Disaster and Failure Studies Program Overview

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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)
- Christchurch, NZ (2011)

### 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)
- Pulsaki Building, Washington, DC (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 (1996)
- 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)
- Witch Creek & Guejito Fire (2007)
- Amarillo (2011)

### Hurricanes
- Camille, MS/LA (1969)
- Alicia, Galveston, TX (1983)
- Hugo, SC (1989)
- Andrew, FL (1992)
- 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)

### 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

### Results:
- Probable technical cause
- Lessons learned: successes and failures
- Improvements to standards, codes, practices, technologies
- Future research priorities
Relevant EL Core Mission Functions

- NIST Organic Act as amended by America COMPETES Act of 2010

\(^1\text{Cited in NIST Organic Act or in other statute}\)
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)
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.
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.
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.
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.
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

- 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

<table>
<thead>
<tr>
<th>Decision Path</th>
<th>Description</th>
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<tbody>
<tr>
<td>Disaster or Failure</td>
<td></td>
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<tr>
<td>Are Initial Recon Criteria Met?</td>
<td>NO</td>
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<tr>
<td>Initial Reconnaissance</td>
<td></td>
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<td></td>
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### Data and Artifacts
- Site documentation and collection of artifacts
- Data about the hazard or threat event(s)
- Safety and performance data for buildings and structures that withstood the event and/or those that were damaged
- Data and documents related to the design, construction, operation, maintenance of the buildings and structures, including standards, codes, and practices used
- Data and documents on the evacuation and emergency response procedures during the event
- Sequence of contributing factors and timeline of event outcomes or consequences
- Reports, papers, and other publications that document the findings, conclusions, and recommendations of technical studies
- Information on changes to standards, codes, and practices based on recommendations

### Data Use
- Promote implementation of recommendations via:
  - Standards and codes development
  - New safety practices and approaches
  - Research & development
## Initial Reconnaissance Criteria

### 1. Substantial Loss of Life or Disabling Injury
- **Single or adjacent structures**: 0 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)**: < 1000 1000 to 9999 ≥ 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)
- **Engineered Building Structures**: Minimal nonstructural damage Significant nonstructural damage Significant structural damage or collapse
- **Transportation & Utility Structures**: Minimal nonstructural damage Minimal structural damage Partial loss of function 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

<table>
<thead>
<tr>
<th>Score</th>
<th>Sum</th>
<th>Low (1)</th>
<th>Med (3)</th>
<th>High (5)</th>
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<td>x 1</td>
<td>x 3</td>
<td>x 5</td>
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### Initial Reconnaissance Criteria (2)

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<thead>
<tr>
<th>Initial Reconnaissance Criteria</th>
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<th>Med (3)</th>
<th>High (5)</th>
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<tr>
<td><strong>6. Stakeholder Concern</strong></td>
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<tr>
<td>Federal disaster declaration</td>
<td>N/A</td>
<td>Declaration; Minimal structural damage</td>
<td>Declaration; Significant structural damage</td>
</tr>
<tr>
<td>Request by other Authorities (local, state, federal)</td>
<td>None</td>
<td>NIST provides complementary expertise</td>
<td>NIST has primary expertise</td>
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<tr>
<td>Public Interest.</td>
<td>Local news</td>
<td>State or regional news</td>
<td>National news</td>
</tr>
<tr>
<td>Unique event with potential broad implications for similar or other types of structures</td>
<td>Minimal impact</td>
<td>Moderate impact</td>
<td>Significant impact</td>
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<tr>
<td><strong>Score</strong></td>
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<td>__ x 3</td>
<td>__ x 5</td>
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<td><strong>Total Score</strong></td>
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<thead>
<tr>
<th><strong>7. Evacuation and Emergency Response</strong></th>
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<tr>
<th><strong>8. International Events</strong> *</th>
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<tr>
<td>Codes, standards and enforcement</td>
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<tr>
<td>Construction practices similar to the U.S.</td>
</tr>
<tr>
<td><strong>Total Score: (From 1-6) * x * = * Sum</strong></td>
</tr>
</tbody>
</table>

* 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.
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

- **Unrestricted Public Access**: Data will be available for viewing and downloading without restriction on a publicly accessible website.
- **View-Only Public Access**: Data will be available for viewing only on a publicly-accessible website.
- **Team-Only Use in Reports and Publications**: Data is available to the team for analysis and may be used in reports and publications. It may not be viewed by the public outside of a Team publication or presentation.
- **Team-Only Access**: Data collected by team are available only to the Team for the purposes of the study.
- **View-Only Access for Team**: Data that is reviewed by team but not collected and preserved by NIST.
Disaster and Failure Event Studies Decision Process

Disaster or Failure

Are Initial Recon Criteria Met?

YES

Initial Reconnaissance

Are Full Recon Criteria Met?

YES

Full Reconnaissance

Are Technical Investigation Criteria Met?

YES

Technical Investigation

NO

Technical Investigation Report with Findings and Recommendations

NO

Full Recon Report with Findings and Recommendations

NO

Initial Recon Report with Observations

Data and Artifacts

- Site documentation and collection of artifacts
- Data about the hazard or threat event(s)
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Data Use

Promote implementation of recommendations via:

- Standards and codes development
- New safety practices and approaches
- Research & development
Tentative Database Repository Development Planning Timeline (Function of Resources)

• May 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 NIST 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
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