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Chemical Supply Chain and Resilience Project Workshop

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Chemical Supply Chain Resilience Analysis for a Hurricane Scenario

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NISAC Hurricane Experience

30 Hurricane/Scenario Landfalls

Real-time Analyses

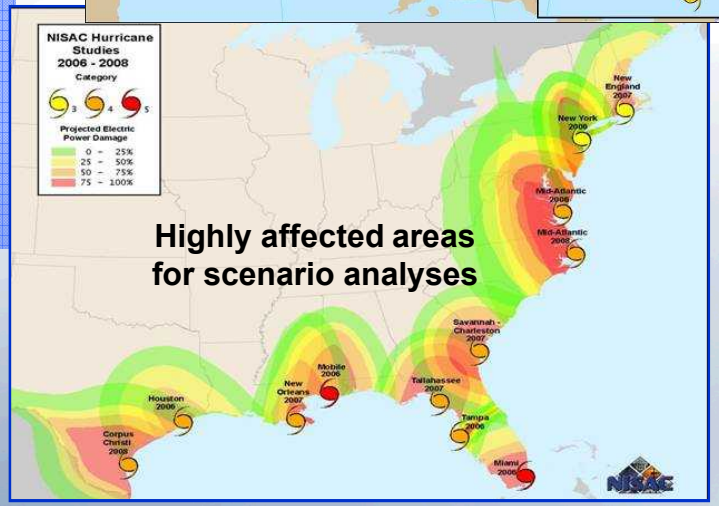
2003: Isabel
2004: Frances, Ivan
2005: Dennis, Emily, Katrina, Rita, Ophelia, Wilma
2006: Ernesto
2007: Flossie, Dean
2008: Gustav, Hanna, Ike
2009: Melor (typhoon), TS Ida

Scenario Analyses

2006: NYC, Mid-Atlantic
Miami, Tampa
Mobile, Houston/Galveston
2007: Yvette (Exercise), Savannah
Tallahassee, New Orleans (Update)
2008: Mid-Atlantic (Update) & Corpus Christi
Zoe (NLE 2-08 Exercise)

Analysis topics include

- Populations affected
- Economic impacts
- Infrastructure sectors and interdependencies
- Lists of important affected facilities



Highly affected areas for scenario analyses

Topics Covered in 48-Hour Report

- Storm/event data
- Storm surge and flooding
- Electric power damage and restoration
- Population
- Energy (petroleum, oil, and lubricants; natural gas, nuclear)
- → Chemical and hazardous materials
- Telecommunications and information technology
- Highways and highway bridges
- Ports and maritime facilities
- Airports and systems
- Rail transportation facilities and systems
- Intermodal transportation
- Emergency services, public health, healthcare, and public broadcast
- → Key interdependencies
- Water systems: drinking water and wastewater treatment systems
- Dams
- Agriculture
- Critical manufacturing
- Banking and finance
- Economic impacts

- Populations affected
- Economic impacts
- Infrastructure sectors and interdependencies
- Lists of important affected facilities

Hurricanes and the Chemical Sector

- **Gulf Coast hurricanes have the potential to significantly affect chemical production due to geographic concentration of chemical production facilities**
- **Hurricanes can affect facilities in several ways:**
  - Threat of a hurricane may prompt production plants to shut down in advance of the storm.
  - Electric power outages can limit production for facilities that do not generate power.
  - Wind can damage plant components and typically results in partial decreases of plant functions
  - Flooding and storm surge can be especially damaging (e.g., equipment may be corroded, electrical equipment may be unusable) and may result in total loss of plant functionality.

Hurricanes and the Chemical Sector (continued)

- **Restoring plant operations depends on the degree of damage:**
  - Restarting an undamaged petrochemical facility generally takes 2 weeks to 1 month.
  - Surge-damaged facilities can take 2 to 6 months or longer and require equipment replacement.
  - Liquid nitrogen may be required to purge and lines and vessels.
- **Hurricane impacts can cascade throughout the chemical sector and to non-chemical infrastructure systems.**

Resilience Analysis Overview

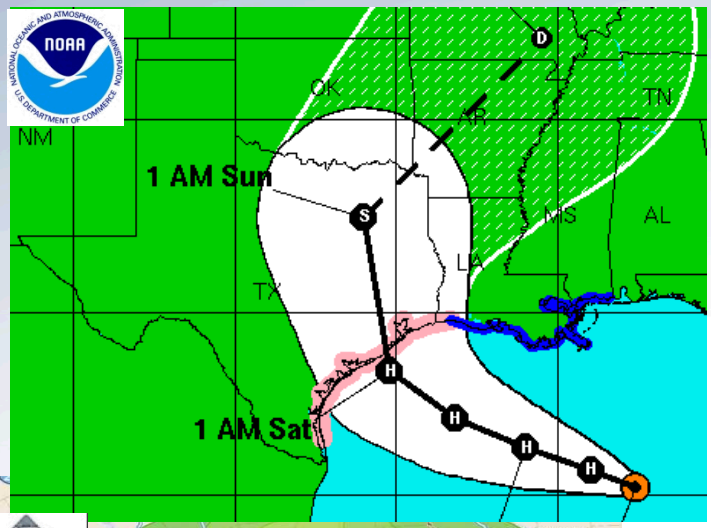
- **Goal: Assess the resilience of portions of the chemical sector to a hurricane scenario.**
- **Analysis needs:**
  - Scenario description (where, how strong, how long, etc.)
  - Data (affected plants, production capacities, etc.)
  - Model and simulation capabilities (how impacts propagate, shortage durations, etc.)
  - Integrating framework (how to combine model output into resilience estimates)
- **This presentation provides an overview of how the project addresses each of these needs.**

Scenario Description

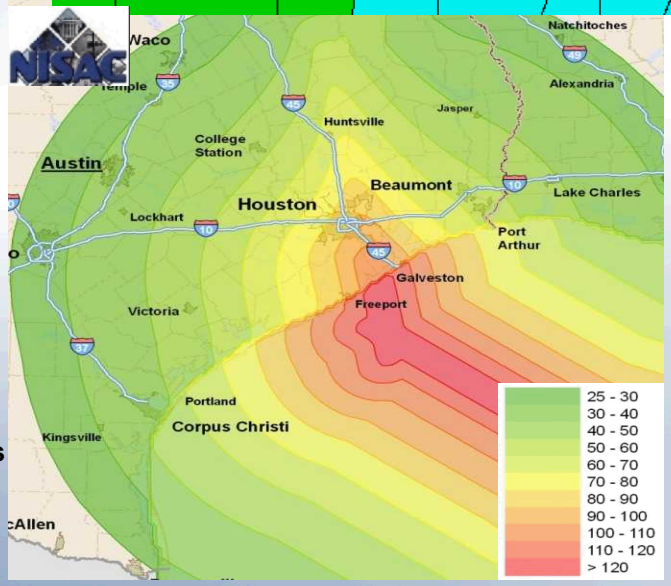
Scenario Conditions:

- Hurricane follows trajectory described by National Oceanic and Atmospheric Administration (NOAA) Advisory 41 for Hurricane Ike
- Category 3 hurricane makes landfall 2 miles southeast of Freeport, TX
- Houston and Galveston, TX, are severely affected
- Maximum sustained winds of 127 mph

Hurricane Trajectory

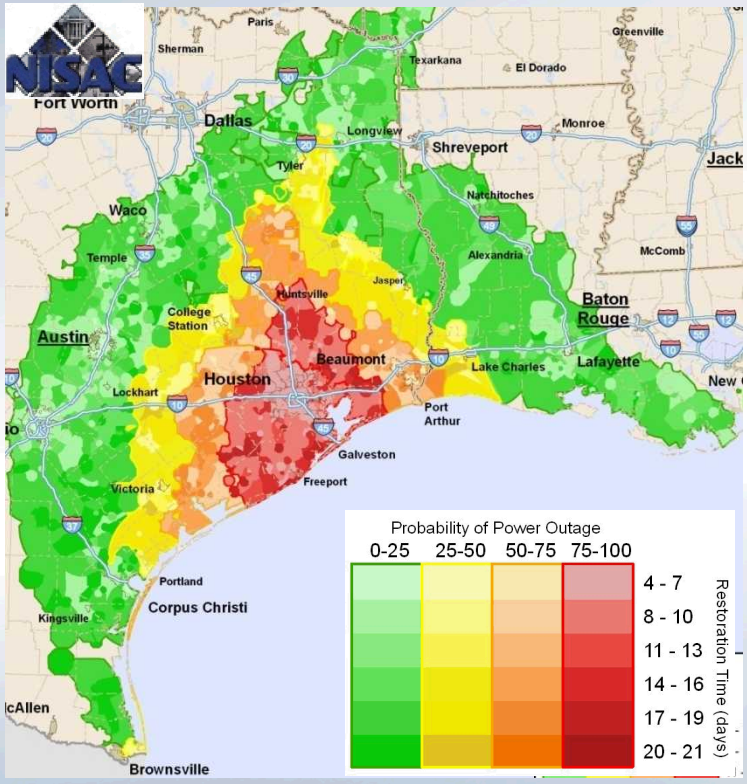


Estimated Wind Speeds



Scenario Assumptions

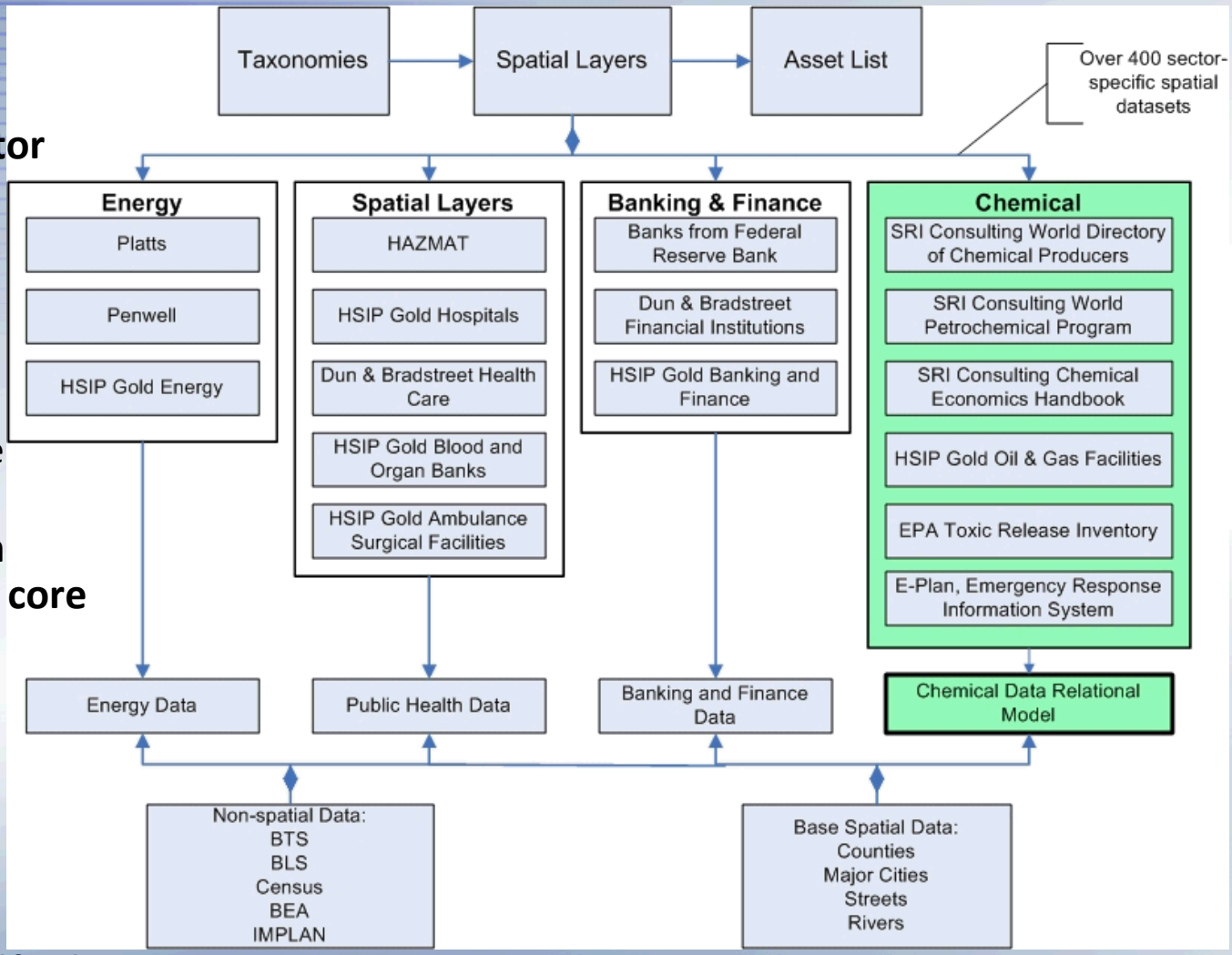
- Electric power outages expected to last 4 to 21 days
- Restarts can be further affected by
  - Limited transportation corridors,
  - Relocated employees, and
  - Ability to acquire raw chemicals.
- Simplifying assumptions:
  - All plants in 50-100% probability zones shut down 2 days in advance of landfall.
  - These plants return to full operational capacity 25 days after initial shutdown.
  - Production capabilities are unaffected at all other plants



Estimated Power Outages and Restoration Times

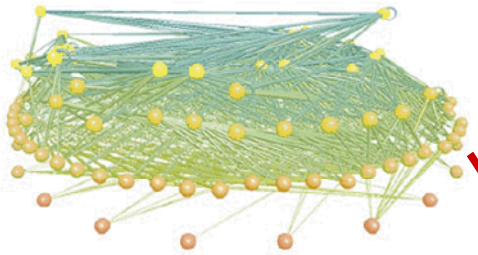
Chemical Data Model

- **Unified chemical sector data model includes**
  - Plant facilities
  - Productions
  - Consumption
  - Imports/exports
  - Other infrastructure interdependencies
- **All models are driven from the same set of core input data**

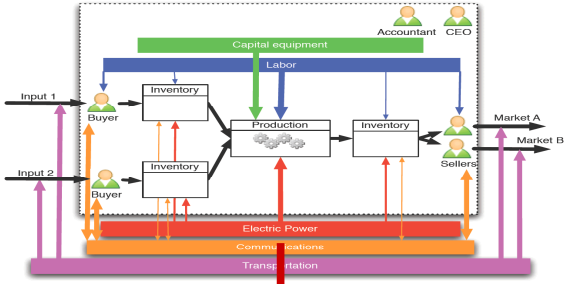


Modeling and Simulation Tools

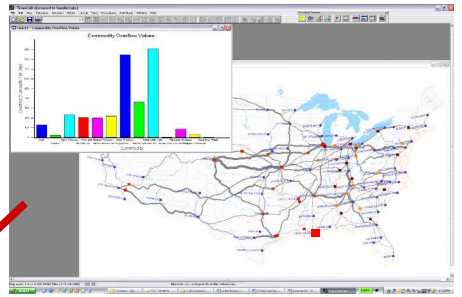
Network Analysis



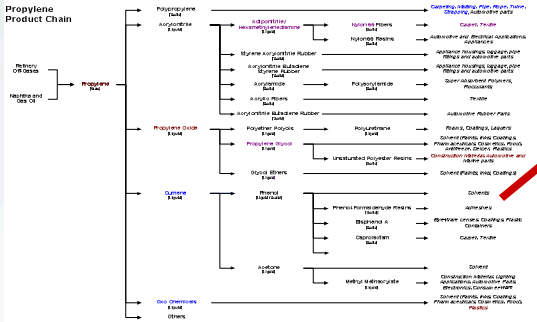
Supply Chain/Economic Analysis



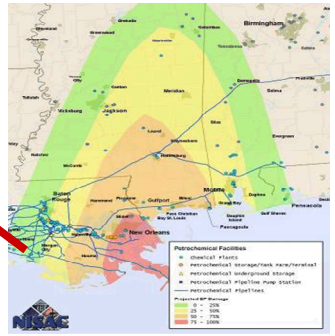
Transportation Analysis



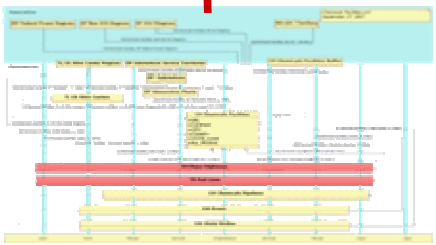
Leveraging existing NISAC models and industry data in combination



Systems Analysis



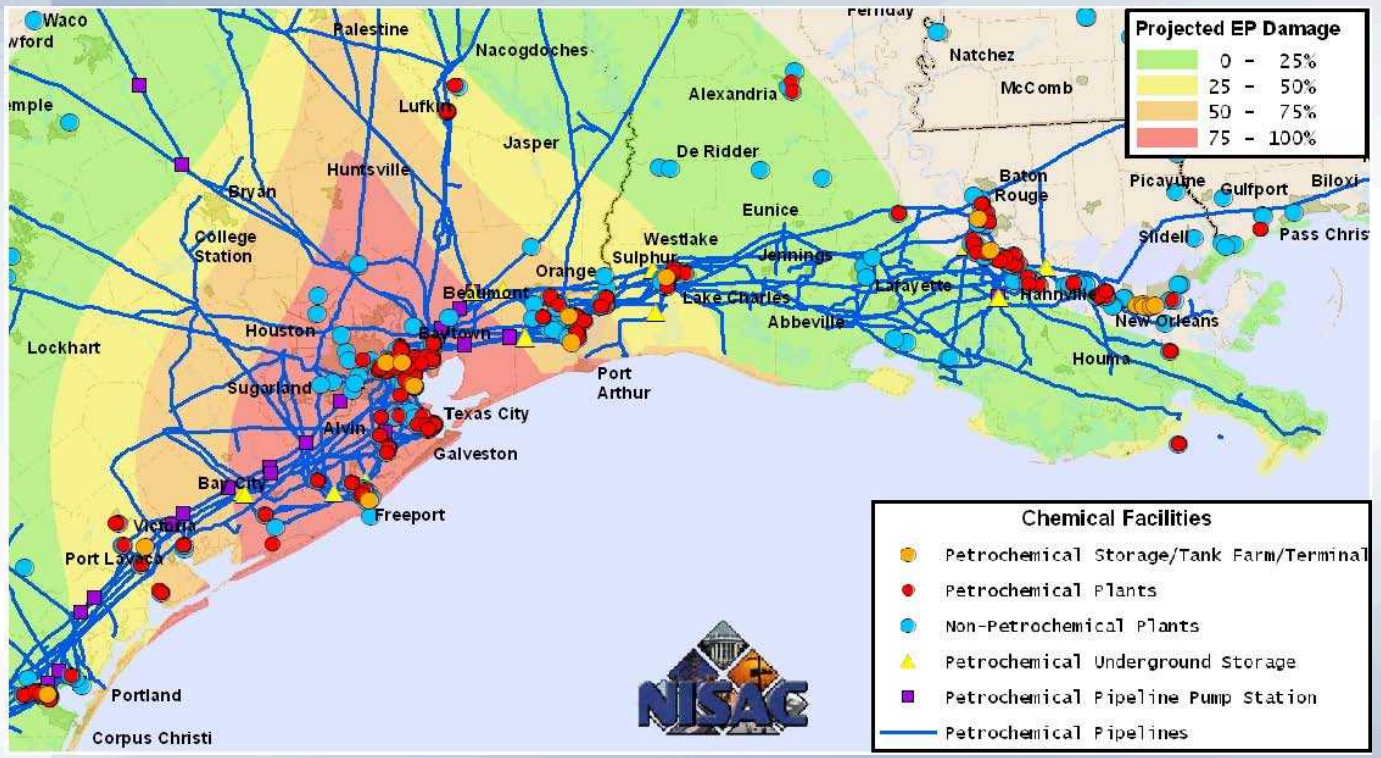
Geospatial Analysis



Infrastructure/Interdependences Analysis

FASTMap

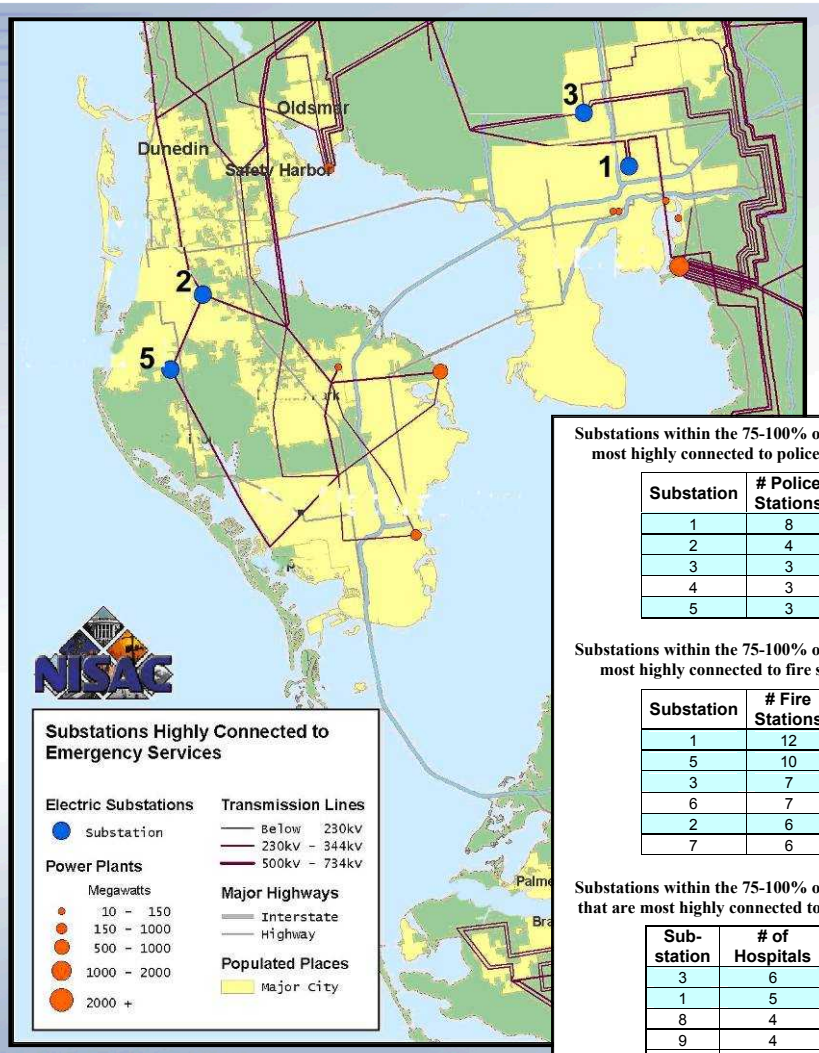
- Begin analysis by identifying potentially affected facilities and associated infrastructures relative to disruption areas



Chemical Facility Locations Relative to Electric Power Outage Contours

Fast Analysis Infrastructure Tool (FAIT)

- **Identify affected infrastructures**
  - Infrastructure elements within a defined area
    - Hurricane path
    - Plume path
  - Infrastructure associations
    - Power plants → substations → transmission lines
  - Infrastructure users
    - Chemical plants
    - Fire stations
    - Police stations
    - Hospitals



Substations within the 75-100% outage area most highly connected to police stations

Substation	# Police Stations
1	8
2	4
3	3
4	3
5	3

Substations within the 75-100% outage area most highly connected to fire stations

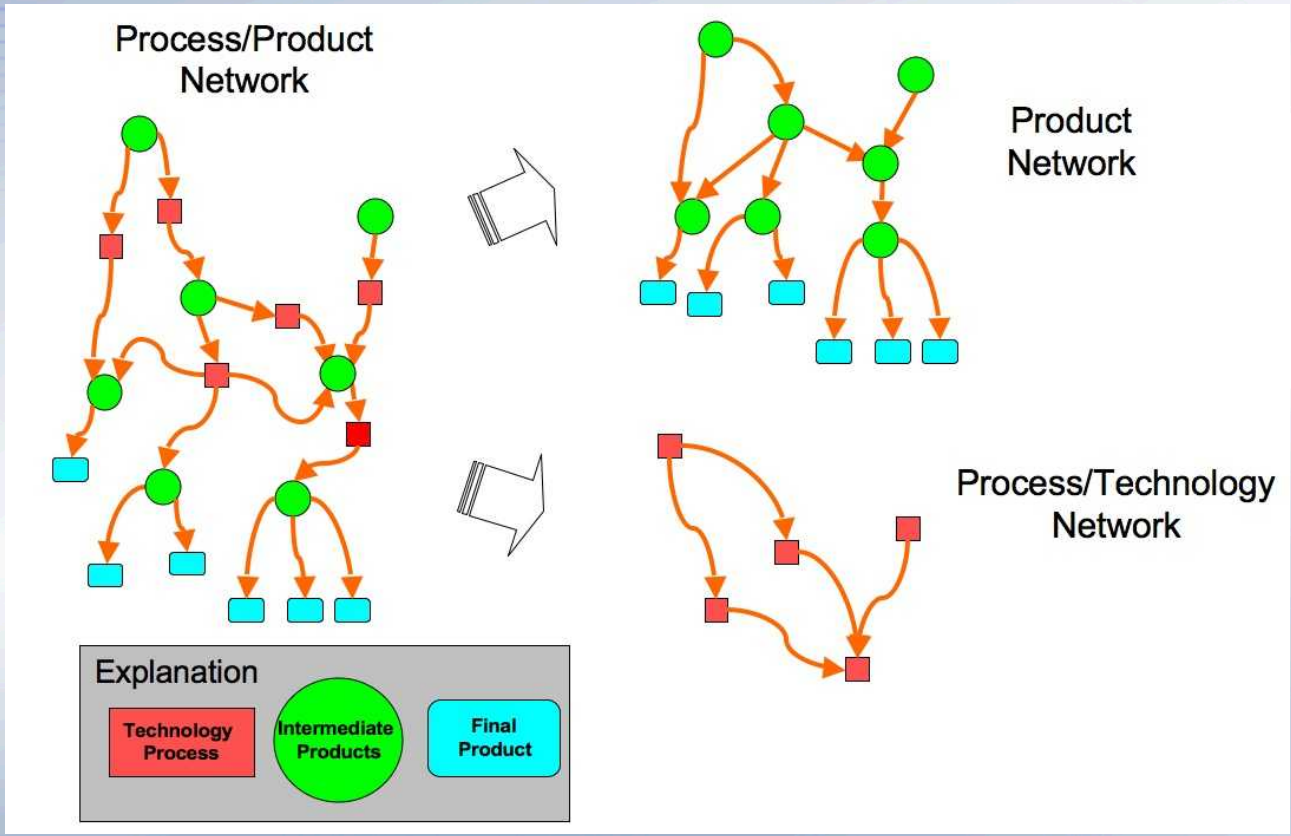
Substation	# Fire Stations
1	12
5	10
3	7
6	7
2	6
7	6

Substations within the 75-100% outage area that are most highly connected to Hospitals

Sub-station	# of Hospitals
3	6
1	5
8	4
9	4
10	3

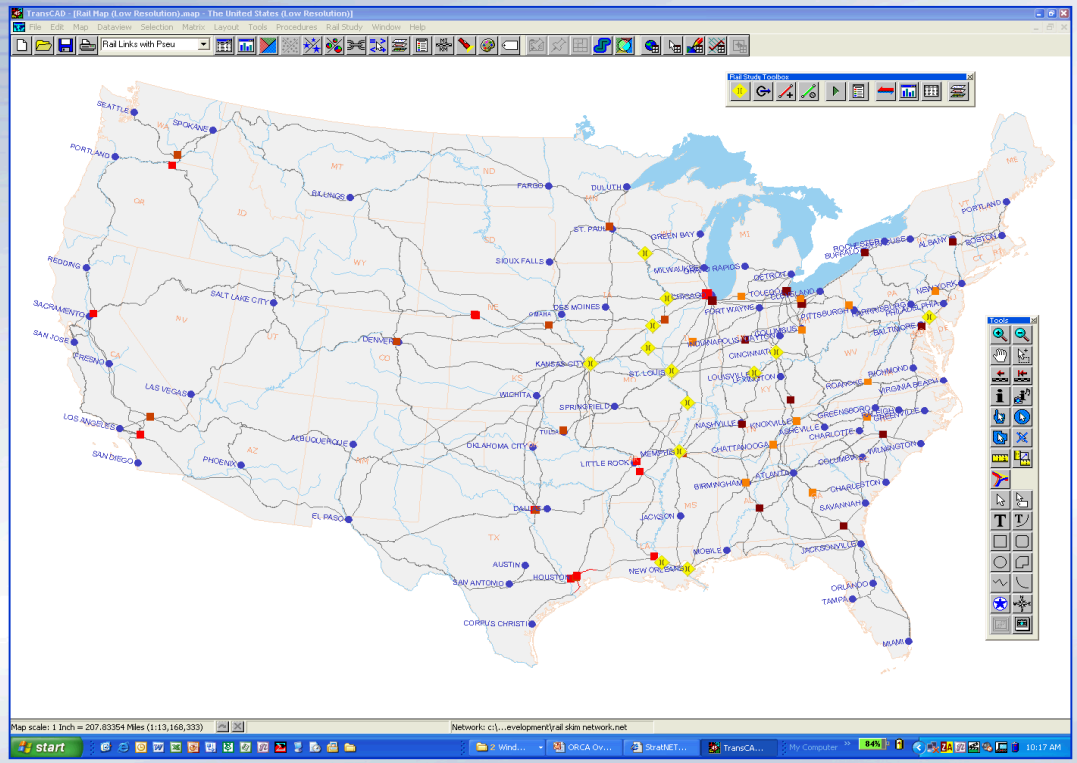
Loki Network Tool

- Perform static evaluations of chemical industry impacts by analyzing networks of chemicals and production technologies



Rail-Network Analysis System (R-NAS)

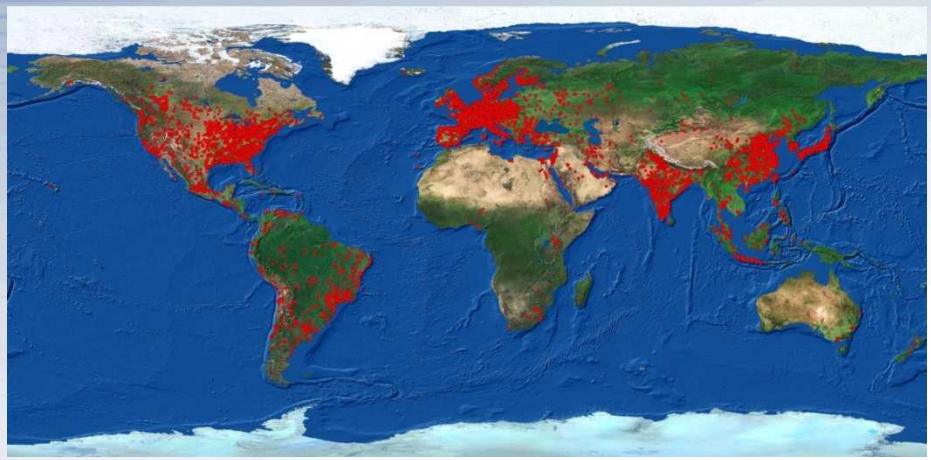
- **Evaluate impacts of transportation disruptions, using R-NAS:**
  - Determine impacts to the national rail network, given an asset disruption or multiple disruptions
  - Evaluate impacts to commodity movement, regional and national economics, and public health and safety

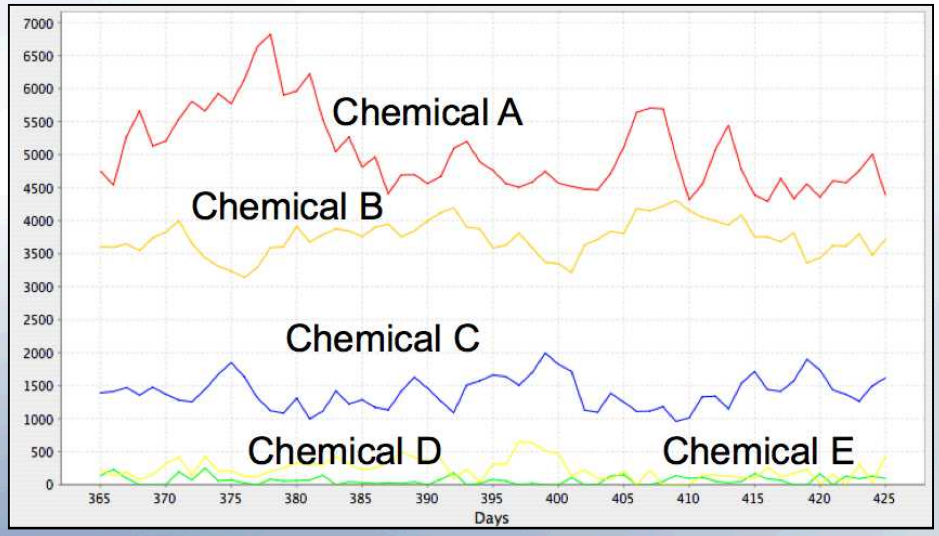


NISAC Agent-Based Laboratory for Economics (N-ABLE™)

Use N-ABLE™ to

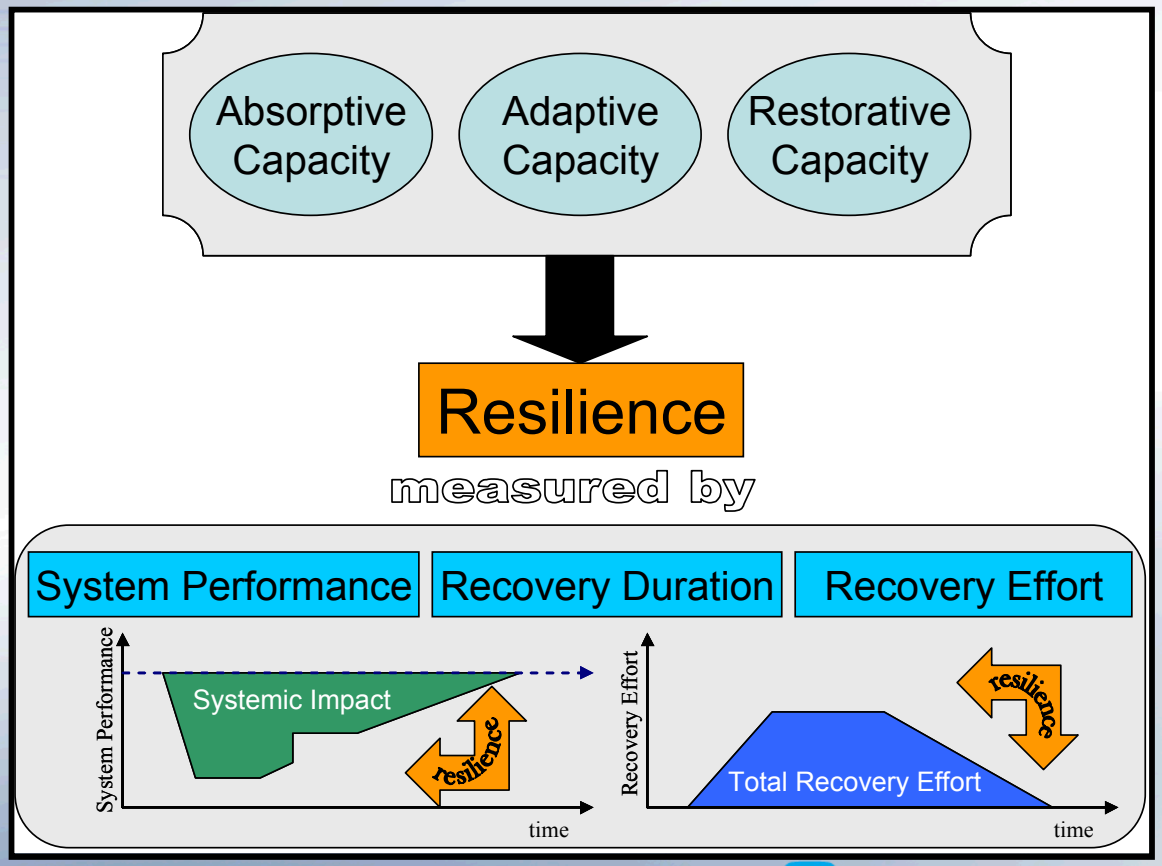
- Simulate individual firm behaviors in global, dynamic supply chains
- Integrate results of other NISAC models
  - Plants
  - Infrastructures
  - Disruption types
  - Disruption duration estimates
- Estimate cascading, economic impacts over time
- Inform resilience analyses by answering the question: Can the sector:
  - Absorb the impact?
  - Adapt to the impact?
  - Quickly recover?





Resilience Assessment Framework

- **Integrate model predictions by using the framework to provide resilience estimates**



Resilience Analysis

- In the scenario resilience analysis, we will focus on the industrial acid components of CHC and CFC supply chains.
- We will primarily use FASTMap, FAIT, and N-ABLE™ tools.
- We will provide quantitative and qualitative resilience estimates.