A Risk Management Framework for Emergency Management

Risk Management in Civil Engineering
Advanced Course
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National Preparedness Vision

A NATION PREPARED with coordinated capabilities to prevent, protect against, respond to, and recover from all hazards in a way that balances risk with resources and need.

National Preparedness Guidelines

- The National Preparedness Guidelines identify three fundamental questions that must be addressed to achieve a Nation prepared.
- ***How prepared do we need to be?***
- ***How prepared are we?***
- ***How do we prioritize efforts to close the difference?***

HAZARD

- Based on the Arabic *al zahr* (dice)
- A source of potential loss or danger, a peril

HAZARD

- A condition with the potential for the community or environment
- The hazard is the potential, the disaster is the actual event

(Drabek)

EMERGENCY

- **AN UNEXPECTED SITUATION OR SUDDEN OCCURRENCE OF A SERIOUS AND URGENT NATURE THAN DEMANDS IMMEDIATE ACTION**

DISASTER

- From the Italian (Latin) *disastro* (ill starred)
- An occurrence inflicting wide spread destruction and distress
- Any occurrence, on a scales sufficient to warrant extraordinary response from outside the affected community, which causes damage, ecological disruption, loss of human lives, deterioration of health and health services. (WHO)

Catastrophe

- From Greek *katastrophe*—to overturn
- A violent, destructive event
- Destruction of physical and social systems to the extent that local governments cannot function and mutual aid for regional sources is impossible. (Quarantelli)
- "Any natural disaster, act or terrorism, or other man made disaster that results in extraordinary levels of casualties or damage or disruption severely affecting the population (including mass evacuations), infrastructure, environment, economy, national morale or government functions in an area" (Post Katrina Act)

Emergencies, Disasters, and Catastrophes

Emergencies	Disasters	Catastrophes
Impacts Localized	Impacts Widespread, Severe	Extremely Large Physical and Social Impacts
Response Mainly Local	Response Multi-Jurisdictional, Intergovernmental, But Bottom-Up	Response Requires Federal Initiative, Pro-Active Response
Standard Operating Procedures Used	Disaster Plans Put Into Effect—But Challenges Remain	Massive Challenges Exceed Those Envisioned in Standard Plans
Vast Majority of Response Resources Are Unaffected	Extensive Damage to, Disruption of, Key Emergency Services	Emergency Response System Paralyzed at Local and Even State Levels
Public Generally Not Involved in Response	Public Extensively Involved in Response	Public Extensively Involved in Response
No Significant Recovery Challenges	Major Recovery Challenges	Cascading Long-Term Effects, With Massive Recovery Challenges

Comparing Catastrophies

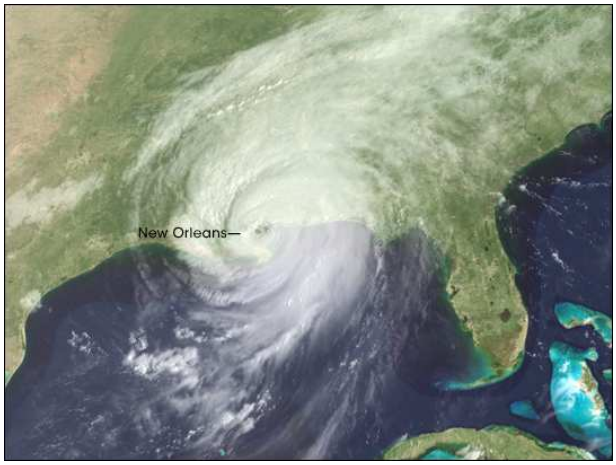
Hurricane Katrina

- 155,000 Sq. Km impacted
- 1,330 deaths
- 700,000 displaced people
- 1,000,000 evacuated.
- 300,000 homes unihabitable
- 250,000 sheltered
- $96 billion damage
- 118 M cubic yards of debris

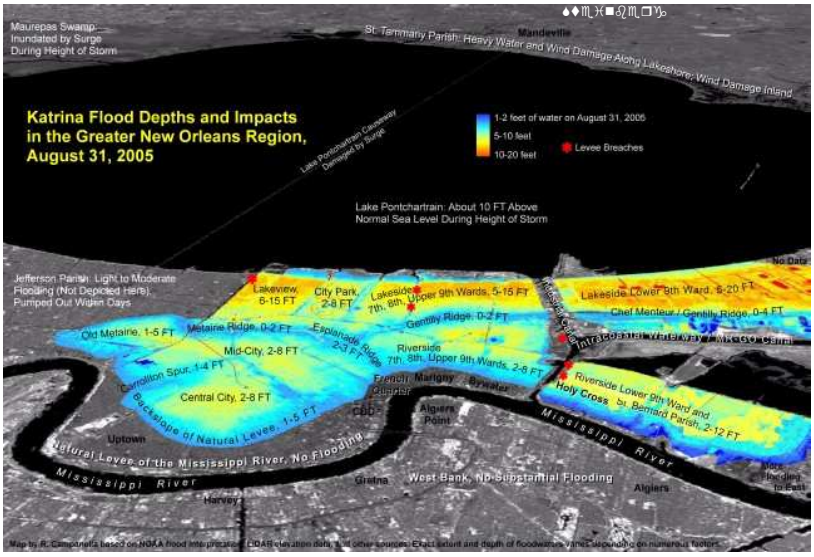
Sichuan M7.9 Earthquake

- 100,000 Sq Km impacted
- 68,146 deaths, 17,516 missing
- 374,131 injured
- 5-11 1M people displaced
- 216,000 buildings destroyed
- 803 dams damaged

Hurricane Katrina
and its aftermath.



Landfall



Map and analysis by R. Campanella, CBR (excerpted from *Geographies of New Orleans: Urban Fabrics Before the Storm*, due out 2006)

RISK Definition

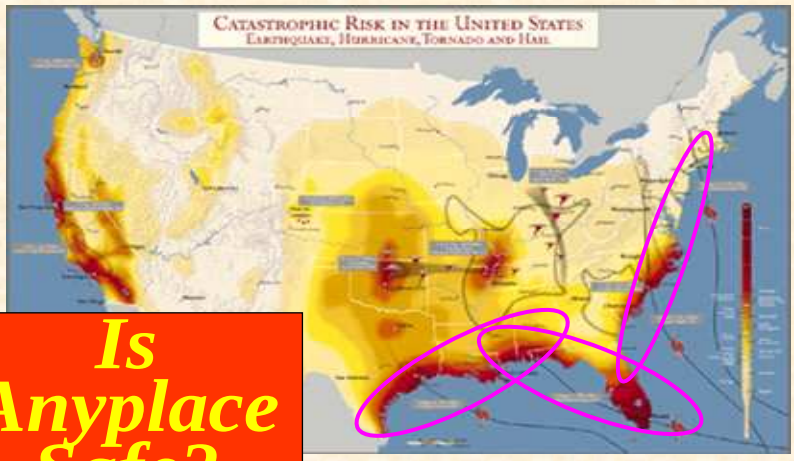
"A measure of potential harm that encompasses threat (hazard), vulnerability, and consequence. Risk is the expected magnitude of loss due to a terrorist attack, natural disaster, or other incident, along with the likelihood of such an event occurring and causing that loss."

NIPP 2006

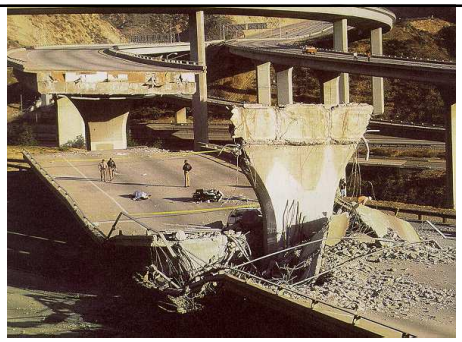
Risk Management Challenge
Potential Catastrophic Events in US

- Severe earthquake in populated area
- West Coast, Hawaii, Alaska Tsunami
- Gulf Coast, East Coast Hurricane
- Dam failures in LA, Columbia River
- Levee failures—Mississippi, Sacramento rivers
- Pandemic Outbreak
- Biological Attack
- Chemical attack or accident
- Nuclear Bomb in US city
- Cyber attack

Most of US Population & Property Has Major CAT Exposure



Is Anyplace Safe?



<u>Risk Perception</u> is biased by low probability events hat have actually occurred. <u>Risk Analysis</u> must also identify and evaluate the risk of rare events that have not yet happened.

A RISK-BASED APPROACH

"We need to adopt a risk-based approach in both our operations and our philosophy. Risk management is fundamental to managing the threat, while retaining our quality of life and living in freedom. Risk management must guide our decision-making as we examine how we can best organize to prevent, respond and recover from an attack."

Remarks as prepared for Secretary Michael Chertoff U.S. Department of Homeland Security George Washington University Homeland Security Policy Institute (3/16/05)

Decisions supported by Risk Management

- Strategic—which policies best protect the nation from natural hazards or terrorist attack?
- Programmatic—which programs will effectively implement strategies?
- Funding—how should funding be allocated between programs, geographical areas?
- Tactical—which specific risk management interventions are cost effective?

U.S Department of Homeland Security Strategic Goals Define an all Hazards, Risk Management Approach

Awareness: **Identify and understand threats, assess vulnerabilities, determine potential impacts**

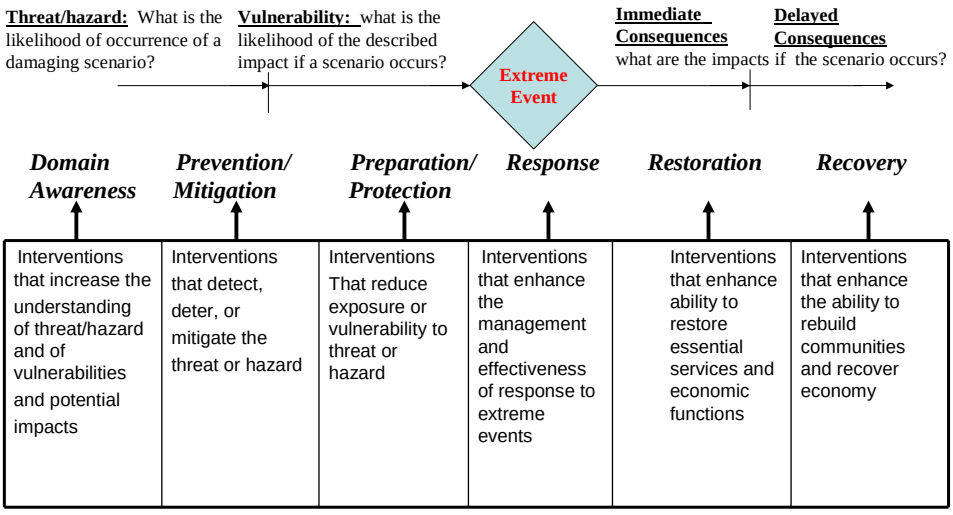
Prevention: **Detect and deter and mitigate threats**

Protection: **Safeguard our people and freedoms, critical infrastructure and the economy.**

Response: **Lead, manage and coordinate the national response to extreme events**

Recover: **Lead national, state, local and private sector efforts to restore services and rebuild communities**

A Risk Management Strategy for Emergency Management



Awareness and Preparedness

Key Tasks

- **Risk communication**
- **Risk characterization**
- **Translation or risk information to appropriate protective actions and operational requirements**

RISK COMMUNICATION QUESTIONS

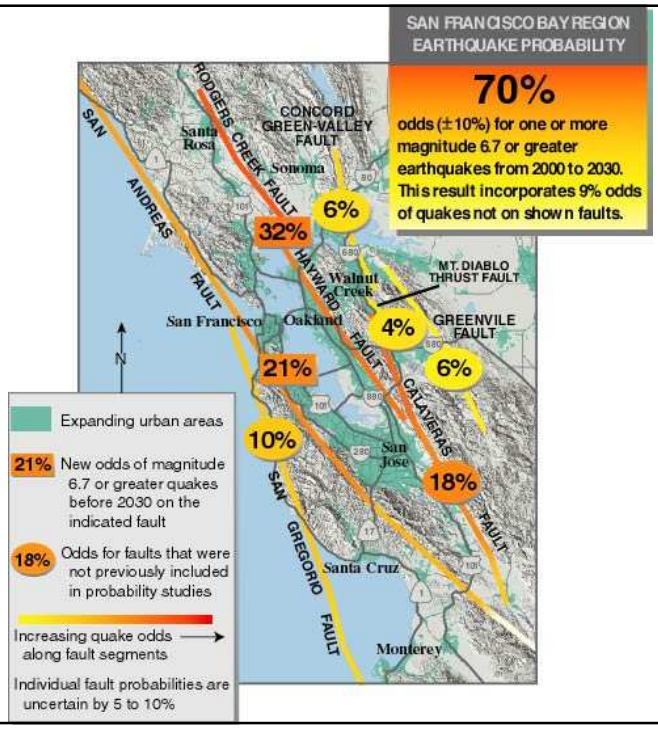
- **To whom do we communicate about risk? – Who are the Stakeholders?**
- **What do we communicate about risk? – How will stakeholders use the information?**
- **How do we communicate about risk? – How should the risk be characterized and presented?**

RISK CHARACTERIZATION

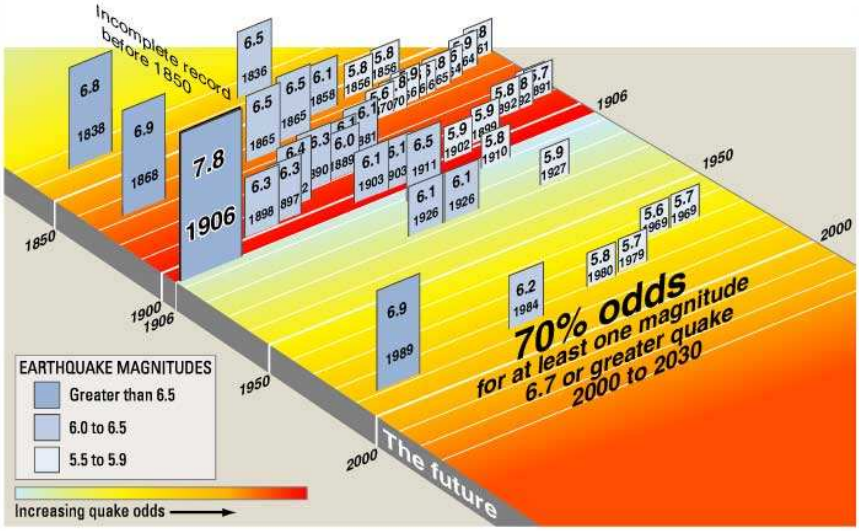
The way the nation handles risk often breaks down at the stage of "risk characterization" when the information in a risk assessment is translated into a form *usable by a risk manager, individual decision maker, or the public*.

Risk characterization is not only a summary or translation of technical results, it should be a *decision driven activity* directed toward informing choices and solving problems

National Research Council 1996
Understanding Risk: Informing Decisions in a Democratic Society

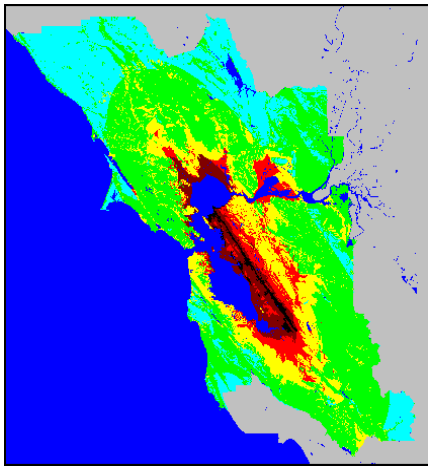


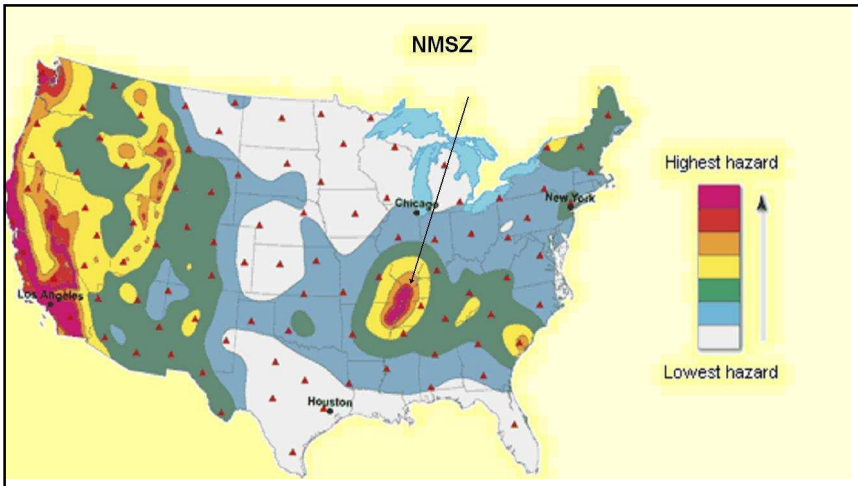
Our History



What Happens - M 7.1 on Entire Hayward Fault

- **155,700 uninhabitable housing units**
- **356,600 people displaced**
- **110,300 peak shelter population**
- **1,639 Road Closures**
- **Entire East Bay isolated**





THE NEW MADRID SEISMIC ZONE PROJECT

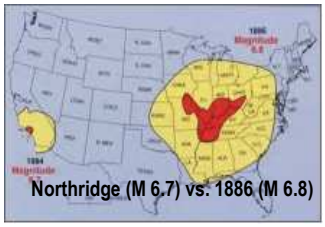
The ICDRM will conduct a requirements analysis and definition of model parameters for response and recovery planning for the estimation of medical, health, mass care, and critical commodity needs.

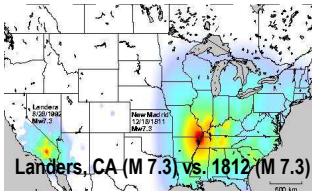
The project objective is to bridge the gap between **loss estimation modeling & preparedness and response decision making**.

New Madrid Seismic Zone Catastrophic Planning:

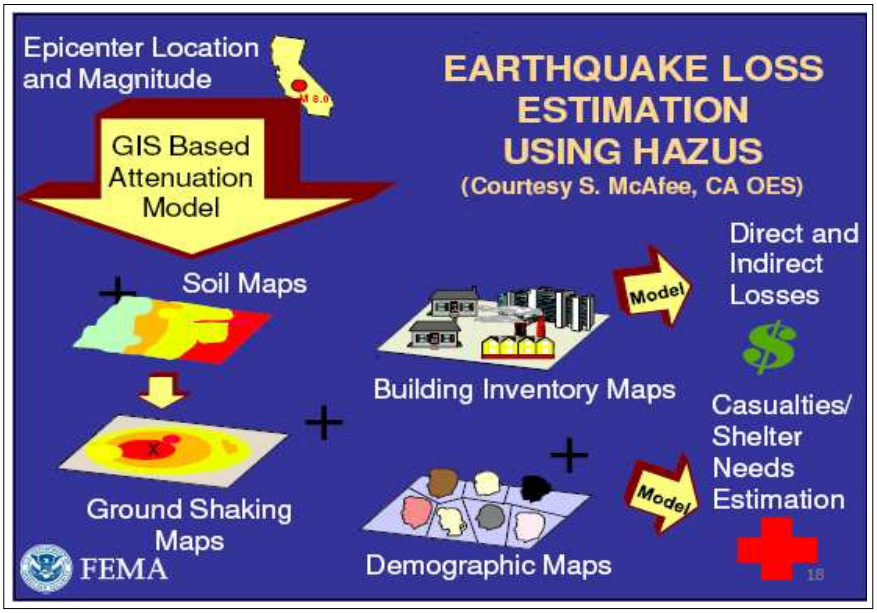
The Challenge in New Madrid

- **NMSZ = Significant Fault Systems, High Consequences**
- **Significant national impact**
  - **Ripple effect across America**
- **Wider-reaching effect than quake in CA**
  - **(See Maps)**
- **Tremendous impact on civil infrastructure and critical facilities**
- **44M people live in eight-state region**
  - **12M in high risk area**
- **Weather & evacuation complications**
- **Impact to the National Infrastructure**
  - **Communications**
  - **Energy**
  - **Transportation**





Understanding HAZUS



Operational Requirements

Planning Efforts

- Social impacts and needs assessments dictate operational requirements
- Capability and Capacity Required
  - Command and Control
  - Mass Care
  - Rescue and Recovery
  - Health and Medical
  - Mortuary
  - Utilities

From Scenario to Operational Requirements

Event Description

Science
Engineering
*Mod*eling

Scenario
Creditable, Consensus Based

+

Physical Impact

Tables in the distributed scenario

Loss Estimation
From HAZUS

+

Socio-Economic Vulnerability

Vulnerability Needs
Extended Modeling

=

Critical Areas

Need for outside assistance at the local, state, and regional levels

Response & Recovery Requirements
Extended Modeling

Capability and Capacity Required

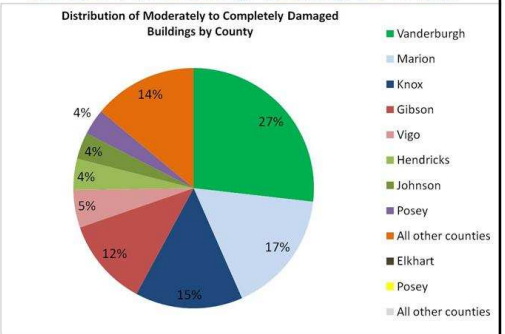
Operational Requirements
Planning

Building Stock Damage

County	Complete damage	At least moderate damage
Knox	16%	19%
Gibson	15%	17%
Vanderburgh	8%	8%
Posey	3%	6%
Sullivan	0%	3%
Vermillion	0%	3%
Vigo	0%	3%

Damage levels for all other counties are less than 3%

Approximately 16,500 buildings (of the over 1.9 million in the state) are expected to incur at least moderate damage. The chart below shows the allocation of these damaged buildings per county.



Utility Interruptions

% of Households without Potable Water

County	Day 1	Day 3	Day 7	Day 30
Knox	98%	97%	97%	85%
Gibson	94%	93%	91%	41%
Vanderburgh	20%	6%	0%	0%
State-wide	22%	17%	14%	10%

% of Households without Power

County	Day 1	Day 3	Day 7	Day 30
Knox	73%	47%	23%	68%
Sullivan	46%	26%	88%	14%
State-wide	8%	5%	2%	1%

Identifying Critical Counties

Security, Water, Energy, Accessibility, Telecom (SWEAT)

Critical Counties	S			W		E	A			T
	Police	Fire	Hospital	Water	Sewage	Electricity	Roads	Bridges	Schools	Telecom
Daviess	Y	Y	Y	G	G	G	G	G	Y	G
Dubois	Y	G	Y	G	G	G	G	G	Y	G
Gibson	Y	Y	Y	R	G	G	G	G	Y	Y
Greene	G	G	G	G	G	G	G	G	G	G
Knox	Y	Y	Y	R	Y	R	G	G	Y	Y
Pike	G	G	W	G	G	G	G	G	G	G
Posey	Y	Y	W	G	G	G	G	G	Y	G
Spencer	G	G	W	G	G	G	G	G	G	G
Sullivan	Y	Y	Y	G	G	Y	G	G	Y	Y
Vanderburgh	G	G	G	Y	G	G	G	G	G	G
Warrick	G	G	R	G	G	G	G	G	G	G

Legend

Values at Day 1

S - Security
Police
Fire
Hospitals

W - Water
Water
Sewage

E - Electricity

A - Accesability
Roads
Bridges
Schools

T - Telephone

G 80 - 100%
Y 40 - 79%
R 0 - 39 %
W Unknown

"At Risk" Populations

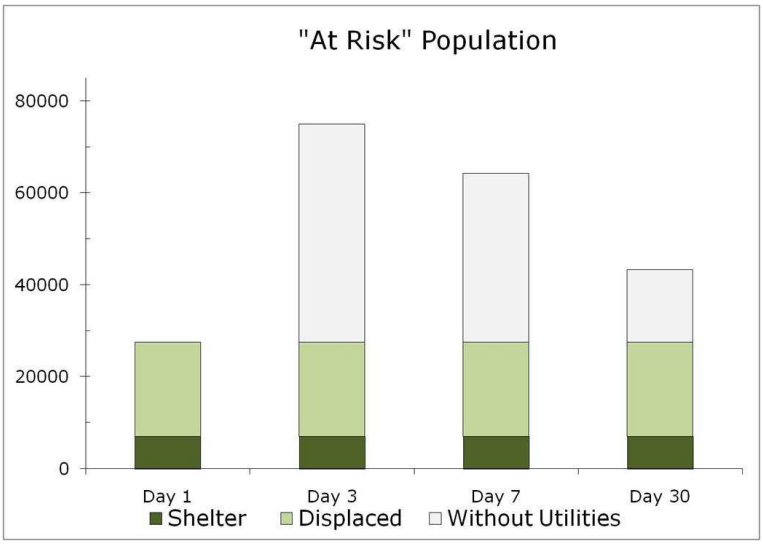
HAZUS estimates displaced population based solely on structural damage to residential buildings. Shelter seeking population is a subset of the displaced population based on demographic socio-economic characteristics such as ethnicity and income level.

The "at risk" population is composed of the displaced population and the following estimated populations:

- *Households without electricity and/or water for an extended period of time (> 3 days).*

- *Efforts are ongoing to include estimates of*
  - *Pre-event homeless*
  - *Institutions (dormitories, nursing homes, etc.)*
  - *Tourists*

Estimated “At Risk” Population



Response and Recovery

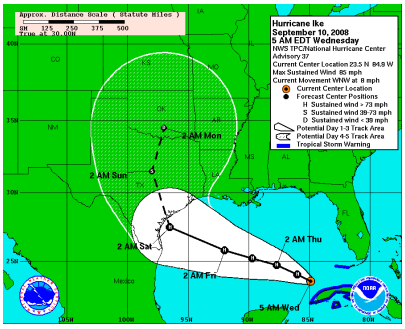
Key requirements

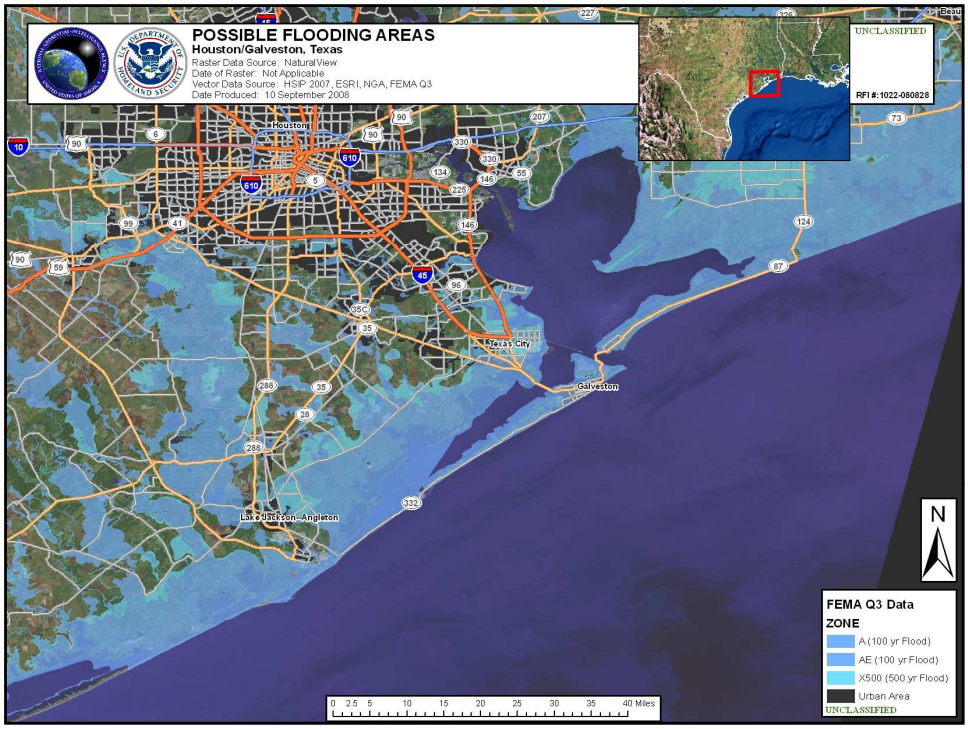
- **Accurate situational awareness**
- **Ability to establish life saving, life sustaining priorities**
- **Ability to establish restoration and recovery priorities**

Storm Characteristics

Landfall Conditions for Advisory 37

- Category 3 storm
- Landfall Projected at 0500 CDT 13 September 2008 approximately 8 Miles SE of Seadrift, TX
- Maximum Sustained Winds 120 mph with gusts to 150 mph
- Tropical storm force winds up to 175 Nautical Miles (201 miles) from center of circulation
- Hurricane force winds up to 35 Nautical Miles (40 miles) from center





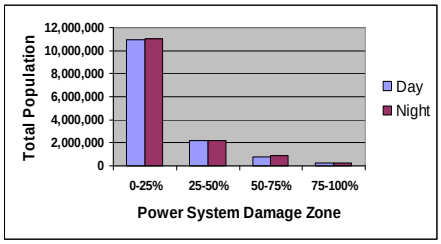
Population Affected by Storm Surge

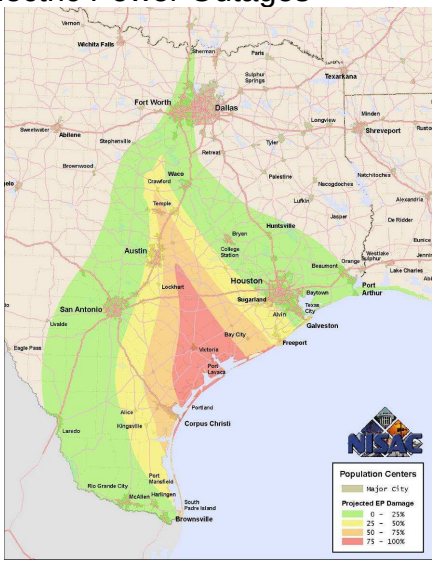
- Most significant storm surge projected in the Freeport area just south of Houston

Depth (ft.)	Affected Daytime Population	Affected Nighttime Population	Housing Units in Surge
1–4	146,300	146,300	61,700
5–8	113,000	112,000	53,600
9–12	86,200	73,500	43,000
>12	25,000	22,400	15,100

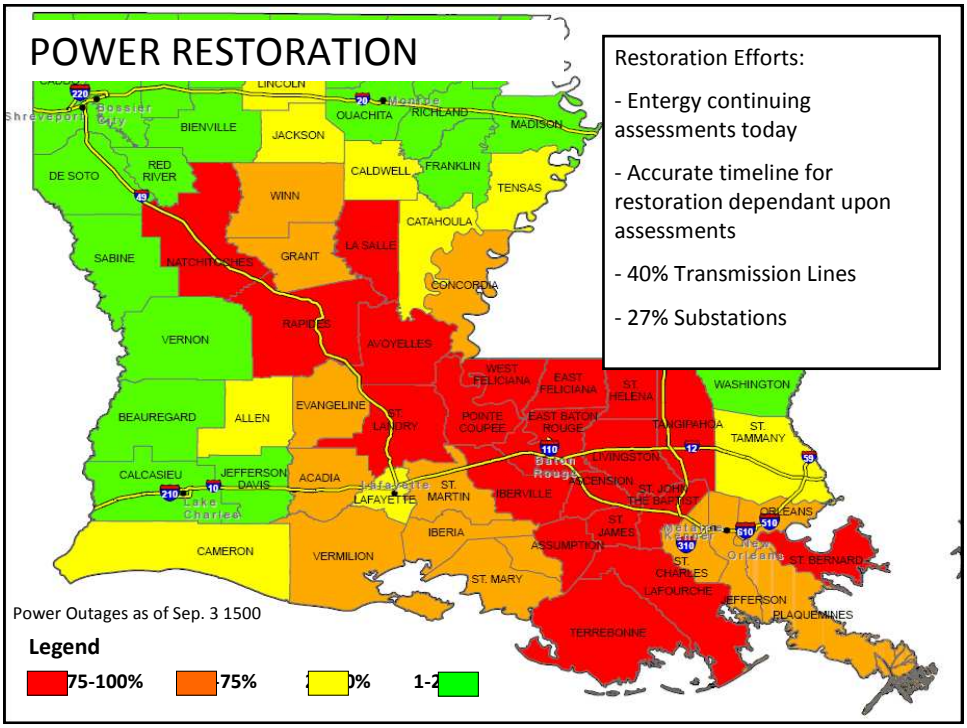
Population Affected by Electric Power Outages

- More than 14 million people live within EP damage contours
- Approximately 250,000 people live in highest impact area





POWER RESTORATION



General Population Shelters

	National Shelter System (NSS)				
	04 SEPT 08 02:00 am EDT				
	State	Total Shelters	Total Population	Evacuation capacity	Used % Capacity
1	Alabama (R4)	52	10,932	22,571	48.43%
2	Arkansas (R6)	27	1,063	5,925	17.94%
3	Florida (R4)	3	70	1,300	5.38%
4	Georgia (R4)	6	671	2,108	31.83%
5	Indiana (R5)	1	0	350	0.00%
6	Kentucky (R4)	1	1,432	3,000	47.73%
7	Tennessee (R4)	37	5,655	13,205	42.82%
8	Oklahoma (R6)	3	1,636	13,055	12.53%
9	Mississippi (R4)	62	6,517	21,536	30.26%
10	Texas (R6)	31	1,639	9,259	17.70%
11	Louisiana (R6)	49	13,356	28,222	47.32%
11	**CURRENT DAY**	**272**	**42,971**	**120,531**	**35.65%**

Issues in using Risk Modeling in Support of Emergency Management

- Models must be appropriate representation of reality
- Data and/or expert judgment must be available to populate models
- Metrics must be developed that allow evaluation of outcomes and determination of response and recovery objectives

RISK ANALYSIS RESULTS CAN BE MISLEADING

Bad data + Good models → Wrong answers

- Is data complete, are all events recorded?
- Is data accurate, are events correctly described?
- Is data timely, does it describe current reality?
- Is data consistent, are events described in multiple ways?

Good data + Bad models → Wrong answers

- Does the model select the appropriate reality?
- Does the model appropriately represent the selected reality?
- Are the assumptions correct?
- Is the math correct?

Fuzzy data + Fuzzy models → Uncertain answers

- What is uncertainty in data, in assumptions, in calculations?

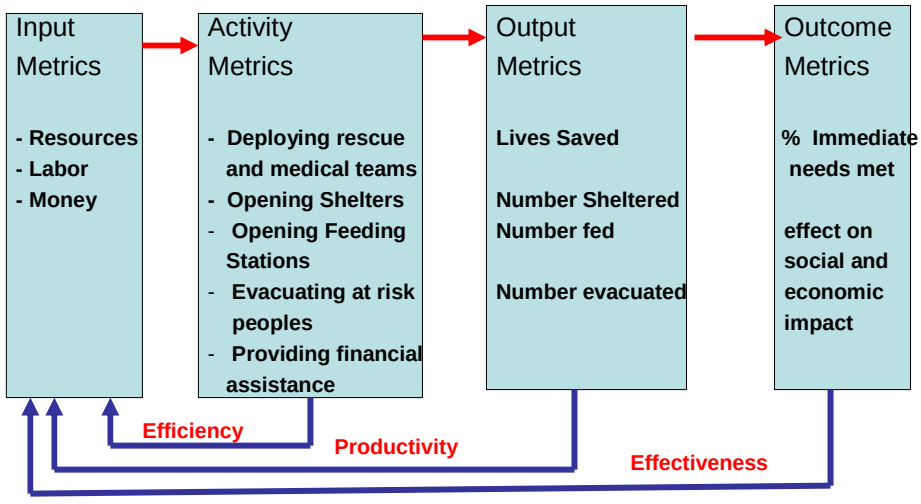
Existing Disaster Metrics

Event	Physical Impact	Socio-Economic Impact
Hurricane -Wind Speed -Category -Storm Surge	Building damage Critical Facility damage Infrastructure damage	Deaths Displaced people Injuries Insured losses Estimated losses
Earthquake -Magnitude -Intensity -Ground Acceleration -Ground Velocity		
Tornado -Saffer-Simpson -Wind Speed		
Flood -Flood Stage -Water Height		

Metrics describing event are more precise than metrics describing physical impact.

Socio-Economic impacts drive response and recovery—metrics are incomplete and inadequate And have not been linked to Physical impacts

Disaster Management Metrics



What is a Successful Disaster Response? (measures of outcomes)

- Claims for Federal disaster assistance payments are process rapidly and applicants are not forced to wait extended periods of time to apply for assistance
- Few if any disaster victims remain stranded in life-threatening situations or without urgent medical attention for more than a few hours
- Few if any disaster victims are left without adequate shelter, food, or water for more than twenty four hours
- Individuals seeking to evacuate are able to do so
- Electricity, water, and communications utilities are restored to the vast majority of people in the affected area within twenty-four to thirty six hours.

Source: James Miskel
Disaster Response and Homeland Security

Four Risk Management Challenges

1. **Developing appropriate scenarios and risk models for rare, extreme events.**
   - Specifying complete set of event scenarios
   - Estimating scenario frequency distribution of scenarios
   - Estimating long term consequences
   - Identifying potential risk management interventions
   - Avoiding modeling what we have already experienced
2. **Developing more rigorous methods of qualitative risk assessments.**
   - DHS, National Labs, US Army Corps of Engineers, US Coast Guard, Transportation Security Administration, University Research Centers all working on improving qualitative methods, particularly for terrorism threat

Four Risk Management Challenges

3. Improving methods of characterizing and effectively communicating results of risk analysis to decision makers and general public.
   - DHS, FEMA, DOD working on structuring and presenting situational awareness information, large gap between decision maker's needs and modeling output.
4. Investment in collection, cleansing and structuring of data required for quantitative risk assessment.
   - Inventory data for structures and infrastructure is not available and/or not accurate
   - Historical data collected for safety investigations, system management, not for risk analysis.
   - Minimal historical data available for terrorism and other new threats.

Thank You

For additional information please contact me at jharrald@vt.edu