

Global Resilience Institute
at Northeastern University

Countering Emerging Threats and Hazards to Critical Infrastructure: The Resilience Imperative

*A presentation to the
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Why Resilience?

A hyper-connected world translates into a greater risk of cascading failures



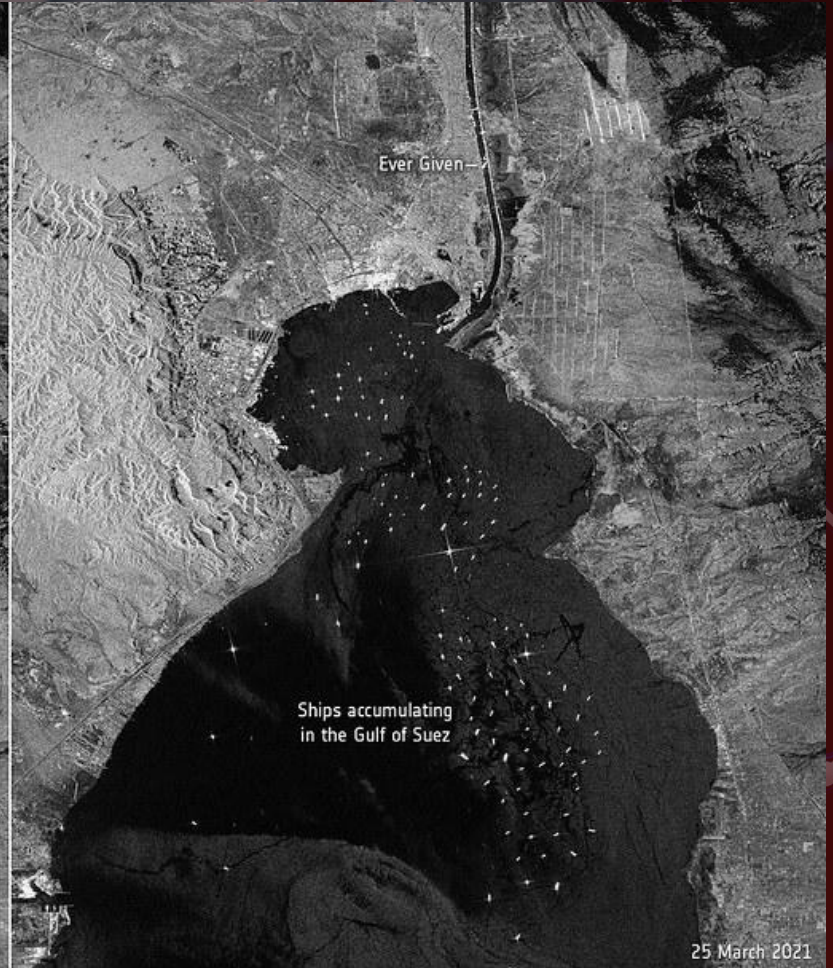
Ever Given Ship Grounding in Suez Canal (23-28 Mar 2021)



6-day canal closure caused a backup of 369 ships carrying \$9.6b in trade



Before: 21 Mar 2021



During: 25 Mar 2021

Port of LA and Long Beach Congestion (Sep-Nov 2021)



Resilience

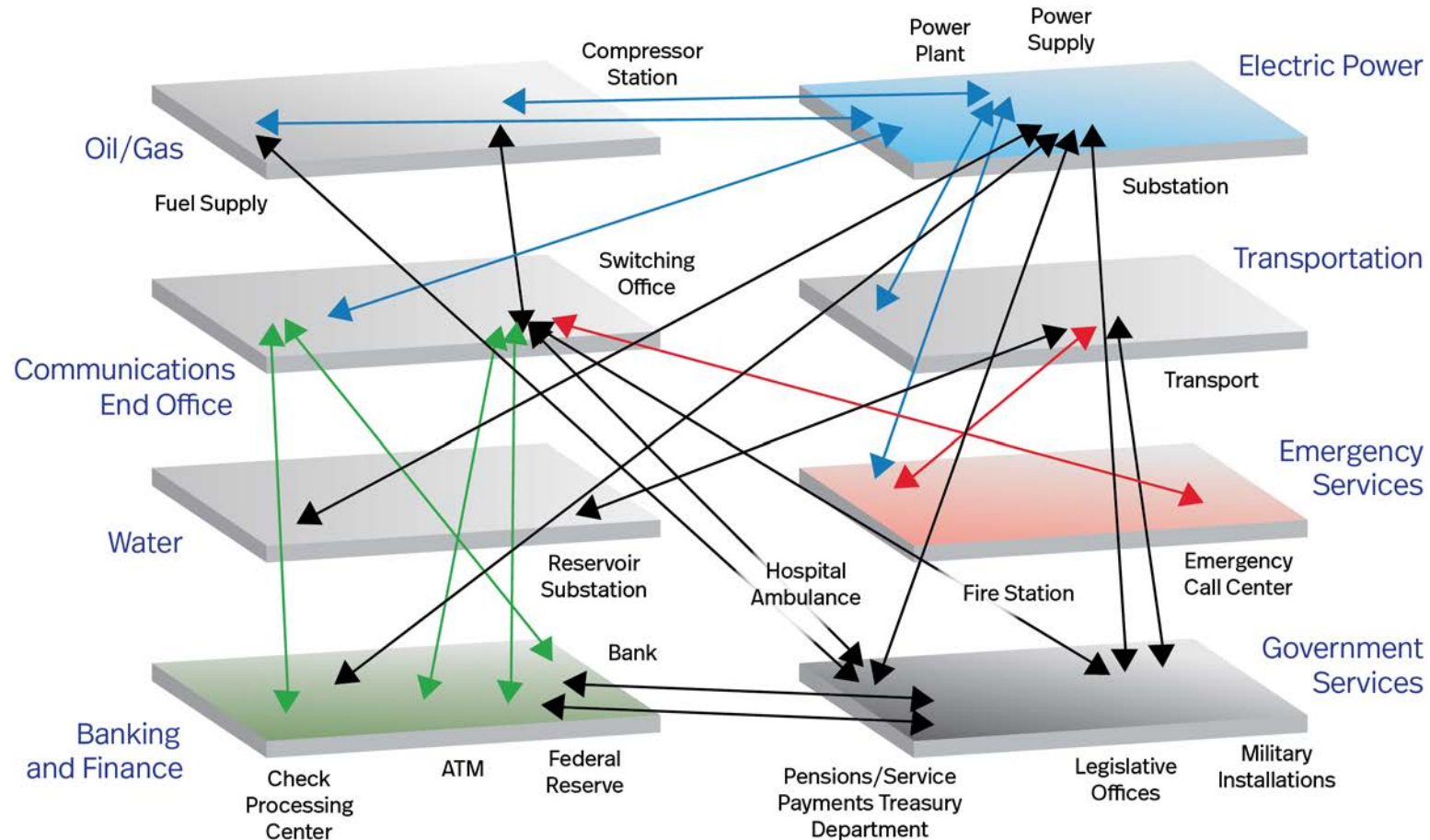
The ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions.

Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents.

– U.S. Presidential Policy Directive 21 (2013)



Understanding the Interdependency Challenge



National Aeronautics and Space Administration. NASA Science News. Severe Space Weather – Social and Economic Impacts. June 2009 at http://science.nasa.gov/science-news/science-at-nasa/2009/21jan_severespaceweather/

THE COMPANIES

U.S.

- Boeing
- Spirit
- Vought
- GE
- Goodrich

CANADA

- Boeing
- Messier-Dowty

AUSTRALIA

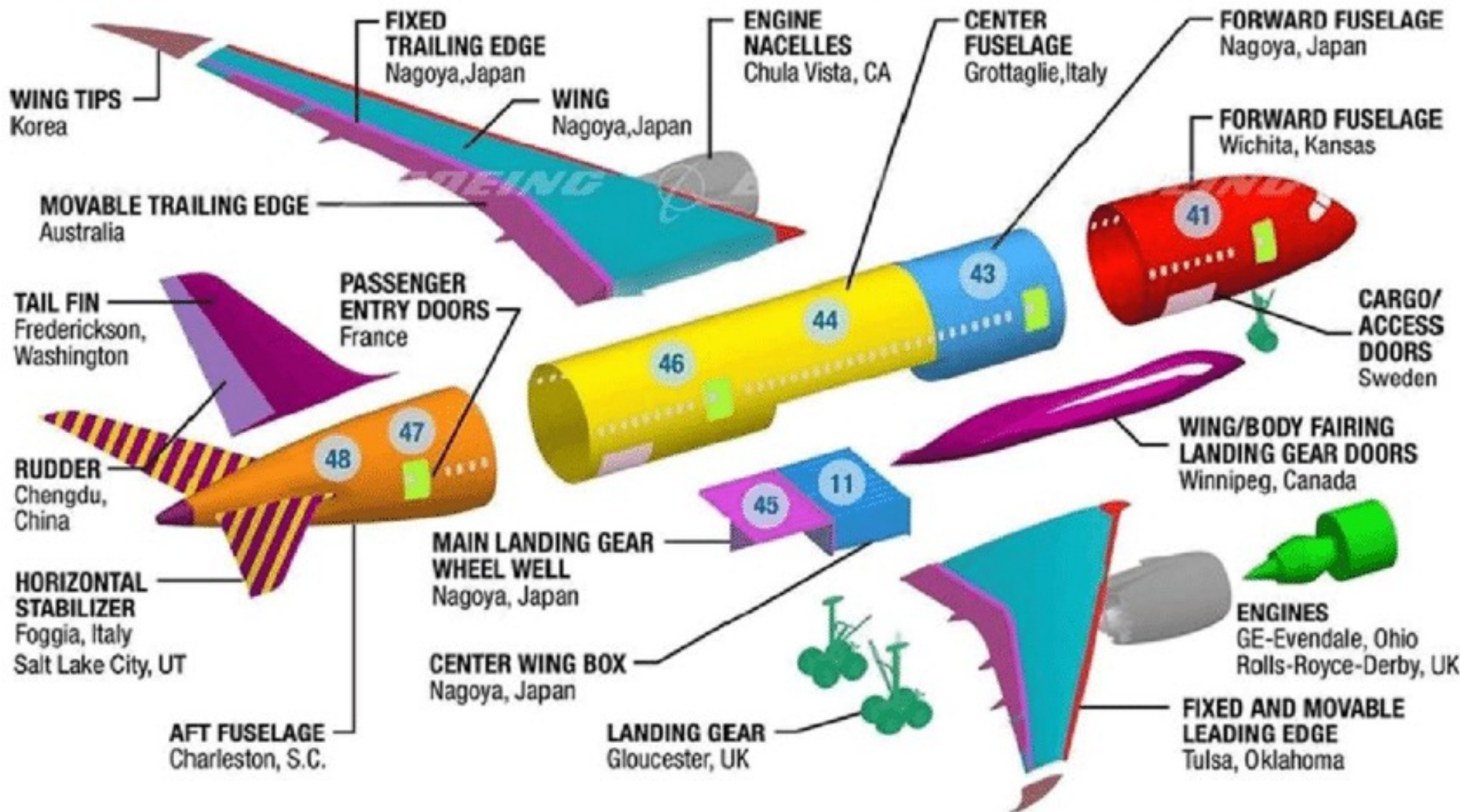
- Boeing

ASIA

- Kawasaki
- Mitsubishi
- Fuji
- KAL-ASD
- Chengdu Aircraft Industrial

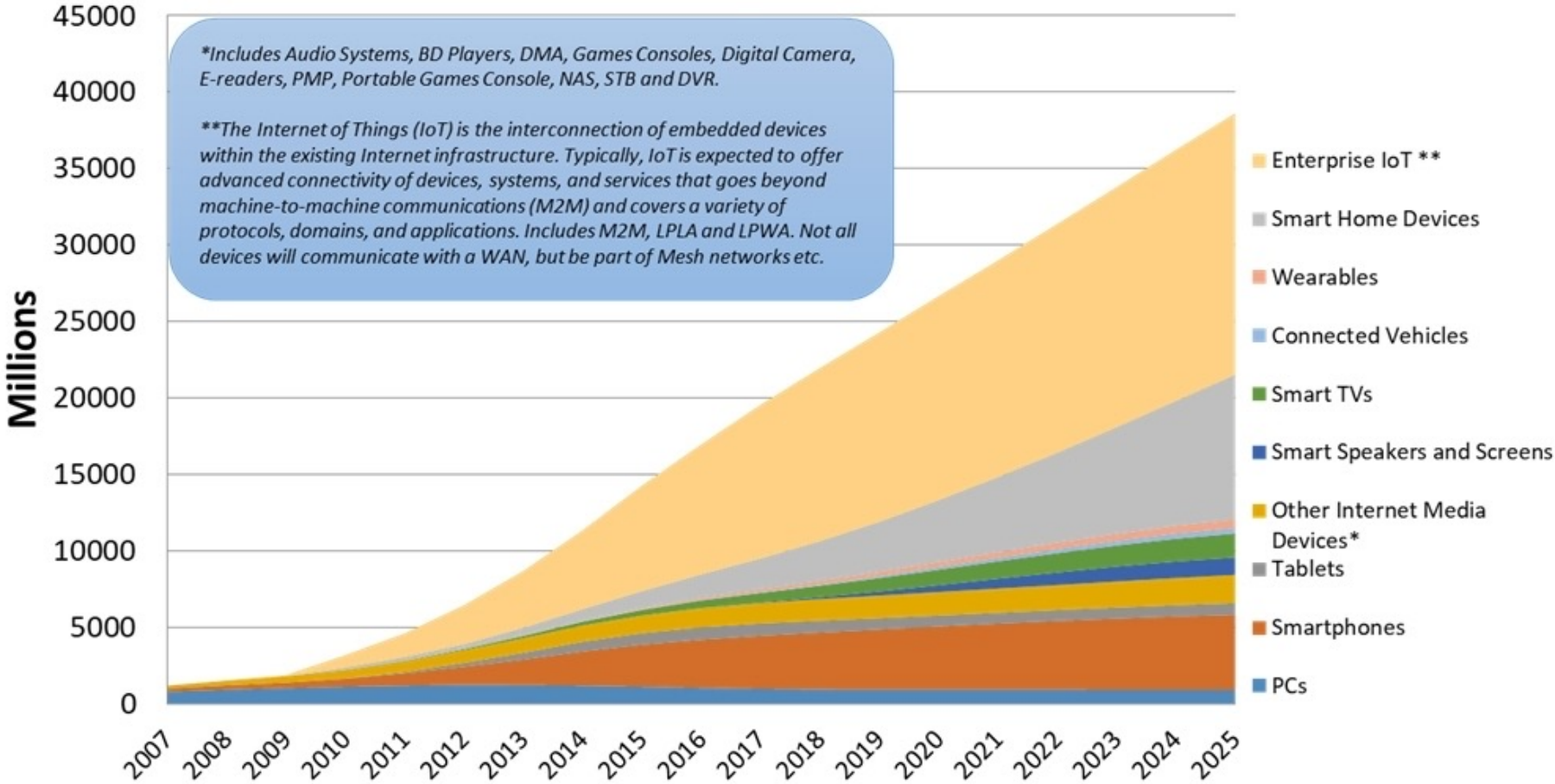
EUROPE

- Messier-Dowty
- Rolls-Royce
- Latecoere
- Alenia
- Saab



Boeing 787

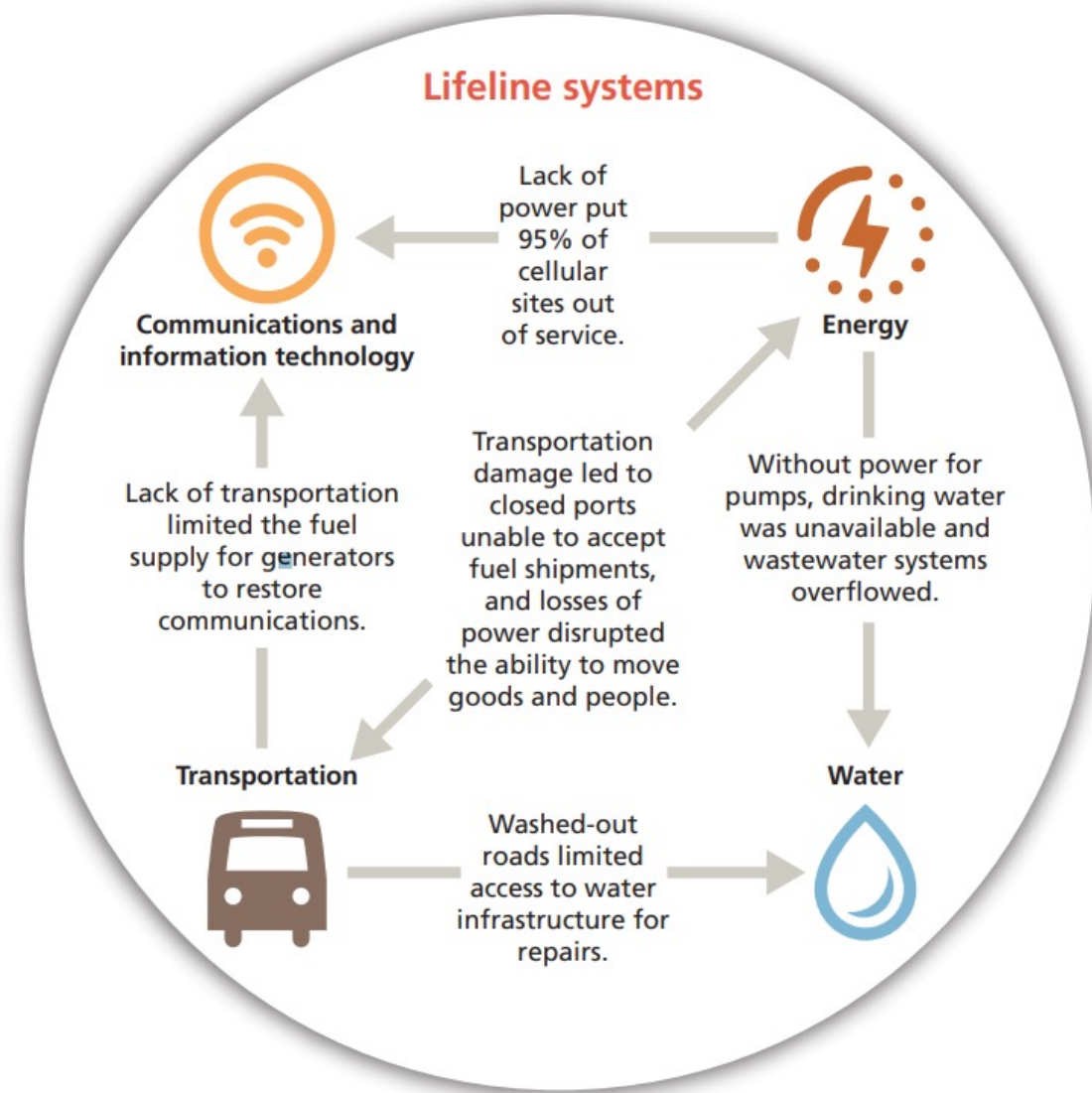
Global Connected and IoT Device Installed Base Forecast



**Internet of Things (IoT)
38 billion
connected
devices by
2025**

Source – Strategy Analytics research services, May 2019: IoT Strategies, Connected Home Devices, Connected Computing Devices, Wireless Smartphone Strategies, Wearable Device Ecosystem, Smart Home Strategies

Puerto Rico: Post-Hurricane Maria



And without those lifeline systems:



Many health care facilities were not open, and people could not travel to those that were.



Emergency services were immobilized.



Many businesses were not open, stores could not get supplies, and people could often not get to the stores or other businesses that were operating.

Fischbach, Jordan R., et. al. "After Hurricane Maria: Predisaster Conditions, Hurricane Damage, and Recovery Needs in Puerto Rico." Homeland Security Operational Analysis Center operated by the RAND Corporation, 2020. https://www.rand.org/pubs/research_reports/RR2595.html.

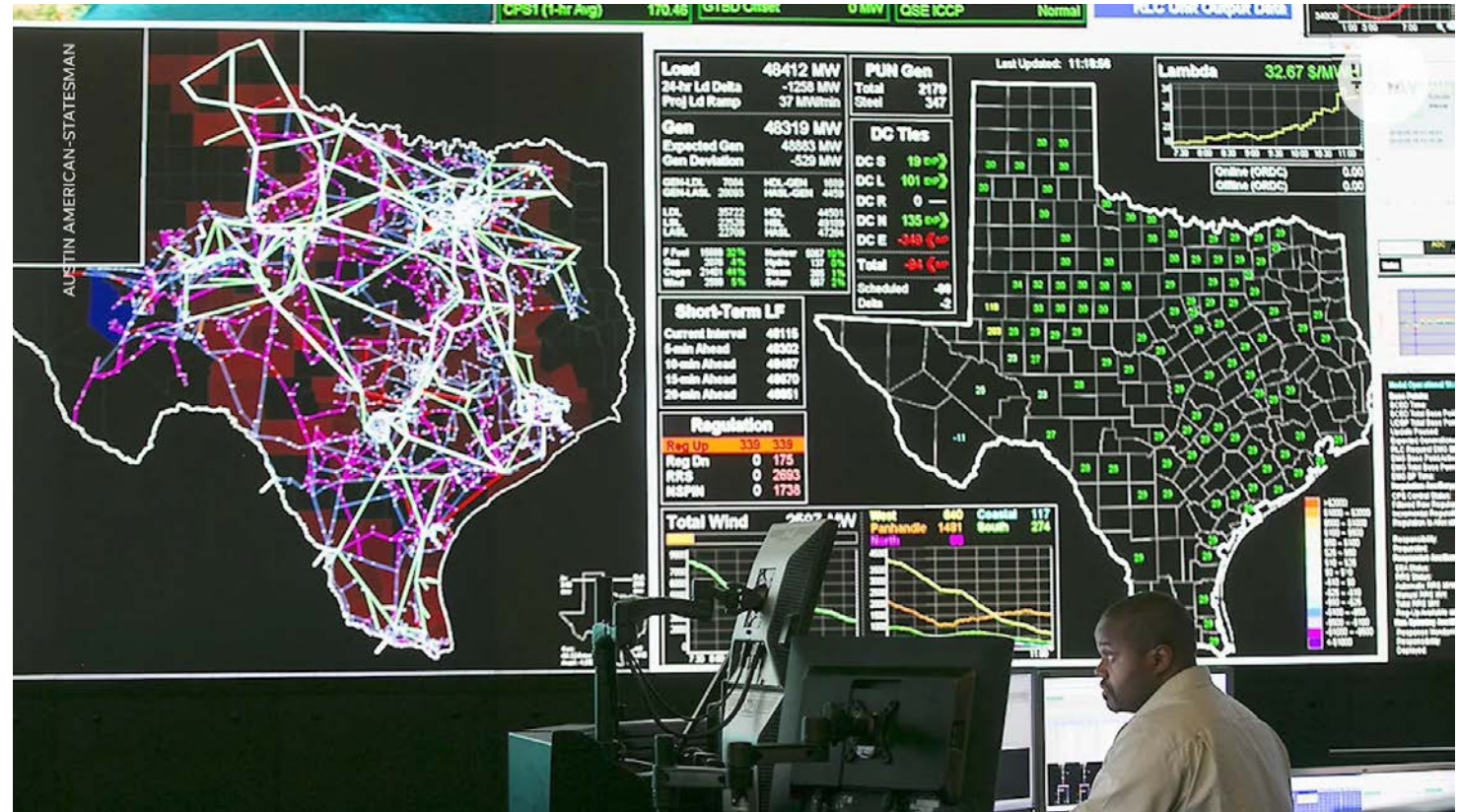
Christmas Day Bombing 2020 – AT&T Service Facility Nashville, TN

- **Communications**: Cellular, wireline telephone, internet service disrupted
- **Public Safety**: Multiple local 911 phone networks knocked down
- **Transportation**: Memphis Air Route Traffic Control Center comms issues led to FAA grounding flights
- **Financial**: Credit card systems and ATMs out of service

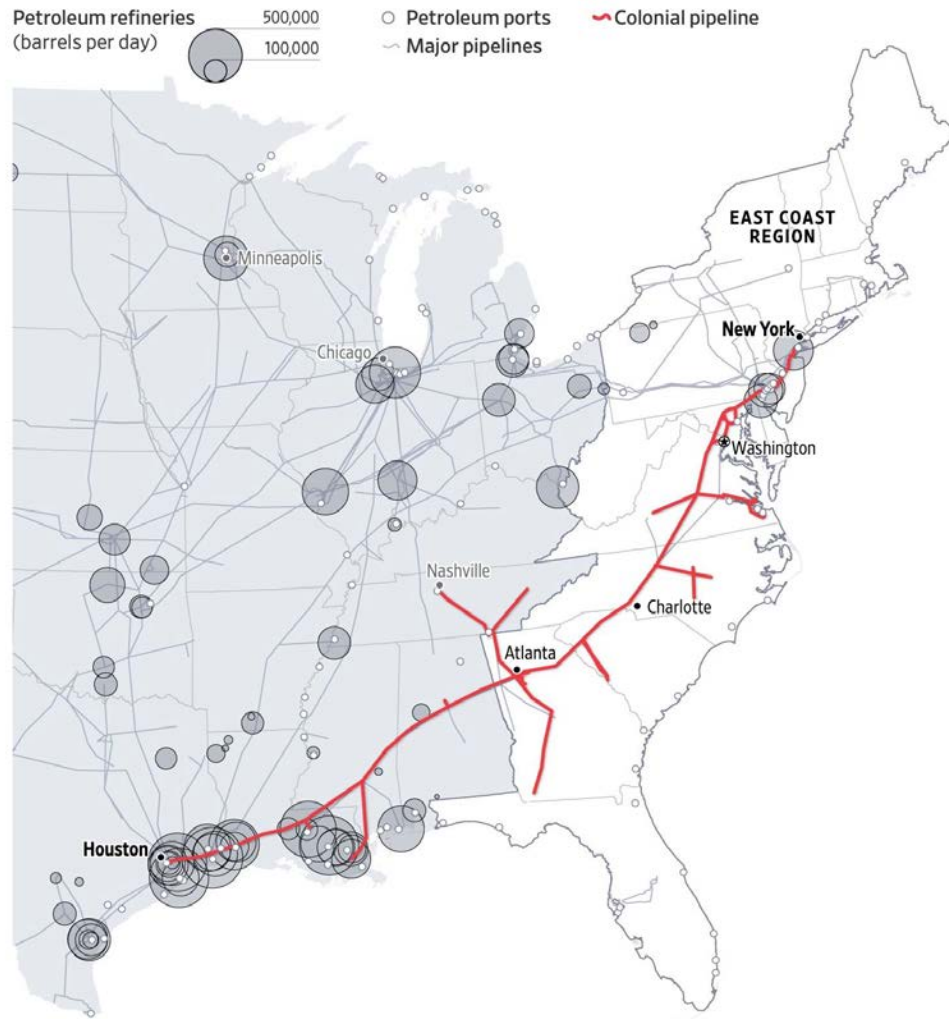


Texas Power Crisis 10-20 February 2021

- Energy: 5m people w/o power at peak
- Water: Service disrupted for 12m people
- Food: Closed grocery stores generated shortages.
- Public Safety: Fire hydrants unusable
- Health: 300 cases of CO poisoning & COVID-19 vaccination disrupted



Colonial Pipeline Cyber-Attack - May 2021



Source: Department of Energy

Colonial at a Glance



2.5M

barrels transported a day



5,500

miles of pipeline



29

refineries connected



267

customer terminals connected



5

miles per hour, the speed shipments move in the pipeline



12

states: the pipeline travels through Texas, Louisiana, Mississippi, Alabama, Georgia, South Carolina, North Carolina, Virginia, Maryland, Delaware, Pennsylvania, and New Jersey



8

major metropolitan areas are served by Colonial's mainline: Birmingham, Ala.; Atlanta; Charlotte, N.C.; Richmond, Va.; Washington, D.C.; Baltimore; Philadelphia; and New York



7

major airports (Nashville, Tenn.; Hartsfield, Ga.; Charlotte-Douglas, N.C.; Raleigh-Durham, N.C.; Greensboro, N.C.; Dulles, Va.; Baltimore/Washington International Thurgood Marshall, Md.) also transfer services to three airports in New York City area via an interconnection with the Buckeye Pipeline system



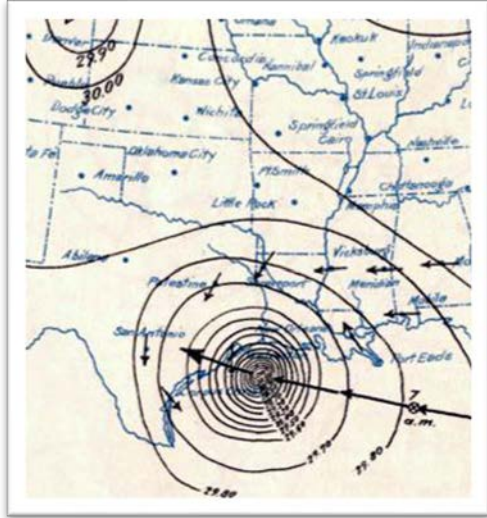
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military bases are served from which up to 10 additional bases from North Carolina to Maine are served

Source: Energy Information Administration

Wall Street Journal, May 13, 2021

“Isaac’s Storm” – 1900 Galveston Hurricane



- Deadliest natural disaster in U.S. history
- Cat 4 hurricane struck Galveston, TX on 9 Sep 1900
- Estimated 8,000 dead
- Every house in the city sustained damage, with at least 3,600 destroyed
- Because of the destruction of the bridges to the mainland and the telegraph lines, no word of the city's destruction was able to reach the mainland



Energy infrastructure can increase the risk of wildland fire outbreaks



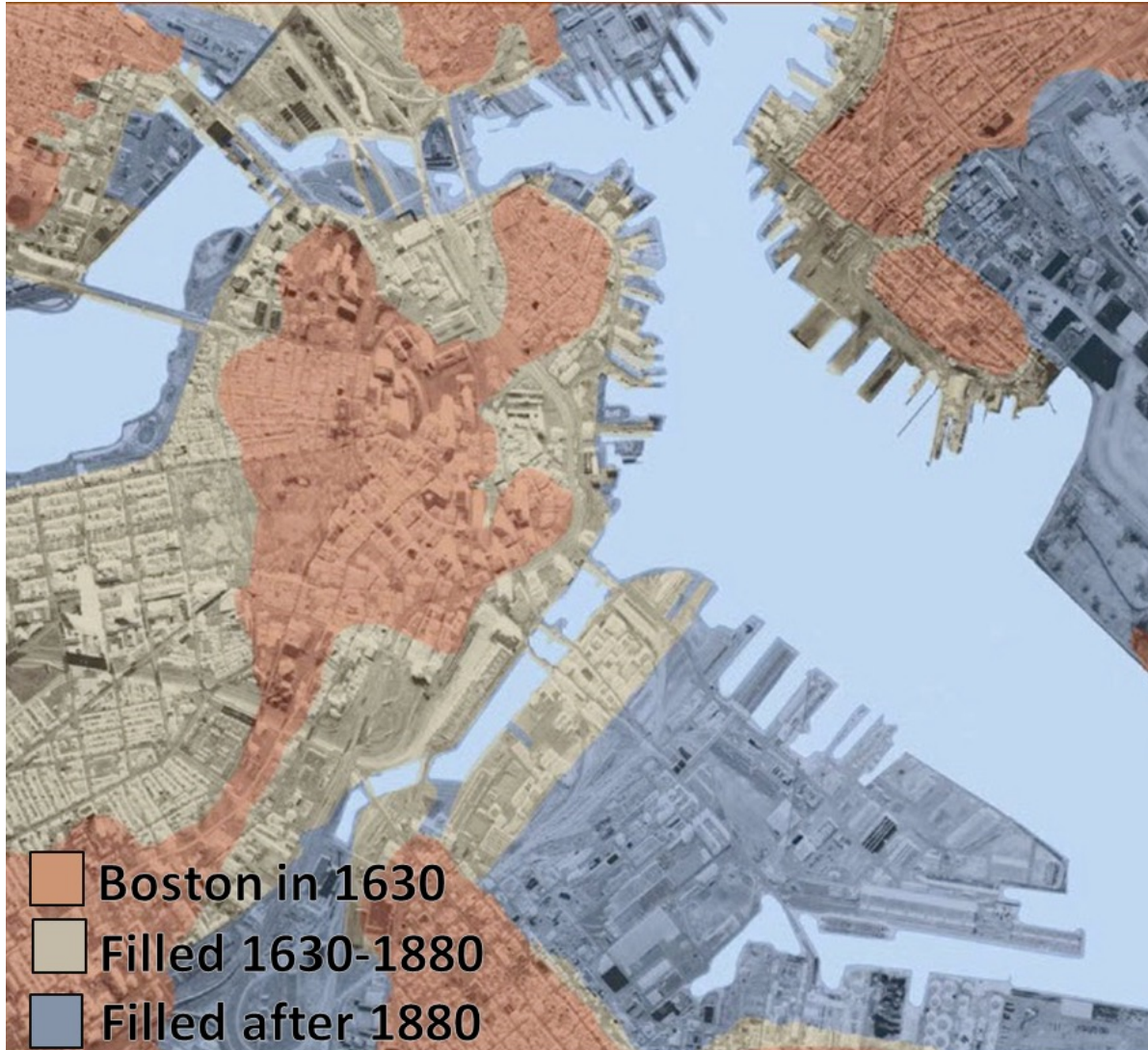
The interdependent drivers leading to more catastrophic Western wildfires are becoming more prevalent:

- The built environment is encroaching on the wildlands.
- The wildlands pose more risk to the built environment due to changing climate



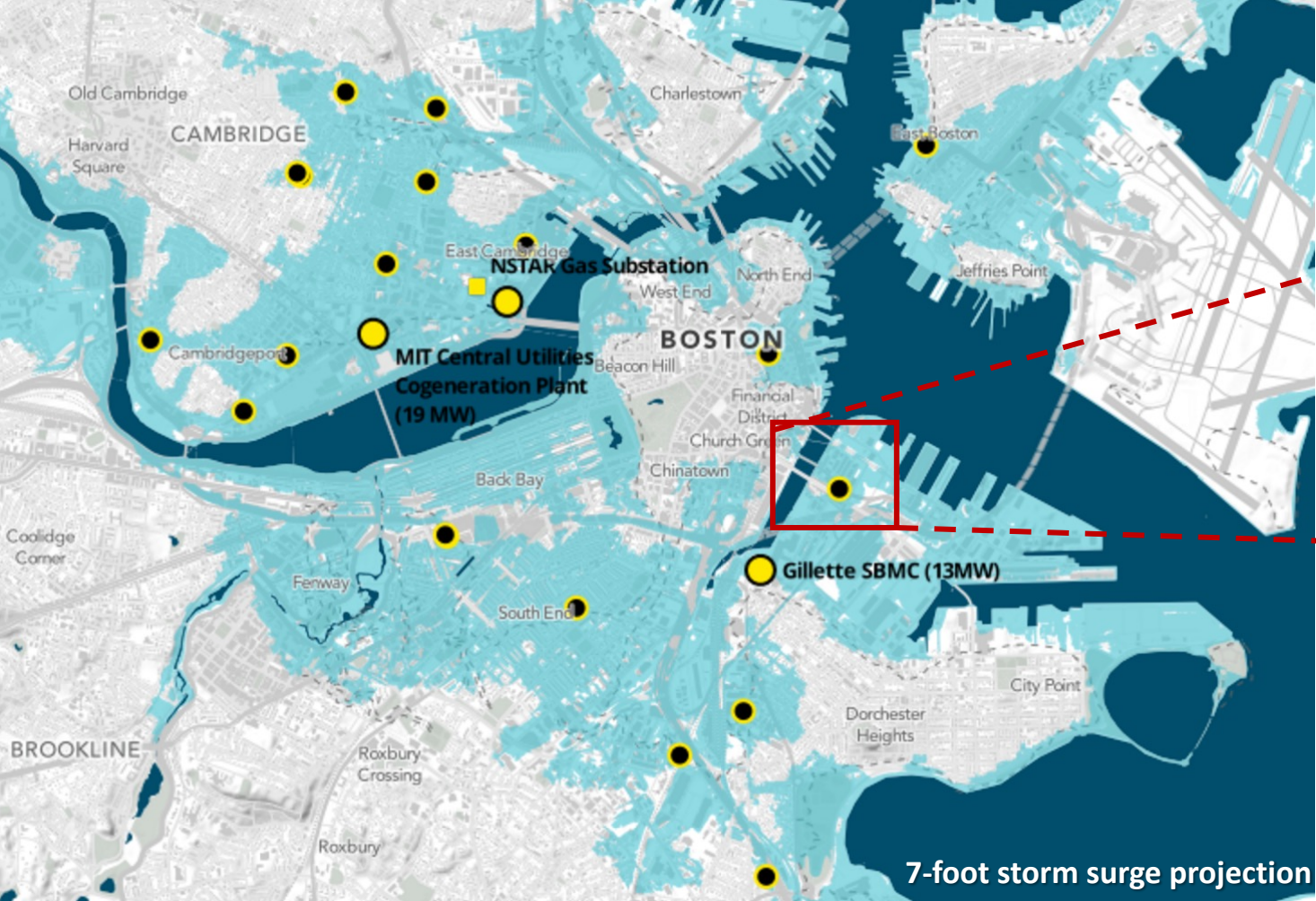
Wildfires pose risks to energy infrastructure in wildland environments

Potential Metro Boston Flooding Disaster Scenario



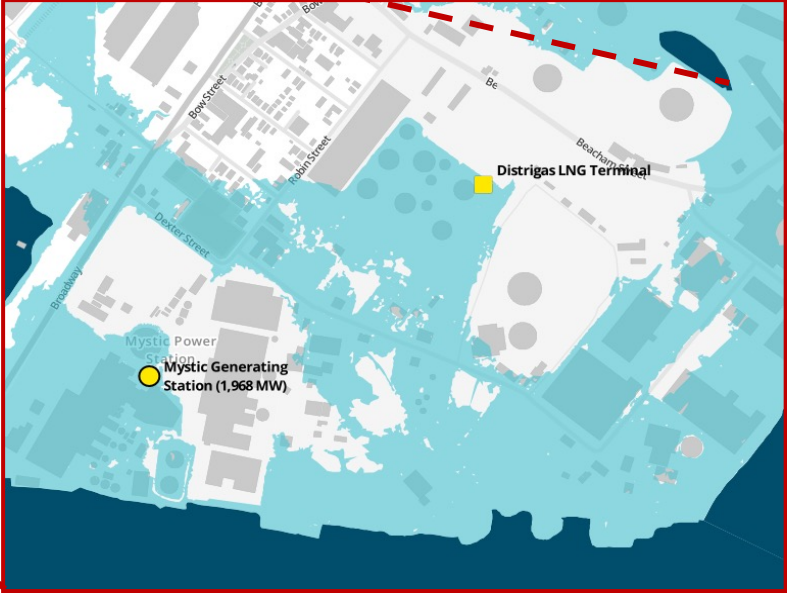
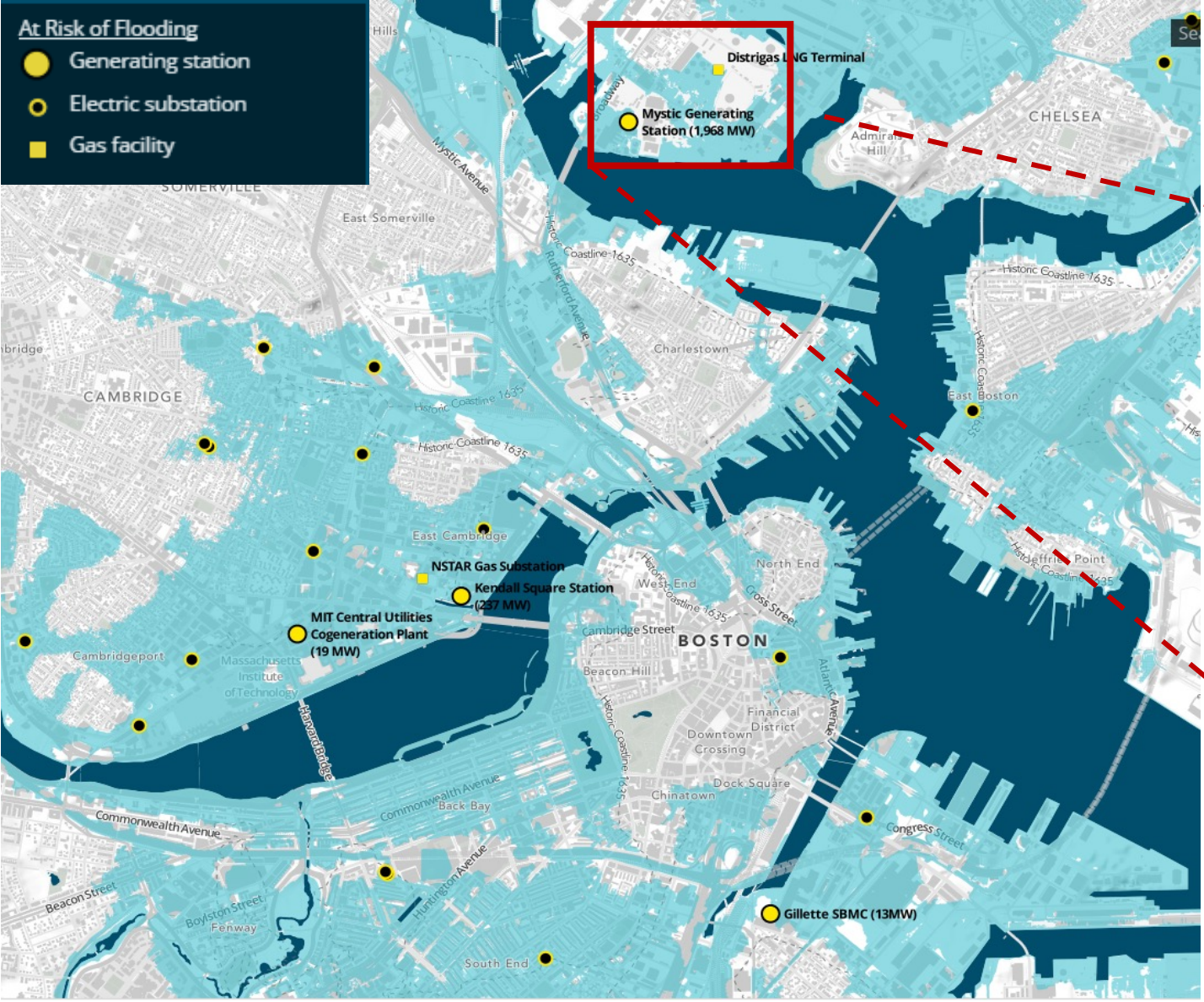
Potential Metro Boston Flooding Disaster Scenario

Substations impacted by 7-foot storm surge



There are **30 substations** in the **Boston metro region** within the projected 7-foot storm surge flood zone.

Potential Metro Boston Flooding Disaster Scenario



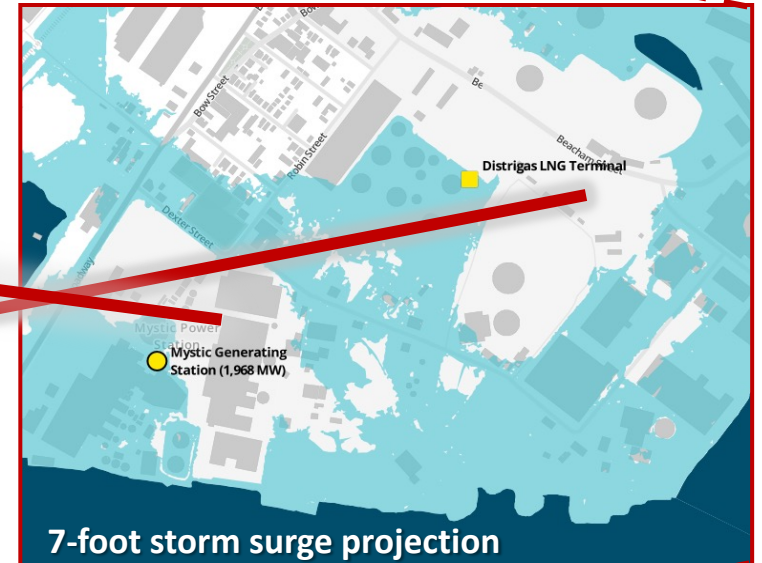
Mystic Generating Station
and
Distrigas LNG Terminal

Energy assets impacted by 7-foot storm surge

Potential Metro Boston Flooding Disaster Scenario

The **Distrigas LNG Terminal** is the only on-shore LNG terminal in the Northeastern U.S. It connects to the three major New England pipelines and National Grid's home heating distribution system.

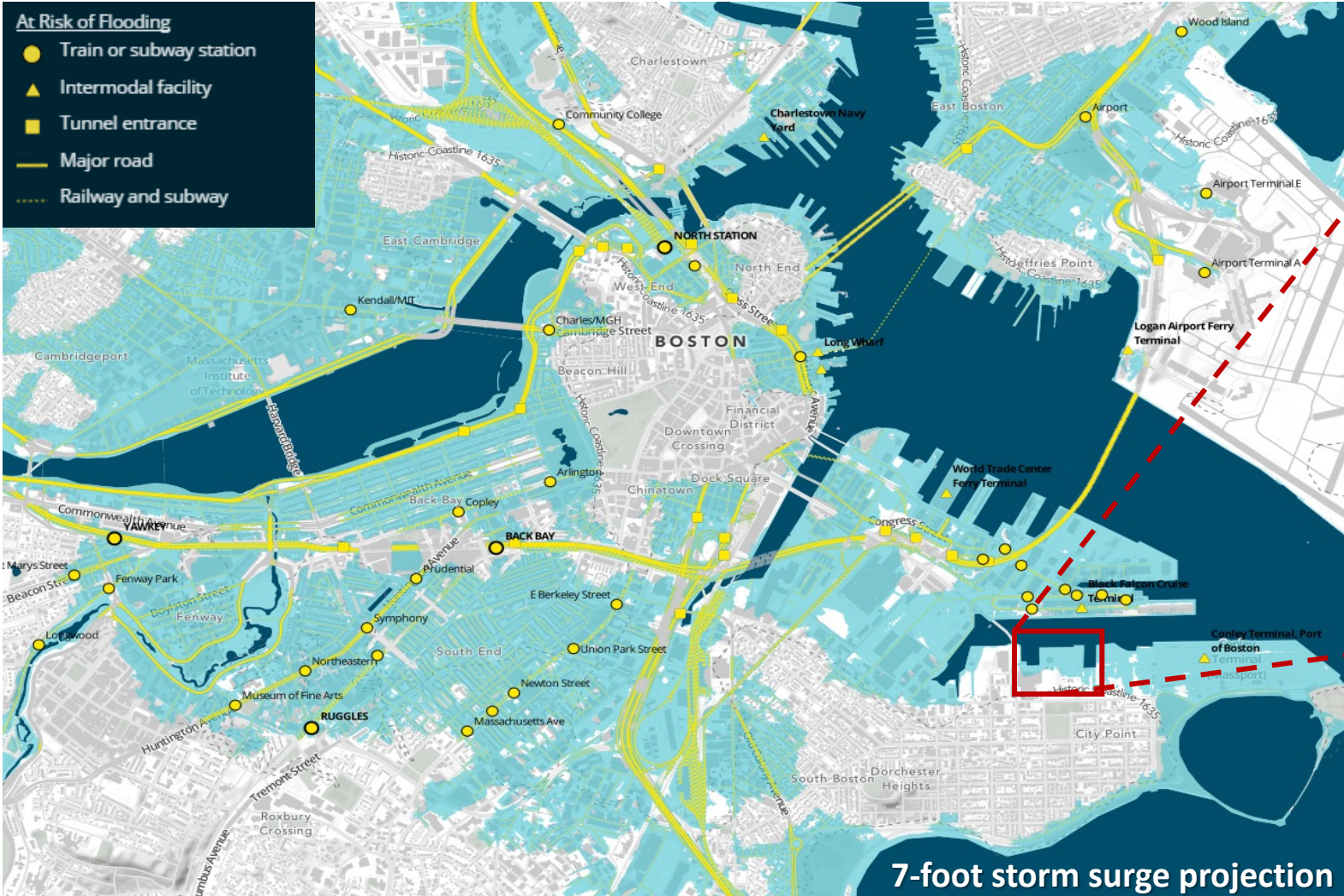
The **Mystic Generating Station** receives natural gas via pipeline from the Distrigas Terminal and provides a significant portion of electricity for metro-Boston.



Sasaki: seachange.sasaki.com

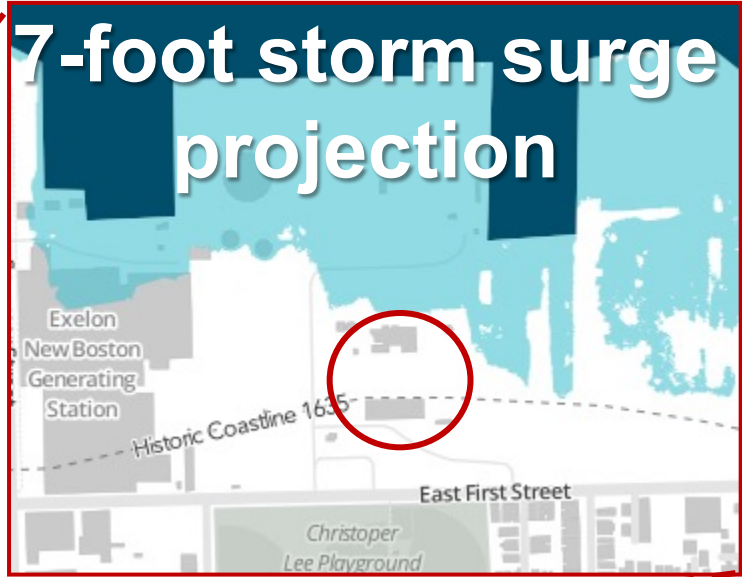
Potential Metro Boston Flooding Disaster Scenario

Transportation assets impacted by 7-foot storm surge



Sasaki: seachange.sasaki.com

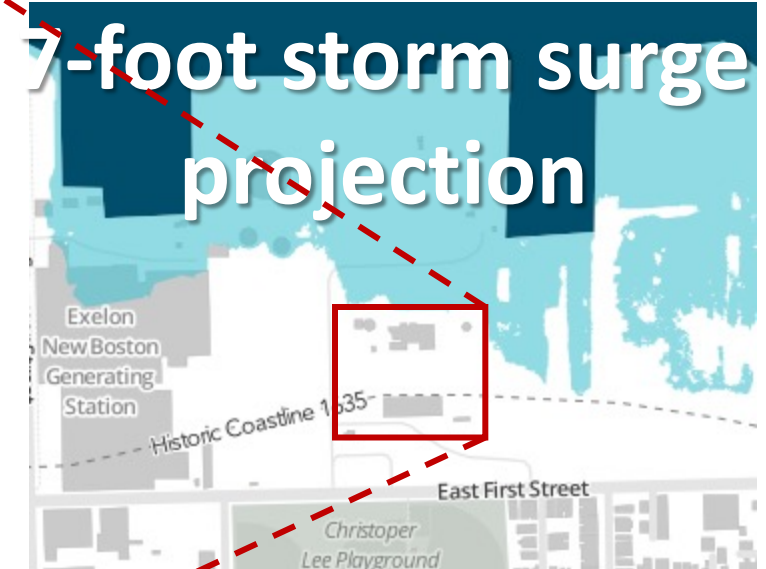
The MBTA's South Boston Power Complex



Potential Metro Boston Flooding Disaster Scenario



The MBTA's South Boston Power Complex



The **MBTA South Boston Power Complex** is the system's main connection to the city's power grid, and it also houses the MBTA's jet-fuel powered back-up generators.



Turbulence has become
the hallmark of the 21st
Century

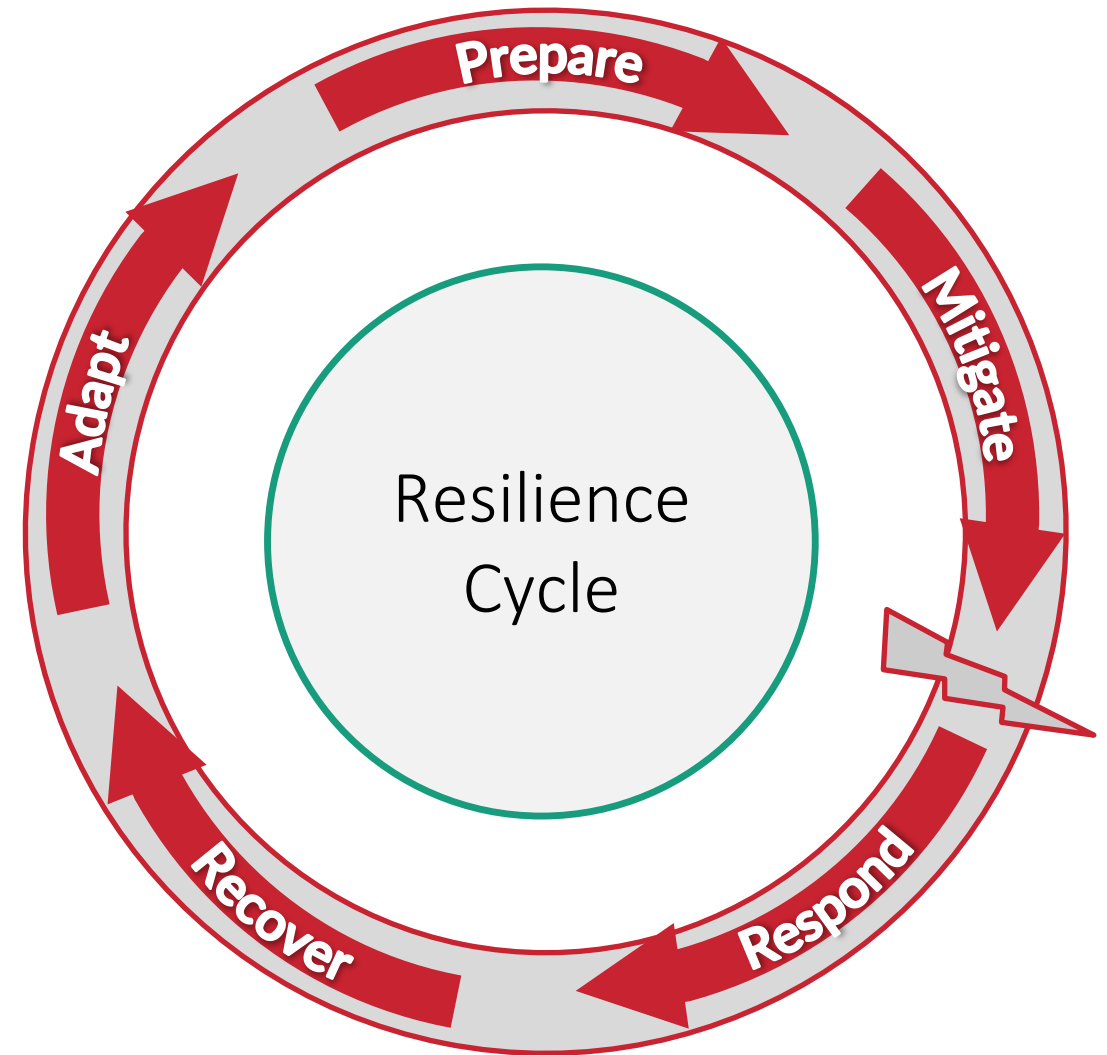


Pre-COVID-19, World Bank estimates
\$300b - \$500b in annual worldwide
economic losses

Putting Resilience into Practice

Resilience measures need to be incorporated into managing the risk of community disruption:

- Prior to a shock or disruption
- During a shock or disruption
- Following a shock or disruption



Adapted from "Resilience Cycle" by Stefan Hiermaier, Director, Fraunhofer EMI

Building Resilience Requires Overcoming 5 Critical Barriers



Risk Illiteracy
and a pervasive lack of
understanding of
interdependent systems



Inadequate designs
for embedding
resilience into
systems at
multiple levels



**Pervasive economic
disincentives**
for investing in resilience



**Inadequate governance
frameworks**
and policy guidance to
foster resilience



**Lack of adequate training
and education** to support
the development and
implementation of tools,
applications, processes
and policies



Goldman Sachs Headquarters 200 West St. New York, NY

Superstorm
Sandy
Pre-Landfall

Oct 28, 2012



“An island of resilience. . . , but in a sea of fragility”

October 29, 2012

**Goldman 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



Goldman
Sachs

Source: Google+ Johannes Sugiharto

The Sand Palace, on 36th Street in Mexico Beach, FL Post-Hurricane Michael Oct 2018



Credit: Johnny Milano for
The New York Times



Babcock Ranch – 12-mile NE of Fort Myers, FL Sep 2020

Post-Hurricane Ian:

- No major property damage
- No loss of power
- No loss of water
- No loss of internet

Climate Resilience:

- Solar-powered community,
Streets designed to flood so houses don't
- Native landscaping along roads helps control storm water.
- Power and internet lines are buried to avoid wind damage.

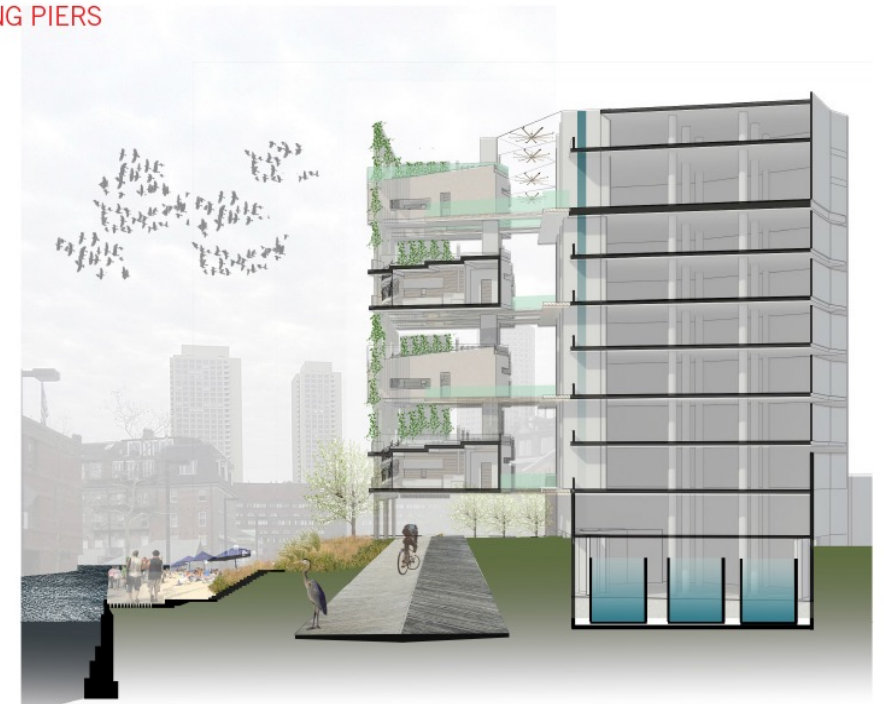
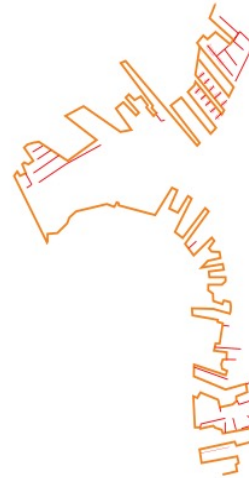


Baking Resilience into Economic Development & Economic Recovery

- Blending development priorities with resilience imperatives
- Adapting codes and incentives to support innovative resilience designs
- Teaming urban planners and regional developers with emergency managers



THE PRINCE BUILDING PIERS



Rather than trying to prevent seawater from entering the city, this proposal welcomes the water and repurposes the outer streetscapes to a new urban seashore.

Led by Stephanie Goldberg AIA & Mark Reed AIA, Boston
<http://www.bostonlivingwithwater.org/portfolio/finalist-princebuildingpiers>

“Emerald Tutu” - Embracing Innovative Nature-based solutions to Climate Adaptation



Project lead: Prof. Julia Hopkins, Northeastern U.

- 7' Circular Mats of Vegetation
- Constructed w/ biodegradable materials
- Grass on top / seaweed below
- Soak-up /disperse wave energy



<https://news.northeastern.edu/2022/07/05/professor-develops-emerald-tutu/>



How to Advance Critical Infrastructure Resilience

It will require accomplishing 4 things concurrently:

1. Support decision-making and planning by harnessing the power of:
 - Network Science
 - Modeling
 - Visualization
 - Sensors
 - Artificial Intelligence/Machine Learning
 - Decision-support tools
2. Devise resilience protocols for mitigating, responding to, recovering from, and adapting to shocks and disruptions
3. Identify and deploy public policy (e.g., standards & codes) and market-based incentives (e.g., insurance) for adopting resilience best practices on local, regional, national, and continental scales

Conclusions relevant to military installations

- ✓ Resilience is a national security issue; i.e., it is critical to mission assurance.
- ✓ Achieving resilience for military installations requires a deeper understanding of the risk of cascading failures to interdependent infrastructure systems beyond military base perimeters.
- ✓ Resilience requires robust civil-military collaboration because military installations will not succeed at isolating themselves from the impacts of large-scale disasters.
- ✓ Military installations need to pro-active in leading efforts within their surrounding communities to “bake-in” resilience into critical civilian systems and functions; i.e., provide technical assistance and economic incentives.



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