



# **Disaster Risk Reduction (DRR) Training**

## **Beyond Codes**

### **Risk Based Life Cycle Planning**

**David Vaughn**

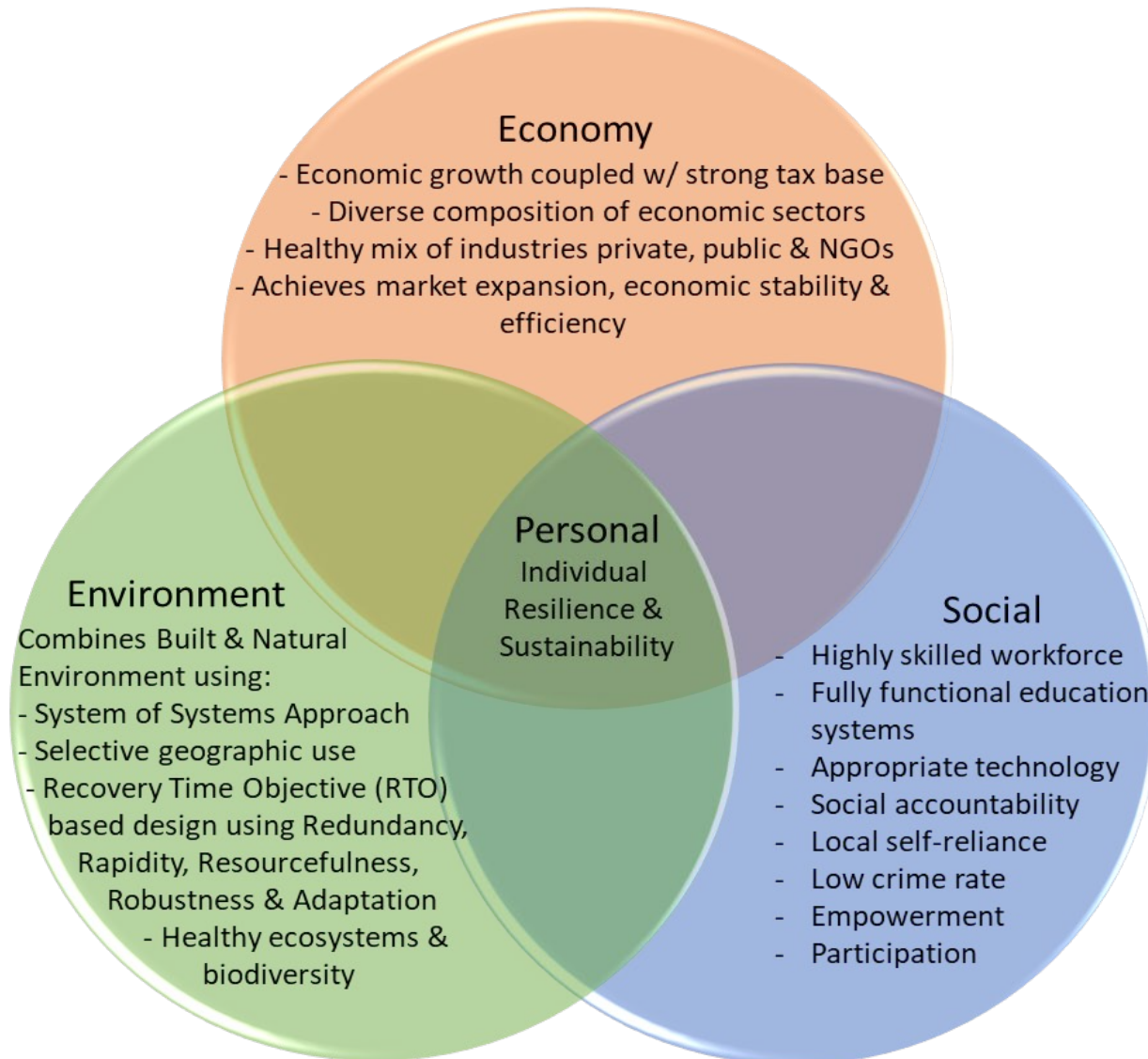
**September 14, 2020**



**RESA**

RISK ENGINEERING AND  
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AT CLEMSON UNIVERSITY

# Resilience and Sustainable Development



# Building Resilience

***Resilience is the ability to adapt to changing conditions, anticipate risk, limit the impacts, and recover rapidly.***

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## Foundations:

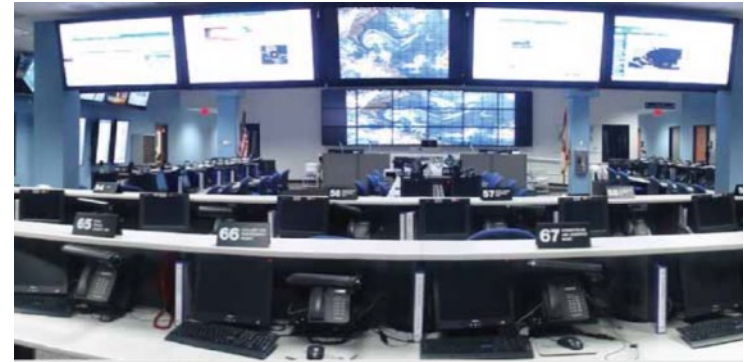
- 1. We can identify the threats**
- 2. We can model the threats to predict the effects (risk)**
- 3. We can create risk management strategies to counter the negative effects**

# Four Players Create a Risk Ecosystem



# Scenario – *Emergency Operations Center in Miami Beach, Florida*

- **Role is to coordinate all emergency preparedness and response for any emergency that may arise in Miami Beach**
- **Citizens depend on the support of the EOC**
- **Designed to withstand extreme hurricanes and be fully operational and self-contained for 168 hours (1 week)**
  - **Includes structural design, food, water, communications, etc.**



[http://www.eri-intl.com/eoc\\_case\\_study.pdf](http://www.eri-intl.com/eoc_case_study.pdf)

# Types of Threats

## ■ Notice vs. zero-notice

- **Black elephants**
- **Black swans**
- **Gray Rhinos**
- **Black Jellyfish**



Known  
Knowns

Known  
Unknowns



Unknown  
Knowns

Unknown  
Unknowns



### Natural Hazards – Geological

- Earthquake
- Tsunami
- Volcano
- Landslide, mudslide, subsidence
- Glacier, iceberg

### Natural Hazards – Meteorological

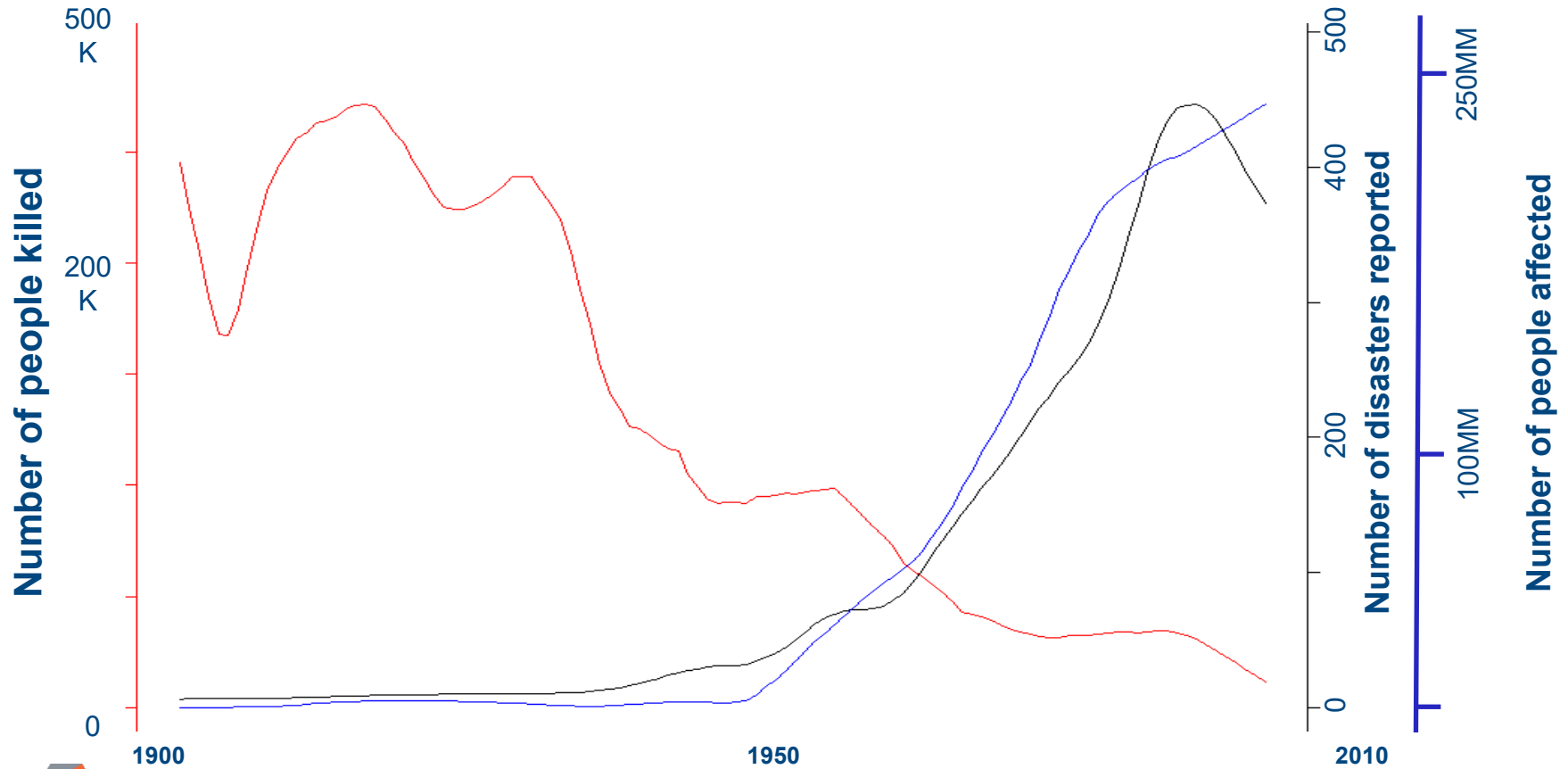
- Drought
- Windstorm, tropical cyclone, hurricane, tornado, waterspout, dust / sandstorm
- Extreme temperatures (heat, cold)
- Lightning strikes
- Snow, ice, hail, sleet, avalanche

### Natural Hazards – Biological

- Diseases (pandemic)
- Animal or insect infestation or damage

# Natural Disaster Summary 1900 to 2011

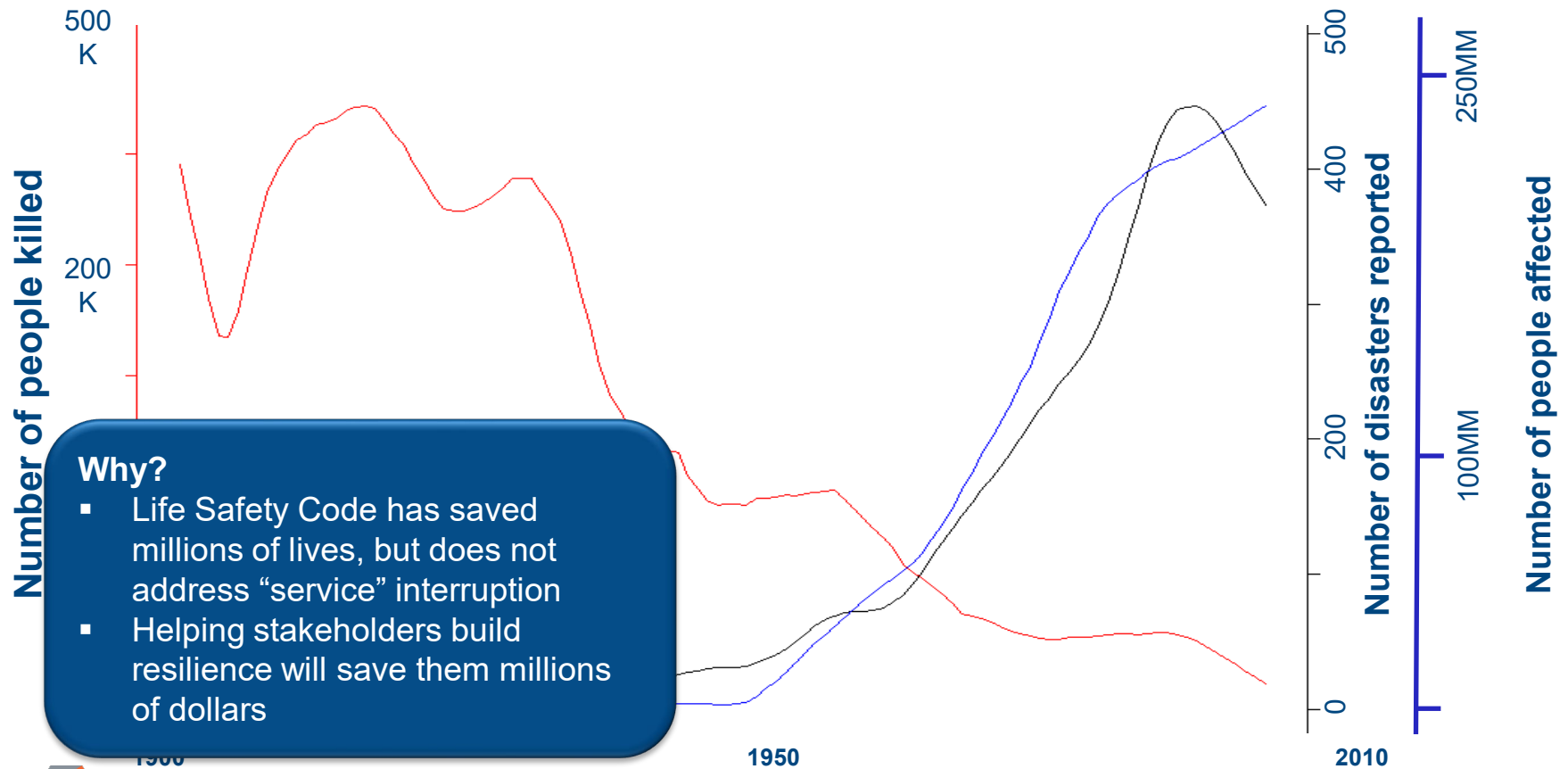
Deaths from natural disasters decrease while frequency of events and number of affected



Source: EM-DAT: the OFDA/CRED International Disaster Database – [www.emdat.be](http://www.emdat.be)

# Natural Disaster Summary 1900 to 2011

Deaths from natural disasters decrease while frequency of events and number of affected



## Why?

- Life Safety Code has saved millions of lives, but does not address “service” interruption
- Helping stakeholders build resilience will save them millions of dollars

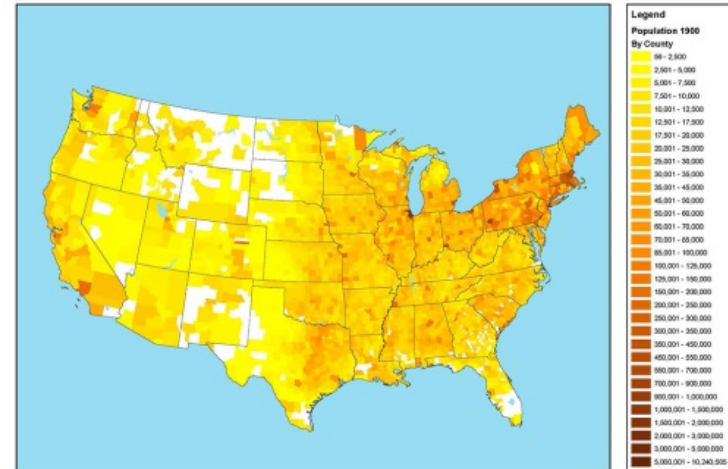
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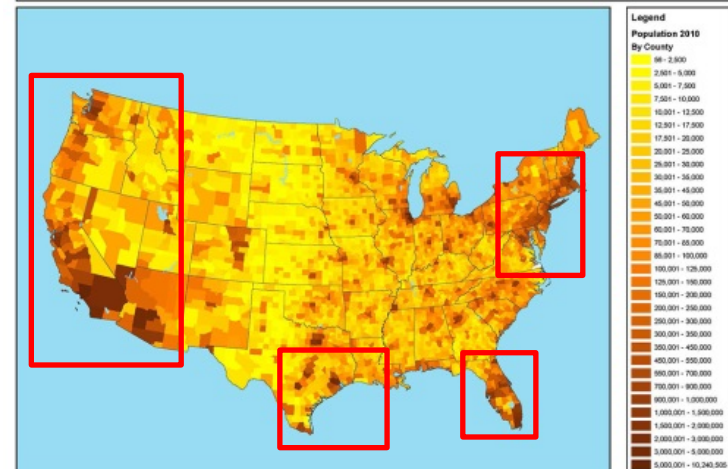
# Population Shifts to Vulnerable Regions

- In 2010, 39% of the U.S. population lived in coastal shoreline counties, which represent less than 10% of the U.S. land area
- Population density in coastal areas expected to increase at more than three times the national average between 2010 and 2020

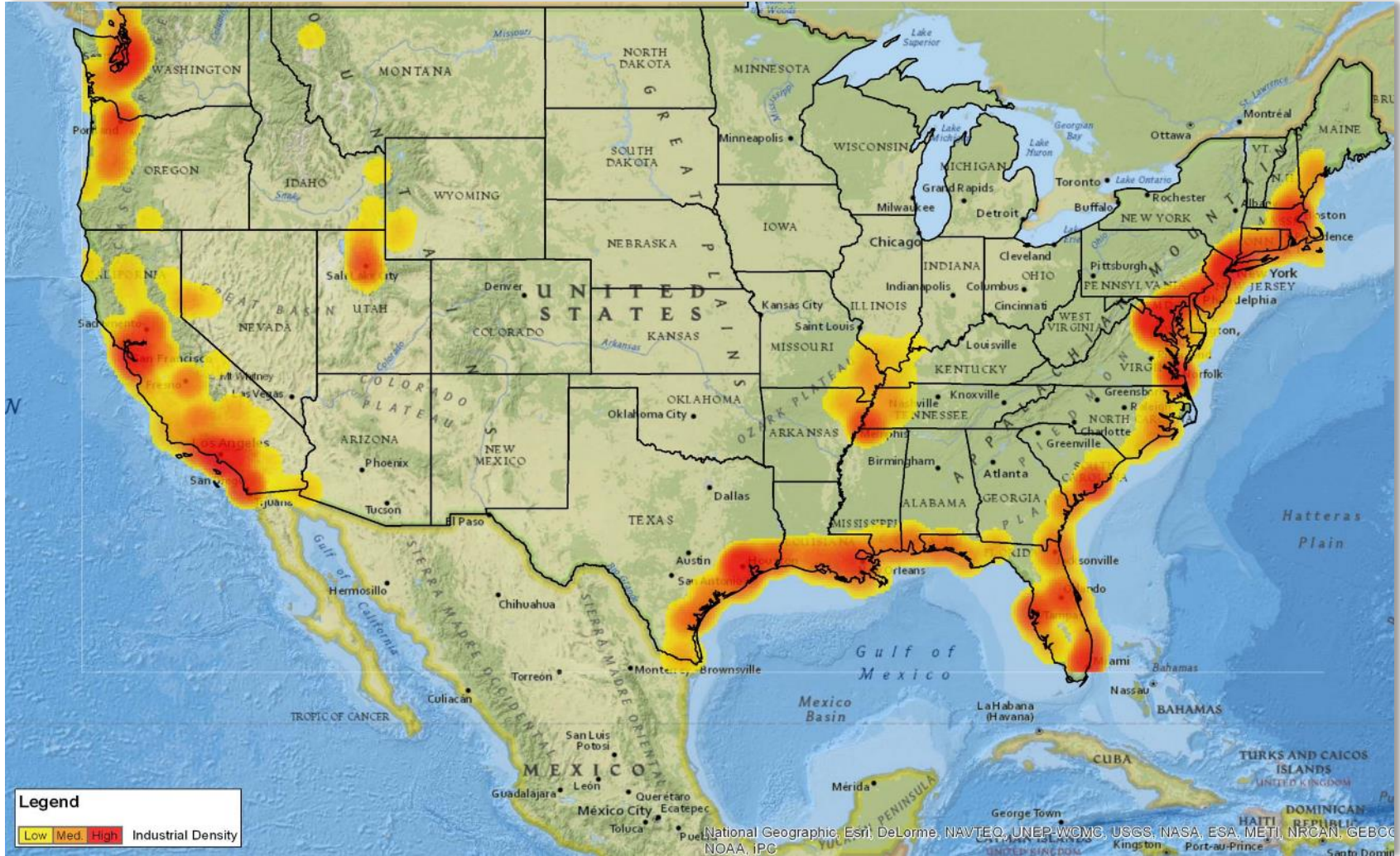
## US Census Population 1900



## US Census Population 2010



# Population & Industry Densities (Business Analyst) in Hurricane & Earthquake Hazard Zones

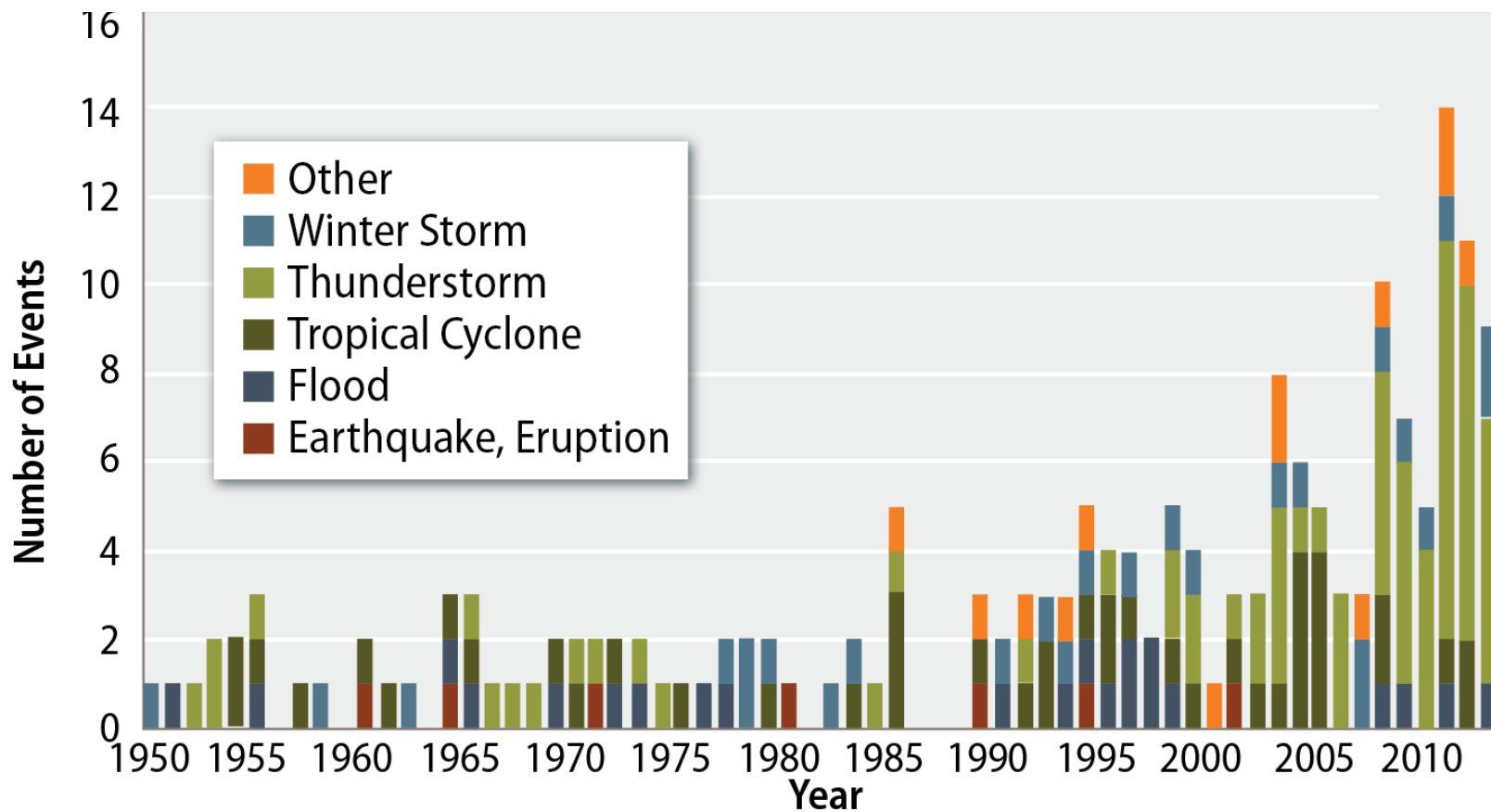


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# Emphasis on Increased Risk

## Number of Natural Catastrophes with at Least \$1 Billion in Economic Loss and / or 50 Fatalities



Source: Munich Re: 2013 Natural Catastrophe Year in Review

# But We Have Insurance - Why Reduce Risk?

- **Sales/customer loyalty**
- **Unrecoverable costs**
- **Shareholder confidence**
- **Employee retention**
- **Productivity and innovation**
- **Regulatory compliance**
- **Insurance premiums**
- **Employee lives**
- **Local tax base**
- **Revenue**
- **Regional economic recovery**

# The Impact on Shareholder Value



Source: *The Impact of Catastrophes on Shareholders Value*, Oxford Metrica.

# Risk Based Life Cycle Planning

## Enterprise Resilience

### Enterprise Planning

- Business continuity plan (BCP) - NFPA 1600
- Map supply chain dependencies
- Threat identification
- High level vulnerability assessments
- Prioritize spending
- Insurance negotiations

### Location Strategies

- Site selection
- Real estate negotiations
- Technical due diligence
- Disposal of assets
- Incentives for retained/expanded facilities

### Resilient Design

- Criticality reviews
- All hazard assessment
- Design threat determination
- Multi-discipline resilient design

### Pre-Event Planning

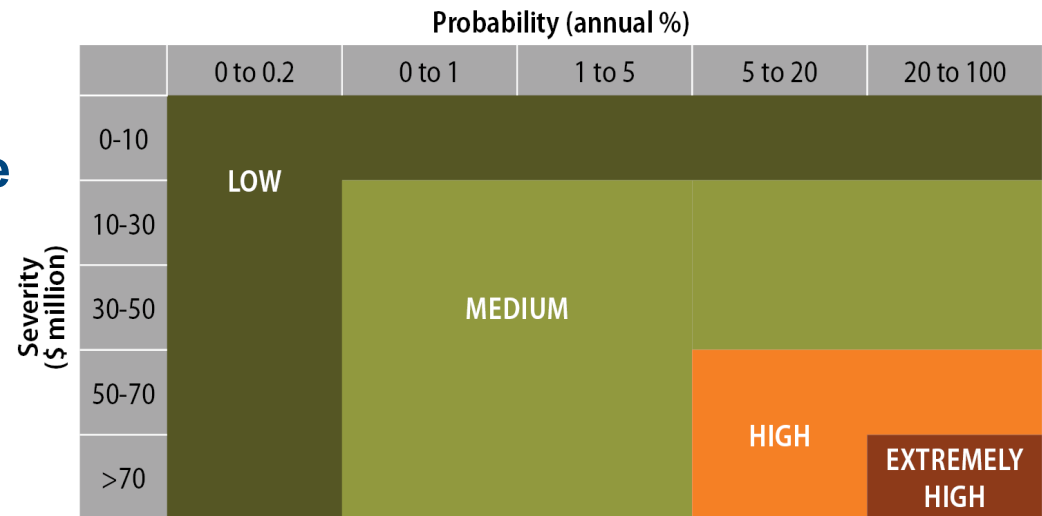
- Site assessment
- Hazard modeling
- Risk mitigation
- Preparedness & planning

### Post-Event Recovery

- Response
- Recovery
- After action review & lessons learned

# Risk

- Risks prioritized based upon likelihood and severity
- Likelihood is the probability of occurrence in each time period
- Severity is the consequence of occurrence
  - Due to downtime, economic loss, environmental impact, societal impact, or lives lost



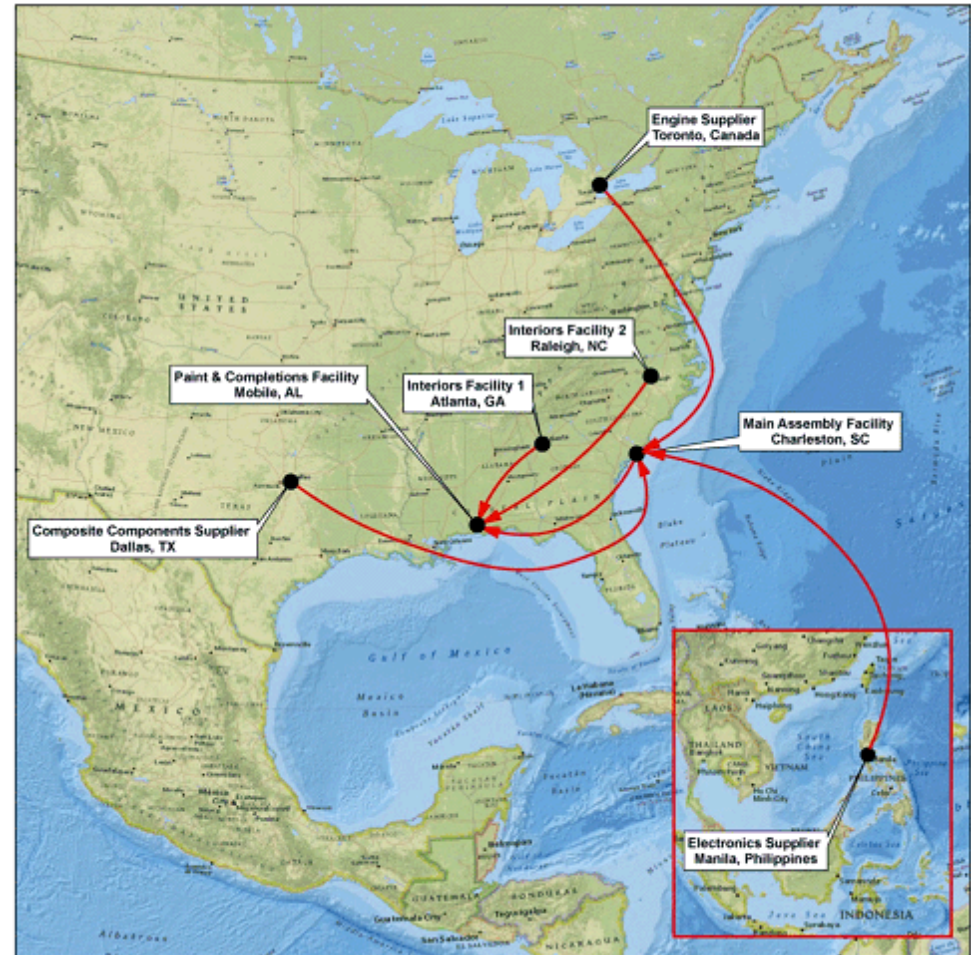
# Risk Management

- **Primary disaster risk management techniques:**
  - **Avoidance**
    - **Location**
  - **Reduction**
    - **Mitigation**
  - **Transference**
    - **Insurance**
  - **Acceptance**



# Enterprise Planning

- BCP Alignment
- Map Supply Chain Dependencies
- Threat Identification
- High-Level Vulnerability Assessments
- Prioritize Spending
- Insurance Negotiations



# Why Enterprise Planning?

## Hurricane Katrina<sub>1</sub>

- **Nearly 7,900 businesses in southeast Louisiana shut down between the 2<sup>nd</sup> quarter of 2005 and 4<sup>th</sup> quarter of 2006**

## Tohoku, Japan Earthquake/Tsunami<sub>2</sub>

- **Post-event, Toyota announced expected 2012 operating profit to fall by 35%**
- **In June 2012, Honda announced profit decreased 63.5% from previous year**

1 [http://usatoday30.usatoday.com/money/smallbusiness/2007-08-28-katrina-finances\\_N.htm](http://usatoday30.usatoday.com/money/smallbusiness/2007-08-28-katrina-finances_N.htm)  
2 [http://www.tthlaw.com/assets/PubArticles/Trembly%20-%20Lessons%20from%20Japan%20\(Bests%20Review%20Mag%20Aug%202011\).PDF](http://www.tthlaw.com/assets/PubArticles/Trembly%20-%20Lessons%20from%20Japan%20(Bests%20Review%20Mag%20Aug%202011).PDF)



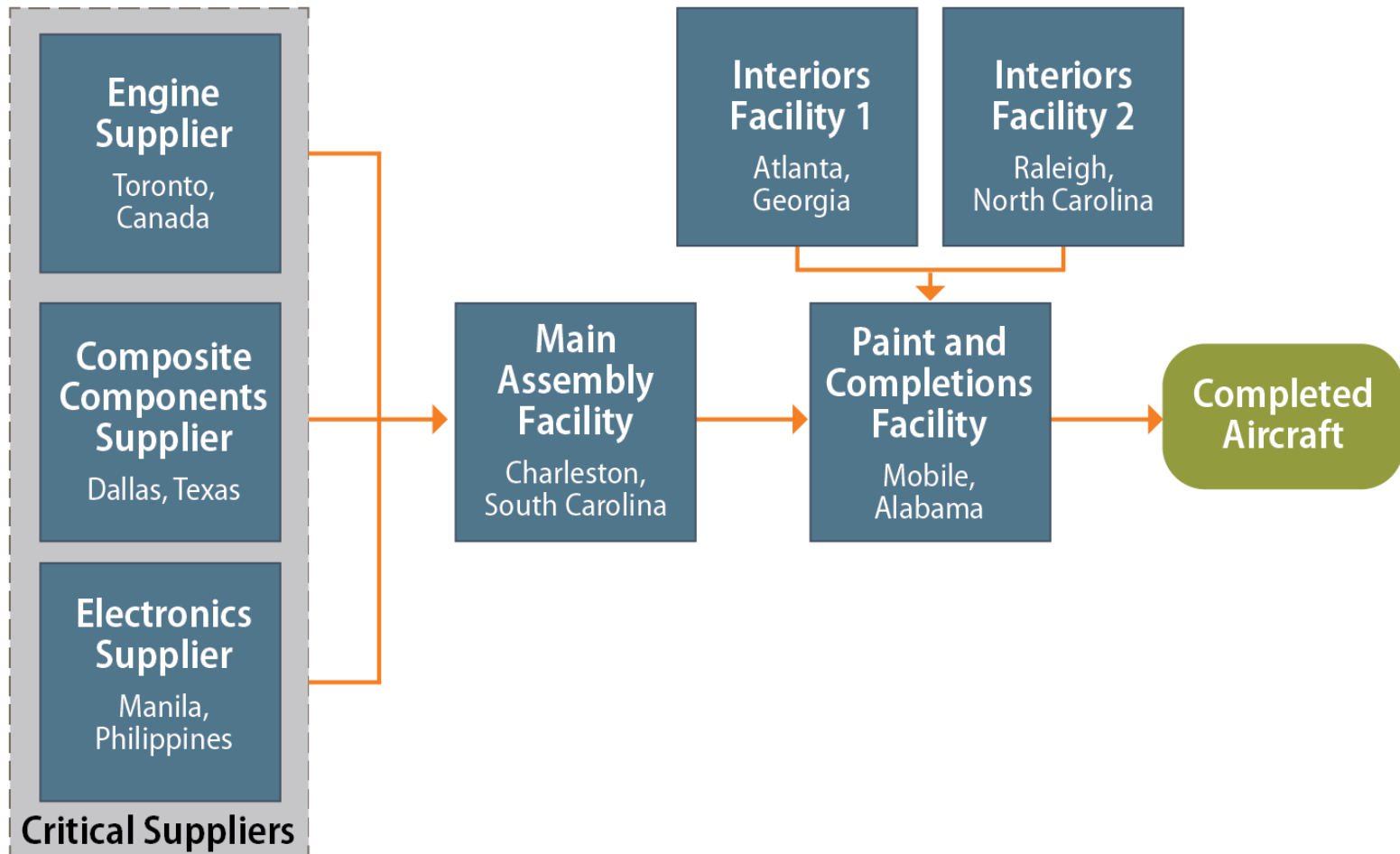
# Value Chain Process Mapping (VCPM)

- **Value chain- the process used to deliver a company's goods or services**
- **VCPM identifies critical nodes and interdependencies**
- **Shows cascade effects of outages**
- **Critical nodes can include equipment, process units, or entire sites (depending on desired granularity)**
- **Identifies internal vulnerabilities and vulnerabilities among suppliers**



# Value Chain Process Map

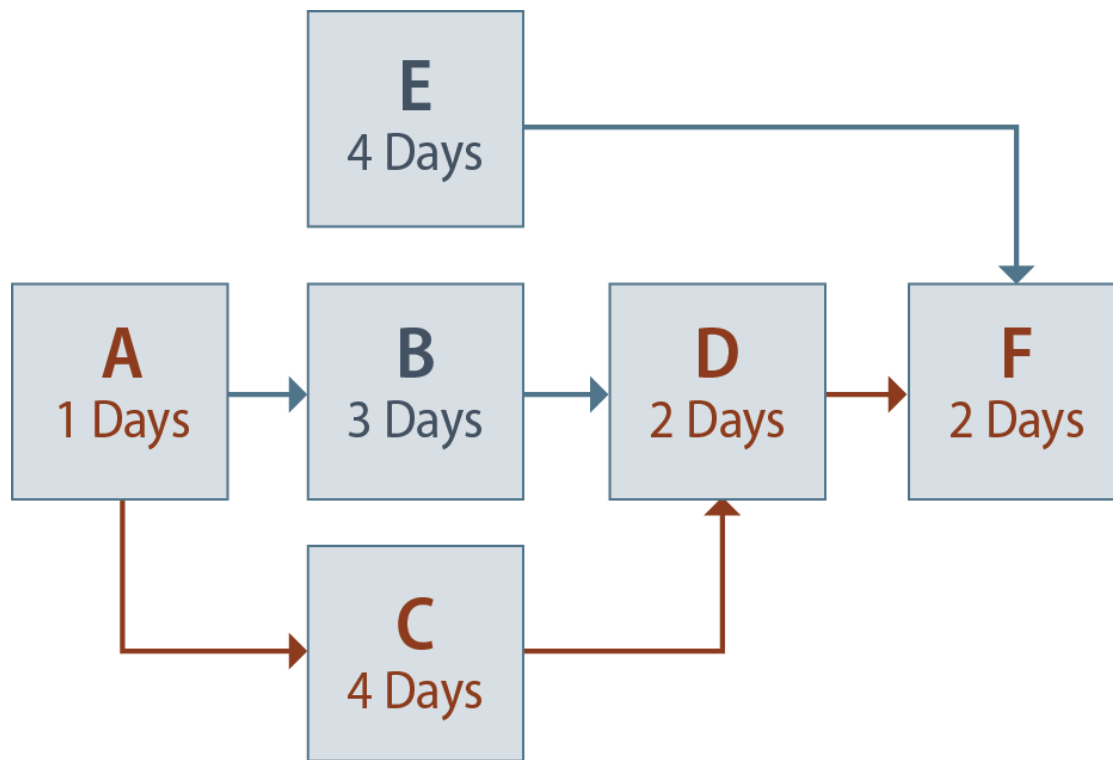
## Enterprise Level Aerospace Example



# Value Chain Process Map

## Assessing Criticality

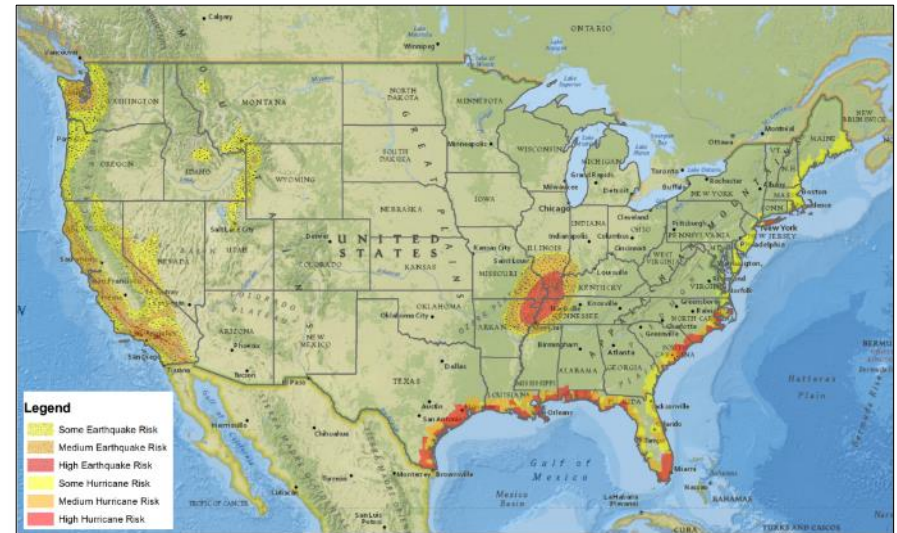
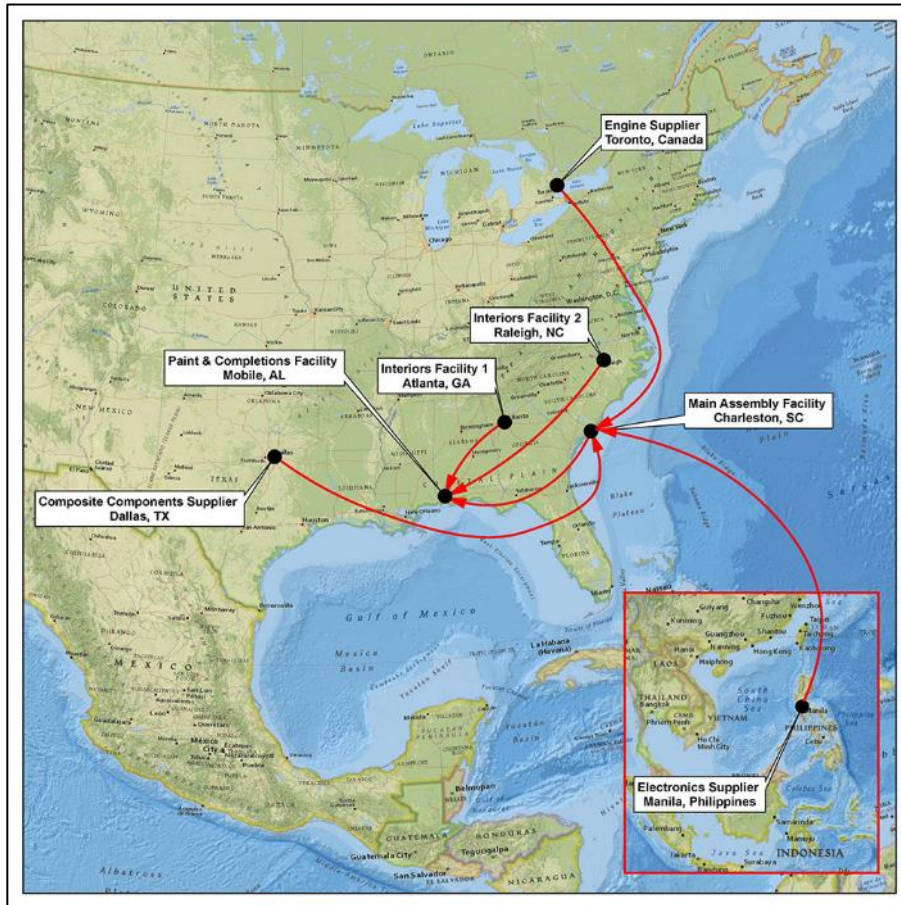
- Criticality assessed using critical path method
- ACDF is critical path in this example



Path	Time
E + F	6 days
A + B + D + F	8 days
<b>A + C + D + F</b>	<b>9 days</b>

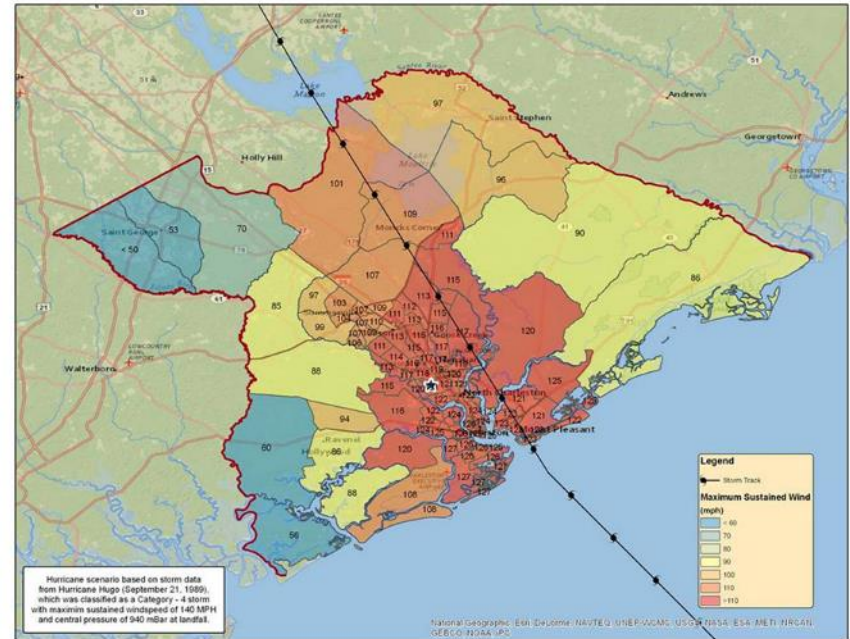
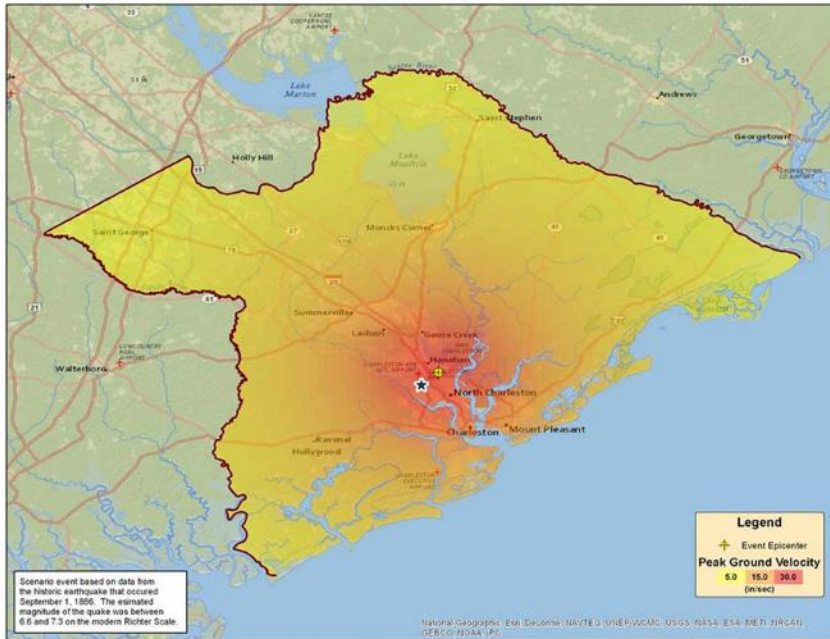
# Value Chain Process Map

## Enterprise Geographic Susceptibility



# Value Chain Process Map

## Detailed Site Exposure- Charleston



# Location Strategies

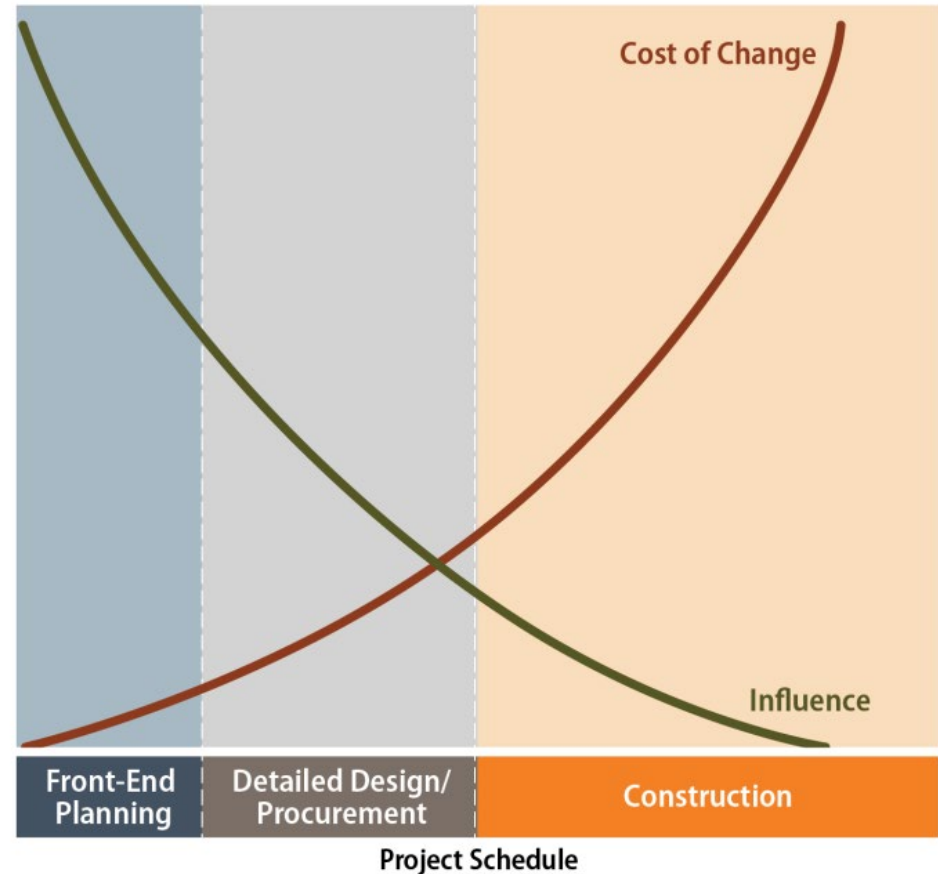
- **Geographic optimization of assets**
- **Site selection**
  - **Logistics**
  - **Threats**
  - **Workforce**
  - **Environment**
  - **Infrastructure**
- **Incentive negotiations**
  - **Tax breaks**
- **Real estate negotiations and valuation**
- **Technical asset due diligence**





# Resilient Engineering

- It is more cost-effective to build in resilience than to retrofit
- Value engineering is shortsighted and can eliminate resilience
- Resilient engineering should be based upon recovery time objective (RTO) and a design threat



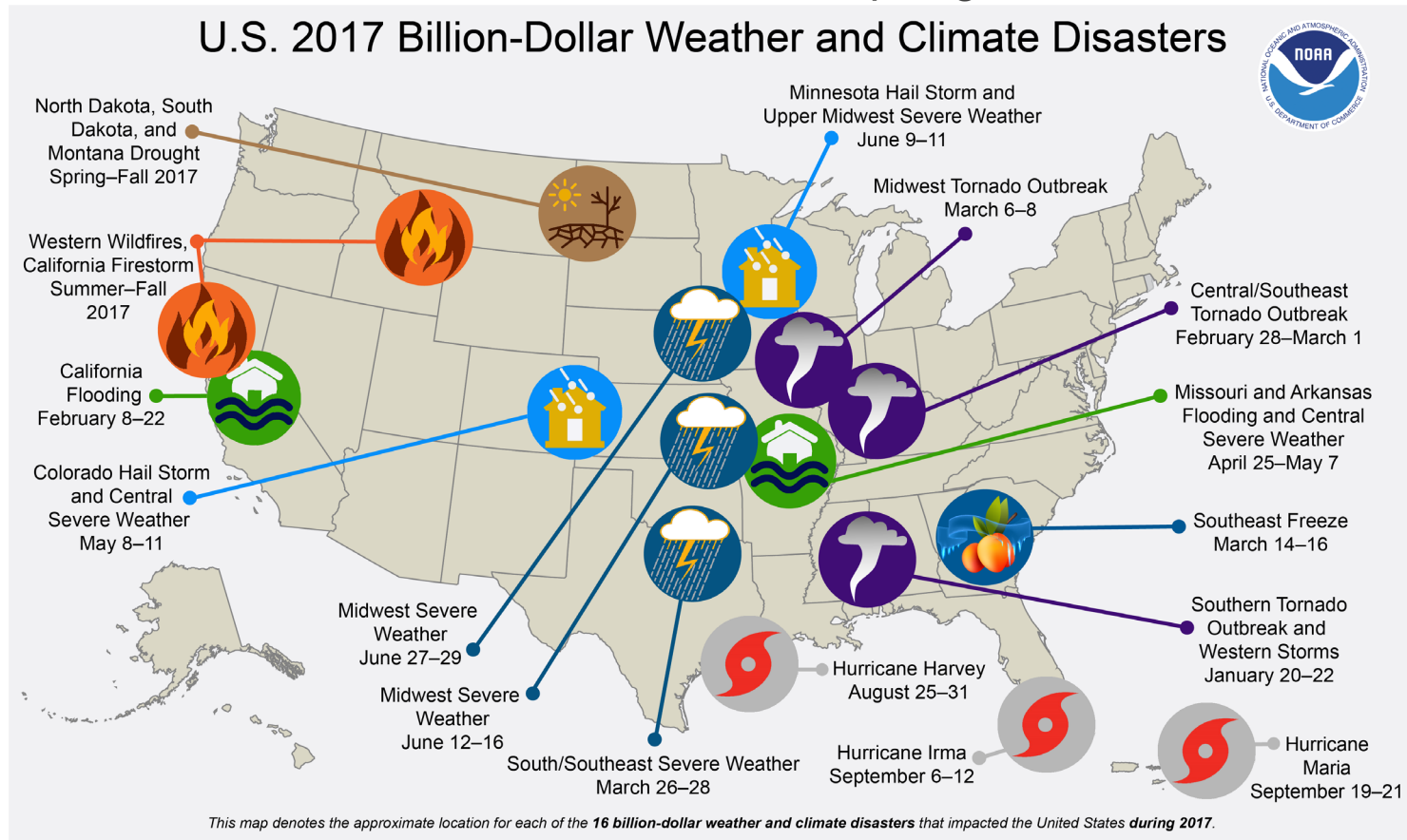
# What Do You Need To Know To Start Planning? What Is Critical?

- **Recovery Time Objective (RTO)**
  - How long can your operations be off-line?
  - Do you have any single points of failure?
  - Is redundancy built into your production process?
- **Threat Hazard Identification and Risk Assessment (THIRA)**
  - Have you identified all your threats?
  - What size threat do you use for planning purposes?
  - **Likelihood: Probabilistic vs. Deterministic approaches**



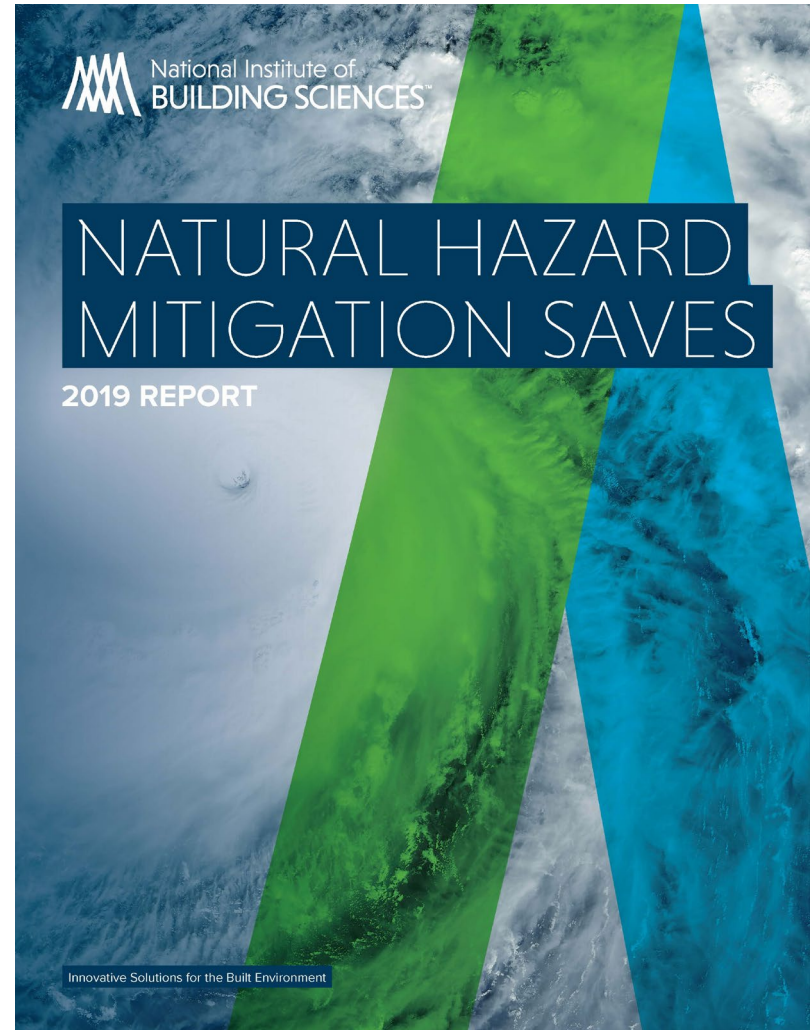
# What are the threats?

- NOAA declared 2017 the costliest year on record
  - 16 events with total costs \$306 billion, eclipsing 2004 record of \$100 billion



# Natural Hazard Mitigation Saves: 2019 Report

The 2019 Report represents the most exhaustive benefit-cost analysis of natural hazard mitigation, from adopting up-to-date building codes and exceeding codes to addressing the retrofit of existing buildings and utility and transportation infrastructure.



<https://www.nibs.org/page/mitigationsaves>



# Is there a Return on Investment?

National Institute of Building Sciences (NIBS)

Natural Hazard Mitigation Saves: 2019 Report:



	ADOPT CODE	ABOVE CODE	BUILDING RETROFIT	LIFELINE RETROFIT	FEDERAL GRANTS
<b>Overall Benefit-Cost Ratio</b>	<b>11:1</b>	<b>4:1</b>	<b>4:1</b>	<b>4:1</b>	<b>6:1</b>
<b>Cost (\$ billion)</b>	<b>\$1/year</b>	<b>\$4/year</b>	<b>\$520</b>	<b>\$0.6</b>	<b>\$27</b>
<b>Benefit (\$ billion)</b>	<b>\$13/year</b>	<b>\$16/year</b>	<b>\$2200</b>	<b>\$2.5</b>	<b>\$160</b>

	ADOPT CODE	ABOVE CODE	BUILDING RETROFIT	LIFELINE RETROFIT	FEDERAL GRANTS
Riverine Flood	6:1	5:1	6:1	8:1	7:1
Hurricane Surge	not applicable	7:1	not applicable	not applicable	not applicable
Wind	10:1	5:1	6:1	7:1	5:1
Earthquake	12:1	4:1	13:1	3:1	3:1
Wildland-Urban Interface Fire	not applicable	4:1	2:1	not applicable	3:1

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# FEMA - National Mitigation Investment Strategy (NMIS)

- **Threats and Hazard Identification.** Build cooperation between private and public sectors by protecting internal interests but sharing threats and hazard identification resources and benefits.
- **Risk and Disaster Resilience Assessment.** Perform credible risk assessments using scientifically valid and widely used risk assessment techniques.
- **Planning.** Incorporate the findings from assessment of risk and disaster resilience into the planning process.
- **Community Resilience.** Recognize the interdependent nature of the economy, health and social services, housing infrastructure and natural and cultural resources within a community.



# FEMA - National Mitigation Investment Strategy (NMIS)

- **Public Information and Warning.** Target messages to reach organizations representing children, individuals with disabilities or access and functional needs, diverse communities and people with limited English proficiency.
- **Long-Term Vulnerability Reduction.** Adopt and enforce a suitable building code to ensure resilient construction.
- **Operational Coordination.** Capitalize on opportunities for mitigation actions following disasters and incidents.



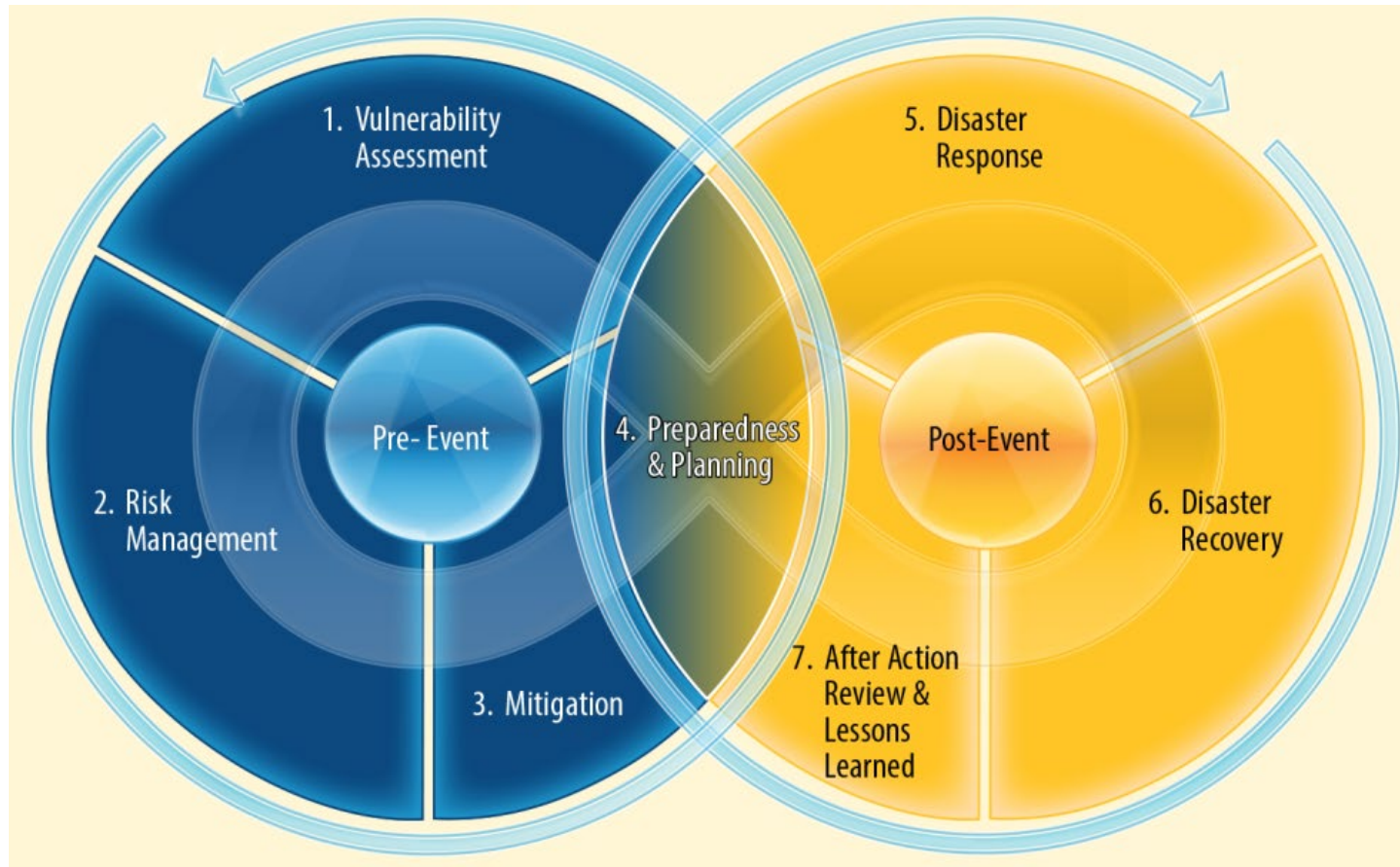
# Resilient Engineering Major Pharmaceutical Company

- **Location: Vacaville, California**
- **Scope: EPV, 2004 - 2006**
- **TIC: \$800 million**
- **Integrated engineering, procurement, and validation**
- **380,000 square feet**
- **Built on unique seismic base isolators. All process support operations were designed in modular equipment arrays to secure the schedule**
- **Design basis exceeded Life Safety Code, targeted critical systems using robust design with redundancies to support low recovery time objective**





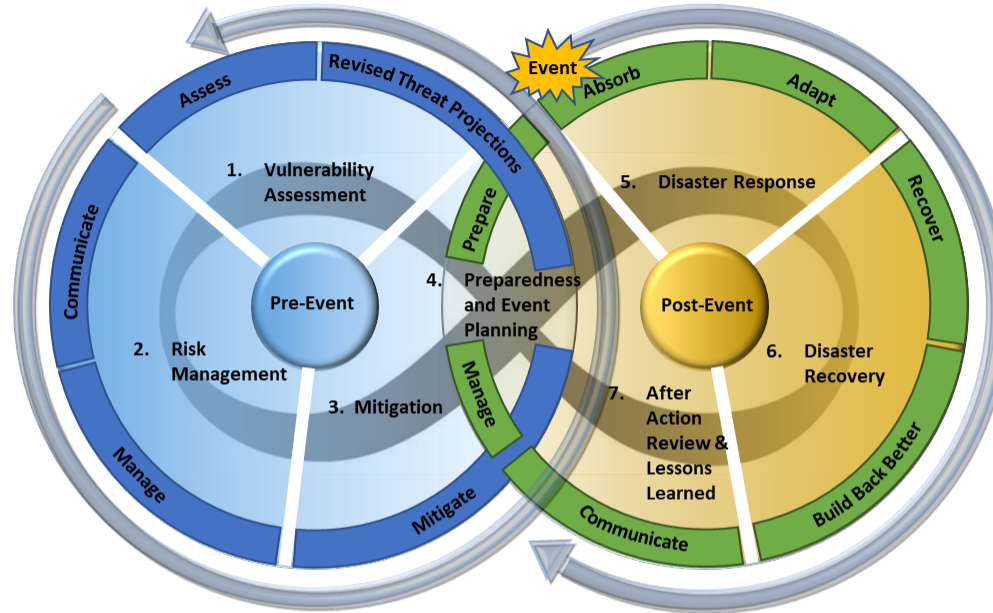
# Resilience Model



# Resilience Model In Detail

## Pre-Event

The components of the Resiliency Model represent a continuous loop of refinement, thus improving resilience.



## Post-Event

These components are only engaged after an event; the purpose is to minimize business impact and to re-establish operations as soon as possible. The unified improvement process is represented by the infinity symbol.

### 1. Vulnerability Assessment

- Perform code and land use plan assessment
- Create geospatial infrastructure database
- Hazard Assessment using Keystone Events
- Model Events
- Overlay models on infrastructure layers
- Determine vulnerabilities

### 2. Risk Management

- Assemble potential vulnerabilities
- Use a system of systems approach with assigned RTOs to determine priorities
- Perform a cost benefit analysis to determine prioritized list if mitigation projects

### 3. Mitigation

- Infrastructure Mitigation
- Non-Infrastructure Mitigation

### 4. Preparedness and planning

- Tabletop Exercises
- Disaster Recovery planning
- Shut-down / Start-up Procedures
- Fly-Away Kits and Rapid Deployment Teams
- EOC Operational Plans & Crisis Communications
- Engagement of all sectors

### 5. Disaster Response

- Save lives
- Prevent further damage
- Put Preparedness Plans in action
- Enact Shelter Plans
- Initial Damage Assessment
- Direct resources as required

### 6. Disaster Recovery

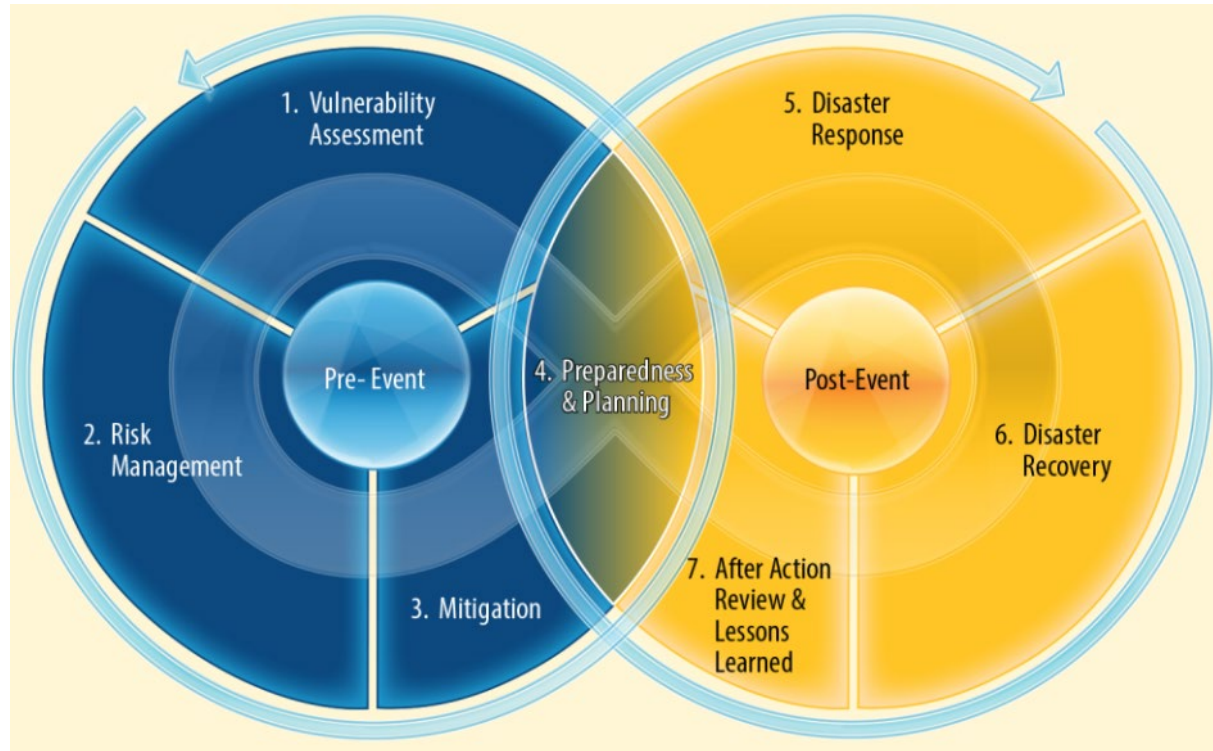
- Return to normal or safer situation
- Mobilize financial assistance
- Build back better
- Consider improvements that will lessen effects of future disasters

### 7. After Action Review & Lessons Learned

- Assemble potential vulnerabilities
- Use a system of systems approach with assigned RTOs to determine priorities
- Perform a cost benefit analysis to determine prioritized list of mitigation projects

# Dimensions of Resilience

- **Governance**
- **Financial**
- **Facilities**
- **Security**
- **Logistics**
- **Equipment**
- **Employees**
- **Infrastructure**
- **Critical Utilities**
- **Communications**
- **Information Technology**
- **Supply Chain Management**



# Vulnerability in Charleston, SC

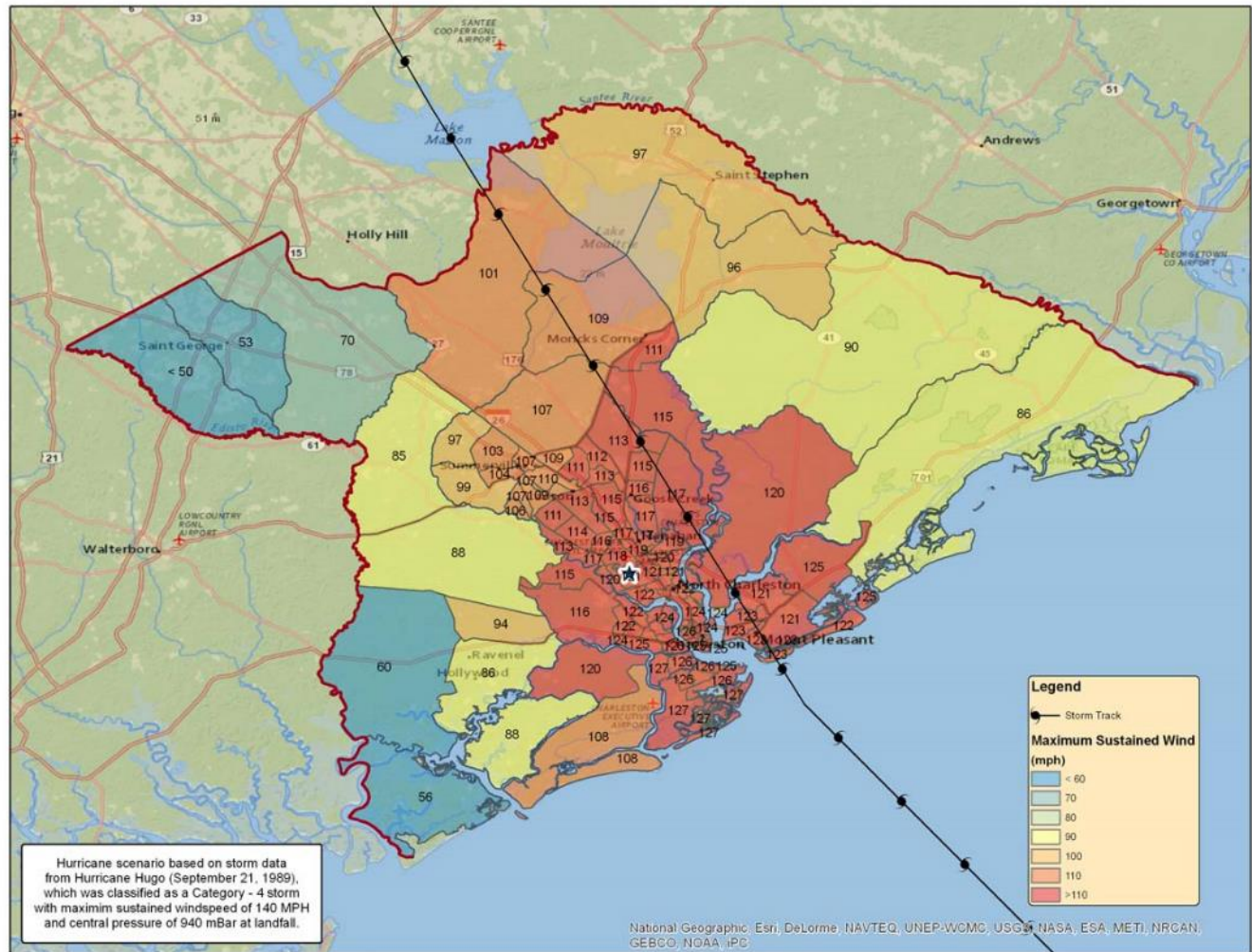


# HAZUS Model – Hurricane

**Location:**  
Charleston, SC

**Event:**  
Hugo

**Output:**  
Sustained Winds

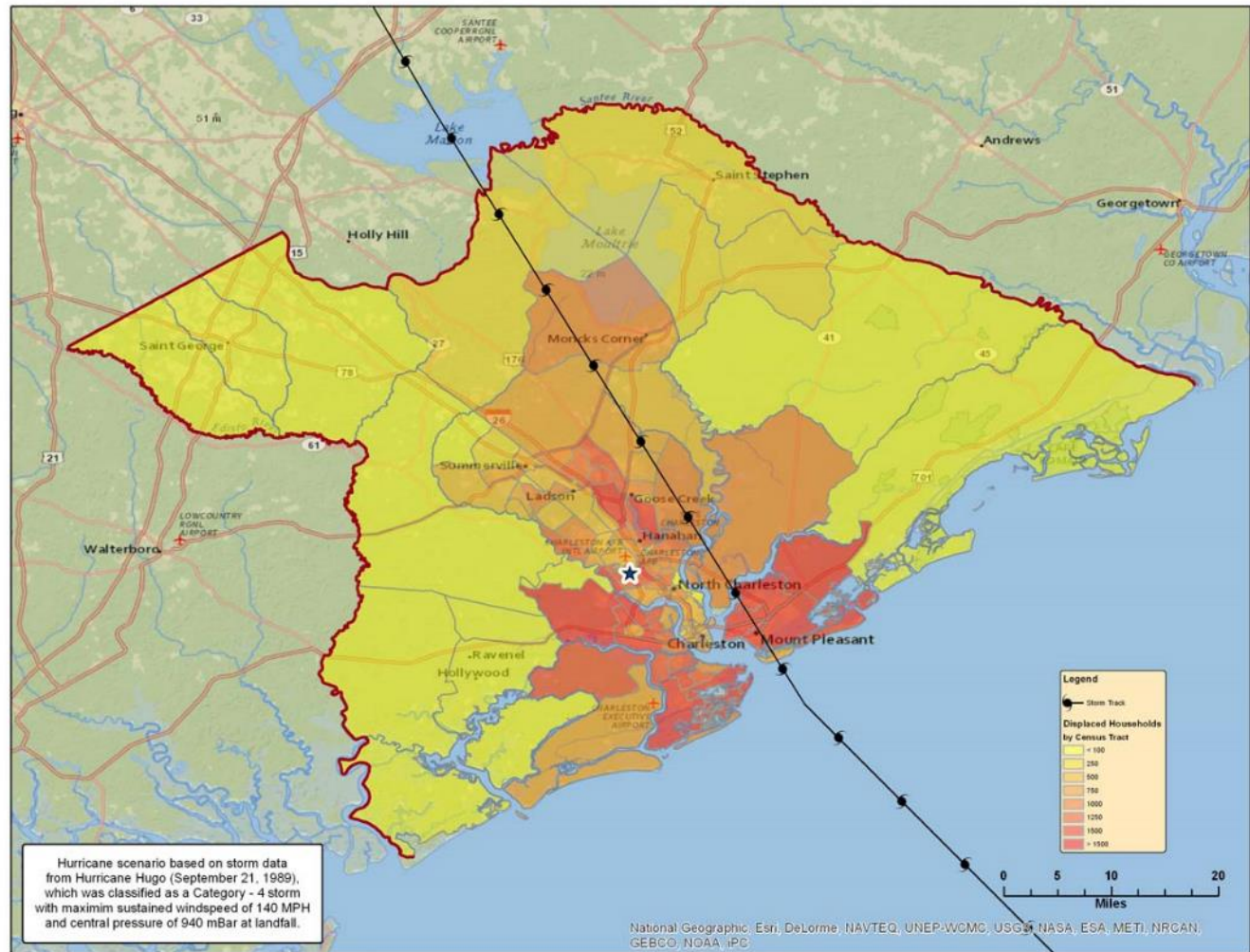


# HAZUS Model – Hurricane

**Location:**  
Charleston, SC

**Event:**  
Hugo

**Output:**  
Displaced  
Households

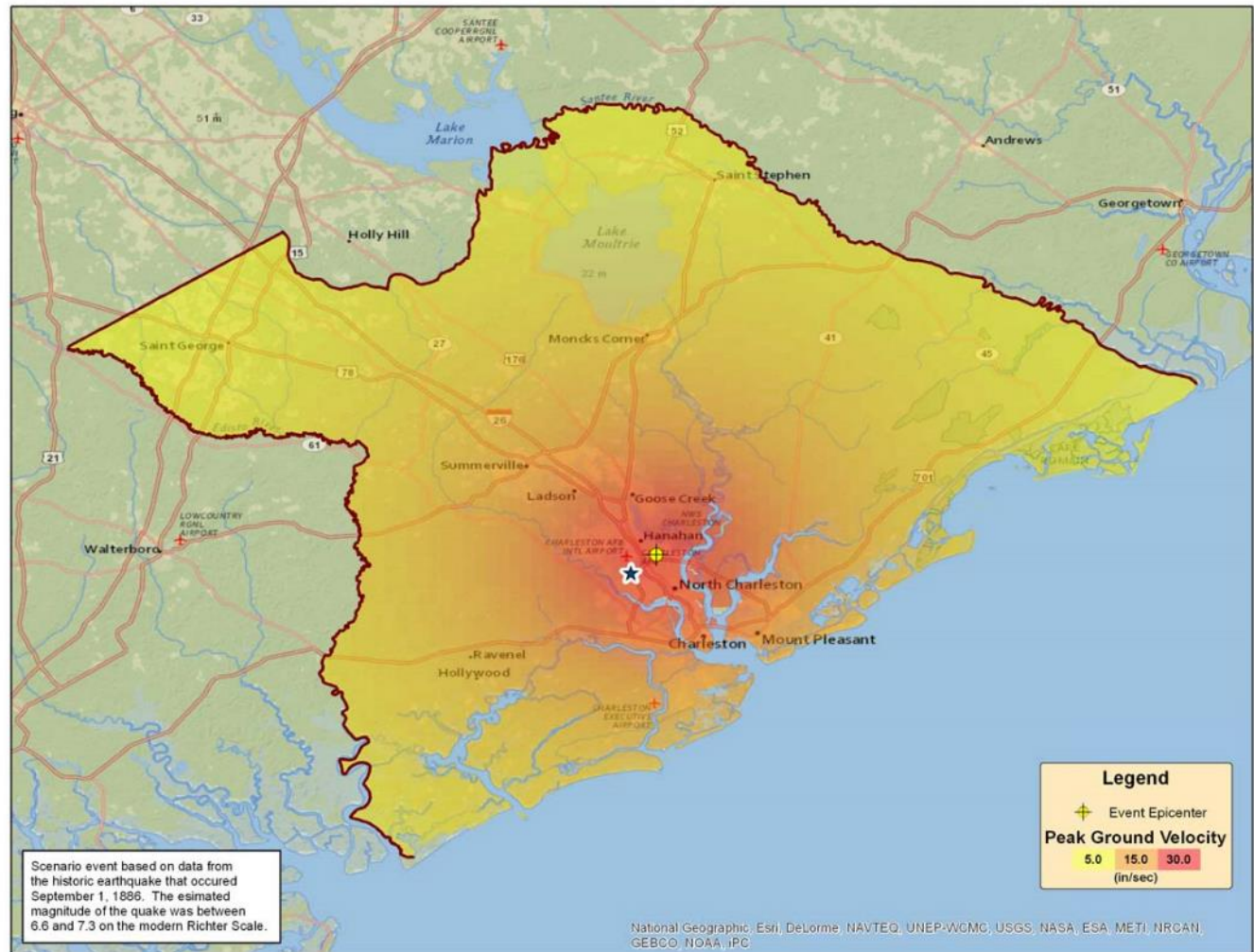


# HAZUS Model – Earthquake

**Location:**  
**Charleston, SC**

**Event:**  
**6.6 to 7.3**  
**Richter Scale**

**Output:**  
**Peak Ground**  
**Velocity**

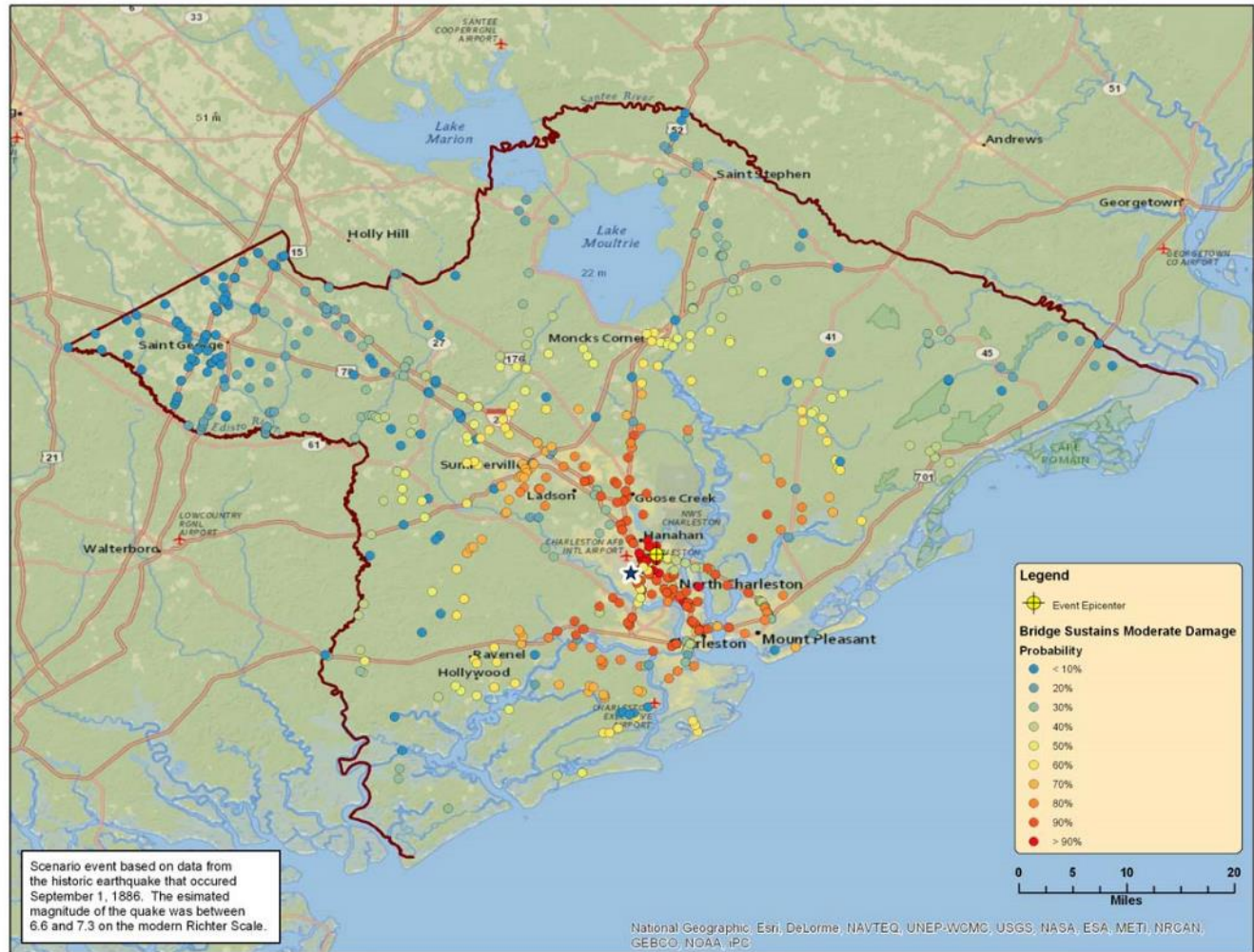


# HAZUS Model – Earthquake

**Location:  
Charleston, SC**

**Event:  
6.8 Richter  
Scale**

**Output:  
Bridges  
Sustaining  
Moderate  
Damage**

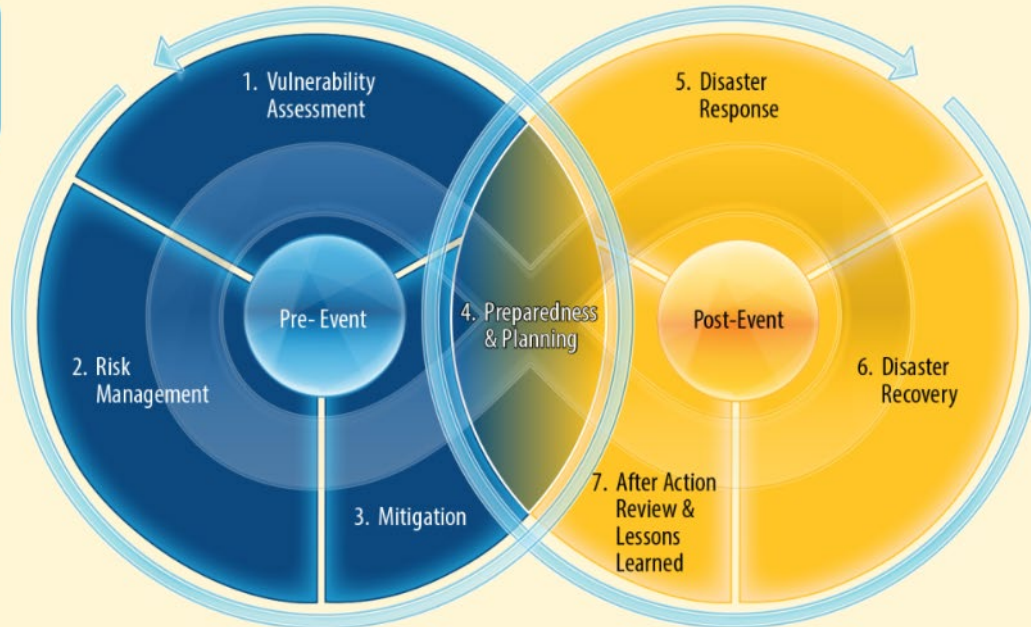




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### 1. Vulnerability Assessment

- Site-specific Disaster Modeling
- Multi-dimensional Vulnerability Assessment
- Readiness Analysis

### 2. Risk Management

- Risk Prioritization and Fit-for-Purpose Plan
- Prioritization of Work Elements

### 3. Mitigation

- Infrastructure Mitigation
- Non-Infrastructure Mitigation

### 4. Preparedness and Planning

- Tabletop Exercises
- Disaster Recovery Planning
- Shut-down/Start-up Procedures
- Fly-Away Kits and Rapid Deployment Teams
- EOC Operations Plans and Critical Communications
- Full-Spectrum Prequalified Bench

### 5. Disaster Response

- Initial Damage Assessment
- Pre-Scripted Plans Aligned with Client and Surety
- Temporary Housing and Equipment
- Management and Craft Labor Surge
- Debris Management

### 6. Disaster Recovery

- Fast-Track Construction Schedule
- Expedient Engineering
- Equipment/Material Procurement
- Testing, Commissioning, and Validation
- Owner's Acceptance and Claims Processing
- Contingency Contracting
- Subcontract Agreement Maintenance

### 7. After Action Review & Lessons Learned

- Critical Review of Pre- and Post-Event Efforts
- Post-Recovery Debriefing and Best Practice Documentation
- Knowledge Management and Sharing

# Risk Based Life Cycle Planning

## Enterprise Resilience

### Enterprise Planning

- Business continuity plan (BCP) – NFPA 1600
- Map supply chain dependencies
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### Post-Event Recovery

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- Recovery
- After action review & lessons learned