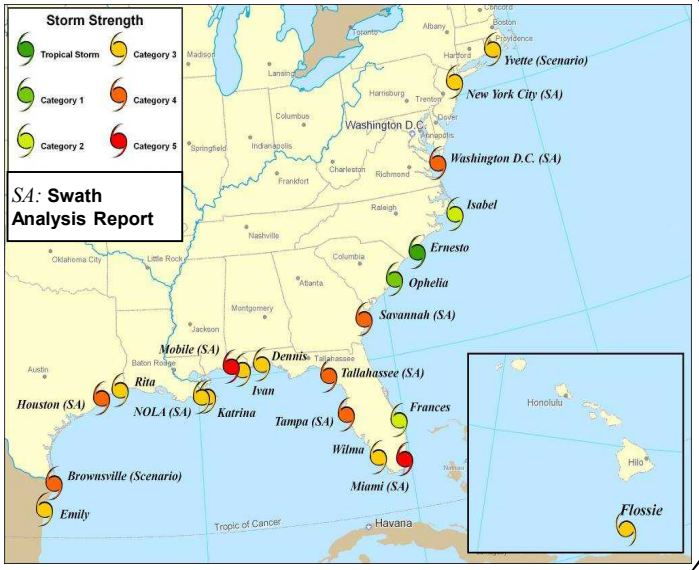
First scenario analyses. Expanded breath and depth, tools and automation enabled more time for analysis

2007

Extended geographic coverage, initiated 2-pagers, greater use of restoration data

2008

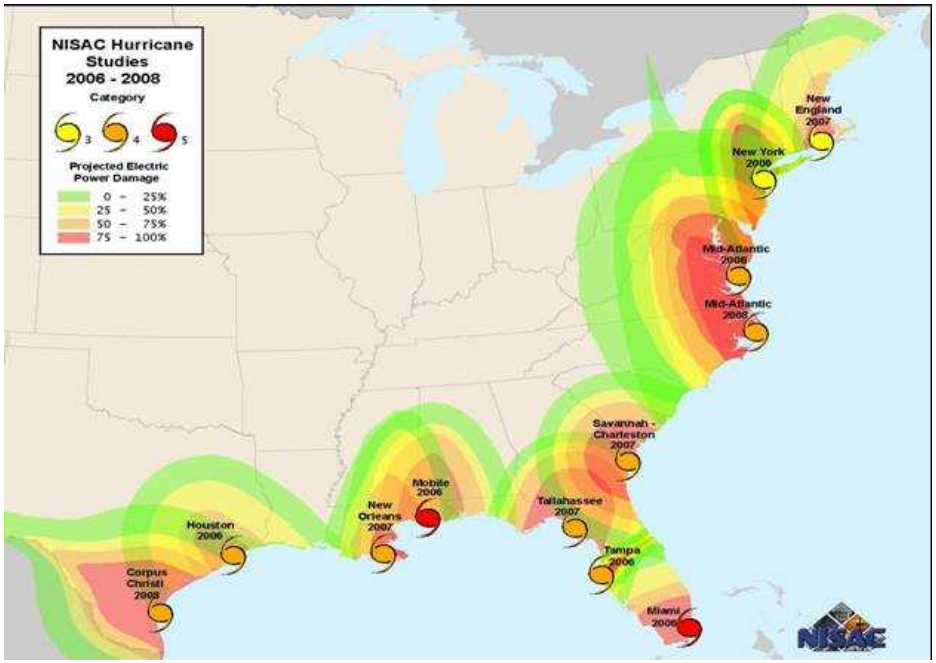
Complete coverage of coastal areas, improvements to algorithms/refinement of models



NISAC Hurricane Analyses: Real and Scenario

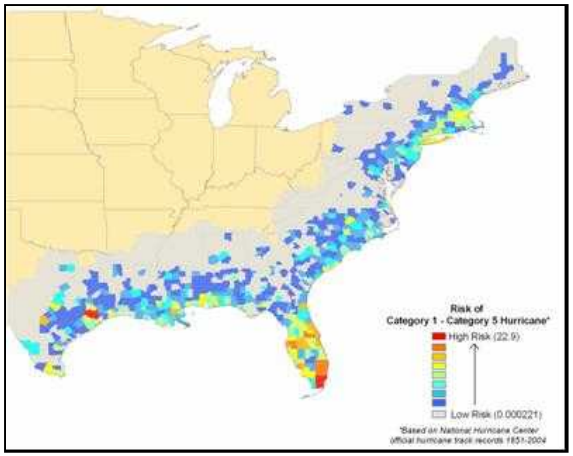
2003: **Isabel**: 1 pre-event; 1 post-event
2004: **Frances**
Ivan
2005: **Dennis**
Emily
Katrina: 2 pre-event; 10 post-event
Rita: 4 pre-event
Ophelia
Wilma: 3 pre-event
2006: NYC Scenario
Mid-Atlantic Scenario
Miami Scenario
Tampa Scenario
Mobile Scenario
Houston/Galveston Scenario
Ernesto
2007: Yvette: Ardent Sentry Scenario
Savannah Scenario
Tallahassee Scenario
New Orleans Update
Flossie
Dean
2008: Mid-Atlantic Scenario update
Corpus Christi Scenario

Bold: indicates real-time analysis

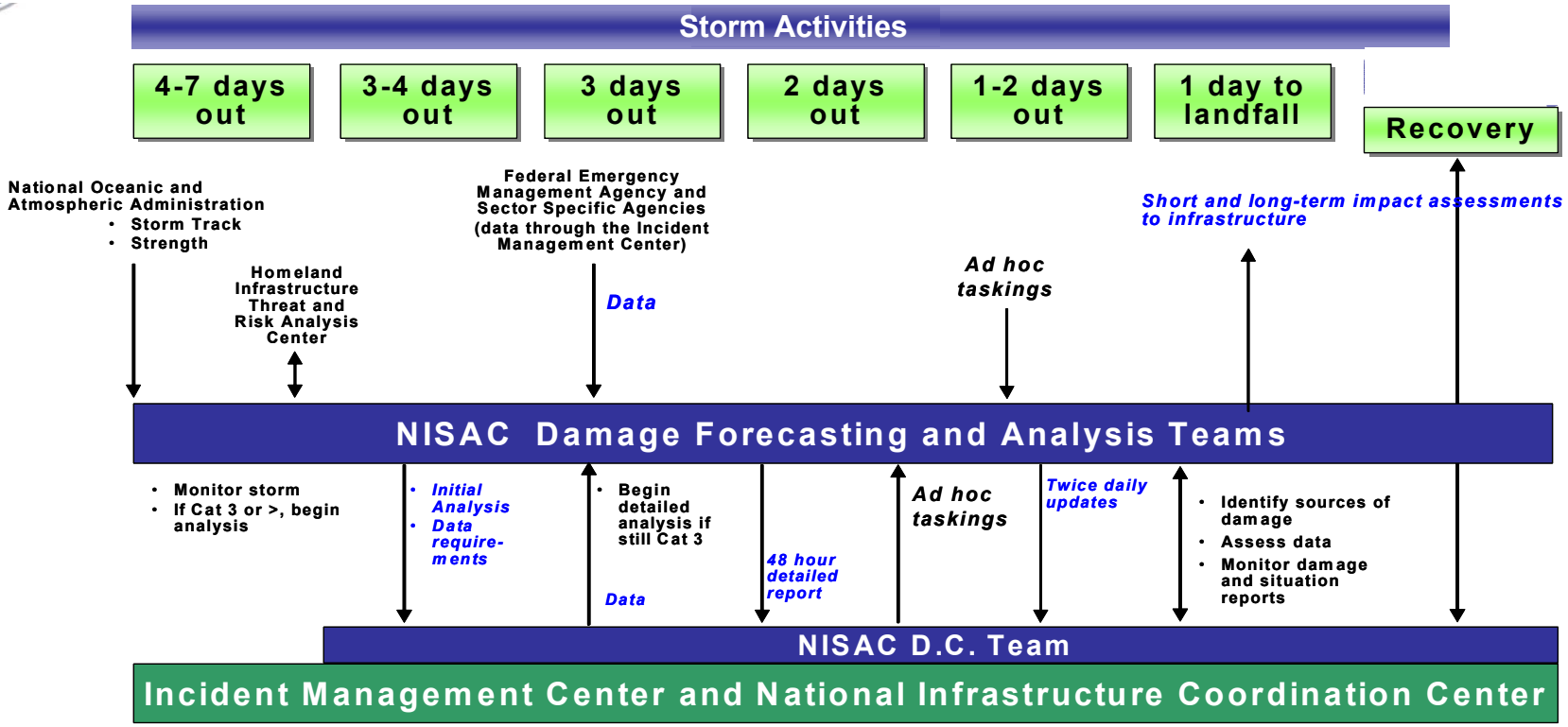


24 Hurricane / Hurricane Scenario Analyses

12 Real-time analyses
12 Scenario analyses
- Situational awareness, information "on the shelf"
- Identify needs - tools and analyses
- Expedite real-time analyses



NISAC Hurricane Analysis Support



L-7 to L-4 Days
Storm Monitoring
Category 2 or above:
Activate Damage Forecast Team

L-4 to L-3 Days
Category 3 or above:
L-96 Hour Preliminary Report
L-72 Hour Preliminary Report

L-2 Days
L-48 Hour Pre-landfall Hurricane Analysis Report
2-Page Summary Report
Activate Damage Analysis Team

L-2 to L-1 Days
Updates to Pre-landfall Report

Post-landfall
Monitor and analyze impacts on critical infrastructure and key resources

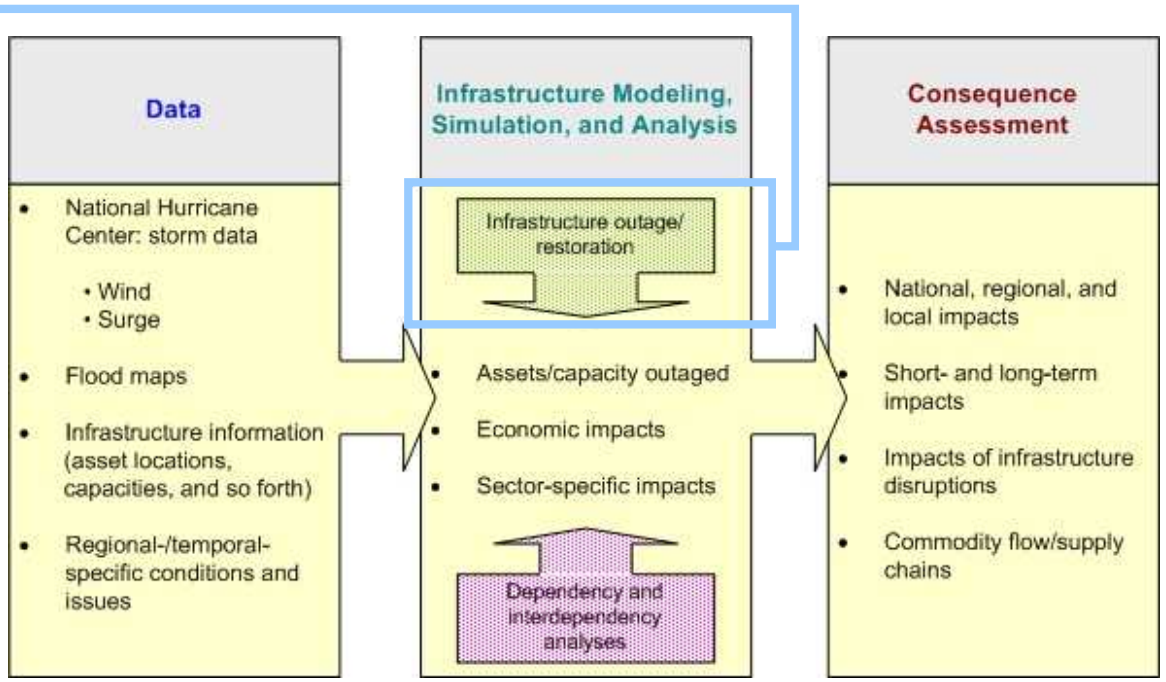
L=Landfall

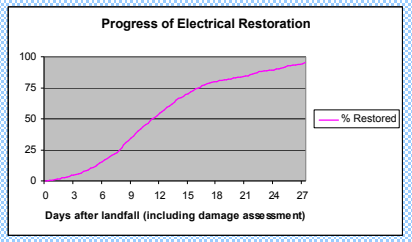
Topics Covered in 48 Hour Report

- Storm/Event Data
- Storm Surge and Flooding
- Electric Power Damage and Restoration
- Population
- Energy
  - Electric Power
  - Natural Gas
  - Petroleum, Oil, and Lubricants (POL)
  - Nuclear Reactors, Material, and Waste
- Chemical and Hazardous Materials
- Telecommunications and Information Technology
- Highways and Highway Bridges
- Ports and Maritime Facilities
- Airports and System Impacts
- Rail Transportation Facilities and System Impacts
- Intermodal Transportation
- Emergency Services, Public Health, Healthcare, Public Broadcast
- Key Interdependencies for Emergency Services
- Water Systems: Drinking Water and Waste Water Treatment Systems
- Dams
- Agriculture
- Critical Manufacturing
- Banking and Finance
- Economic Impacts

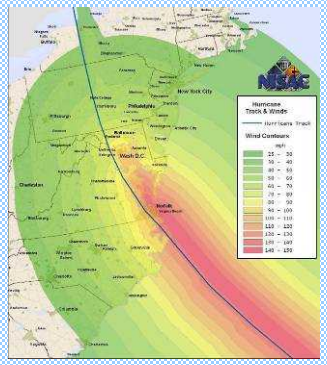
- Populations Affected
- Economic Impacts
- Infrastructure Sectors and Interdependencies

Example Analysis Sequence



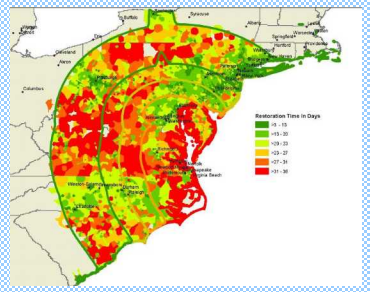


Mid-Atlantic Scenario

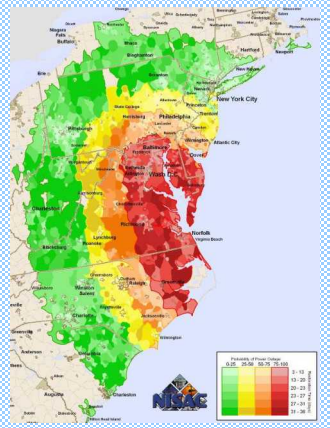


Projected Wind Contours

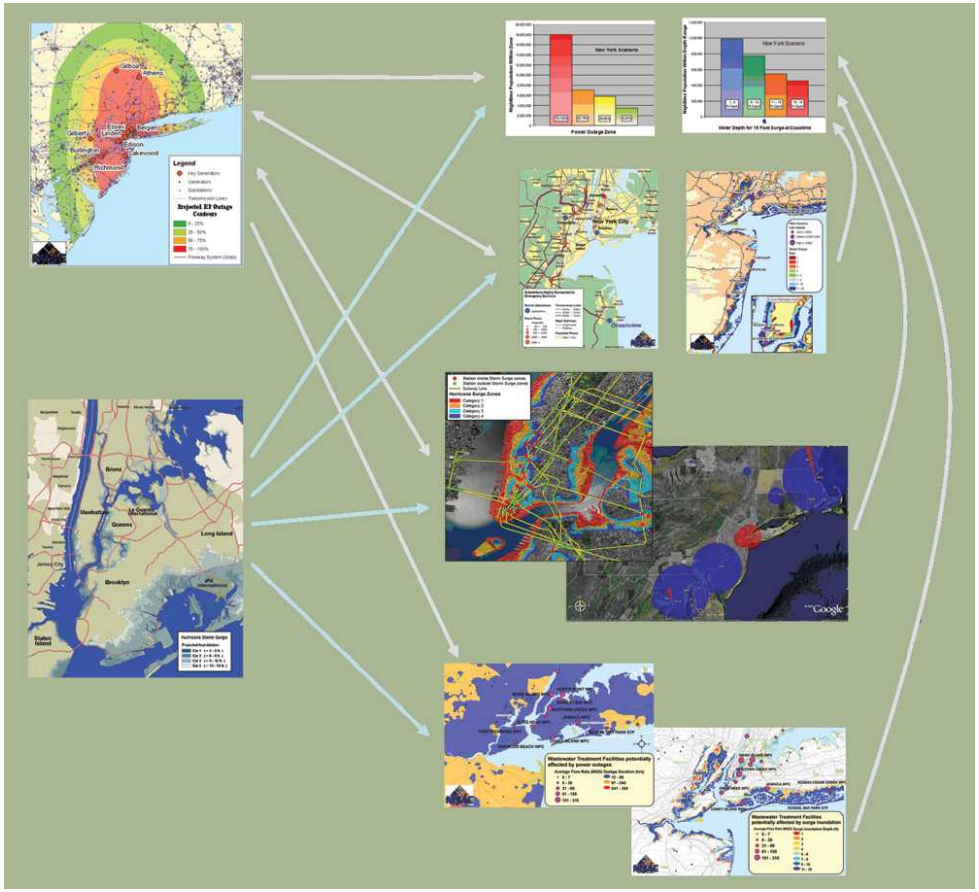
Electric Power Outage Areas



Calculation of Electric Power Restoration Sequence



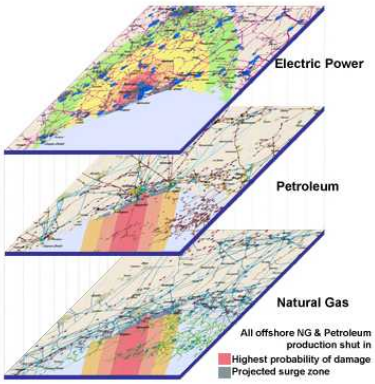
Infrastructure and Interdependencies Analysis



Critical interdependencies among electric power, telecommunications, transportation, and emergency services intensify disruption to population, extend restoration times for all infrastructures.

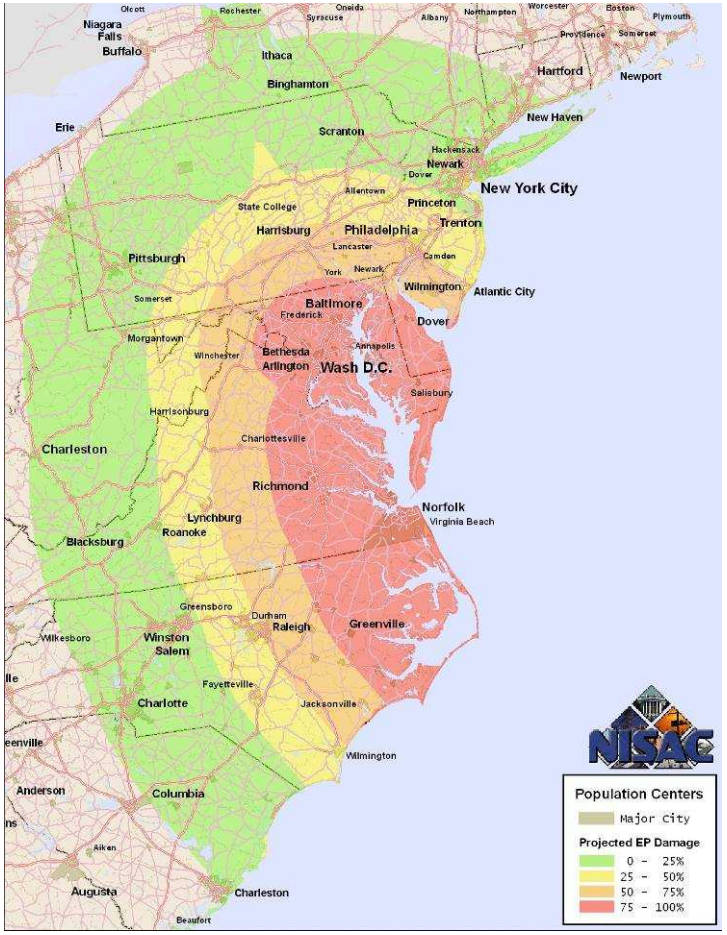
Flood conditions exacerbate electrical disruptions to water and wastewater treatment facilities.

Transportation disruptions in major metropolitan areas have regional and national implications, in addition to their impact on local population movement and ability



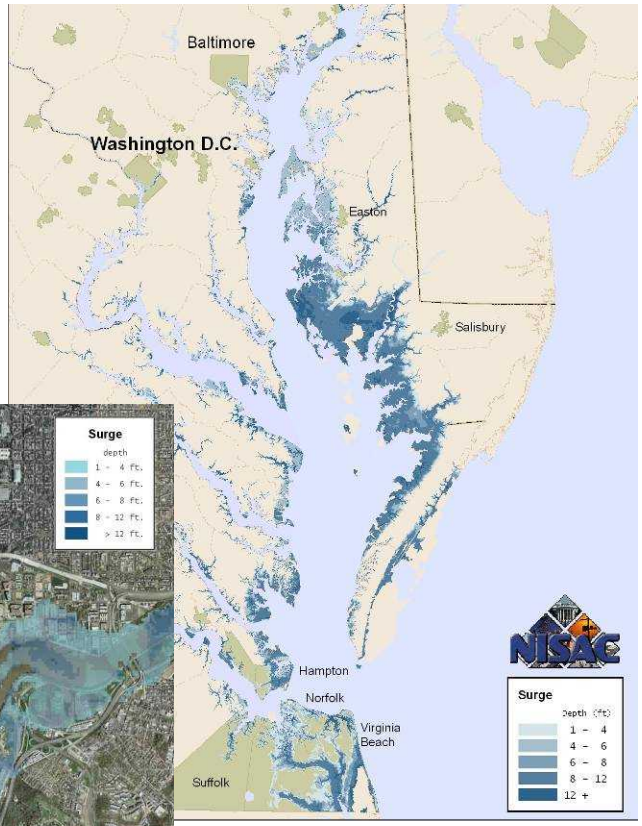
Projected Electric Power Outage Areas for Mid-Atlantic Scenario Hurricane

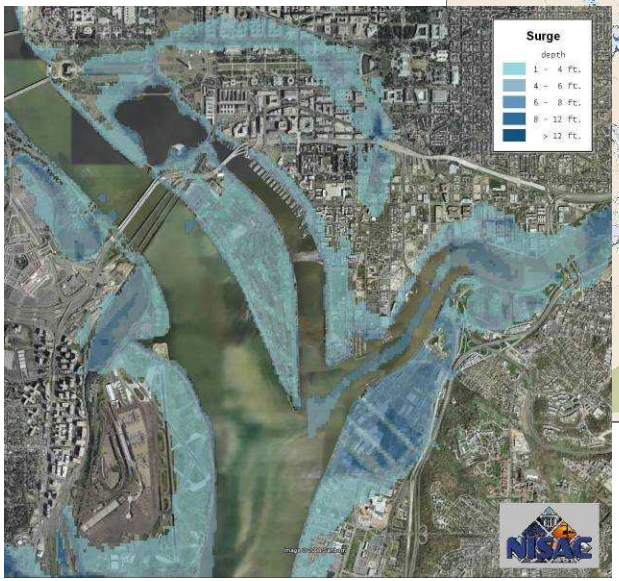
- Damage (thus outage) calculated based on wind speed, wind direction, and knowledge of orientation of transmission grid
  - Red area: projected 75 to 100% outage
  - Orange area: projected 50 to 75% outage
  - Yellow area: projected 25 to 50% outage
  - Green area: projected 0 to 25% outage
- The footprint of this storm is very large. The most highly damaged areas are projected to include:
  - National Capitol Region
  - Norfolk
  - Baltimore



Storm Surge Projection: Mid-Atlantic Scenario Hurricane

- NISAC model used to calculate storm surge inundation
- Storm expected to push a great deal of water into the Chesapeake Bay
  - Storm surge level >12 feet possible in some locations
  - Surge level up to 6 feet possible in parts of DC and Baltimore
  - Extent of flooding in DC metro area is unclear; will depend upon the efficacy of flood control systems.

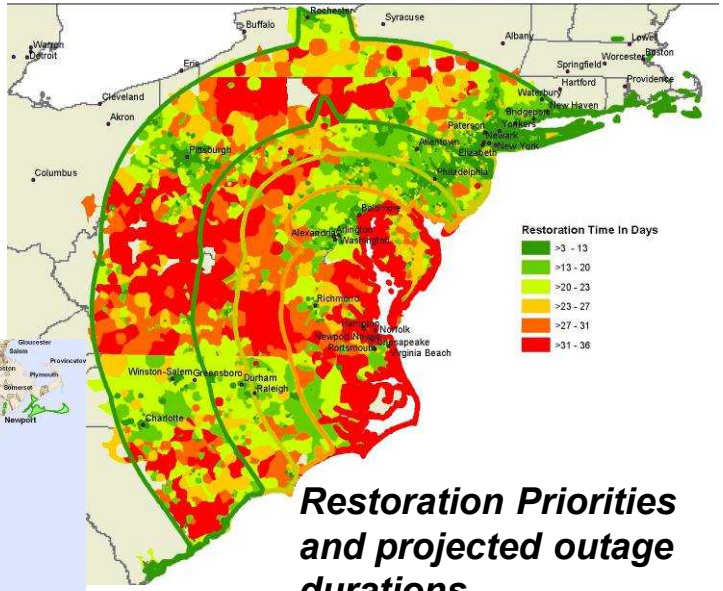




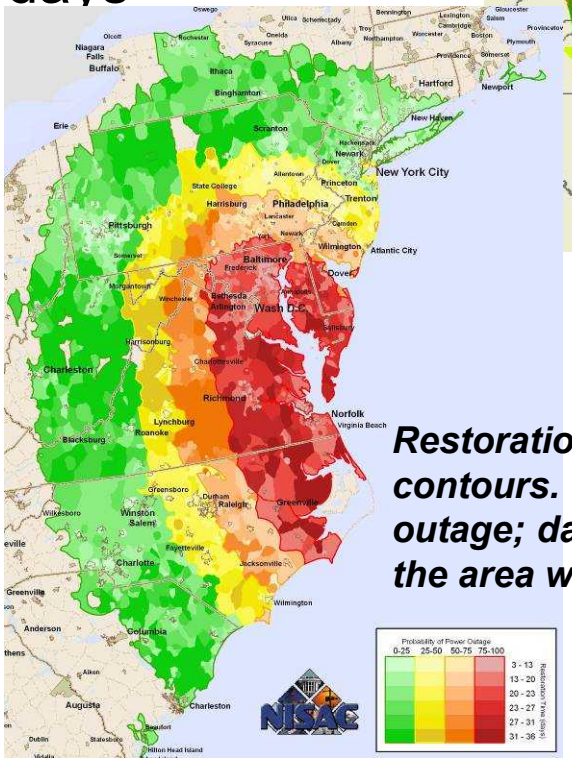
Projected model storm surge for the national capitol region if flood control systems do not function as engineered

Electric Power Restoration Projection: Mid-Atlantic Scenario Hurricane

- 30+ days to complete restoration
- 18 days to 80% restoration
- DC and Baltimore projected to be restored in 3 to 13 days
  - NYC metro region unlikely to be outaged, but if so, restoration will be at highest priority
  - With high priority for restoration, cities will be back on line within 2 weeks



Restoration Priorities and projected outage durations



Restoration priorities and outage probability contours. Color indicates probability of outage; darker shades of each color indicate the area will take longer to restore

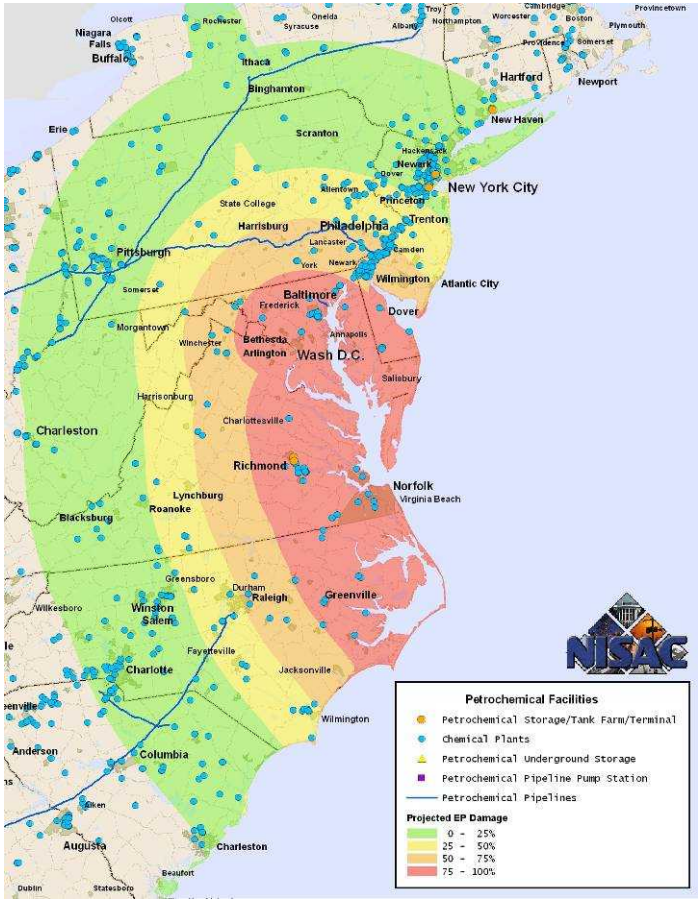
Population Impacts: Mid-Atlantic Scenario Hurricane

- Population affected by power outages
  - 61 million people in entire affected area
  - 23 million expected to lose power
  - 6.5 percent are less than 5 years old
  - 13 percent are over 65
- Population affected by storm surge
  - Approximately 1 million people live in areas projected to be flooded
  - Over 200,000 people live in areas expected to be inundated by over 8 feet of surge
- Although many people are expected to evacuate ahead of the storm, many are expected to need assistance
- Extensive property damage is expected

Chemical Sector Impacts: Mid-Atlantic Hurricane Scenario

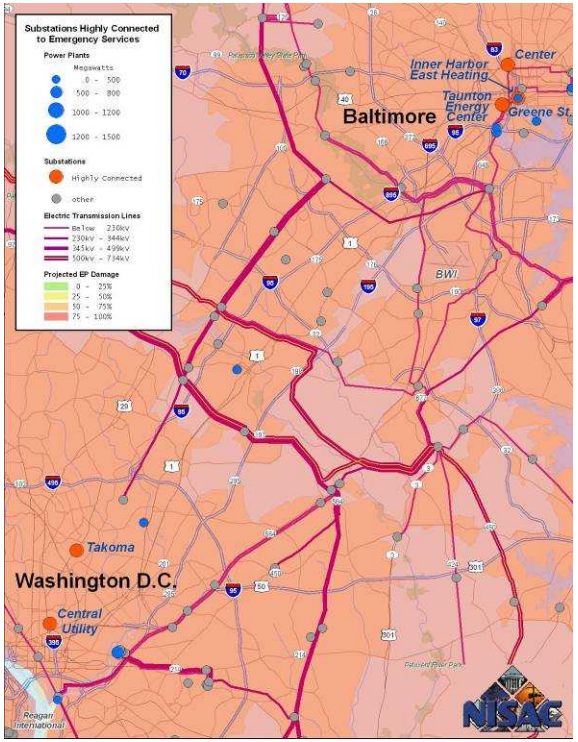
- There are an estimated 570 chemical plants in the disruption zone, although 85% are outside the highest impact area
- Chemical production in affected area includes:
  - 21 chemicals that represent >35% of national demand
  - 100% of 5 specialty chemicals used in agricultural and pharmaceutical industry
  - 45 toxic inhalation hazard (TIH) chemicals
- Chemical facilities shut down at least 48 hours before a forecasted hurricane of Category 3 or above
  - Even without damage, more than 2 weeks are required to bring facilities back online

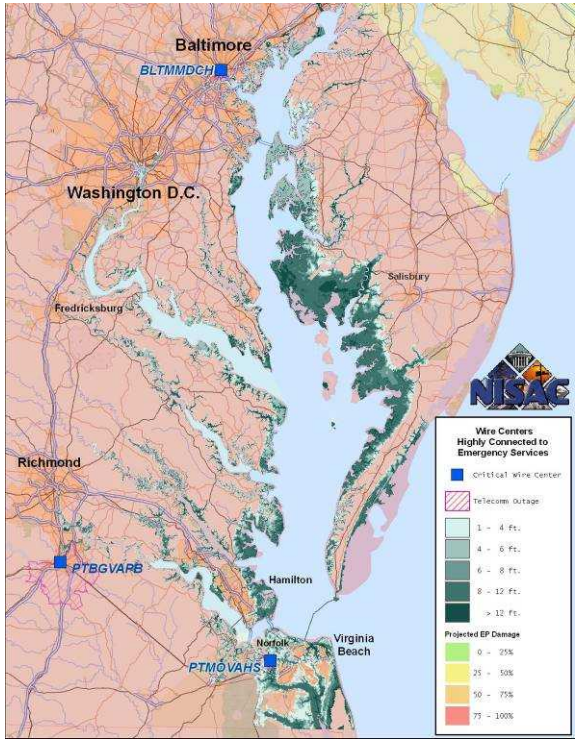
Supply chain impacts are potentially significant for specialty pharmaceuticals and coatings for medicines, and for medical and personal protective equipment (examples include medical gloves, booties, Kevlar®)



Emergency Services Impacts: Mid-Atlantic Scenario Hurricane

- Highly connected utilities crucial to emergency services facility operations in the area of highest impact
  - 6 electric power substations expected to be non-operational for 1-3 weeks
  - 3 telecommunications wire centers expected to be without power for 1-2 weeks
  - 1 wire center in 4-6' surge

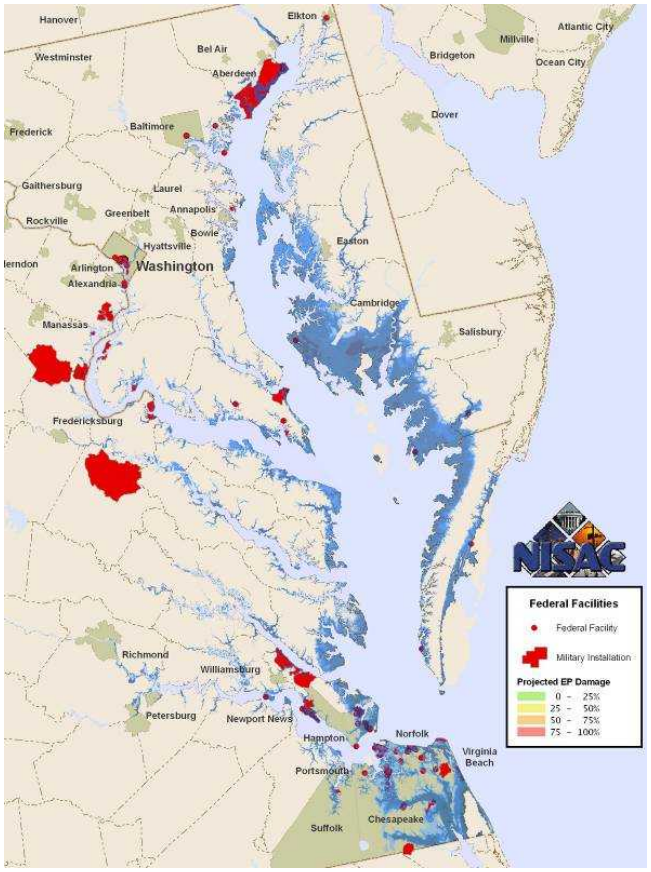


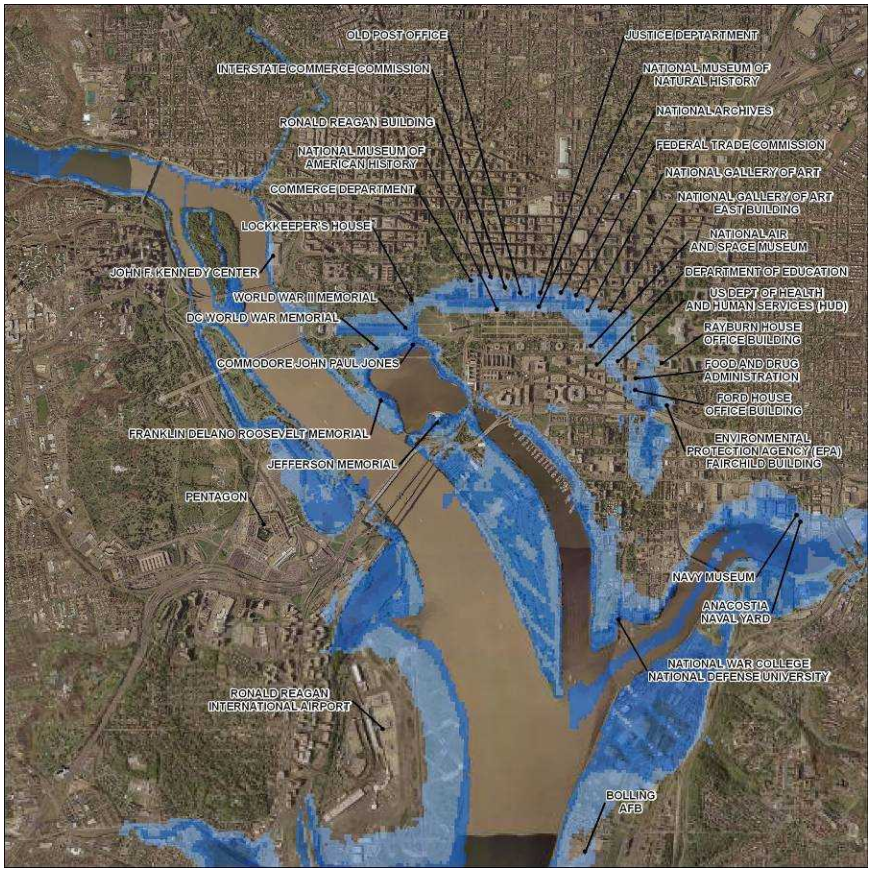


Emergency response delays expected due to transportation, electrical power, and telecommunications disruptions

Communications disruptions could impact 911 service

Government Facility Impacts: Mid-Atlantic Scenario Hurricane



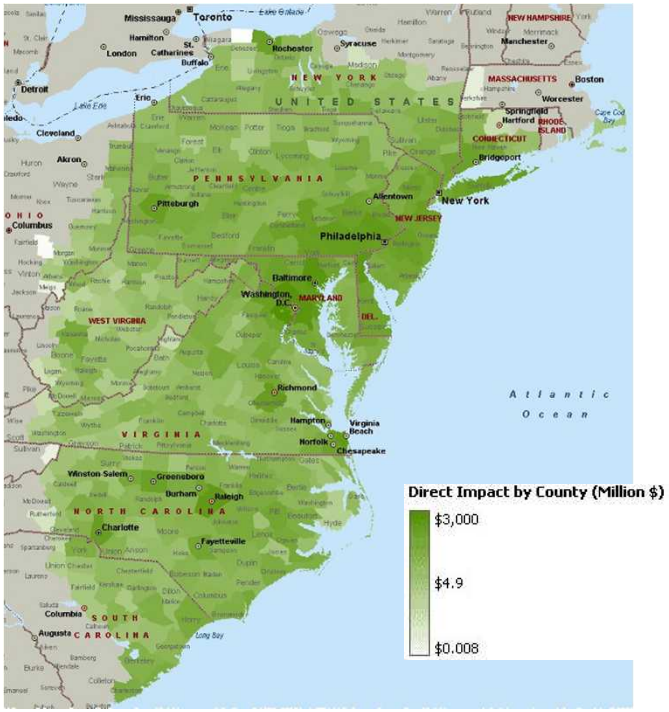


- Total of 96 federal facilities and 40 military installations in entirety of storm surge
- Impacts to various Federal Agency HQs, House Office Buildings, National Archives, Bolling AFB among other facilities in National Capitol Region

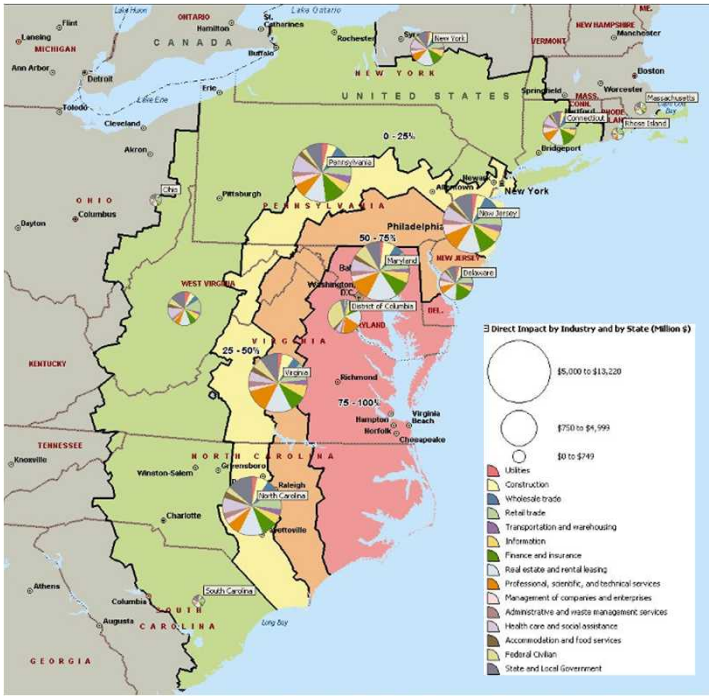
Other Significant Infrastructure Impacts: Mid-Atlantic Scenario Hurricane

- **Public Health**
  - Evacuations / closure of some facilities will increase demand on neighboring regional facilities
- **Telecommunications**
  - Heavy degradation of both wireless and wired network access
  - Risk to long-distance communications most likely in coastal Virginia and Maryland
- **Transportation**
  - Expect airport delays and cancellations due to power outage impacts
  - Ground transportation impacts due to flooding and debris
  - Delays in commodity flow are not expected to create critical commodity shortages
- **Water/Wastewater**
  - Likely need for boil orders and/or bringing water into the area
  - Loss of water supply could impact fire fighting capabilities
  - 4 small water treatment and 2 major wastewater treatment facilities impacted by surge
  - Discharge of raw sewage into waterways and coastal waters possible

Economic Impact Projections: Mid-Atlantic Scenario Hurricane



Distribution of direct gross domestic product (GDP) reductions by county



Distribution of economic impact by state and industry in the storm path

- Direct costs for business interruptions: $64 billion
- Total costs for business interruptions: $178 billion

Impacts of NISAC Analyses

Analysis results have been used in briefings for:

- DHS Assistant Secretary of Infrastructure Protection, Robert Stephan (numerous studies including hurricane analyses, TOPOFF IV, California Wildfires)
- DHS Deputy Under Secretary for National Protection and Programs, Robert Jamison (California wildfires)
- DHS Secretary Michael Chertoff (hurricane analyses – reports on the aftermath of Hurricane Katrina, Hurricane Dean)
- President Bush (Hurricane Katrina, California wildfires)

Analyses have been used in national security exercises

- National Level Exercise – 2
- TOPOFF III and IV
- Ardent Sentry – Northern Edge (Hurricane) and IND (NuDet)
- Senior Officials Exercise IV

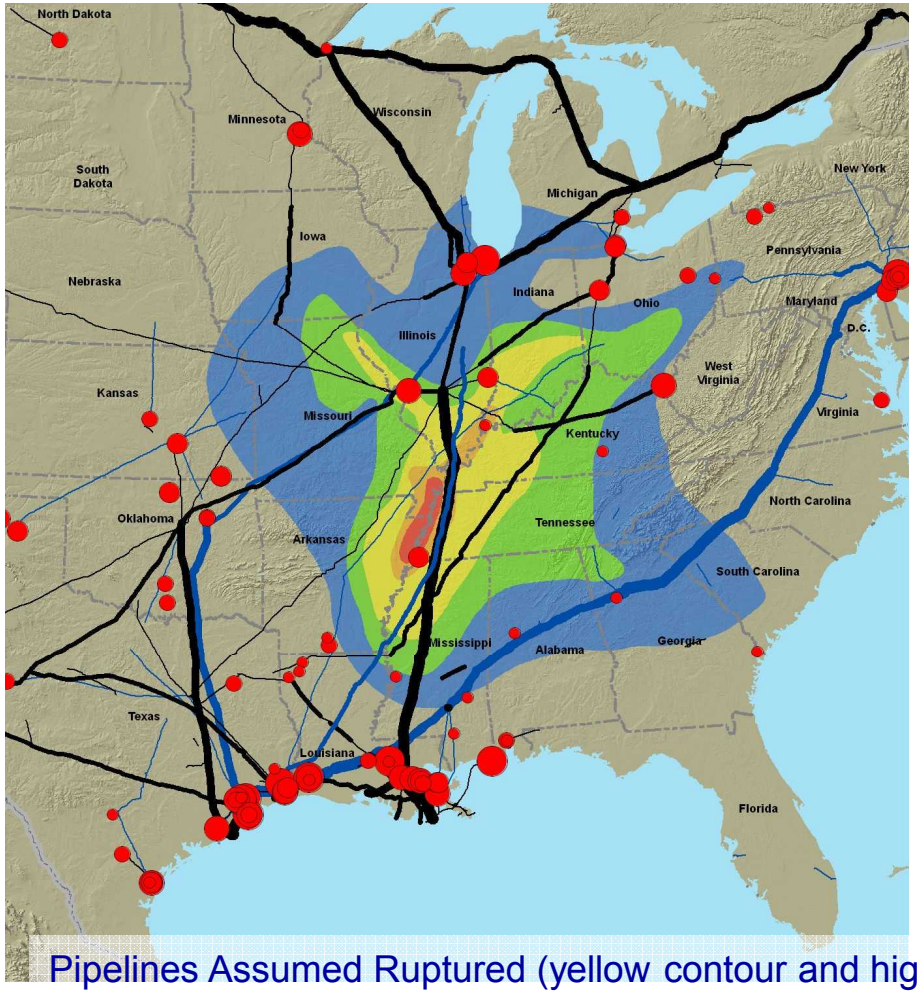
Analyses been requested for policy evaluation

- TIH transportation analysis
- Chlorine analysis

Insights gained

- Avian Influenza / Pandemic Influenza results
- Rail transportation – importance of assets

Petroleum Sector



- For Midwest
  - 1.7m bpd less crude
  - 1.3m bpd less product
  - Leading to a 25% initial supply reduction, increasing to 60% as interruption approaches 3 weeks
- No supply impact on Northeast

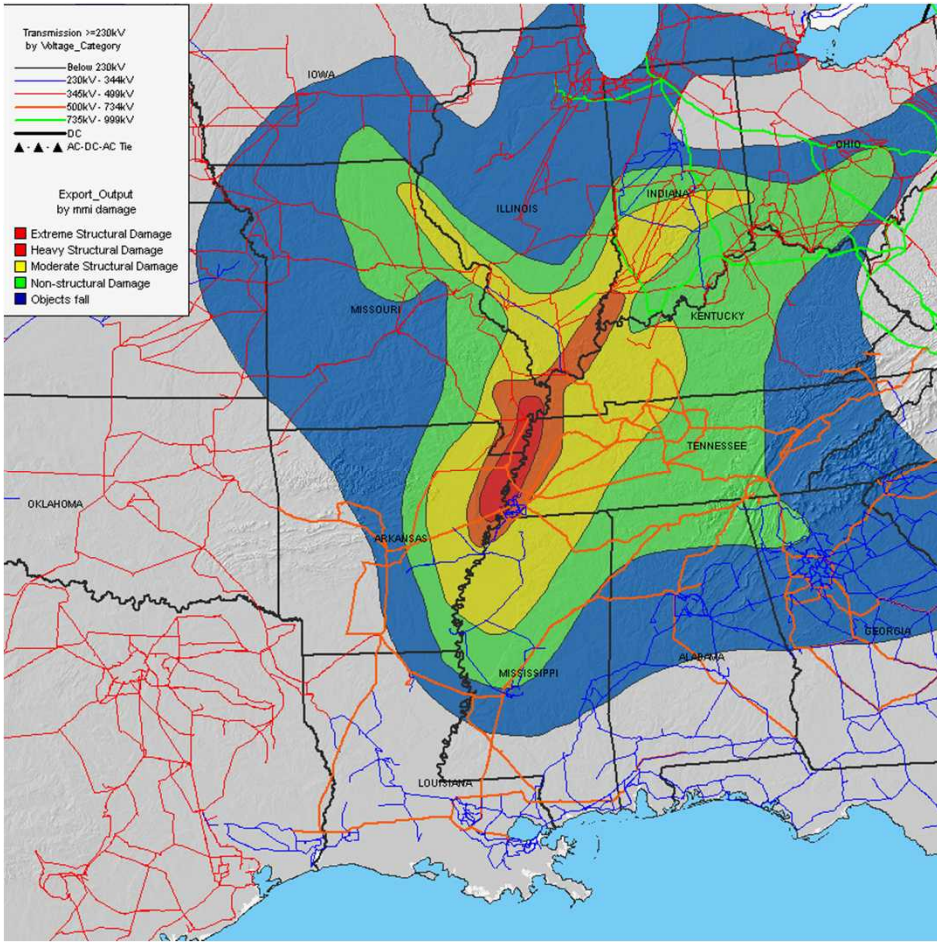
Fuel shortage will impair recovery effort and expand area impacted

Pipelines Assumed Ruptured (yellow contour and higher)

Product: Explorer, Centennial and TE Products

Crude Oil: Capline, Mid-Valley, Enbridge Mid-Continent and ExxonMobile,

Electrical Power Sector

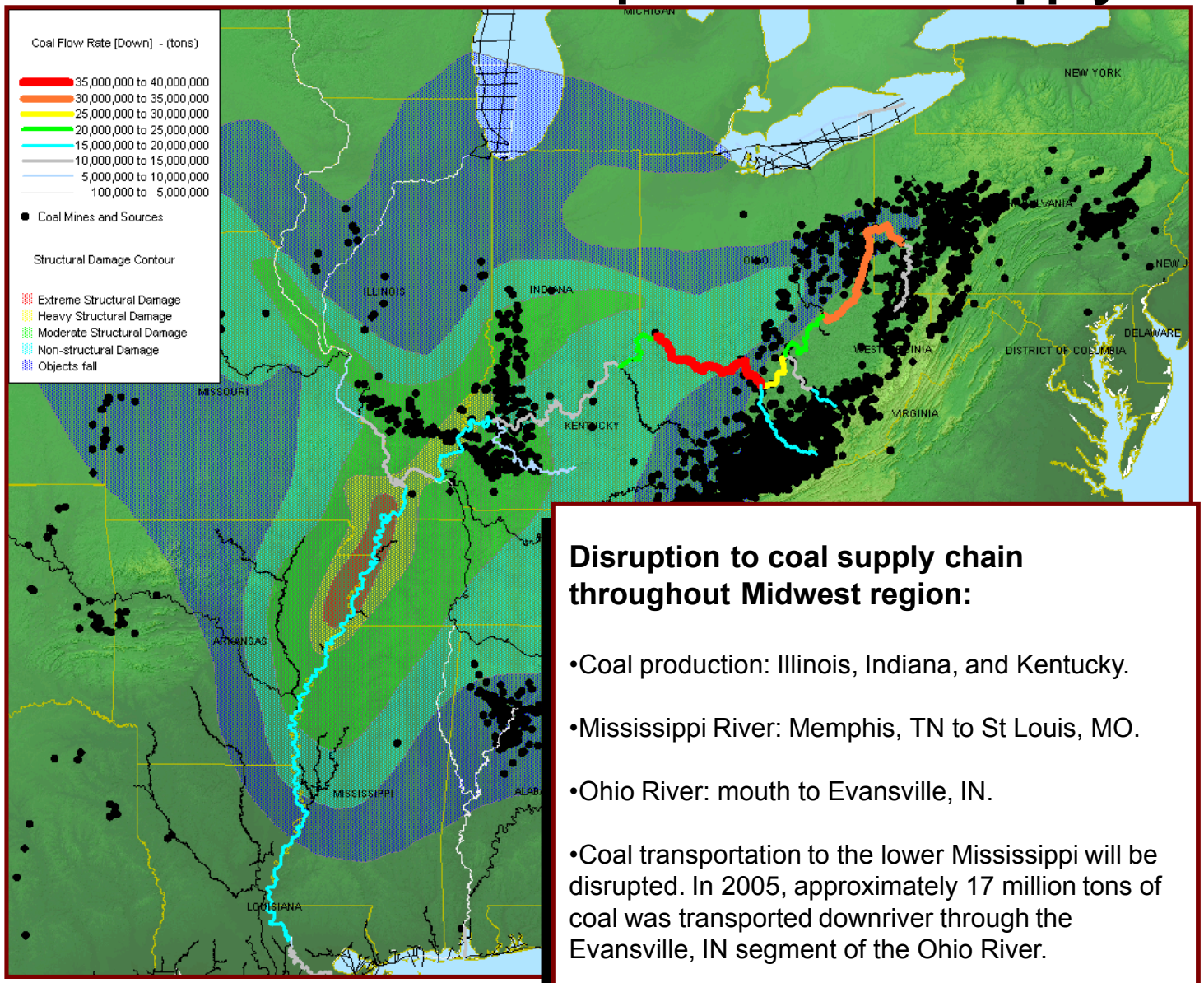


Assumes major substations in yellow contour and higher fail

- Initial regional blackout could extend to the entire east coast and last a week (depending on state of the system at the time of the event)
- Loss of HV transmission across MS river likely to increase power cost
- States outside the damage zone have generation capacity sufficient to satisfy demand

Power outage will impair response time, expand area impacted and economic losses

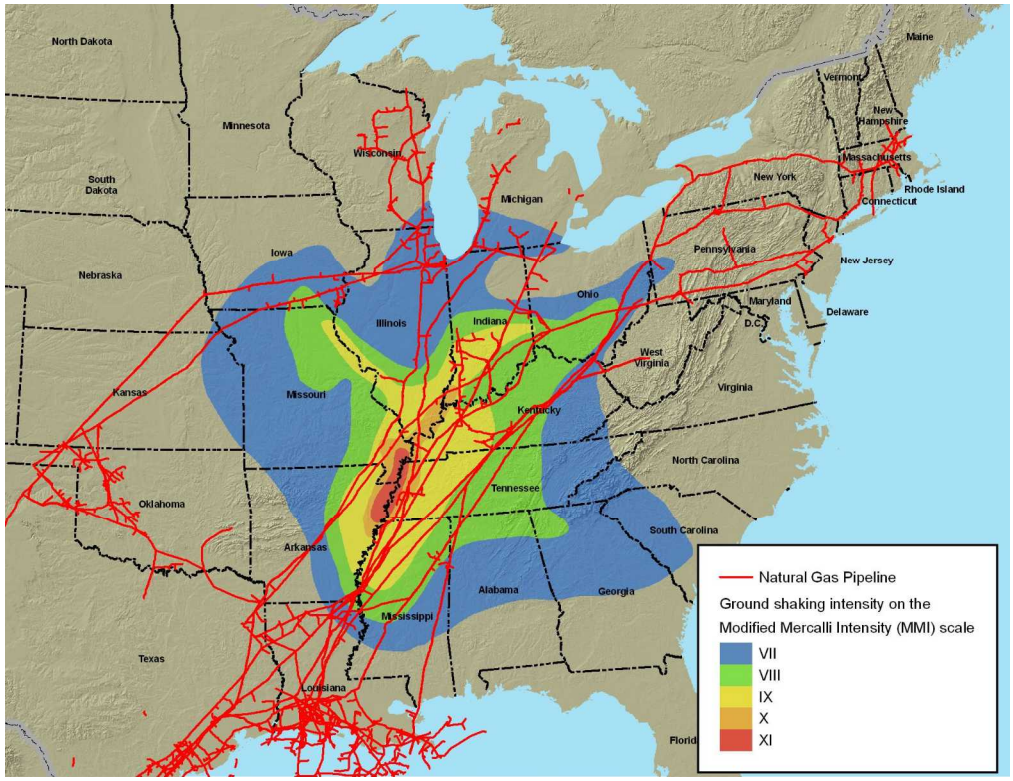
Impact on Coal Supply Chain



Disruption to coal supply chain throughout Midwest region:

- Coal production: Illinois, Indiana, and Kentucky.
- Mississippi River: Memphis, TN to St Louis, MO.
- Ohio River: mouth to Evansville, IN.
- Coal transportation to the lower Mississippi will be disrupted. In 2005, approximately 17 million tons of coal was transported downriver through the Evansville, IN segment of the Ohio River.

Natural Gas Sector



- **About 25% of capacity to Chicago area will be lost**
  - If in summer, can likely maintain normal supply
  - If in winter, deep cuts in consumption would be necessary
- **About 10-20% of capacity to deliver to the northeast US will be lost**
  - The impact to the Northeast will also depend on season, but the ability to replace lost volumes is greater
  - Volumes can be increased on pipelines moving gas East, as well as those moving gas South

Assume pipelines in 2 zones of highest damage (orange and higher) will rupture

Natural Gas disruption will expand area and population impacted if it occurs or extends to winter months

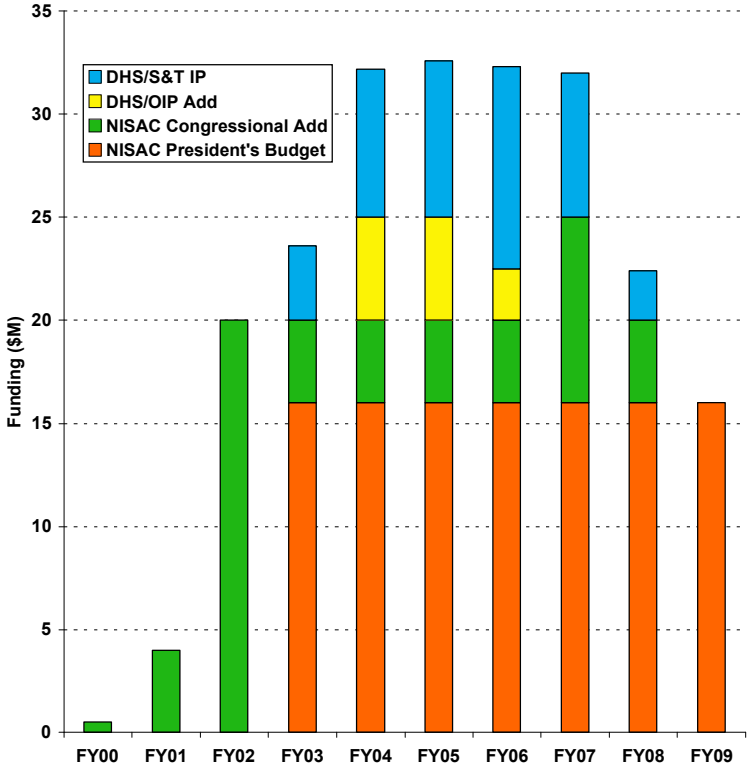
Summary of the 2007 Analysis

- Performed survey of impacts to energy and transportation infrastructures
- Possible electric-power blackout over much of eastern U.S. for up to a week
- Concluded that disruption to oil and natural gas transmission pipelines could cause severe impacts:
  - Capacity to serve the Chicago area with natural gas could be reduced by about 25 percent; capacity to serve the northeast U.S. could be reduced by 10 to 20 percent
  - Possibly a 60 percent shortage in transportation fuels in the central U.S.


NISAC

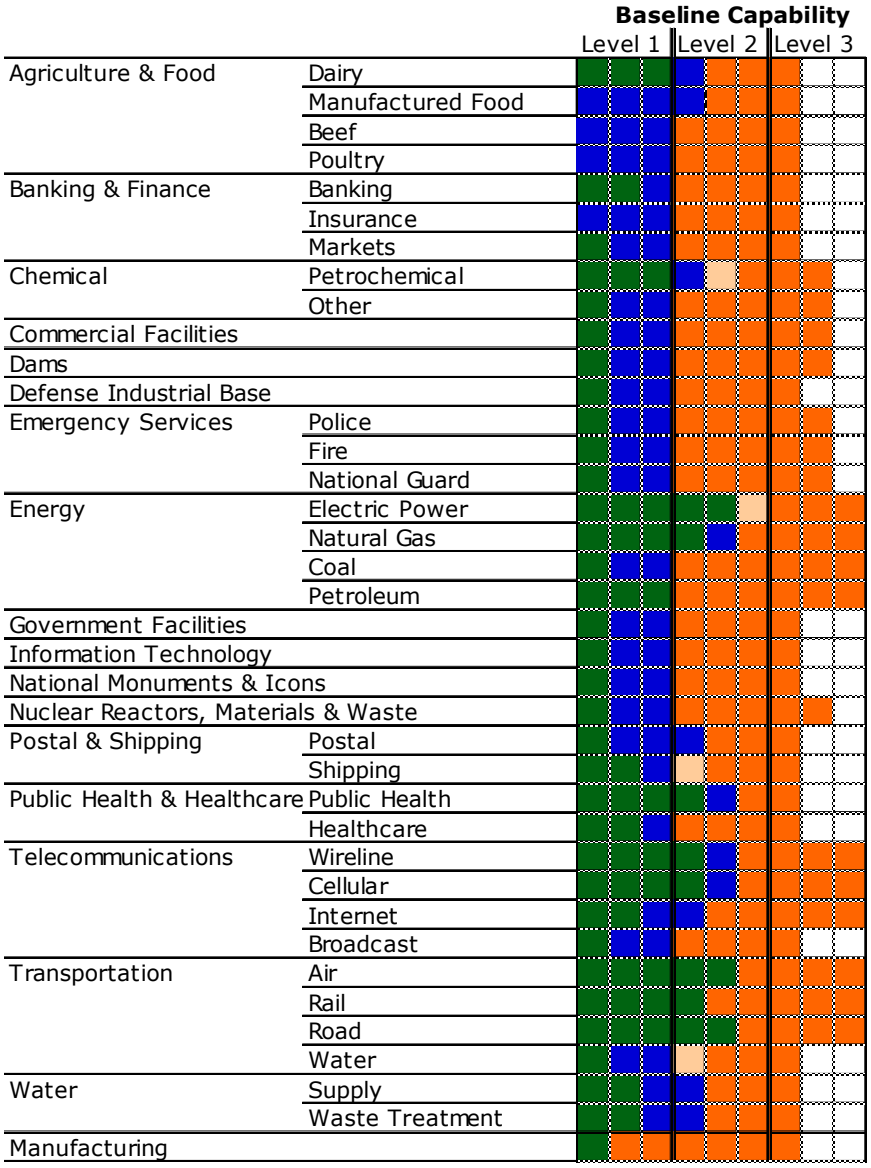
NISAC Funding History

- Initially Congressionally mandated
- President's budget - FY03 through FY09 $16M per year
  - Congressional funding at $20M to $25M
  - FY08 omnibus cut House and Senate $25M to $20M
- FY06 Supplemental (PI) built major capability but was "One-Time"
- DHS/IP "Above Core" funding is no longer budgeted
- Inflation & taxes are also reducing effective funding
  - FY08 DHS/IP Taxes ~$4M



Labs need to plan/staff to expected budgets in FY09 and beyond to meet NISAC mission for DHS

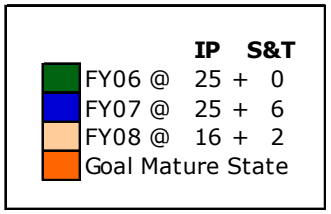
Sector Modeling Capability



Level 1 - Initial screening capability (sector data, aggregate models, single asset or general operation models)

Level 2 - Enhanced screening and priority analysis capabilities (network models with limited asset level representation, intra-sector dependencies and confidence)

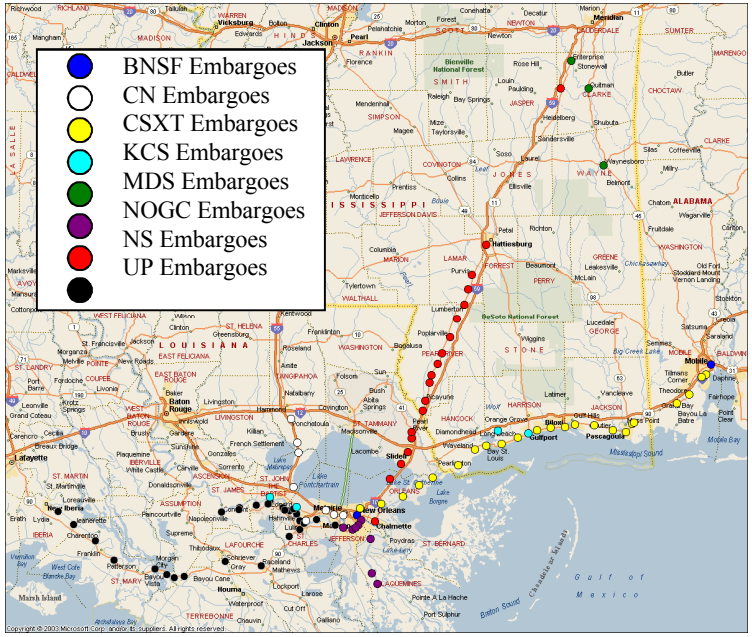
Level 3 – Mature screening and analysis capabilities (detailed, fully-featured, dependency, interdependency, large-scale system, nation-wide coverage and high-degree of confidence)

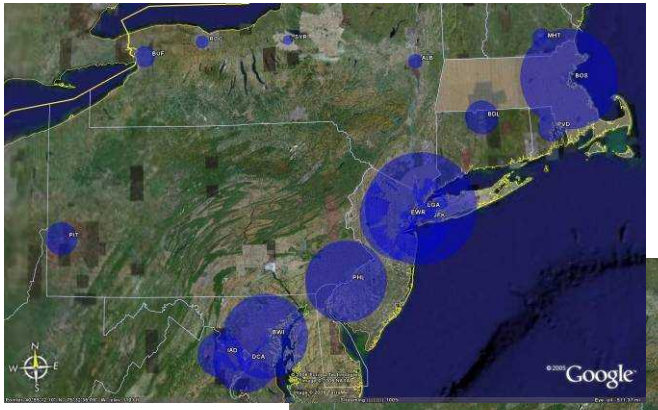


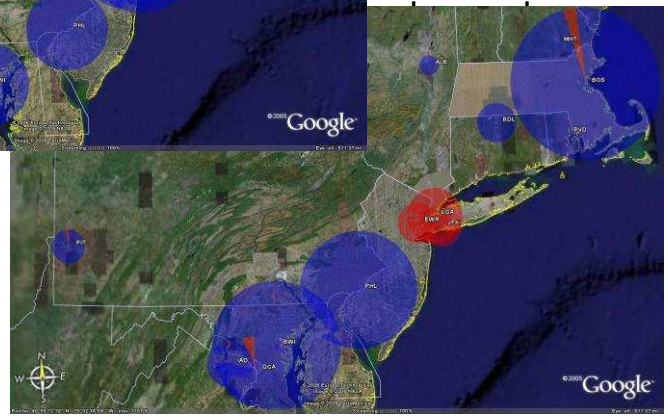
Transportation: Rail and Air

New York City Hurricane Scenario:
How impacts to major airports (JFK, LGA, EWR) affect region/nation

New Orleans Hurricane Scenario:
How impacts to rail lines affect commodity flow







Blue: Demand met

Red: Unmet

Base Case

All demand is met under normal conditions.

Disrupted Case

Demand shifts are only partially met

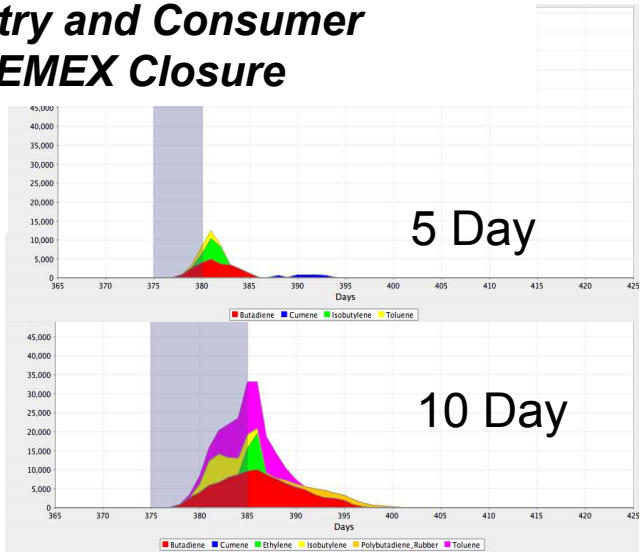
Originating Passenger demand.

Utilization of Longer-Term Efforts: Chemical Supply Chain Analysis

An analytical methodology that represents the chemical supply chain network, captures how a disruption to production or transportation impacts manufacturing and consumption

Hurricane Dean
August 2007

Predicted Industry and Consumer Shortages for PEMEX Closure



Colors represent different petro-chemicals

Results Confirmed Through Consultation with Industry:

- A relatively short closure of the PEMEX facility will cause some raw material availability concerns primarily for the tire and tire product industries
- Minimal effects elsewhere in the economy even for longer durations.
- Behavioral adaptations such a pre-storm surge in crude imports and the precautionary stockpiling of raw materials were not modeled.
    - Results are therefore best viewed as shedding light on short-term difficulties the industry will adapt to, rather than being predictive of catastrophic loss.