Disaster and Failure Studies Program Overview

ACEHR
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Eric Letvin, Director
Disaster and Failure Studies Program
Engineering Laboratory
National Institute of Standards and Technology

Disaster and Failure Studies

Earthquakes
- San Fernando, CA (1971)
- Mexico City, Mexico (1985)
- Loma Prieta, CA (1989)
- Northridge, CA (1994)
- Kobe, Japan (1995)
- Kocaeli, Turkey (1999)
- Maule, Chile (2010)

Hurricanes
- Camille, MS/LA (1969)
- Alicia, Galveston, TX (1983)
- Hugo, SC (1989)
- Andrew, FL (1992)
- Hurricanes Mitch and Georges, LAC (1998)
- Hurricanes Katrina and Rita (2005)

Construction/Building
- Skyline Plaza Apartments, Bailey's Crossroads, VA (1973)
- Willow Island Cooling Tower, WV (1978)
- Kansas City Hyatt Regency, Kansas City, MO (1981)
- Riley Road Interchange, East Chicago, IN (1982)
- Harbor Cay Condominium, Cocoa Beach, FL (1981)
- L'Ambiance Plaza, Hartford, CT (1987)
- Ashland Oil Tank Collapse, Floreffe, PA (1988)
- U.S. Embassy, Moscow, USSR (1987)
- Murrah Federal Building, Oklahoma City, OK (1995)
- World Trade Center Disaster, New York, NY (2001)
- Dallas Cowboys Indoor Practice Facility, (2009)

Tornadoes
- Jarrell, TX (1997)
- Spencer, SD (1998)
- Oklahoma City, OK (1999)

Fires
- DuPont Plaza Hotel, San Juan, PR (1986)
- First Interstate Bank Building, Los Angeles, CA (1988)
- Loma Prieta Earthquake, CA (1989)
- Hillhaven Nursing Home (1989)
- Pulaski Building, Washington, DC (1990)
- Happyland Social Club, Bronx, NY (1990)
- Oakland Hills, CA (1991)
- Hokkaido, Japan (1993)
- Watts St, New York City (1994)
- Northridge Earthquake, CA (1994)
- Kobe, Japan (1995)
- Vandalia St, New York City (1998)
- Cherry Road, Washington, DC (1999)
- Keokuk, IA (1999)
- Houston, TX (2000)
- Phoenix, AZ (2001)
- Cook County Administration Building Fire (2003)
- The Station Nightclub, RI (2003)
- Charleston, SC, Sofa Super Store Fire (2007)
- Witch Creek & Guejito Fire (2007)

Results:

- Probable technical cause
- Lessons learned: successes and failures
- Improvements to standards, codes, practices, technologies
- Future research priorities

Authorities:

- ***NCST Act (2002):*** building failures, evacuation and emergency response procedures
- ***NIST Act (1986):*** structural investigations
- ***Fire Prevention and Control Act (1974):*** fire investigations
- ***NEHRP Reauthorization Act (1990):*** earthquakes
- ***National Windstorm Impact Reduction Act (2004):*** wind, storms and floods
- ***National Response Framework:*** structural and fire safety; disaster operations and situation assessment; urban and industrial hazard analysis; recovery

Relevant EL Core Mission Functions[1]

- National Construction Safety Team Act (2002)
- Fire Prevention and Control Act (1974)
- National Earthquake Hazards Reduction Reauthorization Act (2004)
- National Windstorm Impact Reduction Act (2004)
- NIST Authorization Act of 1986 (15 USC 281a)
- NIST Organic Act as amended by America COMPETES Act of 2010

[1]Cited in NIST Organic Act or in other statute

National Construction Safety Team Act - PL 107-231

- Authorizes Director of NIST to launch teams, when practicable, within 48 hours of building failures.
- Tailored to events involving substantial loss of life or that pose significant potential for substantial loss of life – e.g., extreme natural events (earthquakes, hurricane, tornado, flood, etc.), building fires, failure during construction or in active use, act of terrorism, Presidential disaster declaration, activation of National Response Framework
- Modeled by Congress after NTSB: establishes national capability to investigate major building failures that has not previously existed.
    - NIST is the designated lead agency to assess:
        - Building performance
        - Emergency response
        - Evacuation procedures
    - Priority (except for NTSB and criminal acts)

Typical Study Objectives

1. Establishing the likely technical factor or factors responsible for the damage, failure, and/or successful performance of buildings and/or infrastructure in the aftermath of a disaster or failure event.
2. Evaluating the technical aspects of evacuation and emergency response procedures that contributed to the extent of injuries and fatalities sustained during the event.
3. Determining the procedures and practices that were used in the design, construction, operation and maintenance of the buildings and/or infrastructure.
4. Recommending, as necessary, specific improvements to standards, codes, and practices as well as any research and other appropriate actions based on study findings.
5. Promoting, enabling, and tracking adoption of recommendations through improved standards, codes, and practices as well as any research and other appropriate actions based on study findings.

Types of Disaster and Failure Studies

- An ***Initial Reconnaissance*** is a field study at the disaster or failure site to gather information and to determine if a full reconnaissance study is warranted.

- A ***Full Reconnaissance*** is a fact-finding study of the safety and performance of buildings and infrastructure, hazard(s), and/or emergency response and evacuation procedures that will likely result in new knowledge and/or recommendations for improvements to standards, codes, and practices *based on data collection and interpretation, modest analytical efforts, and judgment of technical experts*.

- A ***Technical Investigation*** is a fact-finding study of the safety and performance of buildings and infrastructure, hazard(s), and/or emergency response and evacuation procedures that *requires in-depth technical study—including extensive use of data, models, analytical and computational tools, laboratory and/or field experiments, and/or interviews*—to develop robust recommendations for improvements to standards, codes, and practices.

- Each of the studies contributes to the disaster and failure events data repository

NIST's Role in Disaster and Failure Studies

- NIST may use any one or a combination of the options below in conducting an initial reconnaissance, a full reconnaissance, or a technical investigation:
  - **NIST may lead post-event studies.** In many cases, these will involve an initial reconnaissance and in-depth technical studies focused on the characterization of the hazard, the safety and performance of buildings and structures, and the associated emergency response and evacuation procedures. Private sector and academic experts may be involved in these studies through contracts.
  - **NIST may coordinate or participate in post-event studies.** These types of studies may involve significant participation and/or coordination by other federal agencies with mission responsibilities and expertise.
  - **NIST may commission or participate in private-sector led post-event studies.** In many cases, these will involve initial reconnaissance and full reconnaissance studies with NIST participation limited to either guidance and oversight or serving as a technical expert. These types of studies will typically involve significant private sector leadership and participation augmented with some public sector experts.
  - **NIST may provide technical assistance** in the reconstruction process for international disaster and failure events at the request of US agencies, industry, private organizations, governments of other nations, or international organizations.

International Disaster and Failure Events

- NIST may conduct reconnaissance of international disaster or failure events when lessons can be learned for the U.S.
- NIST involvement in international disaster or failure studies will be undertaken:
  - In cooperation with other U.S. agencies, industry or private organizations, governments of other nations, or international organizations
  - Generally, for the purpose of establishing or improving practices, codes, and standards in the U.S.
- The decision criteria and guidelines for conducting studies are not intended to preclude situations where NIST is requested by other U.S. agencies, industry, private organizations, governments of other nations, or international organizations to provide technical assistance, on a reimbursable basis, in the reconstruction process for international disaster and failure events.

NIST Actions Required by Statute

- NIST…shall, working with USFA and other appropriate Federal and non-Federal agencies and organizations:
  - Conduct, or enable or encourage the conducting of, appropriate research recommended by the Team
  - Promote (consistent with existing procedures for the establishment of building and infrastructure standards, codes, and practices) the appropriate adoption by the Federal Government, and encourage the appropriate adoption by other agencies and organizations, of the recommendations of the Team with respect to—
    - Technical aspects of evacuation and emergency response procedures
    - Specific improvements to building and infrastructure standards, codes, and practices
    - Other actions needed to help prevent future building and infrastructure failures

Purpose and Scope of Authority

- The purpose of NIST studies is to improve the safety and structural integrity of buildings and infrastructure in the United States and the focus is on fact finding.
- NIST teams are authorized to assess building performance and emergency response and evacuation procedures in the wake of any building failure that has resulted in substantial loss of life or that posed significant potential of substantial loss of life.
- NIST does not have the statutory authority to make findings of fault nor negligence by individuals or organizations.
- Further, no part of any report resulting from a NIST investigation into a building failure or from an investigation under the National Construction Safety Team Act may be used in a suit or action for damages arising out of any matter mentioned in such report (15 U.S.C 281a as amended by Public Law 107-231).

Disaster and Failure Studies Program Plan

- Establish a Disaster and Failure Studies Program within NIST's Engineering Laboratory to manage and coordinate these studies.
- Develop criteria, procedures, and guidelines for
  - Selection of disaster and failure events for study
  - Collection and preservation of data and artifacts
  - Coordination and strategic partnerships with other agencies
  - Field logistics, safety, and security
  - Interactions with the press and public
- Conduct comprehensive studies of disaster and failure events, including data and artifact collection.

Disaster and Failure Studies Program Plan

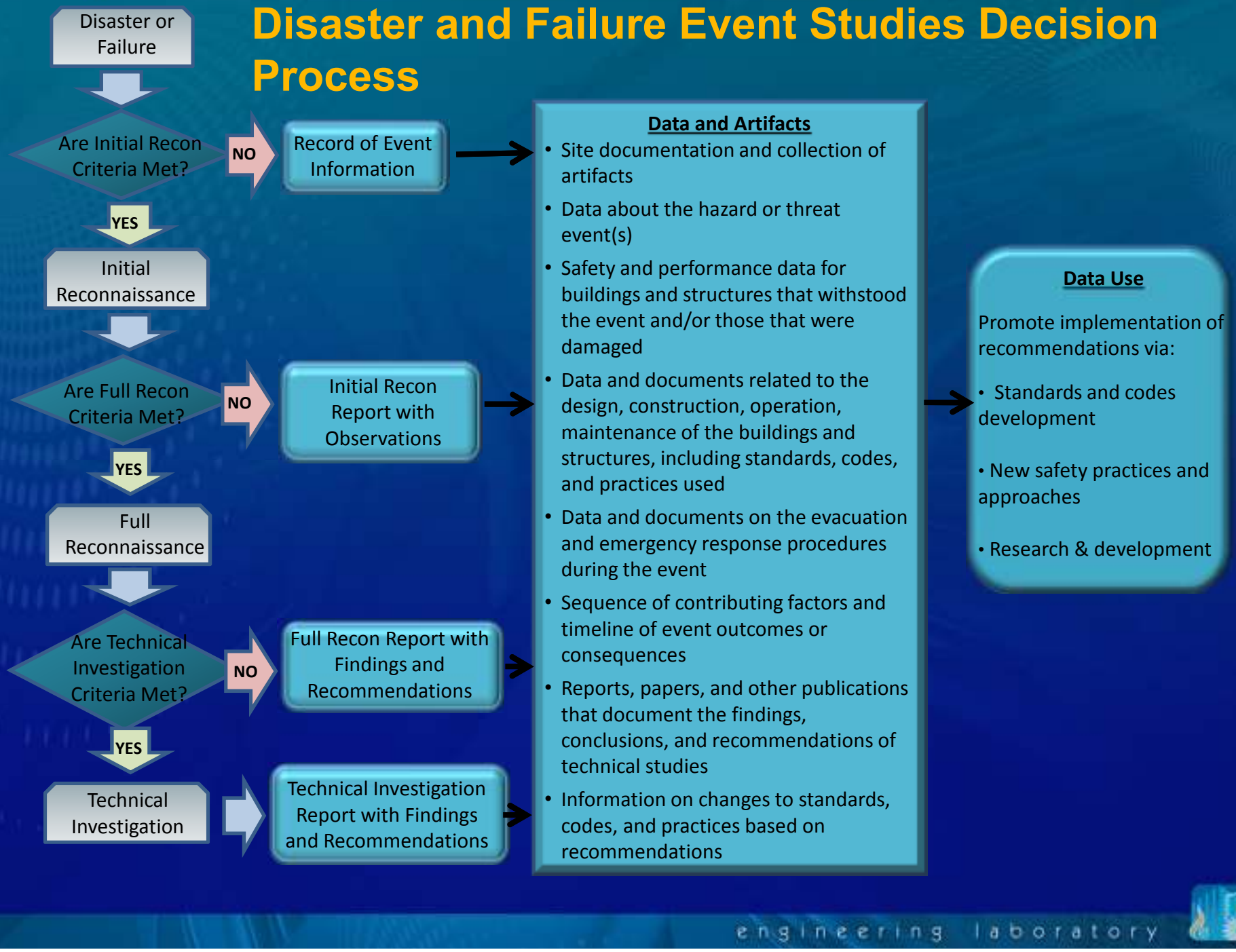
- Develop and maintain an archival repository (database) of disaster and failure events to acquire, preserve, and disseminate information that includes information on the:
  - Hazard events
  - Performance of the built environment (buildings and infrastructure) during hazard events
  - Associated emergency response and evacuation procedures
  - Technical, economic, and social factors that affect pre-disaster mitigation activities and post-disaster response efforts

  Data from former and future NIST studies will be accessible in this repository.
- Enable the development of improved codes, standards and practices based on the findings of disaster and failure event studies.
- Conduct measurement science research to fill gaps in knowledge identified in the findings and recommendations of disaster and failure event studies.

Decision Criteria and Guidelines

- NIST has developed Decision Criteria and Guidelines that provide a rational basis for evaluating the value of conducting a NIST study.
  - NIST will also consider staff availability, resource availability, staff safety, and the quality and adequacy of information and artifacts available to conduct a meaningful study.
  - To the extent practicable, NIST will deploy a team in a timely manner after a disaster or failure event (consistent with statutory requirements)
- If the Congress or the Administration issues a directive to respond to an event, it will result in either a Full Reconnaissance or a Technical Investigation.
- The decision criteria and procedures may be refined as NIST gains experience with their use.

Disaster and Failure Event Studies Decision Process



Initial Reconnaissance Criteria

Initial Reconnaissance Criteria	Low (1)	Med (3)	High (5)
1. Substantial Loss of Life or Disabling Injury			
Single or adjacent structures	0	1 to 2	>2
Community (city, county, metropolitan area)	0 to 3	4 to 9	>10
Region (state to multi-state)	0 to 5	6 to 19	>20
2. Significant Potential for Loss of Life: Exposed Population			
Single structure (occupancy)	<100	100 to 499	≥500
Community (city, county, metropolitan area)	<1 000	1 000 to 9 999	≥10 000
Region (state to multi-state)	<100 000	100 000 to 999 999	≥1 000 000
3. Actual Hazard			
Earthquake	≤ MMI IV	MMI V to VII	≥MMI VIII
Hurricane at Landfall	≤Cat 3	Cat 4	Cat 5
Tornado	≤EF3	EF4	EF5
Coastal Inundation	< 3 ft	3 to 9 ft	≥ 10 ft
Fire Spread in a Structure	Fire spread not beyond area of origin	Fire spread throughout a structure	Fire spread beyond structure of origin
Wildland Urban Interface (WUI)	High Forest Service Fire Danger Rating	Very High Forest Service Fire Danger Rating	Extreme Forest Service Fire Danger Rating
Blast	< 99 lbs. TNT-equivalent	100 - 999 lbs. TNT-equivalent	>1000 lbs. TNT-equivalent
Impact	< 1 x 10^6 ft lb/sec	1 x 10^6 to 1 x 10^7 ft lb/sec	> 1 x 10^7 ft lb/sec
4. Consequences (damage and functionality)			
Failure during Construction	Local structural failure	Partial structural collapse	Total structural collapse
Engineered Building Structures	Minimal nonstructural damage	Significant nonstructural damage Minimal structural damage	Significant structural damage or collapse
Transportation & Utility Structures	Minimal nonstructural damage	Minimal structural damage Partial loss of function	Significant structural damage or collapse Complete loss of function
Non-Engineered Building Structures	Minimal nonstructural damage	Minimal structural damage	Significant structural damage or collapse
5. Need for NIST Involvement			
NIST Authority	Addressed by other authorities – and their mission responsibility and agency expertise	Collaboration with other agencies where NIST provides complementary expertise	NIST has primary authority and/or expertise
Score Sum	**__ x 1**	**__ x 3**	**__ x 5**

Initial Reconnaissance Criteria (2)

Initial Reconnaissance Criteria	Low (1)	Med (3)	High (5)
6. Stakeholder Concern			
Federal disaster declaration	N/A	Declaration; Minimal structural damage	Declaration; Significant structural damage
Request by other Authorities (local, state, federal)	None	NIST provides complementary expertise	NIST has primary expertise
Public Interest.	Local news	State or regional news	National news
Unique event with potential broad implications for similar or other types of structures	Minimal impact	Moderate impact	Significant impact
Score Sum	**__x 1**	**__ x 3**	**__ x 5**
Total Score Total Sum	**__ x 1**	**__x 3**	**__x 5**
7. Evacuation and Emergency Response			
Evacuation	Normal evacuation	Moderate evacuation challenges	Significant evacuation challenges
Emergency Response	Normal operations	Moderate operational challenges	Significant operational challenges
Score Sum	**__ x 1**	**__x 3**	**__ x 5**
8. International Events*			
Codes, standards and enforcement	No building codes, standards, or enforcement	Building codes and standards, but no enforcement	Building codes and standards, with enforcement
Construction practices similar to the U.S.	Minimally similar	Moderately similar	Significantly similar
Total Score: (From 1-6) __x__ = __ Sum	$(0.7)^n$	$(0.9)^n$	$(1.0)^n$

* n is 0,1, or 2, depending on the number of selected items under each ranking category (i.e., Low, Med, or High) for Criteria 8. The factor applied to the Total Score is the product of all three factors.

Examples of Decision Criteria

Year	Event	Criteria 1 to 5 Weighted Score	Total Weighted Score	Evacuation and/ or Emergency Response Score
Blasts and Impacts				
1993	WTC 1 Truck Bombing	4.2	N/A	N/A
2001	WTC 1 and WTC 2 Collapse	5.0	N/A	5.0
2001	WTC 7 Collapse	3.8	4.1	N/A
Fire Events				
2003	Rhode Island Nightclub Fire	4.2	N/A	5.0
2007	Charleston Sofa Super Store Fire	3.8	4.25	3.0
2007	California WUI Fire	4.2	N/A	5.0
Earthquake				
1994	Northridge Earthquake, Los Angeles	4.4	N/A	N/A
2001	Nisqually Earthquake, Seattle	2.7	N/A	N/A
Hurricane				
2005	Hurricane Katrina (Sun, 28 Aug)	3.0	3.5	5.0
2005	Hurricane Katrina (Tues, 30 Aug)	4.7	N/A	5.0
Structural Failures				
1981	Hyatt Regency Walkway Collapse	4.5	N/A	N/A
1981	L'Ambience Plaza	3.5	4.1	N/A
1988	Ashland Tank Failure	2.5	3.6	N/A
2006	Elks Lodge Collapse, Missouri	2.6	N/A	N/A
2009	Dallas Cowboys Collapse	3.5	3.6	N/A

NCST Advisory Committee

Objectives and Duties:

- Advise the Director of the National Institute of Standards and Technology on carrying out the Act by:
  - Providing advice on the functions of National Construction Safety Teams, hereinafter referred to as Teams, as described in section 2(b)(2) of the Act.
  - Providing advice on the composition of Teams under section 3 of the Act.
  - Providing advice on the exercise of authorities enumerated in sections 4 and 5 of the Act.
  - Providing such other advice as necessary to enable the Director to carry out the Act.
- Review and provide advice on the procedures developed under section 2(c)(1) of the Act.
- Review and provide advice on the reports issued under section 8 of the Act.
- Function solely as an advisory body, in accordance with the provisions of the Federal Advisory Committee Act.

Annual Report:

- An evaluation of NCST activities, along with recommendations to improve the operation and effectiveness of NCST
- An assessment of the implementation of the recommendations of the NCST and of the advisory committee

NCST Advisory Committee

- Members are selected on the basis of established records of distinguished service in their professional community and their knowledge of issues affecting NCST studies.
- Members shall reflect the wide diversity of technical disciplines and competencies involved in NCST studies.
- Members are drawn from industry and other communities having an interest in NCST studies, such as, but not limited to, universities, state and local government bodies, non-profit research institutions, and other Federal agencies and laboratories.
- The types of disciplines include: structural engineering (buildings and infrastructure), fire protection, firefighting and emergency response, and human behavior and evacuation. Other disciplines that may be represented include: codes and standards (buildings, infrastructure and fire), architecture, insurance and risk, and materials science and engineering.

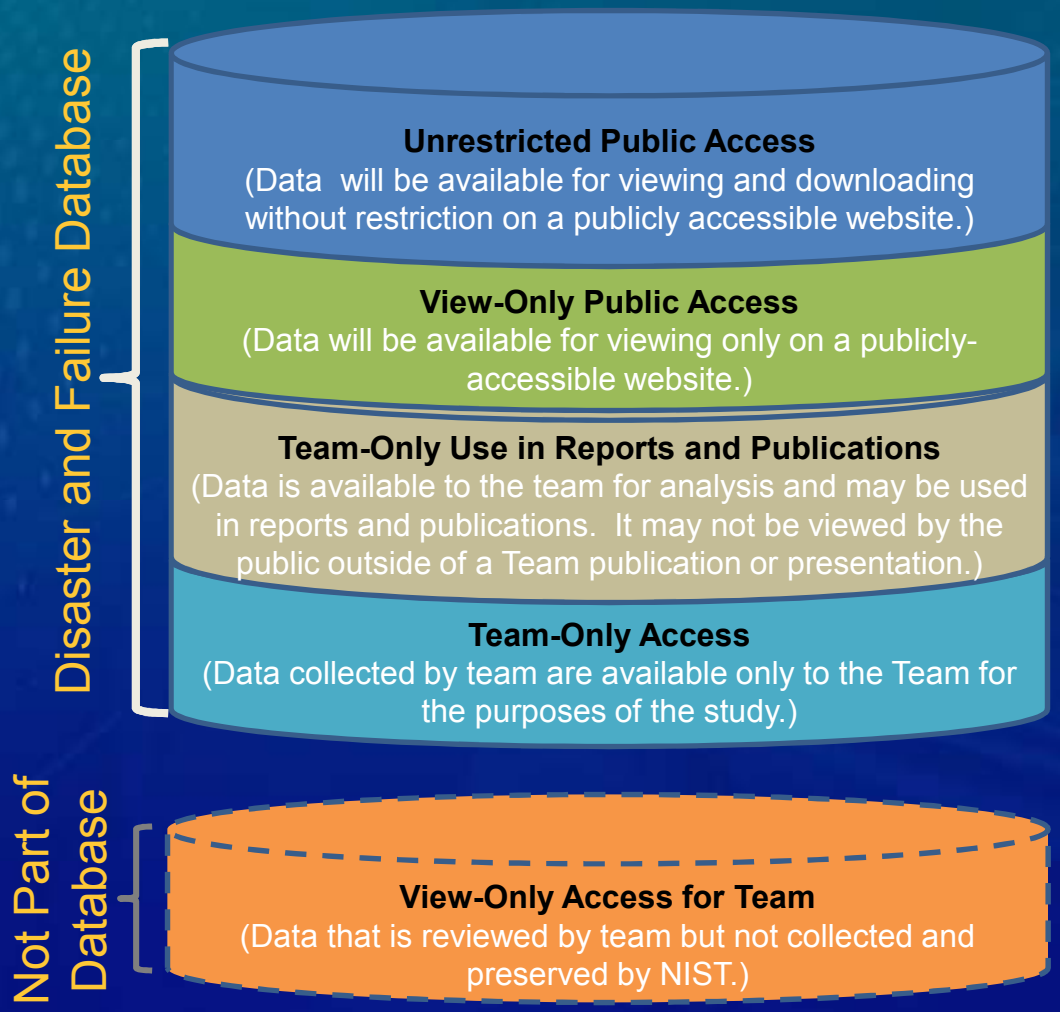
NCST Act Provisions

- "NIST shall enter into a Memorandum of Understanding with each Federal agency that may conduct or sponsor a related investigation, providing for coordination of investigations"
  - Criminal Acts— "If the Attorney General, in consultation with the (NIST) Director, determines and notifies the Director, that circumstances reasonably indicate that the building failure being investigated by a Team may have been caused by a criminal act, the team shall relinquish investigative priority to the appropriate law enforcement agency. The relinquishment of investigative priority by the Team shall not otherwise affect the authority of the Team to continue its investigation under this Act."
  - National Transportation Safety Board—"If the NTSB is conducting an investigation related to an investigation of a Team, the NTSB investigation shall have priority over the Team investigation. Such priority shall not otherwise affect the authority of the Team to continue its investigation under this Act."
- "A Team shall cooperate with State and local authorities carrying out any activities related to a Team's investigation"

Implementing Partnering and Agreements

- Establish strategic partnerships and standing agreements with appropriate federal agencies, state and local governments, academic and industry organizations to ensure effective national coordination in disaster and failure studies.
  - For NEHRP, for example, NIST will develop coordination and partnerships with the U.S. Geological Survey (within which the Post-Earthquake Investigations Program is established by current statute), the Federal Emergency Management Agency, the National Science Foundation, and organizations in the broader NEHRP stakeholder community.
- Establish coordination mechanisms and protocols for technical activities and public communications with partnering program agencies.
- Provide information to other agencies, stakeholders, technical bodies, Congress, and the public.

Types of Data Collected



Tentative Database Repository Development Planning Timeline (Function of Resources)

- Spring 2011 – Previously released World Trade Center Data (about 1.5 TB)
- FY 2011/12 – Develop framework for repository and conduct pilot with a single event's dataset (ATC – Purdue/NEEScom)
  - Assist with draft repository framework and system design (user requirements)
  - Coordinate Chile Earthquake data
  - Create prototype repository
  - Release pilot repository
- FY 2012 – Repository online for future disaster and failure studies
- FY 2012 - Modify user requirements and expand repository
- FY 2014/15 – Repository fully operational and populated with selected historical or future events

Contact Info

Eric Letvin

301 975 5412
eric.letvin@nist.gov

The NIST Engineering Laboratory
100 Bureau Drive Stop 8600
Gaithersburg, MD 20899-8600

www.nist.gov/el