

**National Institute of Standards and Technology  
National Construction Safety Team Act  
Annual Report**

**Fiscal Year (FY) 2014**

## Summary

This annual report to Congress for fiscal year (FY) 2014 is required by the National Construction Safety Team (NCST) Act.

Most notably, during FY 2014, the National Institute of Standards and Technology (NIST) published its final report on the Joplin tornado within 90 days after completion of its NCST Act investigation of this event (NIST NCSTAR 3, *Final Report, Technical Investigation of the May 22, 2011, Tornado in Joplin, Missouri*,<sup>1</sup> March, 2014). This effort began in FY 2011, when NIST Director Patrick Gallagher established a Team under the NCST Act to conduct the technical investigation of the May 22, 2011, Joplin tornado.

The goals of the investigation were to: (1) study the wind environment and technical conditions associated with fatalities and injuries, the performance of emergency communications systems and the public response to such communications, and the performance of residential, commercial, and critical buildings, designated safe areas in buildings, and lifelines; and (2) develop findings and recommendations that can serve as the basis for potential improvements to public safety in tornado, including:

- potential improvements to requirements for design and construction of buildings, designated safe areas, and lifeline facilities in tornado-prone regions;
- potential improvements to guidance for tornado warning systems and emergency response procedures; and
- potential revisions to building, fire, and emergency communications codes, standards, and practices.

The final report of the technical investigation includes 47 findings that support 16 recommendations in the following broad areas: improving understanding of tornado hazard characteristics and associated wind fields; improving performance of buildings, shelters, designated safe areas, and lifelines; and improving performance of emergency communications systems and public response. Specifically, the NIST report includes calls for:

1. developing national performance-based standards for tornado-resistant design of buildings and infrastructure, as well as design methods to achieve those standards;
2. developing improved standards, codes and guidelines for siting, design, installation, and operation of tornado shelters, and installation of additional shelters in tornado-prone areas; and
3. creating national codes and standards for clear, consistent and accurate emergency communications.

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<sup>1</sup> Available at <http://nvlpubs.nist.gov/nistpubs/NCSTAR/NIST.NCSTAR.3.pdf>

NIST also published a report on the preliminary reconnaissance of the Newcastle-Moore tornado that struck Moore, OK, and surrounding areas on May 20, 2013, (NIST SP 1164, *Preliminary Reconnaissance of the May 20, 2013, Newcastle-Moore Tornado in Oklahoma*,<sup>2</sup> December 3, 2013). This report includes observations that support the recommendations made in the Joplin Tornado investigation final report.

In April 2014, NIST created and funded a new project to carry out implementation of the 16 recommendations in the Joplin tornado investigation final report. Highlights of FY 2014 implementation activities include:

- convening implementation strategy meetings with stakeholder federal agencies and standards development organizations;
- creation of a new committee to develop a consensus standard for methods of estimating wind speeds in tornadoes, including improving the Enhanced Fujita Scale as well as standardizing other methods such as radar and forensic engineering estimates; and
- initiating a multi-year effort to develop new tornado hazard maps for use in performance-based design of tornado-resistant buildings and infrastructure.

NIST held one meeting<sup>3</sup> of the NCST Advisory Committee (AC) during FY 2014, on December 10-11, 2013. In that meeting, NIST briefed the AC on the 47 findings and 16 recommendations made in its final report of the Joplin Tornado investigation, provided an update on the work of the Disaster and Failure Studies Program, and responded to and discussed the AC's previous recommendations to NIST from the December 10, 2012, NCST AC meeting.

## Introduction

In October 2002, the NCST Act (P.L. 107-231) was signed into law by President George W. Bush and authorized the Director of NIST to establish and deploy Teams to investigate events leading to failure of a building or buildings that result in substantial loss of life or that pose significant potential for substantial loss of life.

The purpose of these investigations is to improve the safety and structural integrity of buildings in the United States (U.S.). A Team shall:

- (A) Establish the likely technical cause or causes of the building failure;
- (B) Evaluate the technical aspects of evacuation and emergency response procedures;
- (C) Recommend as necessary, specific improvements to building standards, codes, and practices based on the findings made pursuant to subparagraphs (A) and (B); and,
- (D) Recommend any research and other appropriate actions needed to improve the structural safety of buildings, and improve the evacuation and emergency response procedures, based on the findings and recommendations of the investigation.

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<sup>2</sup> Report available at [http://www.nist.gov/customcf/get\\_pdf.cfm?pub\\_id=914721](http://www.nist.gov/customcf/get_pdf.cfm?pub_id=914721)

<sup>3</sup> Meeting summary available at <http://www.nist.gov/el/disasterstudies/ncst/upload/NCSTACmtgDec2013MtgSummary15Jan2014.pdf>

Under Section 10 of the NCST Act, NIST is to provide an annual report to the House Committee on Science, Space, and Technology and to the Senate Committee on Commerce, Science, and Transportation by February 15 of each year. This report is to include:

- (1) A summary of the investigations conducted by Teams during the prior fiscal year;
- (2) A summary of recommendations made by the Teams in reports issued under Section 8 of the NCST Act during the prior fiscal year and a description of the extent to which those recommendations have been implemented; and
- (3) A description of the actions taken to improve building safety and structural integrity by the NIST during the prior fiscal year in response to reports issued under Section 8 of the NCST Act.

This report summarizes NIST's activities under the NCST Act for FY 2014 as required by Section 10 of the Act.

## **1. Investigations Conducted Under the NCST Act during FY 2014**

On March 26, 2014, NIST published its final report<sup>4</sup> on the May 22, 2011, Joplin, Missouri, tornado following the completion of its NCST Act investigation of this event. NIST did not conduct any other investigation under the NCST Act during FY 2014.

On May 22, 2011, a massive tornado impacted Joplin, MO. The tornado was rated EF 5, the most powerful on the Enhanced Fujita (EF) tornado scale. The tornado was on the ground for over 22 miles, including 6 miles through the City of Joplin, where it was nearly a mile wide. The tornado destroyed some 8,000 buildings in its path, killed 161 people, and injured over 1,000, making it the single deadliest tornado in the U.S. since official record keeping began in 1950.

NIST sent four researchers/engineers to Joplin from May 25-28, 2011, to conduct a preliminary reconnaissance of building performance and emergency communications during the tornado. Based on the recommendations of the preliminary reconnaissance and analysis of the additional criteria set forth in the regulations implementing the NCST Act, the NIST Director established a Team under the NCST Act to conduct a more comprehensive study of the disaster.

The goals of the investigation were to: (1) study the wind environment and technical conditions associated with fatalities and injuries, the performance of emergency communications systems and the public response to such communications, and the performance of residential, commercial, and critical buildings, designated safe areas in buildings, and lifelines; and (2) develop findings and recommendations that can serve as the basis for potential improvements to public safety in tornado, including:

- potential improvements to requirements for design and construction of buildings, designated safe areas, and lifeline facilities in tornado-prone regions;
- potential improvements to guidance for tornado warning systems and emergency response procedures; and

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<sup>4</sup> NIST NCSTAR 3, Final Report, National Institute of Standards and Technology (NIST) Technical Investigation of the May 22, 2011, Tornado in Joplin Missouri. Available at <http://nvlpubs.nist.gov/nistpubs/NCSTAR/NIST.NCSTAR.3.pdf>.

- potential revisions to building, fire, and emergency communications codes, standards, and practices.

The Team established the following objectives, consistent with the aforementioned goals:

- Determine the tornado hazard characteristics and associated wind fields in the context of historical data.
- Determine the pattern, location, and cause of fatalities and injuries, and associated performance of emergency communications systems and public response.
- Determine the response of residential, commercial, and critical buildings, including the performance of designated safe areas.
- Determine the performance of lifelines as it relates to the continuity of operations of residential, commercial, and critical buildings.
- Identify, as specifically as possible, areas in current building, fire, and emergency communications codes, standards, and practices that warrant revision.

On November 21, 2013, NIST held a briefing on its Joplin tornado investigation's findings and recommendations for Joplin City officials, then released a draft final report for public comment at a press conference in Joplin, Missouri. The public comment period was open for 45 days, until January 6, 2014. On March 26, 2014, after consideration of all public comments received, NIST issued the final report for the Joplin tornado investigation. The report includes 47 findings that support 16 recommendations, which align with the goals of the investigation.

## **2. Summary of Recommendations Made by Teams in Reports Issued Under Section 8 of the NCST Act during FY 2014**

The NIST final report<sup>5</sup> on its NCST Act investigation of the May 22, 2011, Joplin Tornado made 16 recommendations in the following broad areas: improving understanding of tornado hazard characteristics and associated wind fields; improving performance of buildings, shelters, designated safe areas, and lifelines; and improving performance of emergency communications systems and public response. The 16 Joplin tornado recommendations are shown in Appendix A.

Specifically, the NIST Joplin recommendations include calls for:

- Development of nationally-accepted performance-based standards for tornado-resistant design of buildings and infrastructure, as well as design methods to achieve those standards. The standards will require that critical facilities, such as hospitals, be designed to remain operational in the event of a tornado;
- Development of improved standards, codes and guidelines for siting, design, installation, and operation of tornado shelter, installation of many more shelters in tornado-prone areas, and development of guidance for selection of best available refuge areas in existing buildings;
- Development of nationally-accepted codes and standards for clear, consistent and accurate emergency communications and ensuring that emergency managers, the National Weather Service (NWS), and the news media in local communities have a joint plan for delivering those messages quickly and persuasively during tornados, and

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<sup>5</sup> NIST NCSTAR 3, Final Report, National Institute of Standards and Technology (NIST) Technical Investigation of

- Future research and development of technologies and strategies to advance tornado wind measurements, strengthen emergency communications, increase warning time, derive more accurate tornado hazard maps and significantly improve public response during tornado events.

### 3. Actions Taken to Improve Building Safety and Structural Integrity during FY 2014 in Response to Reports Issued Under Section 8 of the NCST Act

#### a. Actions Related to Report on the NIST World Trade Center Investigation:

In its *Final Report on the Collapse of the World Trade Center Towers*,<sup>6</sup> NIST recommended that “progressive collapse be prevented in building through the development and nationwide adoption of consensus standards and code provisions.” In FY 2012, based on a proposal from NIST, a new ASCE/SEI Standards Committee called the “Disproportionate Collapse Mitigation Standard” Committee was established. This voluntary standards committee is currently developing a standard, scheduled for completion in two years, to address this NIST’s recommendation. NIST staff are members of this standard committee and are fully engaged in translating the results of NIST research into the standard. This would add to the long list of actions that have been taken to improve building safety and structural integrity as a result of NCST investigations. Additional information about changes to building codes and standards can be found at

[http://www.nist.gov/el/disasterstudies/wtc/wtc\\_recommendations.cfm](http://www.nist.gov/el/disasterstudies/wtc/wtc_recommendations.cfm)

#### b. Actions Related to Report on the NIST Joplin Tornado Investigation:

After the publication on March 26, 2014, of its final report on the Joplin tornado, NIST has taken the following actions to begin implementation of the 16 recommendations made in this investigation (Note – the Joplin recommendations are provided in Appendix A):

- Convened strategy meetings with leaderships of key stakeholder organizations having lead responsibility,<sup>7</sup> for implementation of various NIST Joplin recommendations to (1) affirm their commitment to the implementation, (2) develop appropriate strategy, and (3) coordinate respective implementation activities, including:
  - **American Society of Civil Engineers (ASCE):** Worked with ASCE to form, with NIST staff as a co-chair, a committee to develop a new *ASCE/SEI Wind Speed Estimation Standard*, which was approved by ASCE in May 2014. This committee will develop standardized methods for estimating the intensity of tornadoes and other severe wind storms. This new standard directly addresses both Joplin recommendations #2 and #4, and supports Joplin recommendations #1 and #3. In addition, NIST staff formed and led a *Tornado Working Group* within the ad-hoc ASCE committee on *Performance-Based Design for Extreme Wind*, to begin work that addresses Joplin recommendation #5 and supports Joplin recommendation #6.
  - **International Code Council (ICC):** Met in April 2014, discussed and developed joint NIST-ICC action plan for implementation of Joplin recommendations #7, #10,

<sup>6</sup> [http://www.nist.gov/customcf/get\\_pdf.cfm?pub\\_id=909017](http://www.nist.gov/customcf/get_pdf.cfm?pub_id=909017)

<sup>7</sup> Prior to the publication of its final report on the Joplin tornado investigation, NIST consulted with organizations it designated as having lead responsibility for implementation of various NIST Joplin recommendations and obtained their concurrences to serve in that role. These organizations are listed under the “Lead” column of the Recommendation Table in Appendix A.

and #11.

- **Nuclear Regulatory Commission (NRC):** Met in July 2014 and discussed strategy for implementation of Joplin recommendation #3.
  - **National Science Foundation (NSF):** Met in July 2014 and discussed strategy for implementation of Joplin recommendation #15.
  - **Federal Emergency Management Agency (FEMA):** Met in August 2014 and discussed (1) specific code change proposals related to tornado shelters for the 2018 International Building Code (IBC) and International Existing Buildings Code that pertain to Joplin recommendation #7, and (2) revision of FEMA P-361 (Design and Construction Guidance and Considerations for Large Community Storm Shelters and Safe Rooms) in support of Joplin recommendation #8.
  - **National Fire Protection Association (NFPA):** Met in August 2014, discussed and developed joint NIST-NFPA action plan for implementation of Joplin recommendations #3, #11, and #13.
- Awarded contract to develop Tornado Risk Maps for use in tornado-resistant design of buildings. The contractor is Applied Research Associates, Inc. (ARA), a firm with strong expertise in wind engineering. This effort directly addresses Joplin recommendation #3 and provides prerequisite technical underpinning for recommendations #5 and #6.

For actions taken by NIST to improve building safety and structural integrity during FY 2014 in response to studies conducted under other NIST authorities, see Appendix B.

#### **4. Other NIST Activities Related to the NCST Act**

No other NIST activities related to the NCST Act other than those described above took place during FY 2014.

**Appendix A**  
**Recommendations of NIST NCST Act Joplin Tornado Investigation (NIST NCSTAR 3, March 2014)**

Recommendation	Interested Parties	Lead
<i>Group 1: Tornado Hazard Characteristics and Associated Wind Field</i>		
<b>Recommendation 1:</b> NIST recommends that a capacity be developed and deployed that can measure and characterize actual tornadic wind fields, including near-surface wind fields, for use in the engineering design of buildings and infrastructure. This would require enhancement and widespread deployment of cost-effective, advanced technologies, including weather radar.	Academia, DOE, FEMA, NWS, NRC, NSF	NOAA
<b>Recommendation 2:</b> NIST recommends that information gathered and generated from tornado events (such as the Joplin tornado) should be stored in publicly available and easily accessible databases to aid in the improvement of tornado hazard characterization.	Academia, FEMA, NGA	NWS
<b>Recommendation 3:</b> NIST recommends that tornado hazard maps for use in the engineering design of buildings and infrastructure be developed considering spatially based estimates of the tornado hazard instead of point-based estimates.	ASCE, DOE, FEMA, ICC, NRC	NIST
<b>Recommendation 4:</b> NIST recommends that new damage indicators (DIs) be developed for the Enhanced Fujita tornado intensity scale to better distinguish between the most intense tornado events. Methodologies used in the development of new DIs and associated degrees of damage (DODs) should be, to the extent possible, scientific in nature and quantifiable. As new information becomes available, a committee comprised of public and private entities should be formed with the ability to propose, accept, and implement changes to the EF Scale. The improved EF Scale should be adopted by NWS.	Academia, ATC, FEMA, NRC, NSF, OSTP	NWS

Recommendation	Interested Parties	Lead
<b>Group 2: Performance of Buildings, Shelters, Designated Safe Areas, and Lifelines</b>		
<b>Recommendation 5:</b> NIST recommends that nationally accepted performance-based standards for the tornado-resistant design of buildings and infrastructure be developed and adopted in model codes and local regulations to enhance the resiliency of communities to tornado hazards. The standards should encompass tornado hazard characterization, performance objectives, and evaluation tools. The standards shall require that critical buildings and infrastructure such as hospitals and emergency operations centers be designed to remain operational in the event of a tornado.	Academia, ATC, Design and construction industry (including ACI, AISC, AWS, NAHB, PCA, SDI, SJI, TMS), FEMA, ICC, NFPA	ASCE
<b>Recommendation 6:</b> NIST recommends the development of risk-balanced, performance-based tornado design methodologies such that all building components and systems meet or exceed the same performance objectives when subjected to tornado hazards.	Academia, ASCE, ATC, Design and construction industry (including ACI, AISC, AWS, NAHB, PCA, SDI, SJI, TMS), ICC, NFPA	NIST, FEMA
<b>Recommendation 7:</b> NIST recommends that: (a) a tornado shelter standard specific for existing buildings be developed and referenced in model building codes; and (b) tornado shelters be installed in new and existing multi-family residential buildings, mercantile buildings, schools and buildings with assembly occupancies located in tornado hazard areas identified in the performance-based standards required by Recommendation 5.	Academia, FEMA, NAHB, NFPA, States and authorities having jurisdiction (AHJ) in tornado-prone areas	ICC
<b>Recommendation 8:</b> NIST recommends the development and implementation of uniform national guidelines that enable communities to create safe and effective public sheltering strategies. The guidelines should address planning for siting, designing, installing, and operating public tornado shelters within the community.	IAEM, IAFC, ICC, NAC, NCSL, NEMA, NFPA, NSF, NWS	FEMA
<b>Recommendation 9:</b> NIST recommends that uniform guidelines be developed and implemented nationwide for conducting assessment of tornado risk to buildings and designating best available tornado refuge areas as an interim measure within buildings until permanent measures fully consistent with Recommendations 5 and 7 are implemented.	Academia, DHS S&T, IAEM, IAFC, ICC, NAC, NCSL, NEMA, NFPA, States and AHJs in tornado-prone areas	FEMA
<b>Recommendation 10:</b> NIST recommends that aggregate used as surfacing for roof coverings and aggregate, gravel, or stone used as ballast be prohibited on buildings of any height located in a tornado-prone region.	ASCE, NFPA, SPRI, States and AHJs	ICC

Recommendation	Interested Parties	Lead
<p><b>Recommendation 11:</b> NIST recommends that enclosures of egress systems (elevators, exits, stairways) in critical facilities in tornado-prone areas be designed to maintain their functional integrity when subjected to tornado hazards.</p>	BOMA	ICC, NFPA
<p><b>Recommendation 12:</b> NIST recommends that (a) tornado vulnerability assessment guidelines for critical facilities be developed and (b) owners and operators of existing critical facilities in tornado-prone areas perform tornado vulnerability assessments, which includes steps to protect the functionality of (1) backup power supplies, (2) vertical movement within the building (elevator equipment and shaft enclosures), and (3) means of egress illumination (battery-powered lighting in addition to backup power), in a tornado event.</p>	BOMA, DHS IP, DHS S&T, IFMA, NFPA, States and AHJs	FEMA
<p><b>Group 3: Pattern, Location, and Cause of Fatalities and Injuries, and Associated Performance of Emergency Communications Systems and Public Response</b></p>		
<p><b>Recommendation 13:</b> NIST recommends the development of national codes and standards and uniform guidance for clear, consistent, recognizable, and accurate emergency communications, encompassing alerts and warnings, to enable safe, effective, and timely responses among individuals, organizations, and communities in the path of storms having the potential to create tornadoes.</p> <p>NIST also recommends that emergency managers, the NWS, and the media develop a joint plan and take steps to make sure that accurate and consistent emergency alert and warning information is communicated in a timely manner to enhance the situational awareness of community residents, visitors, and emergency responders affected by an event.</p>	Academia, FEMA, IAEM, ICC, NEMA, and NWS	NFPA
<p><b>Recommendation 14:</b> NIST recommends that the full range of current and next-generation emergency communication “push” technologies (e.g., GPS-based mobile alerts and warnings, reverse 9-1-1, outdoor siren systems with voice communication, NOAA weather radios) be deployed and utilized to maximize each individual’s opportunity to receive emergency information and respond safely, effectively, and in a timely fashion.</p>	Academia, DHS, FCC, IAFC, NEMA, NFPA, NWS	FEMA
<p><b>Recommendation 15:</b> NIST recommends research be conducted to identify the factors that will significantly enhance public perception of personal risk and promote rapid and effective public response during emergencies, including tornadoes.</p>	Academia, DHS, ICC, NFPA, NWS	NSF, NIST

Recommendation	Interested Parties	Lead
<p><b>Recommendation 16:</b> NIST recommends that technology be developed to provide tornado threat information to emergency managers, policy officials, and the media on a spatially resolved real-time basis to supplement the currently deployed official binary warn/no warn system.</p>	<p>FEMA, IAEM, Media industry, NEMA, NFPA</p>	<p>NOAA</p>
<p><b>Recommendation 16: CONTINUED</b>  NIST recommends that tornado threat information be provided to emergency managers, policy officials, and the media on a spatially resolved real-time basis by frequently updating gridded probabilistic hazard information that is merged with other GIS information to supplement the currently deployed binary warn/no warn system.</p>	<p>NOAA</p>	<p>NOAA</p>

**Key:** ACI, American Concrete Institute; AHJ, authority having jurisdiction; AISC, American Institute of Steel Construction; ASCE, American Society of Civil Engineers; AWS, American Welding Society; DHS, U.S. Department of Homeland Security; DOE, U.S. Department of Energy; FCC, Federal Communications Commission; FEMA, Federal Emergency Management Agency; IBC, *International Building Code*; ICC, International Code Council; IRC, *International Residential Code*; NEMA, National Emergency Management Association; NFPA, National Fire Protection Association; NIST, National Institute of Standards and Technology; NOAA, National Oceanic and Atmospheric Administration; NRC, U.S. Nuclear Regulatory Commission; NSF, National Science Foundation; NWS, National Weather Service; OSTP, Office of Science and Technology Policy; PCA, Portland Cement Association; SDI, Steel Deck Institute; SJI, Steel Joist Institute; TMS, The Masonry Society.

## Appendix B

### Studies Conducted and Actions Taken by NIST to Improve Building Safety and Structural Integrity under Legal Authorities other than the NCST Act in FY 2014

#### B.1 Studies Conducted

##### Newcastle-Moore, Oklahoma, Tornado

As NIST was nearing completion of its NCST Act technical investigation of the Joplin tornado, another massive and deadly EF-5 tornado struck the midwest – this time just south of Oklahoma City, on May 20, 2013. The tornado caused 24 fatalities, including seven schoolchildren who were taking shelter in their designated tornado safety area at the Plaza Towers Elementary School. Approximately 2,400 buildings were damaged or destroyed, including two elementary schools and the only hospital in the City of Moore.

NIST decided to conduct a preliminary reconnaissance of the Newcastle-Moore tornado to identify information that might be relevant to aspects of the Joplin tornado investigation. The objectives of the Newcastle-Moore Tornado preliminary reconnaissance were therefore limited to:

- Collecting data and information on the performance of the emergency communications systems immediately prior to and during the tornado; and
- Collecting data and information on the response of critical and educational facilities (specifically, the Moore Medical Center and Briarwood and Plaza Towers Elementary Schools) to the tornado, including emergency operations, the physical performance of the buildings and designated safe areas, and life safety outcomes.

The preliminary reconnaissance was conducted in cooperation with staff from NOAA's National Severe Storms Laboratory. The preliminary reconnaissance Team documented the physical damage to understand the performance of buildings and designated safe areas, as well as life safety outcomes. In addition, NIST interviewed first responders, emergency managers, NWS meteorologists, teachers and staff at the elementary schools, staff from the Moore Medical Center, and others.

NIST released its report<sup>8</sup> on the Newcastle-Moore tornado on December 3, 2013. This report includes observations that support the recommendations in the Joplin Tornado investigation final report. One of the key observations described in the preliminary reconnaissance report was that designated safe areas at one of the impacted elementary schools did not provide life safety protection. Seven schoolchildren died and others were injured when part of the building's designated safe area, in which they were located, collapsed.

#### B.2 Actions Taken to Improve Building Safety and Structural Integrity

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<sup>8</sup> NIST SP 1164, Preliminary Reconnaissance of the May 20, 2013, Newcastle-Moore Tornado in Oklahoma. National Institute of Standards and Technology, December, 2013. Available at [http://www.nist.gov/manuscript-publication-search.cfm?pub\\_id=914721](http://www.nist.gov/manuscript-publication-search.cfm?pub_id=914721).

NIST's Disaster and Failure Studies Program coordinates its efforts with the NIST Engineering Laboratory's Codes and Standards Program to promote, enable, and track the adoption of NCST investigation recommendations, as well as other NIST studies' recommendations to improve building safety and structural integrity through improved standards, codes, and practices and through any research and other appropriate actions. NIST issued its final report on the Sofa Super Store fire that occurred in Charleston, SC, in March 2011. The final report included recommendations that have resulted in significant code changes and proposed changes<sup>9</sup>.

In FY 2014, NIST worked with the ICC's Code Technology Committee (CTC) to move forward with three additional code change proposals responsive to the recommendations of NIST's Charleston Sofa Super Store Fire study. Proposed code requirements involved the installation of automatic water sprinklers, improved and systematic recordkeeping, and periodic inspections for retail, manufacturing and storage occupancies that display, fabricate or store upholstered furniture or mattresses.

Prior to the Charleston Sofa Super Store Fire, automatic water sprinklers were not mandatory in occupancies involving upholstered furniture less than 12,000 ft<sup>2</sup>. The NIST Sofa Super Store Fire Report recommended reducing the 12,000 ft<sup>2</sup> limit to 2,000 ft<sup>2</sup> for both new and existing occupancies. For new occupancies, the 2015 International Fire Code (IFC) include a reduced limit depending on the occupancy use; manufacture-2,500 ft<sup>2</sup>, display and sale- 5,000 ft<sup>2</sup>, storage -2,500 ft<sup>2</sup>. While the reduction does not achieve the NIST recommendation of 2,000 ft<sup>2</sup>, the reduction from 12,000 ft<sup>2</sup>, to either 2,500 ft<sup>2</sup> or 5,000 ft<sup>2</sup>, does significantly improve the fire safety of furniture related occupancies. However, the IFC only applied to new occupancies and the NIST recommendations included both new and existing occupancies. For existing occupancies, the 2015 International Existing Building Code (IEBC Sprinklers in Section 904.1.3 for Alteration Level 3) includes a requirement that when existing furniture-related occupancies undergo a major alteration, the occupancy must be improved to meet the IBC requirements. While this requires some existing occupancies to include automatic sprinklers, it does not fully achieve the NIST recommendation that all existing furniture-related occupancies to be sprinklered, however it does significantly improve the fire safety of existing furniture-related occupancies.

The 2015 IFC (Recordkeeping in Section 107.3) also includes improved requirements for more systematic recordkeeping of periodic inspections, tests, maintenance, and other operations of fire protection systems for buildings. The fire code official will now have the authority to prescribe form and format of the recordkeeping. Additionally, records will be kept for a minimum of three years. Better records will assist in verifying that appropriate inspections and maintenance are completed and will significantly improve the fire safety for occupants.

NIST was not successful in getting Recommendation 3, Qualified Fire Inspectors and Building Plan Examiners, incorporated into the International Fire Code. ICC's Code Technology Committee has forwarded these recommendations to the Fire Code Action Committee (F-CAC) for follow-up. NIST continues to work with F-CAC to incorporate

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<sup>9</sup> See: <http://www.nist.gov/el/disasterstudies/fire/upload/RecommendationsCharlestonSofaStoreFire.pdf>

these recommendations into a future IFC.

### **B.3 Pilot Demonstration of an Impact Evaluation Protocol**

Under the authority of the National Construction Safety Team (NCST) Act, NIST can establish a Team to determine and issue reports on the likely cause(s) of building failures. These reports include recommendations, but there has been no systematic method or protocol available to evaluate the impact of these recommendations.

A protocol for evaluating the impact of NIST recommendation has been developed through a collaborative effort between NIST's Engineering Laboratory and the Fire Protection Research Foundation (research component of the National Fire Protection Association). The development of the impact evaluation protocol is described in detail in the pilot study report.<sup>10</sup>

The evaluation protocol begins by arranging report recommendations into two groups:

- 1) Adoption/Enforcement recommendations for changes in the rules and practices that define local environments and first responder effectiveness; and
- 2) Research recommendations for research on incident related phenomena and mitigation methods that will lead to recommendations for changes in rules.

For the first group, the evaluation protocol requires analysis of changes to a) model building and fire codes, and b) local practices. Because changes are usually made in the model codes as a first step and then local jurisdictions adopt the model codes, it is necessary to examine changes at both levels. The general approach of the protocol is to analyze the requirements related to the NIST recommendation before the recommendations were issued, and compare them to later editions of the codes and standards. This should be done for all editions issued after an event because sometimes it takes several code revision cycles for standard development organizations and jurisdictions to implement and adopt the changes. The protocol considers information on:

- a) *adoption* of requirements (for those life safety systems and practices), which connects the gap between impact of recommendations at the national level (on model codes and standards) and impact at the local level (on local requirements and practices);
- b) *compliance* with requirements (for life safety systems of properties but not for fire responder practices); and
- c) *timing of changes* in requirements, as this is the most accessible information indicating a role on NIST recommendations and other national changes or guidance following a major incident in changing local practices (e.g., some localities may already have local practices that match the recommendations).

For the second group, the evaluation protocol requires conducting a literature review of a) published research, b) program, plans, and agendas for research not yet completed, c) research conducted as input to revisions of model codes, standards, and similar documents.<sup>11</sup>, and d) research on the effectiveness of model codes, standards, and similar documents. The research

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<sup>10</sup> Hall, J.R. Jr., Karter, M., Kimball, A., and Yin, M., "Pilot Demonstration of an Impact Evaluation Protocol: NIST NCST Recommendations Arising from The Station Nightclub Fire", The Fire Protection Research Foundation, Quincy MA, November 2014, 194 p.

<sup>11</sup> Standards development organizations including ASTM, International Code Council (ICC), International Organization for Standardization (ISO), NFPA, and Society of Fire Protection Engineers (SFPE).

recommendations are intended to lead to research that will in turn result in new rules and practices. To provide some assessment of the degree of progress toward this goal, the protocol requires evaluating the literature sources on the following:

- a) quality* (e.g., originality, peer-reviewed), including notes on availability as applicable (e.g., proprietary vs. non-proprietary), and
- b) relevance* (e.g., relevance to topic, degree of progress toward eventual goal of recommendations on rules and practices) using a rating system

After completing an analysis of changes to model codes and local practices, and a review of the research literature, the impact evaluation protocol includes a second round of analyses focused on the synergies between the change analysis and literature review. Research on a topic can inform changes to model codes and standards as well as local practices. The literature review on any research related recommendations and the findings from the analysis of changes to model codes and local practices must be reviewed and analyzed for any links. However, this is often a long process, thus it is recommended above that this type of evaluation be completed more than once. This type of comparison can also give an idea of what changes may be on the horizon associated with more recently completed research.