



Northeastern University
Center for Resilience Studies

Understanding the Challenges & Opportunities of the Resilience Imperative

Resilience Week 2014

“Transforming the Resilience fo Cognitive, Cyber-Physical Systems”

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Community Resilience and Critical Infrastructure Resilience is a Global Imperative

“The abiding strategy of our parents’ generation was “containment” of communism in order to be free. The abiding strategy of our generation has to be “resilience.” **We will only be free to live the lives we want if we make our cities, country and planet more resilient.**”

* Tom Friedman, *The New York Times*, May 24, 2014

Major Sources of Risk to Critical Infrastructure

- More users that push or exceed infrastructure design capacity
- Aging without adequate investment in maintenance and repair
- Rising urbanization, particularly in coastal areas with substantial exposure to the effects of climate change
- External shocks from naturally occurring and man-made sources
- The absence of political will for undertaking the advanced planning and long-term investment in building, upgrading, and adequately maintaining infrastructure

***REQUIRES A NEW EMPHASIS ON BOLSTERNING
CRITICAL INFRASTRUCTURE RESILIENCE***

Challenges: Why are we not investing in resilience?

1. **We don't recognize how unprepared we are to handle foreseeable risks and uncertainties.**
 - We overestimate our current capabilities to handle challenges
 - We have a bias that discounts leading indicators of disruptive events in our future
 - Stationarity assumptions that were embraced in the 20th Century infrastructure designs are obsolete
 - Elected officials view acknowledging risks that they believe that lack adequate resources to respond to as a political liability.

Challenges: Why are we not investing in resilience?

2. We don't have incentives to create resilience.

- There are few rewards for investment—in too many cases there are actually penalties.
- Routine efficiency and optimization are valued over investments in continuity of function in the face of anticipated and unexpected disruptions.
- We have become skilled at transferring risk to someone else and not working collaboratively to take risk on directly.
- We are not sure how to measure resilience so we are at a loss on how to reward efforts to enhance it.

Challenges: Why are we not investing in resilience?

3. We don't know how to measure resilience because there is not yet consensus on how to create it.

There are lots of isolated success stories in disparate domains, but we do not yet have an overall set of best practices for resilience. We have insights from various academic disciplines, but we still lack an integrative framework.

Challenges: Why are we not investing in resilience?

4. There are organizational or governance barriers to creating resilience:

- Lifeline infrastructures (e.g., transportation, energy, communication, & water) are almost always regional
- Infrastructure sectors are inherently interdependent
- Regional infrastructure sectors are vulnerable to multiple hazards

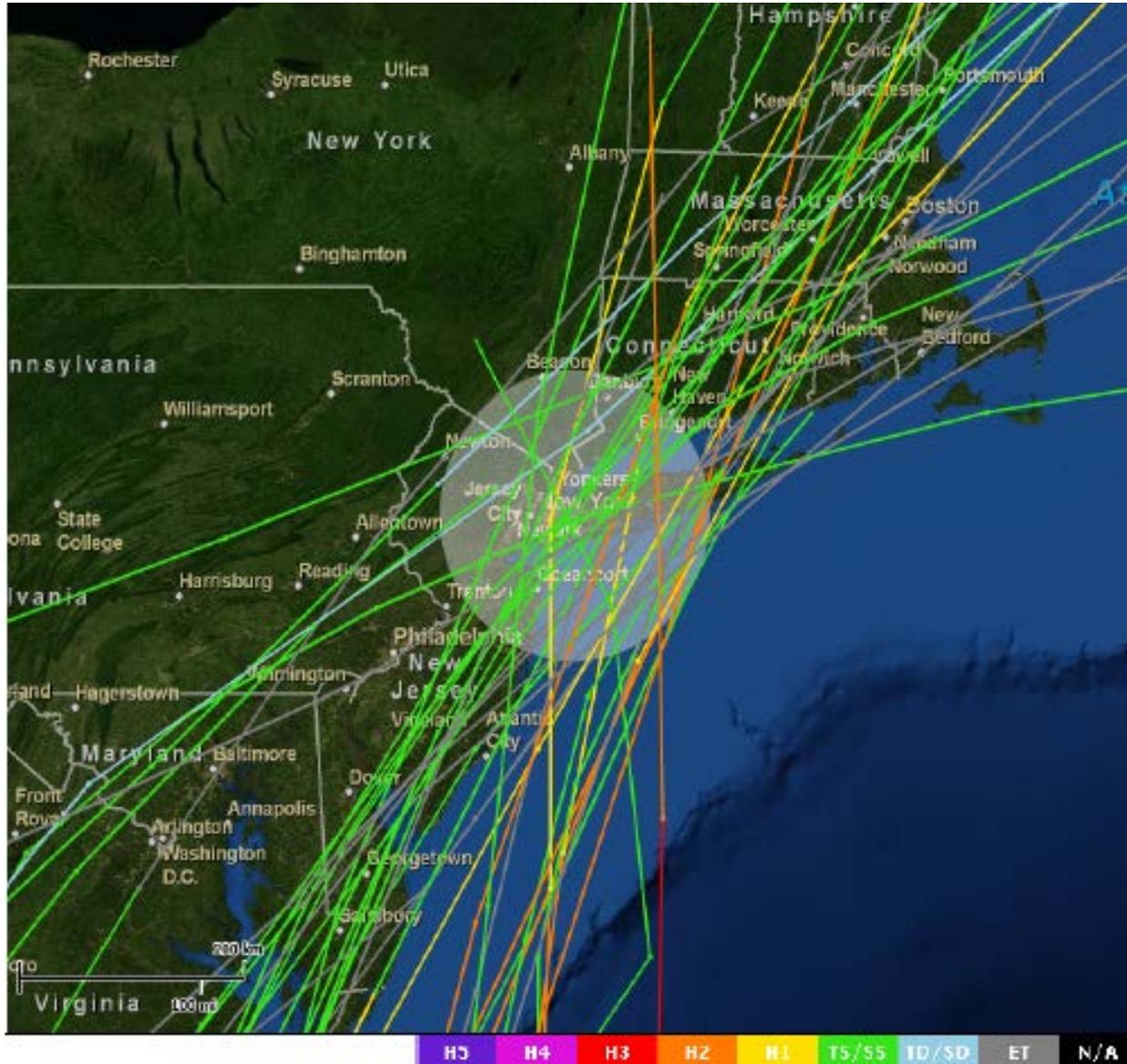
YET, we are organized around:

- Local and state jurisdictions
- Individual infrastructure sectors
- The last hazard

Hurricane Sandy – a “predictive surprise”



Hurricane Track Map: New York City, 1861-2008, as of January 2011

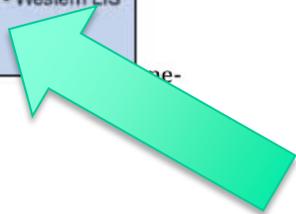


Category	Count
Category 5 (H5)	3
Category 4 (H4)	3
Category 3 (H3)	7
Category 2 (H2)	3
Category 1 (H1)	10
Trop./Sub. Storm (TS/SS)	11
Trop./Sub. Depression (TD/SD)	0
Extratropical (ET)	3
Unknown (N/A)	0

Source: Rae Zimmerman, Constructed from NOAA, CSC.













Manhattan 34th St. and 1st Avenue

Comparative Resilience: Oct 28, 2012



Goldman Sachs Headquarters
200 West St. New York, NY



Citigroup Headquarters
388 Greenwich Street New York, NY

Goldman Sachs Headquarters

Oct 29, 2012



200 West St. HQ is dry and has electric power, but . . .

- *No employees due to disruption of transportation system.*
- *Little ability to telecommute due to region wide power outages*



Verizon Headquarters & Switching Center 140 West St.



Verizon Headquarters & Switching Center 140 West St.



Cable Vault Room at Verizon Headquarters 140 West St.

“Before the Storm” October 28, 2012

Metropolitan
Transportation
Authority







“Before the Storm” October 28, 2012

NJ TRANSIT
The Way To Go.
PASSENGER RAIL SYSTEM

Map Legend:
Stations in Bold are Transfer Points

New Jersey
Transit





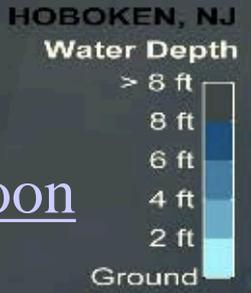
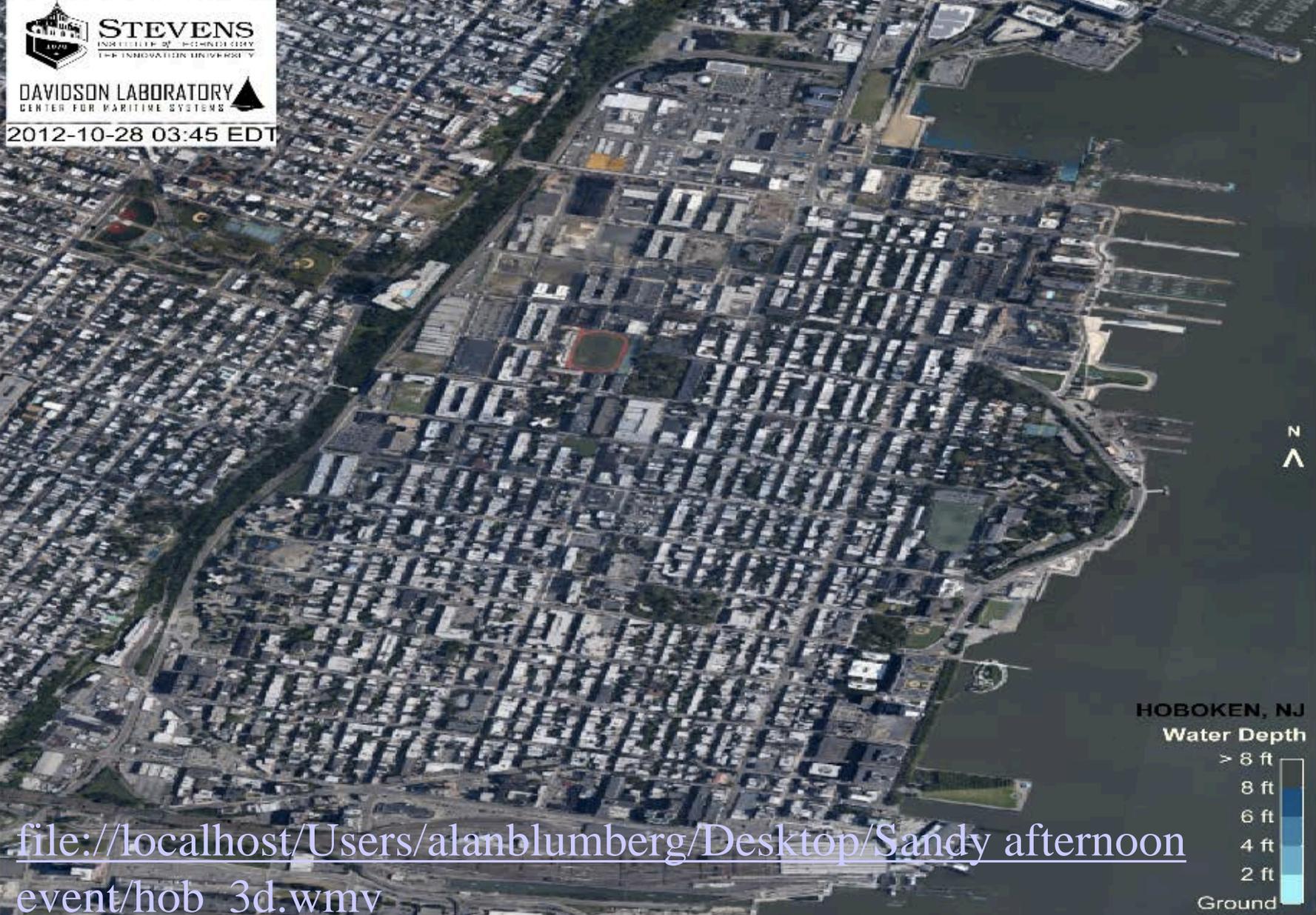
Hoboken, NJ – Train and Ferry Terminal



NJ Transit Terminal - Hoboken

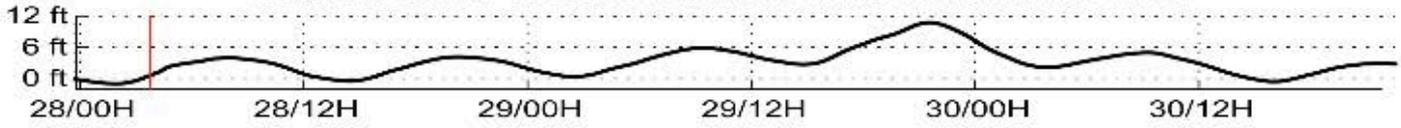


New Jersey Transit - 345 Trains damaged by flooding at the Meadowlands Maintenance Complex & Hoboken Yard totaling \$120 million



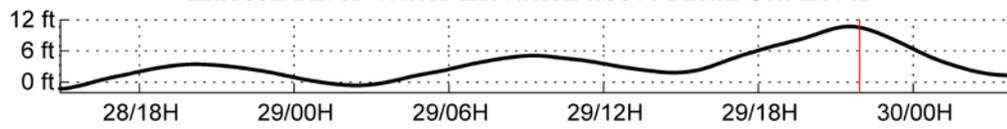
[file://localhost/Users/alanblumberg/Desktop/Sandy afternoon event/hob_3d.wmv](file://localhost/Users/alanblumberg/Desktop/Sandy%20afternoon%20event/hob_3d.wmv)

Hudson River Water Elevation above Mean Sea Level





Hudson River Water Elevation above Mean Sea Level



The Goal of Critical Infrastructure Security: Bolstering Resilience

- Move beyond threat-based protection to bolstering the continuity/rapid recovery of the essential functions provided by critical infrastructure

“The term *resilience* refers to the ability to **prepare for** and **adapt to** changing conditions and **withstand** and **recover rapidly** from disruptions. Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents.*

* President Policy Directive 21 - Critical Infrastructure Security and Resilience
February 12, 2013



The Resilience-Centric Approach

- Distinguish between *critical processes*, *essential function* & full / “normal” function
- Identify and adopt *resilience design features, processes, and protocols* that mitigate the risk of disruption, and speed recovery when mitigation measures fail.
- Resilience design options include:
 1. *Cushionability* – graceful degradation of non-essential function during periods of stress
 2. *Resistance* – redirecting threat/hazard away from essential function
 3. *Robustness* – harden critical processes & essential function
 4. *Redundancy* – have spares to provide critical processes and essential function
 5. *Graceful extensibility*—the capacity for the infrastructure to adapt to deal with an uncertain future risk environment.

PUTTING RESILIENCE INTO PRACTICE

Pre-event:

- Modeling
- Resilience Design (for predictive risk vs. experienced risk)
- Contingency planning and exercises
- Maintain Situational Awareness

During event:

Resourcefulness – decision making and actions should be done nimbly and competently so as to mitigate consequence and support rapid recovery

Post event:

- Restore critical processes and essential function
- Restore full / normal function
- Learn, adapt and improve resilience design

Resilience as a Deterrent

Resilience Reduces Risk by Undermining Threat

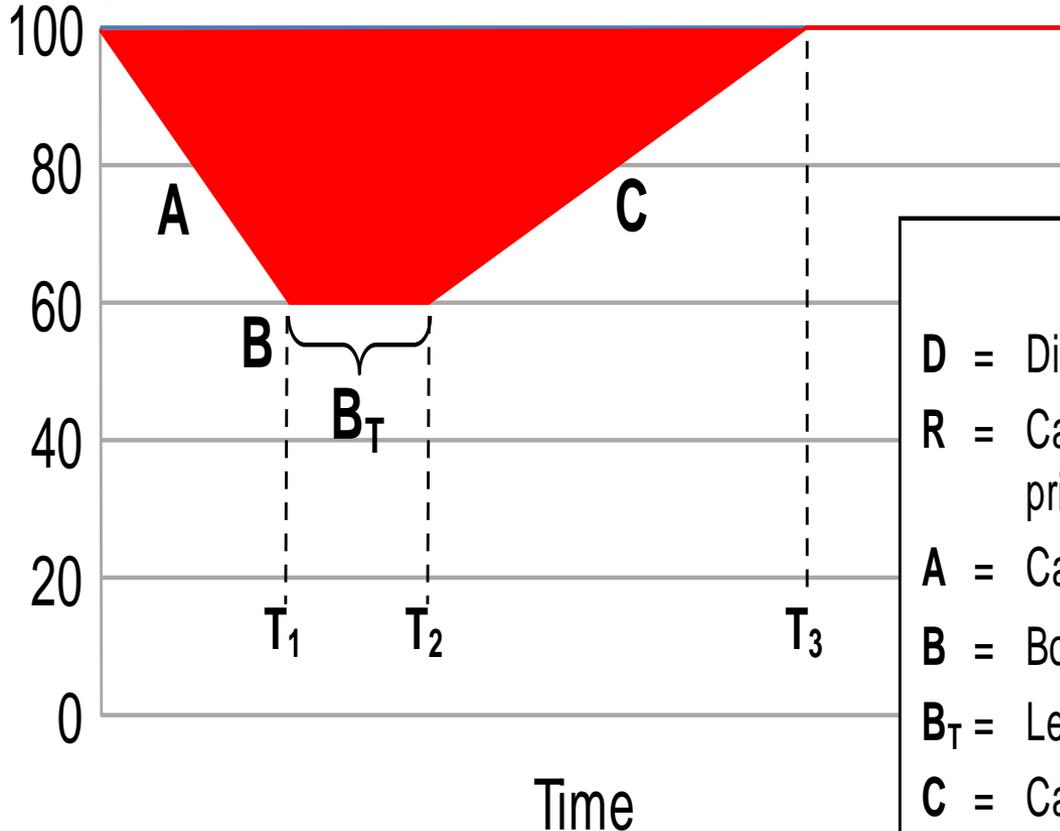
Threat = Intent x Capability

Less vulnerability translates into elevating the requirement that an adversary possess more capability to overcome safeguards

Less consequence will undermine intent; i.e., there is little motivation for carrying out an attack if it does not achieve mass destruction and disruption

Performance
(Percent)

D → R

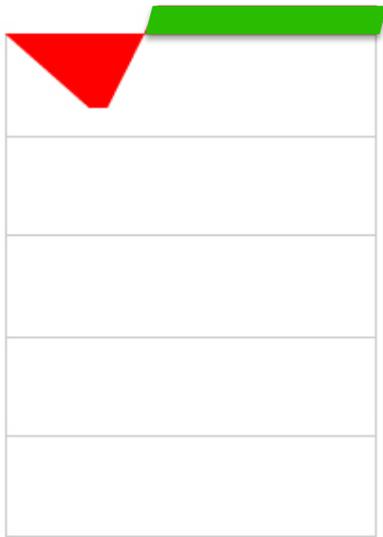


Resilience Parameters

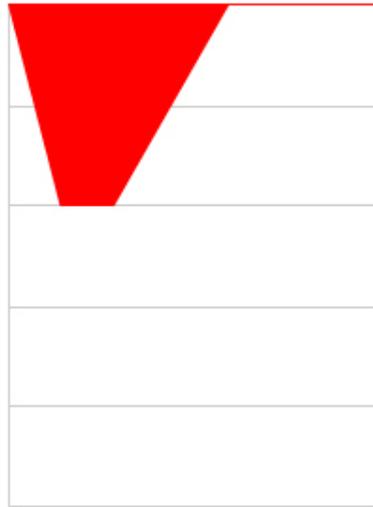
- D = Disruption to System
- R = Capability to attenuate or mitigate effect prior to or at time of event
- A = Capability to absorb and degrade
- B = Bottom out; Threshold Level
- B_T = Length of time at bottom
- C = Capability to reconstitute back to initial level

Source: J. Kahan, et. Al., *Risk and Resilience: Exploring the Relationship*, Homeland Security Studies and Analysis Institute, Nov 20, 2010 & Mary Ellen Hynes, “Extreme Loading of Physical Infrastructure” presentation at the 4th *DHS University Network Summit*, March 11, 2010;

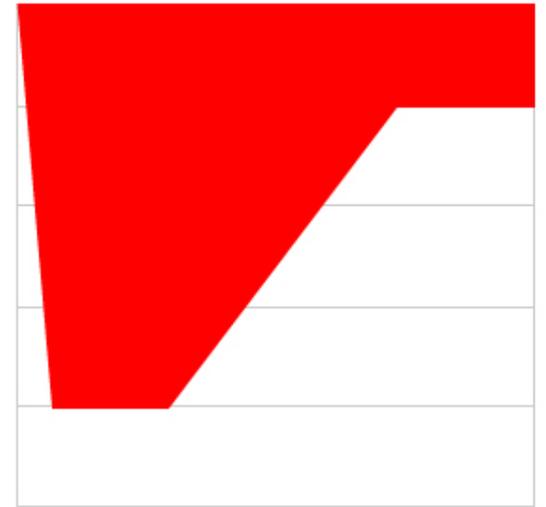
Best (relatively small area)



Acceptable (relatively average area)



Worst (relatively large area)



Hurricane Sandy's Impact on NY/NJ Liquid Fuels Distribution System

SUPPLY (42m gallons of petroleum products per day)

- Port closure during and following the storm halted all maritime shipments. (60+%)
- Bayway Refinery and Hess Port Reading Refinery disabled due to loss of commercial and generator power, damage to marine terminal, and damage to electrical equipment. (20%)
- Colonial Pipeline stopped deliveries to northern NJ due to damage to receiving terminals and power outages impacted its operations. This slowed product movement throughout entire pipeline back to the Gulf Coast (15%)

DISTRIBUTION:

- Damage to dock facilities disrupted barge movements of gasoline
- Gas station closures: 60% of NJ; 70% of Long Island
- Gas rationing implemented in New Jersey (11 days) and New York (15 days)

Multi-jurisdiction & interdependency Challenges

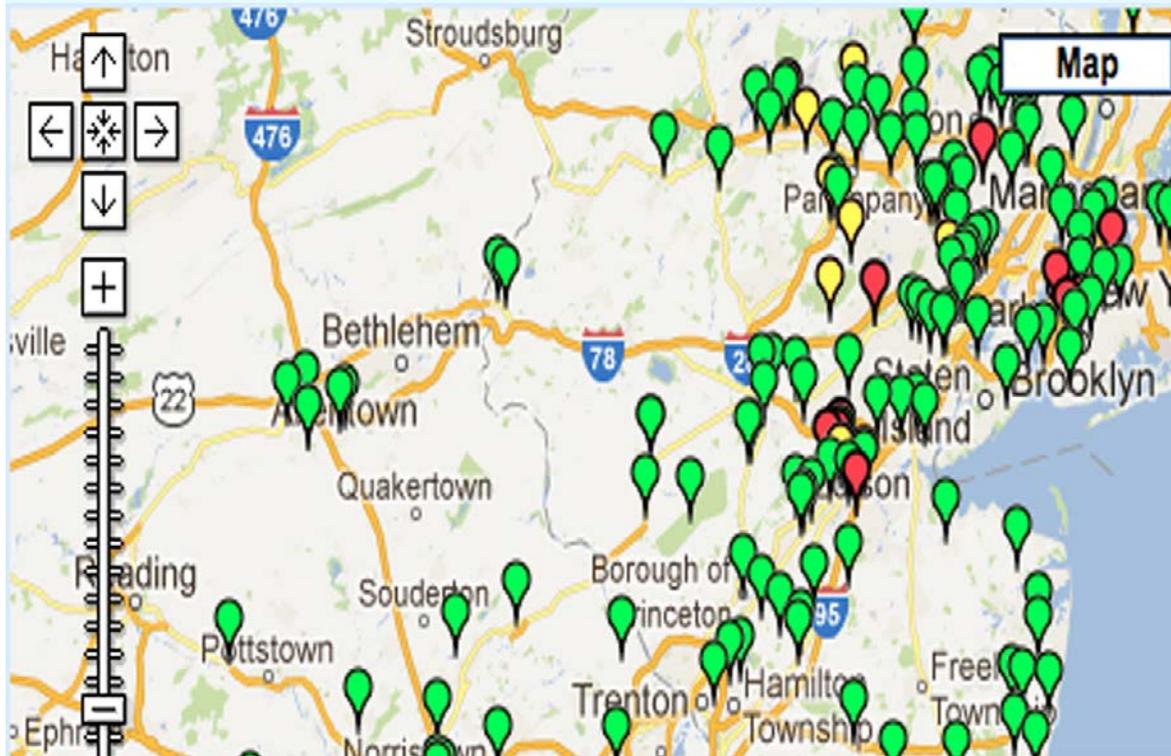
- Petroleum supply and distribution system spans multiple states though key infrastructure for a region is concentrated in only a few places.
- Refineries and pipelines need electricity to operate.
- Vehicles for repairing electrical distribution lines need a reliable supply of gasoline or diesel fuels.
- Transportation conveyances are required to move fuel to commercial and residential users
- Transportation conveyances require fuel to operate
- Gas stations require electricity to operate pumps and telecommunications to support credit/debit card purchases

1



Need Gas?

Scholars Organizing Culturally Innovative Opportunities



High school students create the app, “Need Gas” to show which gas stations were open. <http://mappler.net/gasstation/>

CONCLUSIONS

- Resilience requires greater emphasis on and investment in forecasting, modeling, monitoring, and assessment capabilities that can support mitigation, speed response and recovery, and inform adaptation in the aftermath of disruptive incidents.
- Large-scale disasters impact regional systems and therefore require an enhanced capacity for undertaking preparedness, response, and recovery at a regional level.
- Resilience requires a deeper understanding of interdependencies and the cascading effects that a major disruption can generate.
- Companies and communities need to “bake-in” resilience into their critical systems and functions.
- When disaster’s strike, the first responders are always local and citizens are indispensable strategic assets.
- Local, regional, and national competitiveness will increasingly be defined by the level of resilience that communities and countries have to withstand, nimbly respond, and rapidly recover from shocks and disruptive events. People will chose to invest in companies and live in areas that possess resilience and gravitate away from those that do not.