Seismic Hazards & Infrastructure: A Historic Perspective

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NEHRP Advisory Committee on Earthquake Hazards Reduction
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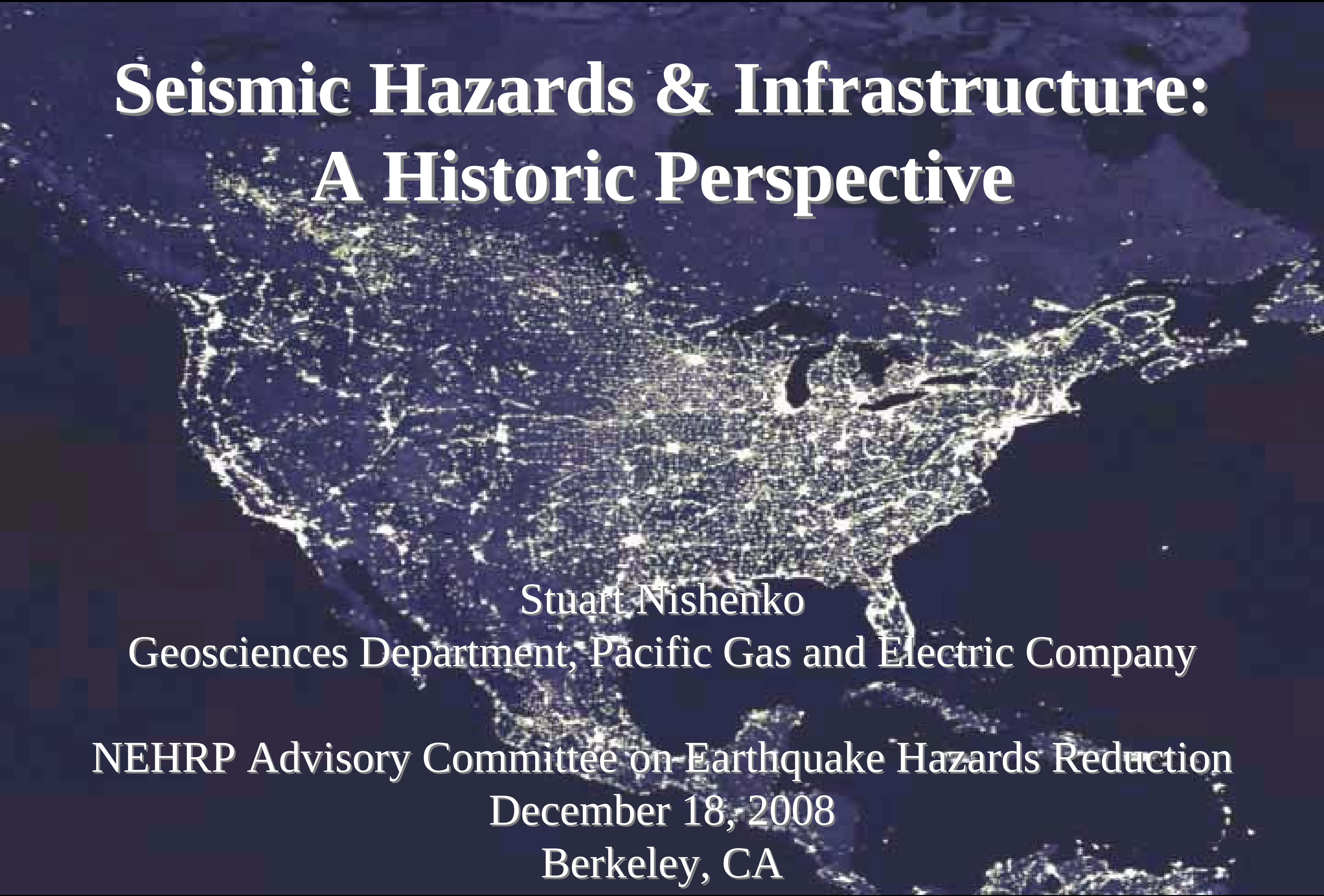
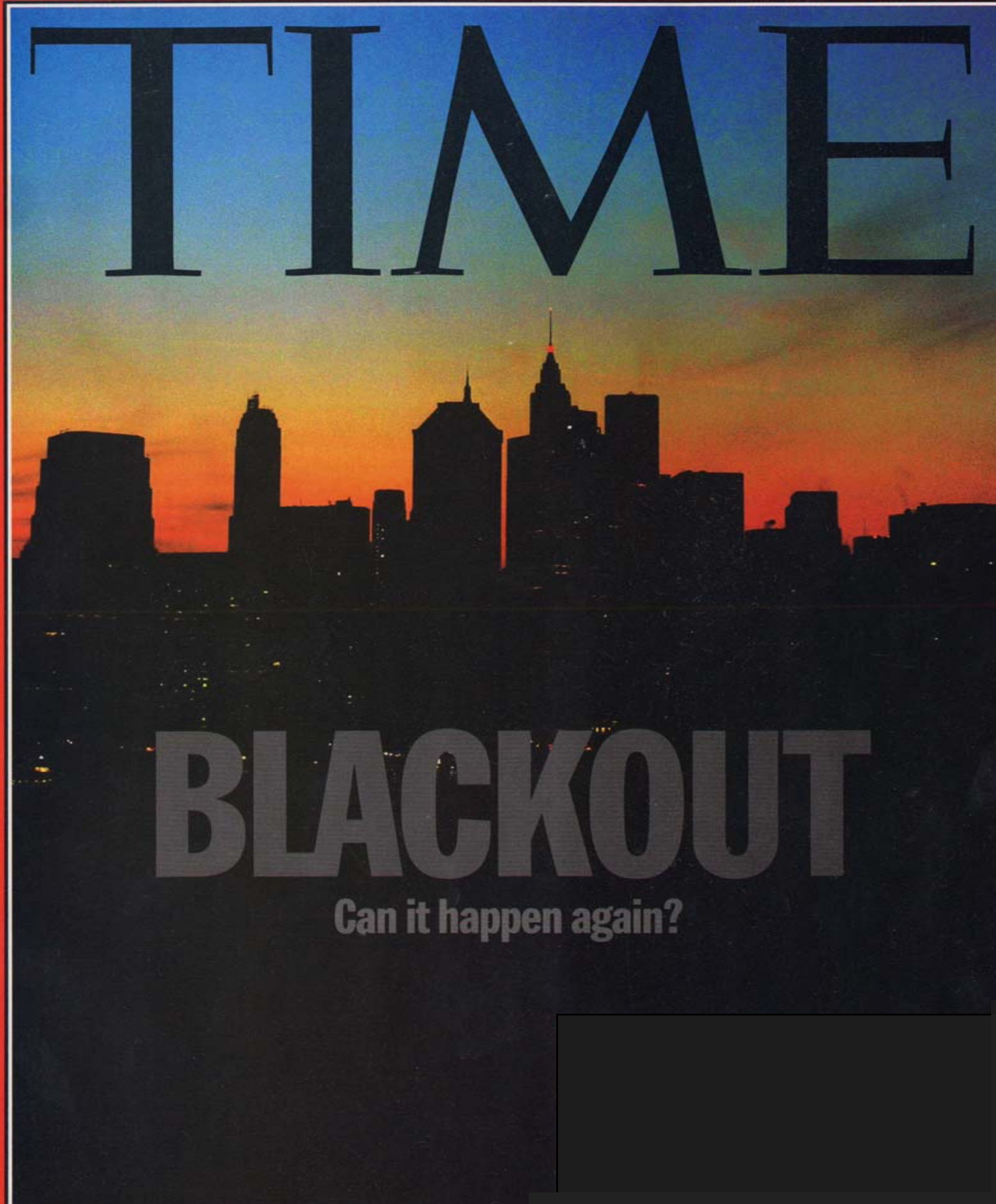


NASA, 2001



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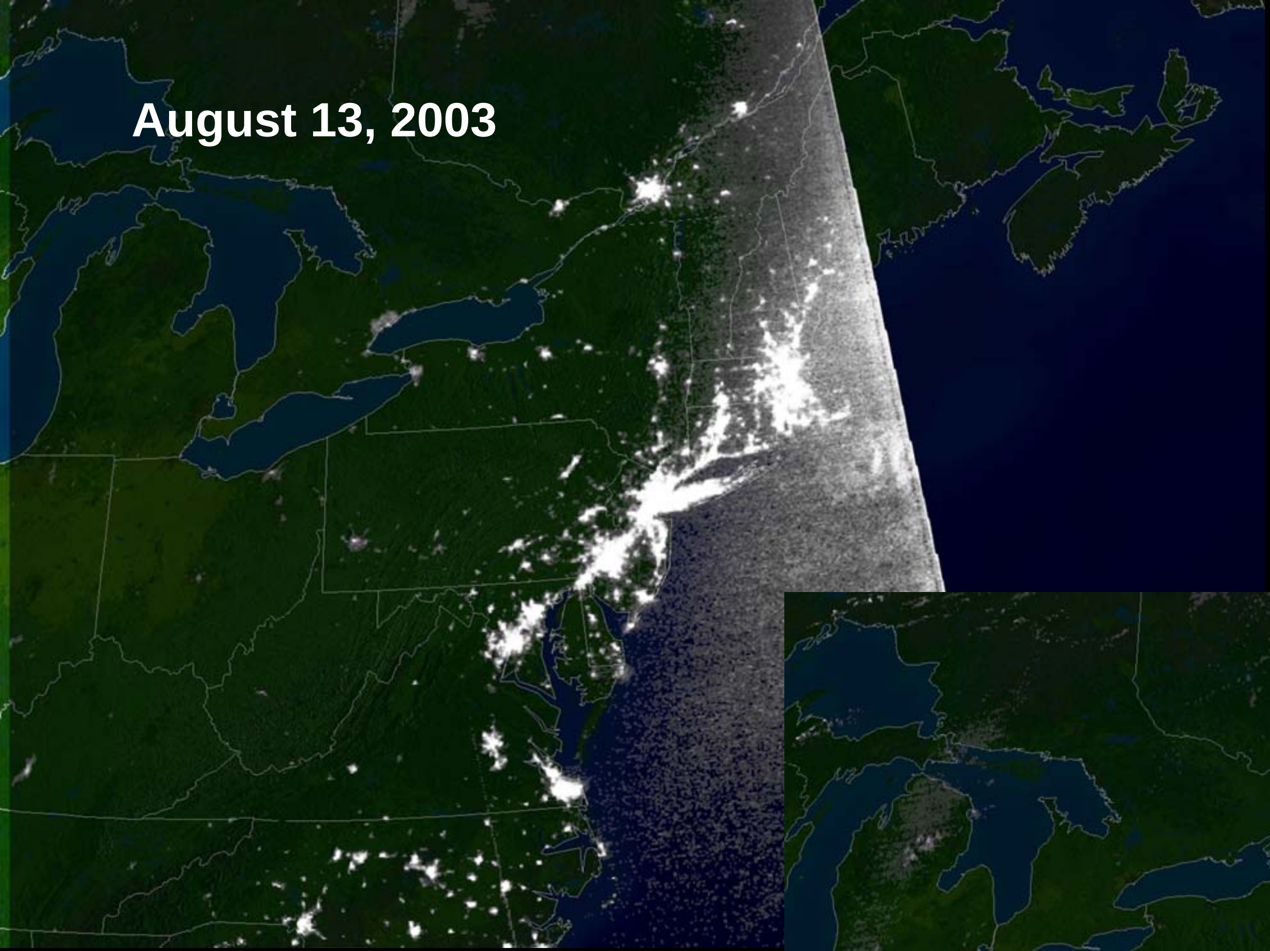
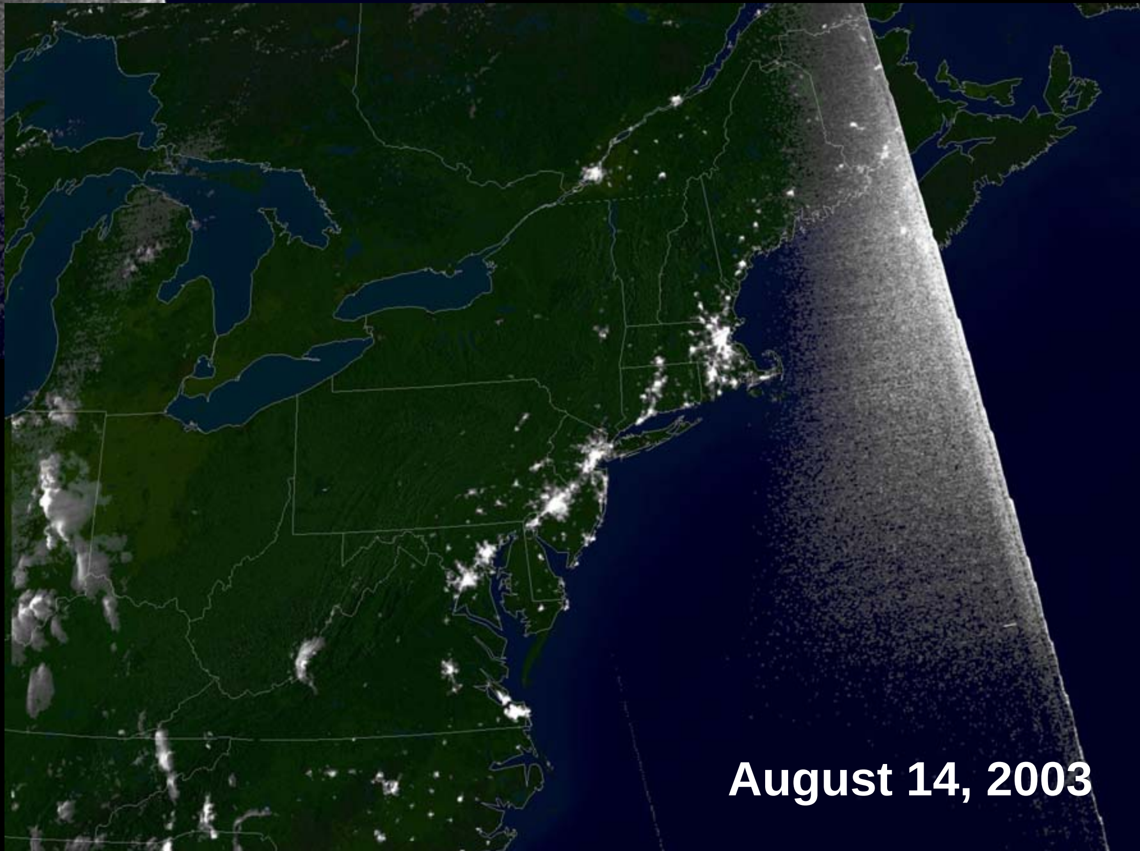




NOAA,2003

PROGRESS REPORT

America's Infrastructure

DATE 2003

Roads	D+	↓
Bridges	C	↔
Transit	C-	↓
Aviation	D	↔
Schools	D-	↔
Drinking Water	D	↓
Wastewater	D	↓
Dams	D	↓
Solid Waste	C+	↔
Hazardous Waste	D+	↔
Navigable Waterways	D+	↓
Energy	D+	↓

America's Infrastructure GPA **D+**

Total Investment Needs (estimated five-year need) **$1.6 Trillion**

ASCE, 2004

Infrastructure Categories

- **Utility**
  - **Electric Power**
  - **Natural Gas**
  - **Liquid Fuel**
  - **Telecommunications**
  - **Water**
  - **Wastewater**
- **Transportation**
  - **Highways**
  - **Rail**
  - **Waterways**
  - **Ports & Harbors**
  - **Air**
- **Cyber**

Grand Challenges *for* Disaster Reduction

A Report of the
Subcommittee on Disaster Reduction

Grand Challenge 4

Recognize and Reduce Vulnerability of Interdependent Critical Infrastructure

Critical Infrastructure

For the Government:

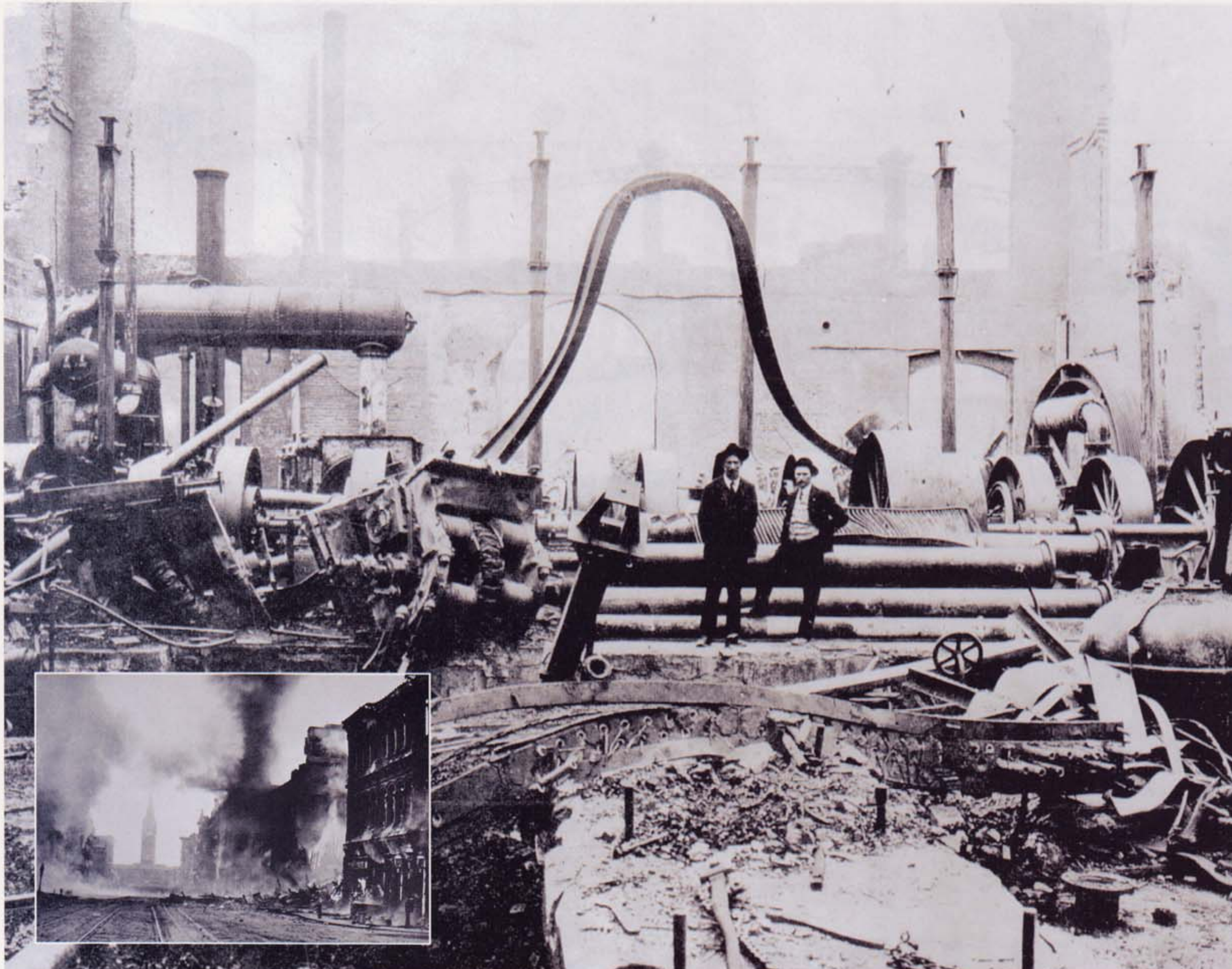
Those facilities that must remain mission operational during periods of national crisis or emergency. *[Outside the fence]*

For the Private Sector:

What each owner decides. *[Inside the fence]*

Key Characteristics of Lifeline Systems

- Design based on system performance
- Requirements different than those for buildings
- Multi-jurisdictional regulatory oversight
- Owners/operators have special knowledge



EARTHQUAKE AND FIRE: Two San Francisco Gas and Electric Co. employees view the ruins of Station "B," Third and Townsend streets; INSET: Market Street, between Stuart and Second; April 18-23, 1906.

Milestones

1971 San Fernando earthquake (M 6.4) - ‘birth of lifeline earthquake engineering’

1974 Technical Council on Lifeline Earthquake Engineering (TCLEE)

ASCE Technical Council on Lifeline Earthquake Engineering (TCLEE)

Lifelines are the systems and facilities that provide services vital to the function of an industrialized society and important to the emergency response and recovery after a natural disaster. These systems and facilities include communication, electric power, liquid fuel, natural gas, transportation (airports, highways, ports, rail and transit), water, and wastewater.

Purpose:
To advance the state-of-the-art and practice of lifeline earthquake engineering through the following endeavors:

- Participate in the development of guidelines, pre-standards and standards for the seismic design and construction of lifelines;
- Encourage lifeline organizations, industries and associated manufacturers, associations and professionals to consider earthquakes and their impacts in the planning, design, emergency planning and operation of lifelines;
- Serve as a primary resource for establishing broad consensus on lifeline issues;
- Identify and prioritize research needs related to lifeline planning, design, construction and operation; and
- Support and/or conduct programs for education and technology transfer on lifeline seismic issues.

EARTHQUAKE INVESTIGATION
ELECTRICAL POWER AND COMMUNICATIONS LIFELINES
GAS AND LIQUID FUELS LIFELINES
PORT AND HARBOR LIFELINES
SEISMIC RISK
TRANSPORTATION LIFELINES
WATER AND WASTEWATER LIFELINES
PUBLICATIONS
TCLEE EARTHQUAKE REPORTS

Milestones

1977 Creation of NEHRP (Public Law 95-124)

1985 BSSC Workshop – Abatement of Seismic Hazards to Lifelines – An Action Plan

1986 National Center for Earthquake Engineering Research (NCEER)

1989 NIBS Report – Strategies and Approaches for Implementing A Comprehensive Program to Mitigate the Risk to Lifelines from Earthquakes and Other Natural Hazards

Loma Prieta earthquake (M 7.1) – 'wake up call' for the SF Bay region


PG&E

California Policy on Acceptable Level of Earthquake Risk*

Each utility shall withstand earthquakes to:

- Provide protection of life
- Limit damage to property, and
- Provide for resumption of utility service in a reasonable and timely manner

**California Seismic Safety Commission/CPUC Safety Branch (1992)*
California Earthquake Loss Reduction Plan (1997)

California Utilities and Transportation Systems Earthquake Risk Management Policy Requirements*

Policy to manage earthquake risks:

- **Program to understand hazards and system vulnerabilities**
- **Plan to implement risk management options**
- **Dedicated staff**
- **Dedicated budget**
- **Accountability**

**** California Seismic Safety Commission/CPUC Safety Branch***

Milestones

1990 NEHRP Reauthorization (Public Law 101-614) - FEMA & NIST to develop a plan for adopting design and construction standards for lifelines

1991 NIST Workshop on Developing and Adopting Seismic Design and Construction Standards for Lifelines

1994 Northridge earthquake (M 6.7)

1995 FEMA 271 – Plan for Developing and Adopting Seismic Design Guidelines and Standards for Lifelines

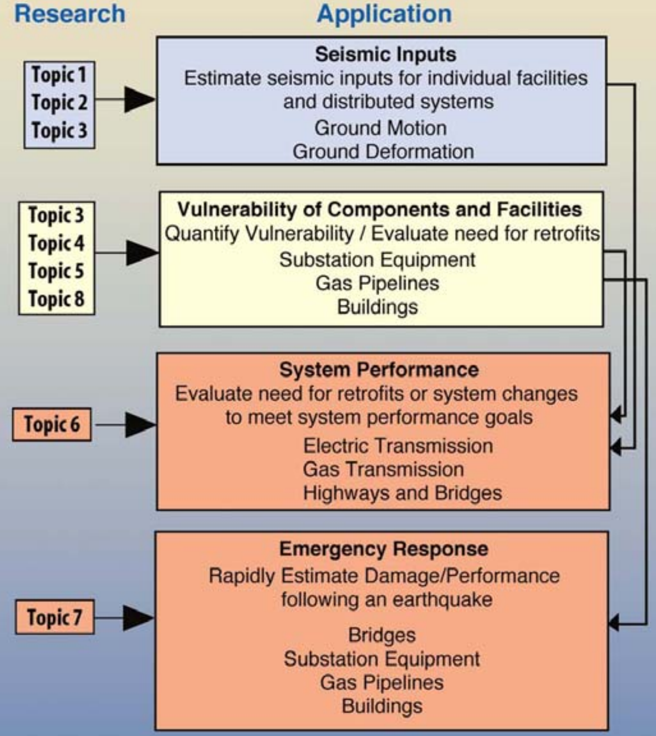
1997 Pacific Center for Earthquake Engineering Research (PEER)

PEER Lifelines Program

Providing data, models, and methods needed to improve the earthquake reliability and safety of lifelines systems.

Implementation of Research Results

A key feature of the Lifelines Program is that the research results are implemented rapidly by the sponsors of the research.



http://peer.berkeley.edu/lifelines

PEER is administered under the National Science Foundation's Engineering Research Centers Program and is headquartered at UC Berkeley. PEER is funded by NSF, the state governments of California and Washington, and private industry and businesses.

PEER Lifeline Projects

Substation Equipment & Buildings Research

- Rigid/ Flexible Bus Interactions
  - Theoretical
  - Experimental
- Input Ground Motions for Simulator Testing
- Seismic Qualification and Testing of 230 / 500 kV Disconnect Switches and 196 and 500 kV Transformer Bushings
- Substation Equipment Database Development
- Seismic Assessment Building Guidelines

PEER support for IEEE 693 – Recommended Practice for Seismic Design of Substations

Milestones

1997 ASCE Lifeline Policymakers Workshop

1998 NCEER become Multidisciplinary Center for Earthquake Engineering Research (MCEER)

American Lifelines Alliance - cooperative agreement between FEMA and ASCE

American Lifelines Alliance

A Public-private Partnership to Reduce Risk to Utility and Transportation Systems from Hazards

www.americanlifelinesalliance.org

General ALA Approach

- Facilitate the creation, adoption, and implementation of national consensus guidelines
- Utilize Industry and Corresponding Advisors to generate project ideas
- Increase awareness at conferences and through focused studies and pilot projects.

American Lifelines Alliance Matrix of Standards and Guidelines for Natural Hazards

OIL PRODUCTS SYSTEMS		NATURAL HAZARD PROVISIONS[8]		
COMPONENT	GUIDE/STANDARD[1]	LOADING	DESIGN	EXISTING[7]
System Reliability[6]				
Buried Pipelines	ASME/ANSI B31.4	none[2]	none	
	ASCE TCLEE 1984	earthquake	earthquake	•
Aboveground Piping	ASME/ANSI B31.4	none[2]	none	
	ASME/ANSI B31.3	none[2]	earthquake, wind, ice	
	API 2510			
	API 2508			
	ASCE TCLEE 1984	earthquake	none	•
Pumping Station Piping	ASME/ANSI B31.3	none[2]	earthquake, wind, ice	
	ASME/ANSI B31.4	none[2]	none	
	API 2510			
	ASCE TCLEE 1984	earthquake	none	•
Well Facilities	ASME/ANSI B31.4	none[2]	none	
	ASME/ANSI B31.3	none[2]	earthquake, wind, ice	
	API RP 14E			
Refineries	API 2508			
	ASCE Petrochem.	earthquake, wind	earthquake, wind	•
	ASME/ANSI B31.3	none[2]	earthquake, wind, ice	
	ASME BPV[3]	none[2]	earthquake, wind, ice	
Storage Tanks	API 620	earthquake, wind	earthquake, wind	•
	API 650	earthquake, wind	earthquake, wind	•
	NFPA 59			
	API 2508			
	ASCE TCLEE 1984	earthquake	earthquake	•

NATURAL GAS SYSTEMS		NATURAL HAZARD PROVISIONS[8]		
COMPONENT	GUIDE/STANDARD[1]	LOADING	DESIGN	EXISTING[7]
System Reliability[6]				
Buried Pipelines	ASME/ANSI B31.8	none[2]	none	
	PRCI (2000)	earthquake	earthquake	•
	ASCE TCLEE 1984	earthquake	earthquake	•
Aboveground Piping	ASME/ANSI B31.3	none[2]	earthquake, wind, ice	
	ASME/ANSI B31.8	none[2]	none	
	ANSI Z223.1	none[2]		
	NFPA 54, SGC, IFGC	none[2]		
	ASCE TCLEE 1984	earthquake	none	•
Compressor Station Piping	ASME/ANSI B31.3	none[2]	earthquake, wind, ice	
	ASME/ANSI B31.8	none[2]	none	
	ASCE TCLEE 1984	earthquake	none	•
Well Facilities	ASME/ANSI B31.8	none[2]	none	
	API RP 14E			
LNG Facilites				
System Reliability[6]	NFPA 59A	earthquake	earthquake	
Piping	NFPA 59A	earthquake	earthquake	
Storage Tanks	***API 620***	earthquake, wind	earthquake, wind	
	API 650	earthquake, wind	earthquake, wind	
	ASME BPV[3]	none[2]	earthquake, wind, ice	
	NFPA 59A	earthquake, ref. ANSI A58.1 for wind and snow	earthquake, ref. ANSI A58.1 for wind and snow	
	ASCE 1984	earthquake	earthquake	

WATER SYSTEMS (Potable & Raw)		NATURAL HAZARD PROVISIONS[8]		
COMPONENT	GUIDE/STANDARD[1]	LOADING	DESIGN	EXISTING[7]
System Reliability[6]				
Buried Pipelines	AWWA M11	none[2]	none	
	ASCE TCLEE 15	earthquake	earthquake	•
Aboveground Pipelines	ASME/ANSI B31.3	none[2]	earthquake, wind, ice	
Pumping Plants	ASME B31.3	none[2]	earthquake, wind, ice	
Storage Tanks	ACI 350	earthquake	earthquake	•
	AWWA D[5]	earthquake, wind, snow	earthquake, wind, snow	•
	ASCE 1984	earthquake	earthquake	•
Well Facilities				
Canals				

WASTE WATER SYSTEMS		NATURAL HAZARD PROVISIONS[8]		
COMPONENT	GUIDE/STANDARD[1]	LOADING	DESIGN	EXISTING[7]
System Reliability[6]				
Buried Pipelines	AWWA M11	none[2]	none	
	ASCE TCLEE 15	earthquake	earthquake	•
Aboveground Pipelines	ASME/ANSI B31.3	none[2]	earthquake, wind, ice	
Treatment Plants	ASME B31.3	none[2]	earthquake, wind, ice	•
	WEF	earthquake, flood		•
Storage Tanks	ACI 350	earthquake	earthquake	•
	AWWA D[5]	earthquake, wind, snow	earthquake, wind, snow	•
	ASCE 1984	earthquake	earthquake	•

ELECTRIC POWER SYSTEMS		NATURAL HAZARD PROVISIONS[8]		
COMPONENT	GUIDE/STANDARD[1]	LOADING	DESIGN	EXISTING[7]
System Reliability[6]				
Substations	IEEE-693	earthquake	earthquake	•
	RUS 1724e*	wind, ice, earthquake	wind, ice, earthquake	•
	ASCE Manual 96	earthquake	earthquake	•
Transmission Towers & Poles	***ASCE-10****	wind, ice, earthquake	wind, ice, earthquake	•
	ASCE Manual 72*	wind, ice, earthquake	wind, ice	•
	ASCE Manual 74	wind, ice, earthquake[2]	wind, ice	•
	ASCE Manual 91*	wind, ice, earthquake	wind, ice, earthquake	•
	ASCE Concrete Poles*	wind, ice, earthquake	wind, ice, earthquake	•
	PCI Prest. Conc. Poles*	wind, ice, earthquake	wind, ice, earthquake	•
	RUS 1724e*	wind, ice, earthquake	wind, ice, earthquake	•
	IEEE 605*	wind, ice, earthquake	wind, ice, earthquake	•
	IEEE 691*	none	none	•
	IEEE 693	earthquake	earthquake	•
	NESC	wind, ice, earthquake	wind, ice	•
Distribution Poles	NESC	wind, ice, earthquake	wind, ice	•
	RUS 160-2*	wind, ice, earthquake	wind, ice, earthquake	•
Buried Conduits				

REVISED MAY 2004

TELECOMMUNICATION SYSTEMS		NATURAL HAZARD PROVISIONS[8]		
COMPONENT	GUIDE/STANDARD[1]	LOADING	DESIGN	EXISTING[7]
System Reliability[6]				
Towers, Masts and Poles	TIA/EIA 222G (2003)	earthquake, wind, ice	earthquake, wind, ice	•
	TIA/EIA 222F	wind, ice	wind, ice	•
Buried Cables	***Bell Core***	earthquake, flood	earthquake, flood	
Underwater Cables				
Aboveground Cables	***Bell Core***	earthquake, wind, ice, snow	Earthquake, wind, ice, snow	
Switching Equipment	***Bell Core***	earthquake, fire	earthquake, fire	
Cable Trays	***SMACNA***	none	earthquake	
	BSP (Bell System Practice)	none	earthquake	
	ASCE 7	earthquake, wind, ice, snow	earthquake, wind, ice, snow	

PORTS AND INLAND WATERWAYS		NATURAL HAZARD PROVISIONS[8]		
COMPONENT	GUIDE/STANDARD[1]	LOADING	DESIGN	EXISTING[7]
System Reliabilty[6]	***ASCE TCLEE 12***	earthquake		•
Piers/Wharves	***NCEL R-939***	earthquake	earthquake	
	NAVFAC DM-25.1			
	ASCE TCLEE 12	earthquake	earthquake	•
	NFESC TR-2069SHR	earthquake	earthquake	
Breakwaters/Jetties	***NCEL R-939***	earthquake	earthquake	
	ASCE TCLEE 12	earthquake	earthquake	•
Sea Walls	***NCEL R-939***	earthquake	earthquake	
	ASCE TCLEE 12	earthquake	earthquake	•
Container Handling	ASCE-7	earthquake, wind, snow, ice	earthquake, wind, snow, ice	
	IBC, SBC, UBC	earthquake, wind, snow, ice	earthquake, wind, snow, ice	
	ASCE TCLEE 12	earthquake	earthquake	•
	AISC	none[2]	earthquake, wind, snow, ice	
Cargo Movement	ASCE-7	earthquake, wind, snow, ice	earthquake, wind, snow, ice	
	IBC, SBC, UBC	earthquake, wind, snow, ice	earthquake, wind, snow, ice	
	ASCE-ASCE TCLEE 12	earthquake	earthquake	•
Marine Oil Terminals	***CSLC***	earthquake	earthquake	
	NFESC, TR-2103-SHR	earthquake	earthquake	
	ASCE-7	earthquake, wind, snow, ice	earthquake, wind, snow, ice	
	NFPA[4]	earthquake	earthquake	

HIGHWAYS AND ROADS		NATURAL HAZARD PROVISIONS[8]		
COMPONENT	GUIDE/STANDARD[1]	LOADING	DESIGN	EXISTING[7]
System Reliability[6]	***FHWA 106***	earthquake	earthquake	
Bridges	***AASHTO***	earthquake, wind, snow, ice, flood	earthquake, wind, snow, ice, flood	•
	CALTRANS	earthquake, wind, snow, ice, flood	earthquake, wind, snow, ice, flood	•
	FHWA-RD-94-052	earthquake	earthquake	•
	FHWA 106	earthquake	earthquake	•
Embankments	***CALTRANS***	earthquake	earthquake	•
Road Beds				
Culverts	***AASHTO***	none[2]	none	
	CALTRANS	none[2]	none	
Tunnels	***AASHTO***	none[2]	none	
	CALTRANS	none[2]	none	
Retaining Walls	***FHWA 106***	earthquake	earthquake	
Signs	ASCE-7	earthquake, wind, snow, ice	earthquake, wind, snow, ice	
	IBC, SBC, UBC	earthquake, wind, snow, ice	earthquake, wind, snow, ice	

RAILROAD		NATURAL HAZARD PROVISIONS[8]		
COMPONENT	GUIDE/STANDARD[1]	LOADING	DESIGN	EXISTING[7]
System Reliability[6]	AREMA Ch. 9			
Bridges	AREMA Ch. 7	wind	wind	
	AREMA Ch. 8	wind, ice	wind, ice	•
	AREMA Ch. 9	earthquake	earthquake	•
	AREMA Ch. 15	wind	wind	•
Embankments	AREMA Ch. 9	earthquake	earthquake	earthquake
Rails, Ties, and Ballast	AREMA Ch. 9	earthquake	earthquake	earthquake
Culverts	AREMA Ch. 9	earthquake	earthquake	earthquake
Tunnels	AREMA Ch. 9	earthquake	earthquake	earthquake
Signs	ASCE-7	earthquake, wind, snow, ice	earthquake, wind, snow, ice	
	IBC, SBC, UBC	earthquake, wind, snow, ice	earthquake, wind, snow, ice	

ELECTRICAL, MECHANICAL, AND ARCHITECTURAL COMPONENTS		NATURAL HAZARD PROVISIONS		
COMPONENT	GUIDE/STANDARD[1]	LOADING	DESIGN	EXISTING[7]
Elect./Mech. Equip	ASCE-7	earthquake, wind, ice	earthquake, wind, ice	
	ASCE TCLEE 1984	earthquake	earthquake	•
	ASME BPV[3]	none[2]	earthquake, wind	
	NFPA[4]	earthquake	earthquake	
	IBC, SBC, UBC	earthquake, wind	earthquake, wind	
	SMACNA	earthquake	earthquake	•
Suspended Ceilings	***IBC, SBC, UBC***	earthquake	earthquake	
Elevated Floors				

NOTES

1. Documents in by ***bold italics*** indicate that the guidelines were not produced by a consensus process as defined for SDO's approved by the American National Standards Institute
2. "none" applies if a guideline or standard does not specifically identify how loads are to be obtained; if a group of standards is referenced, the natural hazard listed may be only covered in one document
3. ASME BPV refers to the ASME Boiler and Pressure Vessel Code that typically governs the design of all pressurized containers
4. NFPA refers to various NFPA standards governing fire protection systems
5. AWWA D refers to various AWWA standards governing water storage tanks
6. "System Reliability" is a component of design referring to practices that are specifically developed to provide reasonable assurance that consequences of a natural hazard on system service will meet the goals establised by stakeholders (owners, operators, regulators, insurers, customers, and users). Consequences are defined by multiple performance requirements but typically include impact on public safety, duration of service interruption, and costs to repair damage.
7. **Existing** indicates that analysis or design procedures (NOT LOADS) could be applied for existing components
8. **Loading** refers to whether or not specific loads for various natural hazards are defined; "Design" refers to the existence of design and/or analysis procedures that account for loads arising from natural hazards

ALA Manmade Hazards Matrix Summary

ELECTRIC POWER		MANMADE HAZARD PROVISIONS		
COMPONENT	GUIDE/STANDARD	LOADING	DESIGN	EXISTING
System Reliability	$ ∅	Radiological, Blast, Cyber	Biological, Blast, Cyber	
Transmission Towers	∅	Blast	Blast	
Distribution Poles	∅	Blast	Blast	
Buried Conduits	∅	Radiological	Radiological	
Substations	IEEE (1) $ ∅	Chemical Radiological	Radiological	
Elect./Mechanical Equipment	∅	Radiological, Cyber	Radiological, Cyber	

NATURAL GAS		MANMADE HAZARD PROVISIONS		
COMPONENT	GUIDE/STANDARD	LOADING	DESIGN	EXISTING
System Reliability	NPC (2) ∅	Radiological, Blast	Cyber Radiological	
Buried Pipelines	DOT (3) DOT (4) DOT (5) DOT (6)	Blast Blast Blast	Chemical Blast	
Aboveground Piping	DOT (7) DOT (8) DOT (9) DOT (10)	Blast Blast Blast	Chemical Blast	
Compressor Station Piping				
Well Facilities				
Offshore Production Installations	ISO (11) $	Chemical, Blast		
Elect./Mechanical Equipment	$ ∅	Radiological	Radiological	

OIL PRODUCTS		MANMADE HAZARD PROVISIONS		
COMPONENT	GUIDE/STANDARD	LOADING	DESIGN	EXISTING
System Reliability	NPC (12) $ ∅	Cyber Radiological, Blast	Cyber Radiological, Blast	
Buried Pipelines	∅	Blast	Blast	
Aboveground Piping	∅	Blast	Blast	
Pumping Station Piping	∅	Blast	Blast	
Well Facilities	∅	Blast	Blast	
Refineries	∅	Blast	Blast	
Storage Tanks	$ ∅	Blast		
Elect./Mechanical Equipment	∅	Radiological, Blast, Cyber		

LNG SYSTEMS		MANMADE HAZARD PROVISIONS		
COMPONENT	GUIDE/STANDARD	LOADING	DESIGN	EXISTING
System Reliability	$ ∅	Radiological, Blast, Cyber	Radiological, Blast, Cyber	
Piping	∅	Blast	Blast	
Storage Tanks	∅	Blast	Blast	
Elect./Mechanical Equipment	∅	Radiological, Blast, Cyber	Radiological, Blast, Cyber	

WATER SYSTEMS (POTABLE & RAW)		MANMADE HAZARD PROVISIONS		
COMPONENT	GUIDE/STANDARD	LOADING	DESIGN	EXISTING
Treatment Units	(13) USACHPPM (14)		Chemical, Biological Biological	
System Reliability	(15) (16)		Chemical, Biological, Radiological, Cyber Chemical, Biological	
Buried Pipelines				
Aboveground Pipelines				
Pumping Plants	$			
Storage Tanks	$			
Well Facilities				

WASTEWATER SYSTEMS		MANMADE HAZARD PROVISIONS		
COMPONENT	GUIDE/STANDARD	LOADING	DESIGN	EXISTING
System Reliability				
Buried Pipelines				
Aboveground Pipelines				
Pumping Plants	NFPA (17) $	Chemical, Blast		
Storage Tanks	$			

TELECOMMUNICATIONS SYSTEMS		MANMADE HAZARD PROVISIONS		
COMPONENT	GUIDE/STANDARD	LOADING	DESIGN	EXISTING
System Reliability	SEI (18) $ ∅	Cyber Radiological, Blast	Cyber Radiological, Blast	
Towers, Masts and Poles	∅	Biological	Biological	
Buried Cables				
Underwater Cables				
Aboveground Cables				
Switching Equipment	∅	Radiological, Cyber	Radiological, Cyber	
Cable Trays				

PORTS AND INLAND WATERWAYS		MANMADE HAZARD PROVISIONS		
COMPONENT	GUIDE/STANDARD	LOADING	DESIGN	EXISTING
System Reliability	$ ∅		Blast	
Piers/Wharves	$ ∅		Blast	
Breakwaters/Jetties	∅		Blast	
Sea Walls	∅		Blast	
Container Handling				
Cargo Movement				
Marine Oil Terminals	$ ∅		Blast	

HIGHWAYS AND ROADS		MANMADE HAZARD PROVISIONS		
COMPONENT	GUIDE/STANDARD	LOADING	DESIGN	EXISTING
System Reliability				
Bridges	$			
Embankments				
Road Beds				
Culverts				
Tunnels				
Retaining Walls				
Signs				

RAILROAD		MANMADE HAZARD PROVISIONS		
COMPONENT	GUIDE/STANDARD	LOADING	DESIGN	EXISTING
System Reliability				
Bridges	$			
Embankments				
Rails, Ties, and Ballast	$			
Culverts				
Tunnels				
Signs				

INFRASTRUCTURE INTERDEPENDENCIES		MANMADE HAZARD PROVISIONS		
COMPONENT	GUIDE/STANDARD	LOADING	DESIGN	EXISTING
System Reliability	∅	Chemical, Biological, Radiological, Blast, Cyber	Chemical, Biological, Radiological, Blast, Cyber	

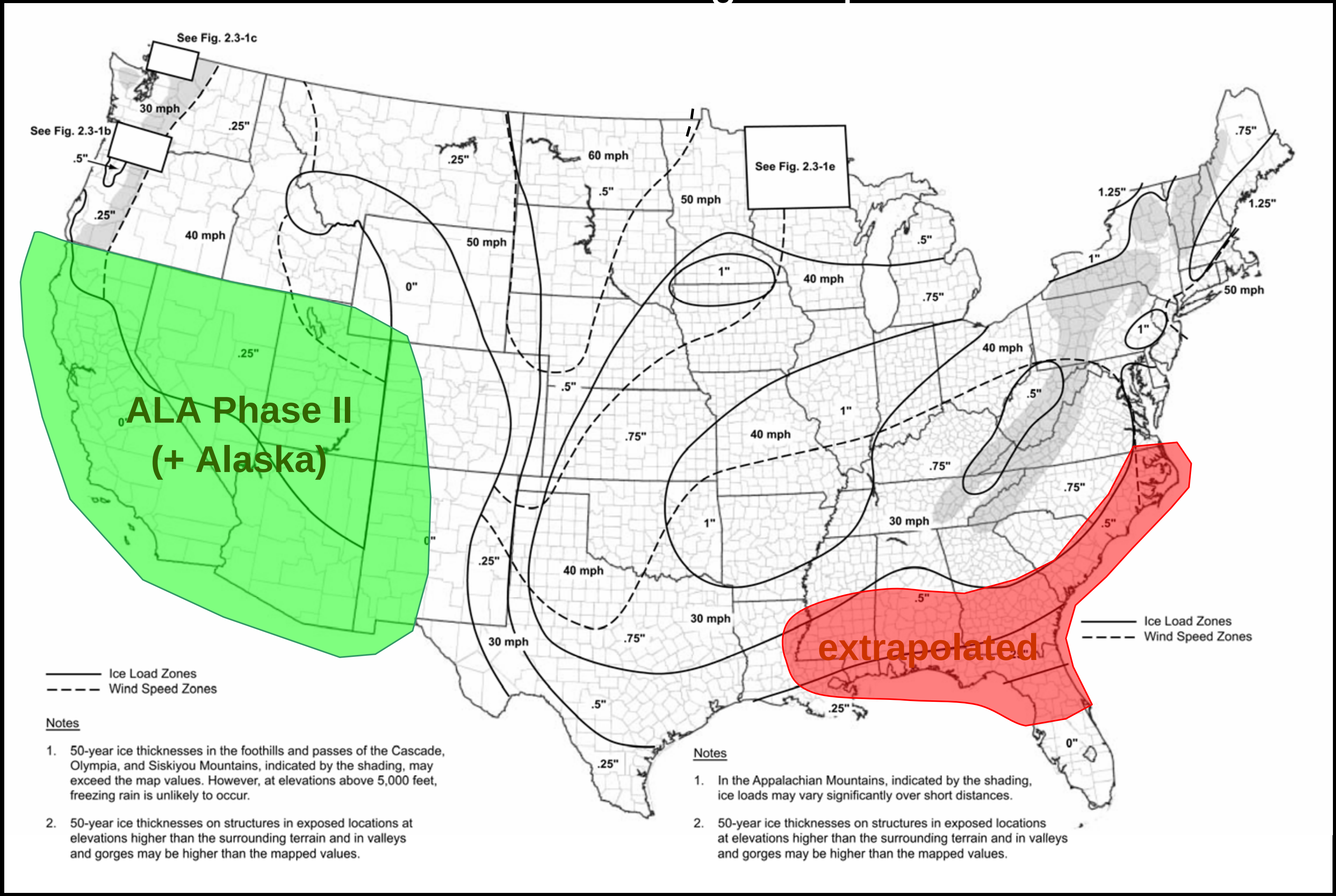
REVISED JANUARY 2003

KEY TO TABLE

* = Guidelines & Standards **not** produced by an ANSI approved standard developing organization.
A = Guidelines & Standards produced by an ANSI approved standard developing organization.
_ = Empty box indicates guidelines and standards related to the specified hazards are not available.
$ = Standards have been identified, but must be purchased for review. See appendices B-M.
∅ = Government standards exist, but are issued fro a controlled or sensitive source.
Loading: Whether or not specific loads for various identified hazards are defined.
Design: Existence of design and/or analysis that account for loads arising specified hazards.
Existing: Analysis or design procedures (not loads) could be applied for existing components.
IEEE (1): Guide for Containment and Control of Oil Spills in Substations.
NPC (2): Securing Oil and Natural Gas Infrastructures in the New Economy.
DOT (3): CFR 49, 195.8, Transportation of Hazardous Liquids or CO_2 in Pipelines Constructed with other than Steel Pipe.
DOT (4): CFR 49, 192.755, Transportation of Natural Gas by Pipeline, Minimum Federal Safety Standards, Protecting Cast Iron Pipelines.
DOT (5): CFR 49, 192.614, Damage Prevention Program.
DOT (6): CFR 49, 149.442, Damage Prevention Program.
DOT (7): CFR 49, 195.8, Transportation of Hazardous Liquids or CO_2 in Pipelines Constructed with other than Steel Pipe.
DOT (8): CFR 49, 195.55 Protecting Cast Iron Pipelines.
DOT (9): CFR 49, 192.614, Damage Prevention Program.
DOT (10): CFR 49, 149.442, Damage Prevention Program.
ISO (11): Petroleum and Gas industries- Control and mitigation of fires and explosions on offshore production installations.
NPC (12): Securing Oil & Natural Gas Infrastructures in the New Economy.
US Congress (13): Safe Drinking Water Act.
USACHPPM (14): Biological Warfare Agents as Threats to Potable Water, Environ Health Perspectives 107:975-984.
US Congress (15): Water Infrastructure Security and Research Development Act.
US Congress (16): HR 3178 and the Development of Anti-Terrorism Tools for Water Infrastructure.
NFPA (17): Standard for Fire Protection in Wastewater Treatment and Collection Facilities.
SEI (18): The CERT Guide to System and Network Security Practices.

Draft map for ASCE 74

Ice thicknesses from freezing rain for a 50-yr return period with concurrent gust speeds



AmericanLifelinesAlliance

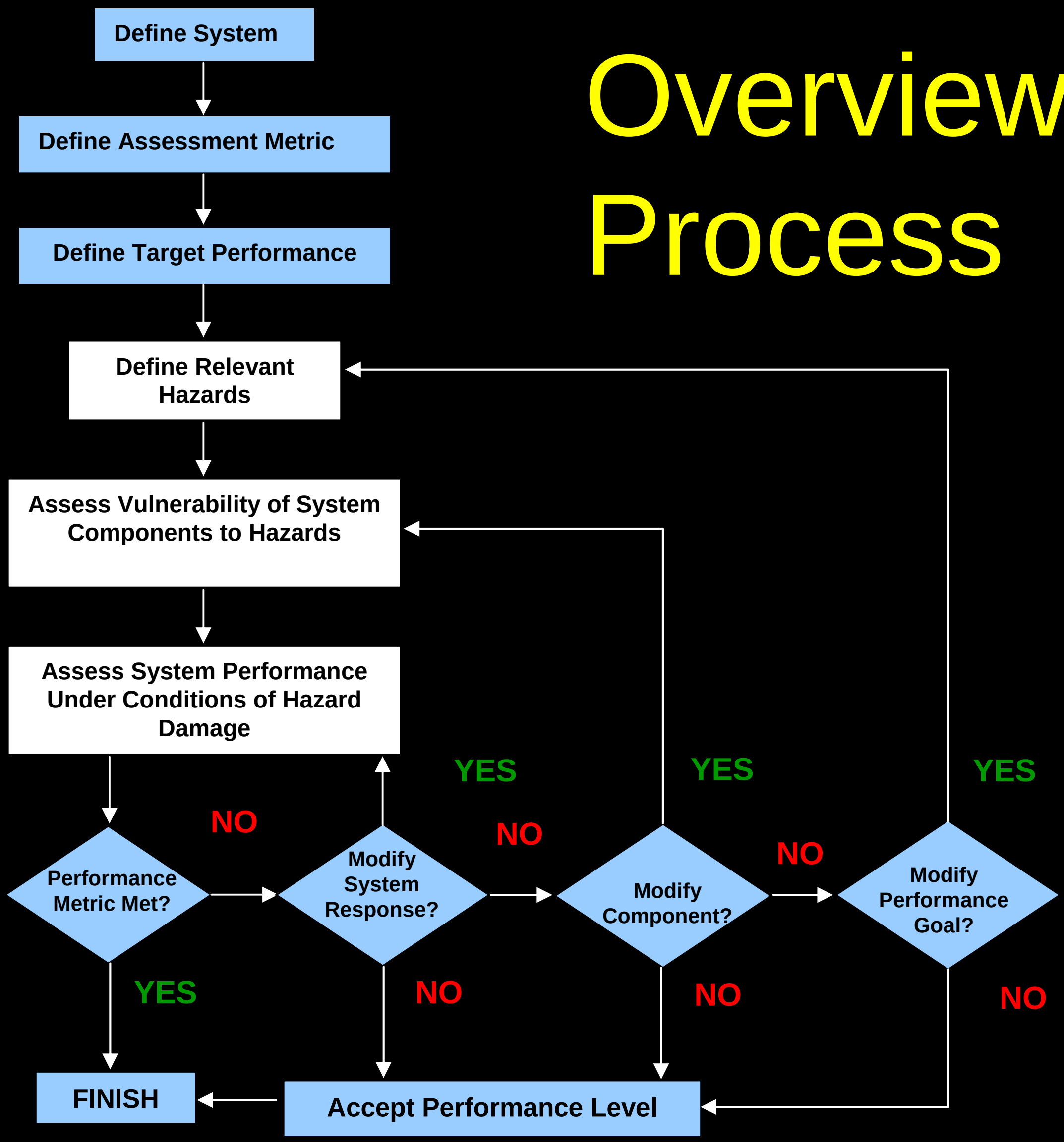
A public-private partnership to reduce risk to utility and transportation systems from natural hazards and manmade threats

Guideline for Assessing the Performance of Electric Power Systems in Natural Hazard and Human Threat Events

FEMA

National Institute of BUILDING SCIENCES

Overview of Process



Milestones

2001 September 11

2002 ALA transferred to National Institute of Building Sciences (NIBS) Multihazard Mitigation Council (MMC)

2003 Department of Homeland Security

Homeland Security Presidential Directive 7: Critical Infrastructure Identification, Prioritization, and Protection

2006 National Infrastructure Protection Plan

National Infrastructure Protection Plan

2006

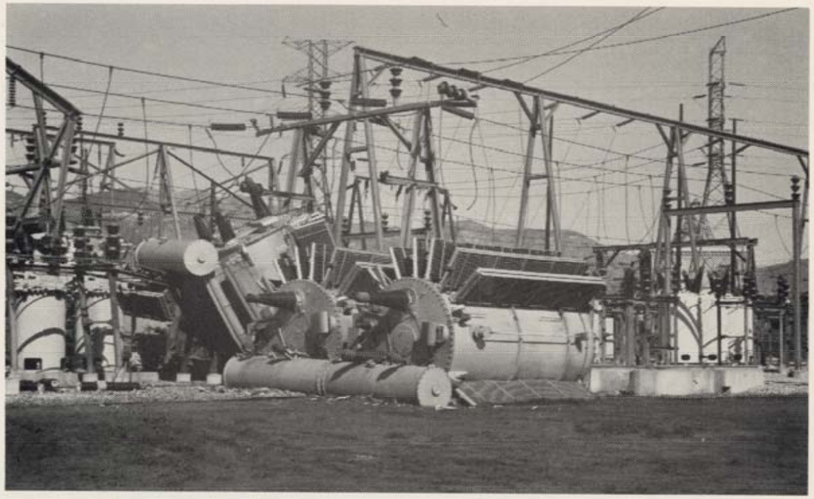
Homeland Security

ATC 25

SEISMIC VULNERABILITY AND IMPACT OF DISRUPTION OF LIFELINES IN THE CONTERMINOUS UNITED STATES

ATC

APPLIED TECHNOLOGY COUNCIL



Funded by
Federal Emergency Management Agency

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Power Systems, Transportation and Communications Lifeline Interdependencies

March 2006

FEMA

National Institute of BUILDING SCIENCES

NIST Technical Note 1476

Performance of Physical Structures in Hurricane Katrina and Hurricane Rita: A Reconnaissance Report

National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

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American Lifelines Alliance Workshop on Unified Data Collection

November 2007

FEMA

National Institute of BUILDING SCIENCES

Next Steps:

Immediate –

- Promote the use of existing standards and guidelines for new construction and upgrades

Longer Term –

- Develop consensus on level of hazard to be considered for use in new design or upgrades

- Develop and implement post-earthquake data collection/archive program

Expect the Unexpected