Disaster Resiliency and NFPA Codes and Standards

Final Report

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FOREWORD

The term *resiliency* has been used with increasing frequency in the context of how we build for, plan for, and respond to the variety of events that could interrupt the desired normalcy. Often these disruptive events are characterized as disasters, so *disaster resiliency* is a common pairing of terms for discussing and defining the concept. In response to the growing use of the term, the Fire Protection Research Foundation requested a review of its codes and standards and appropriate outside literature to identify how the terms and concepts apply to the National Fire Protection Association's (NFPA) activities. The title selected for that initiative was *Disaster Resiliency and NFPA Codes and Standards*. Since its formation, the NFPA has addressed fire as *the* disruptive event. The objective of this project is to include other disruptive events (disasters) in addition to, or in place, of fires. This review is intended *to identify those provisions in NFPA codes and standards that embody the concepts of resiliency and compile available information to serve as a technical reference for those documents.* This review is also intended to identify *key gaps in knowledge necessary to support the integration of resiliency concepts into NFPA codes and standards*. The specific tasks identified in the scope of work include:

Literature Review
Codes and Standards Mapping and Gap Assessment, and
Report on all Findings

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The content, opinions, and conclusions contained in this report are solely those of the authors.

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The Fire Protection Research Foundation plans, manages, and communicates research on a broad range of fire safety issues in collaboration with scientists and laboratories around the world. The Foundation is an affiliate of NFPA.

About the National Fire Protection Association (NFPA)

NFPA is a worldwide leader in fire, electrical, building, and life safety. The mission of the international nonprofit organization founded in 1896 is to reduce the worldwide burden of fire and other hazards on the quality of life by providing and advocating consensus codes and standards, research, training, and education. NFPA develops more than 300 codes and standards to minimize the possibility and effects of fire and other hazards. All NFPA codes and standards can be viewed at no cost at www.nfpa.org/freeaccess.

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Introduction

The term *resiliency* has been used with increasing frequency in the context of how we build for, plan for, and respond to the variety of events that could interrupt the desired normalcy. Often these disruptive events are characterized as disasters, so *disaster resiliency* is a common pairing of terms for discussing and defining the concept. In response to the growing use of the term, the Fire Protection Research Foundation requested a review of its codes and standards and appropriate outside literature to identify how the terms and concepts apply to the National Fire Protection Association's (NFPA) activities. The title selected for that initiative was *Disaster Resiliency and NFPA Codes and Standards*. Since its formation, the NFPA has addressed fire as *the* disruptive event. The objective of this project is to include other disruptive events (disasters) in addition to, or in place, of fires. This review is intended *to identify those provisions in NFPA codes and standards that embody the concepts of resiliency and compile available information to serve as a technical reference for those documents.* This review is also intended to identify *key gaps in knowledge necessary to support the integration of resiliency concepts into NFPA codes and standards*. The specific tasks identified in the scope of work include:

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The literature review provides relevant extracts from a variety of sources and is intended to include a pathway for understanding how the concepts of resilience could apply to the wide range of NFPA codes and standards. The mapping is intended to be both a benchmarking of the current codes and standards and an identification of a path forward for incorporating resilience concepts. The gap assessment is intended to identify knowledge gaps or other barriers to implementation.

NFPA's mission is *to reduce the worldwide burden of fire and other hazards on the quality of life by providing and advocating consensus codes and standards, research, training, and education*. Currently the focus of the majority of NFPA codes and standards is fire, electrical, and life safety. However, with the introduction of NFPA 5000 *Building Construction and Safety Code* in 2002, the scope of activities expanded to address other design hazards including natural hazards. Likewise, NFPA's long history in developing documents for the fire service provides a perspective on the emergency response aspect of disaster resilience. As the nation moves forward to incorporate *Disaster Resiliency* as a national priority, standards organizations will be expected to play a critical and complementary role in achieving that goal.

Literature Review

The literature review is divided into sections, starting with definitions of resilience. As will be noted, there are a variety of definitions for resiliency or resilience, since the concept(s) has been applied very broadly. NFPA will have to determine what definition and concepts apply to its current and future activities. This review starts with wide definitions and then narrows to *disaster resiliency* as characterized in several federal government initiatives. Following the definitions is a discussion of the performance goal described in the literature as necessary to achieve resilience. Next is a review of suggested frameworks within which the codes and standards may be required to merge. Then there is a discussion of the role of codes and standards as defined by other research efforts in the literature. Finally, there is a section on the approaches in other regulatory or standards organizations, which could provide some suggested references for addressing the risk-informed, performance-based applications for integrating *resiliency* concepts into NFPA codes and standards.

Definitions of Resilience

A valuable starting place for understanding the evolution of the term and concepts of resilience is an article by Norris, F.P., et al. titled *Community Resilience as a Metaphor, Theory, Set of Capacities and Strategy for Disaster Readiness.* The article outlines 40 years of use of the term in physical, ecological, social, and community resilience. The article includes an extensive bibliography outlining this history. Norris defines resilience as *a process linking a set of adaptive capacities to a positive trajectory of functioning and adaptation after a disturbance.* That definition probably has more traction with community psychologists. However, it does raise two interesting concepts that 1) resilience is a process not just a result or outcome and 2) resilience is adaptive (dynamic not static). Zolli and Healy provide a valuable insight into the concept of resilience and how it could be applied to NFPA's mission and standards:

> *Around the world, in disciplines as seemingly disconnected as economics, ecology, political science, cognitive science, and digital networking, scientists, policymakers, technologists, corporate leaders and activists alike are asking the same basic questions: What causes one system to break and another to rebound? How much change can a system absorb and still retain its integrity and purpose? What characteristics make a system adaptive to change? In an age of constant disruptions, how do we build in better shock absorbers for ourselves, our communities, companies, economies, societies and the planet?*
>
> *Defining resilience more precisely is complicated by the fact that different fields use the term to mean slightly different things. In engineering, resilience generally refers to the degree to which a structure like a bridge or building can return to a baseline state after being disturbed. In emergency response, it suggests the speed with which critical systems can be restored after an earthquake or a flood…Though different in emphasis, each of these definitions rests on one of two aspects of resilience: continuity and recovery in the face of change.*

Although the definitions are diverse, the application to NFPA codes and standards will fall into one or both of these two aspects: *continuity or recovery.*

Another excellent reference with broad discussions on resilience is *Resilience Engineering: Concepts and Precepts*, edited by Hollnagel, Woods, and Leveson. This compilation of papers from a symposium offers insight into resilience engineering as a companion to safety management, both for systems and for organizations. One point related here from Westrum's discussion on *Resilience Typology* is particularly useful in understanding how codes and standards could influence resilience:

> *Protecting the organization from trouble can occur proactively, concurrently, or as a response to something that has already happened. These are all part of resilience, but they are not the same. Resilience thus has three major meanings.*
>
> - *Resilience is the ability to prevent something bad from happening.*
> - *Or the ability to prevent something bad from becoming worse,*
> - *Or the ability to recover from something bad once it has happened.*

This insight adds *prevention* either as part of, or in addition to, *continuity.*

The first official US government use of the concepts of resilience appears in the National Security Strategy, May 2010:

> *At home, the United States is pursuing a strategy capable of meeting the full range of threats and hazards to our communities. These threats and hazards include terrorism, natural disasters, large-scale cyber attacks, and pandemics. As we do everything within our power to prevent these dangers, we also recognize that we will not be able to deter or prevent every single threat. That is why we must also enhance our resilience—the ability to adapt to changing conditions and prepare for, withstand, and rapidly recover from disruption…*
>
> ***Improve Resilience Through Increased Public-Private Partnerships****:*
>
> *When incidents occur, we must show resilience by maintaining critical operations and functions, returning to our normal life, and learning from disasters so that their lessons can be translated into pragmatic changes when necessary. The private sector, which owns and operates most of the nation's critical infrastructure, plays a vital role in preparing for and recovering from disasters. We must, therefore, strengthen public-private partnerships by developing incentives for government and the private sector to design structures and systems that can withstand disruptions and mitigate associated consequences, ensure redundant systems where necessary to maintain the ability to operate, decentralize critical operations to reduce our vulnerability to single points of disruption, develop and test continuity plans to ensure the ability to restore critical capabilities, and invest in improvements and maintenance of existing infrastructure.*

This policy use is expanded on in Presidential Policy Directive (PPD) 8, *National Preparedness*, which includes the following definitions of interconnected terms:

> *For the purposes of this directive:*
>
> *(a) The term "national preparedness" refers to the actions taken to plan, organize, equip, train, and exercise to build and sustain the capabilities necessary to prevent, protect*

against, mitigate the effects of, respond to, and recover from those threats that pose the greatest risk to the security of the Nation.

(b) The term "security" refers to the protection of the Nation and its people, vital interests, and way of life.

(c) The term "resilience" refers to the ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies.

(d) The term "prevention" refers to those capabilities necessary to avoid, prevent, or stop a threatened or actual act of terrorism. Prevention capabilities include, but are not limited to, information sharing and warning; domestic counterterrorism; and preventing the acquisition or use of weapons of mass destruction (WMD). For purposes of the prevention framework called for in this directive, the term "prevention" refers to preventing imminent threats.

(e) The term "protection" refers to those capabilities necessary to secure the homeland against acts of terrorism and manmade or natural disasters. Protection capabilities include, but are not limited to, defense against WMD threats; defense of agriculture and food; critical infrastructure protection; protection of key leadership and events; border security; maritime security; transportation security; immigration security; and cybersecurity.

(f) The term "mitigation" refers to those capabilities necessary to reduce loss of life and property by lessening the impact of disasters. Mitigation capabilities include, but are not limited to, community-wide risk reduction projects; efforts to improve the resilience of critical infrastructure and key resource lifelines; risk reduction for specific vulnerabilities from natural hazards or acts of terrorism; and initiatives to reduce future risks after a disaster has occurred.

(g) The term "response" refers to those capabilities necessary to save lives, protect property and the environment, and meet basic human needs after an incident has occurred.

(h) The term "recovery" refers to those capabilities necessary to assist communities affected by an incident to recover effectively, including, but not limited to, rebuilding infrastructure systems; providing adequate interim and long-term housing for survivors; restoring health, social, and community services; promoting economic development; and restoring natural and cultural resources.

Likewise, PPD 21, *Critical Infrastructure Security and Resilience* expands the definition of resilience and charges the Department of Homeland Security with championing the national effort.

The term "resilience" means the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions. Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents.

> *The Secretary of Homeland Security shall provide strategic guidance, promote a national unity of effort, and coordinate the overall Federal effort to promote the security and resilience of the Nation's critical infrastructure. In carrying out the responsibilities assigned in the Homeland Security Act of 2002, as amended, the Secretary of Homeland Security evaluates national capabilities, opportunities, and challenges in protecting critical infrastructure; analyzes threats to, vulnerabilities of, and potential consequences from all hazards on critical infrastructure; identifies security and resilience functions that are necessary for effective public-private engagement with all critical infrastructure sectors; develops a national plan and metrics, in coordination with SSAs and other critical infrastructure partners; integrates and coordinates Federal cross-sector security and resilience activities; identifies and analyzes key interdependencies among critical infrastructure sectors; and reports on the effectiveness of national efforts to strengthen the Nation's security and resilience posture for critical infrastructure.*

The PPD applications of the term *resilience* emphasizes the continuity aspect using withstand, the recovery aspect using recover, and the adaptive aspect using adapt. Later, the role of planning, or *prepare for,* will be discussed, more as a preparedness tool than a definition of resilience.

The pairing of the concept of *resiliency* with the characterization of the disruptive or adverse event as a disaster is well expressed by the National Academies' Committee on Increasing National Resilience to Hazards and Disasters. Their report *Disaster Resilience: A National Imperative* fine tunes the definition as:

> ***Resilience****: The ability to prepare and plan for, absorb, recover from, or more successfully adapt to actual or potential adverse events.*

The Committee further elaborates on the concept in its comment:

> ***What Is Resilience?***
> *Although resilience with respect to hazards and disasters has been part of the research literature for decades the term first gained currency among national governments in 2005 with the adoption of The Hyogo Framework for Action by 168 members of the United Nations to ensure that reducing risks to disasters and building resilience to disasters became priorities for governments and local communities (UNISDR, 2007). The literature has since grown with new definitions of resilience and the entities or systems to which resilience refers (e.g., ecological systems, infrastructure, individuals, economic systems, communities). Disaster resilience has been described as a Process, an outcome, or both, and as a term that can embrace inputs from engineering and the physical, social, and economic sciences.*

In response to PPD-21, Department of Homeland Security (DHS) embarked on two parallel efforts*, National Infrastructure Protection Program (NIPP) 2013, Partnering for Critical Infrastructure Security and Resilience* (initiated with NIPP 2006 and 2009) and *National Disaster Recovery Framework: Strengthening Disaster Recovery for the Nation,* developed by FEMA in 2011. NIPP 2013 builds on the definition of PPD-21 and defines resilience and recovery as follows:

> ***Resilience*** *- The ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions; includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents.*

> ***Recovery*** *- Those capabilities necessary to assist communities affected by an incident to recover effectively, including, but not limited to, rebuilding infrastructure systems; providing adequate interim and long-term housing for survivors; restoring health, social, and community services; promoting economic development; and restoring natural and cultural resources.*

NIPP 2013 focuses on Critical Infrastructure, which it defines as:

> ***Critical Infrastructure****. Systems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters. (Source: §1016(e) of the USA Patriot Act of 2001 (42 U.S.C. §5195c(e))*

Within the context of NIPP 2013, security is interwoven with resilience and another Key Concept presented is that both security and resilience are strengthened through risk management, which will be discussed later in the review.

FEMA's *National Disaster Recovery Framework* (NDRF) uses a similar definition of resilience:

> ***Resilience*** *– Ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies.*

Within the context of the NDRF, sustainability is partnered with resilience. One of the Core Principles identified in the NDRF is titled *Resilience and Sustainability:*

> *A successful recovery process promotes practices that minimize the community's risk to all hazards and strengthens its ability to withstand and recover from future disasters, which constitutes a community's resiliency. A successful recovery process engages in a rigorous assessment and understanding of risks and vulnerabilities that might endanger the community or pose additional recovery challenges. The process promotes implementation of the National Infrastructure Protection Plan (NIPP) risk management framework to enhance the resilience and protection of critical infrastructure against the effects of future disasters. Resilience incorporates hazard mitigation and land use planning strategies; critical infrastructure, environmental and cultural resource protection; and sustainability practices to reconstruct the built environment, and revitalize the economic, social and natural environments.*

Understanding how these definitions could apply to NFPA's mission is clarified in planning efforts such as the work of The Infrastructure Security Partnership (TISP). In *Regional Disaster Resilience: A Guide to Developing an Action Plan* 2011 Edition, TISP couples resilience specifically with disasters and infrastructure:

> *Disaster Resilience (for regions and communities): Capability to prepare for, prevent, protect against, respond or mitigate any anticipated or unexpected significant threat or event, including terrorist attacks, and to adapt to changing conditions and rapidly recover and reconstitute critical assets, operations, and services with minimum damage and disruption to public health and safety, the economy, environment, and national security.*

> *Infrastructure Resilience: The ability to resist, absorb, and recover from or successfully adapt to adversity or a change in conditions; capacity to recognize threats and hazards and make adjustments that will improve future protection efforts and risk reduction measures.*

The National Infrastructure Advisory Council offers its definition of infrastructure resilience in its September 8, 2009 report:

> *Infrastructure resilience is the ability to reduce the magnitude and/or duration of disruptive events. The effectiveness of a resilient infrastructure or enterprise depends upon its ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event.*

Similarly, the Disaster Roundtable of the National Research Council in the report of its 12th meeting, *Creating a Disaster Resilient America: Grand Challenges in Science and Technology,* refers to disaster resilience communities:

> *Disaster resilience communities can be understood as those that have the capacity to take the requisite mitigation and preparedness actions to withstand extreme natural or human events. .. Resiliency embodies four basic dimensions of society-the technical, organizational, social and the economic.*

The common themes from these many definitions can be summarized for their use in characterizing the role of NFPA codes and standards as follows:

1. Resilience includes *technical, organizational, social and economic* dimensions.
2. Resilience requires actions described as planning, preparing, preventing, protecting, mitigating and responding.
3. Resilience requires preparation and response to be adaptive.
4. Resilience should focus on minimizing *damage and disruption to public health and safety, the economy, environment, and national security.*

Specific to design standards activities, a fifth theme can be added regarding continuity of functionality:

5. Resilience includes the ability of structures and systems to withstand these external events, whether natural or human-created.

Performance Goals and Objectives

NIPP 2013 provides a clear and useful set of goals regarding the strengthening of the security and resilience of the national critical infrastructure. However, these goals apply equally well to the broader applications of disaster resilience. Likewise, these goals speak to NFPA's mission.

> *Assess and analyze threats to, vulnerabilities of, and consequences to critical infrastructure to inform risk management activities;*

Secure critical infrastructure against human, physical, and cyber threats through sustainable efforts to reduce risk, while accounting for the costs and benefits of security investments;

Enhance critical infrastructure resilience by minimizing the adverse consequences of incidents through advance planning and mitigation efforts, and employing effective responses to save lives and ensure the rapid recovery of essential services;

Share actionable and relevant information across the critical infrastructure community to build awareness and enable risk-informed decision making; and

Promote learning and adaptation during and after exercises and incidents.

In conjunction with these goals, NIPP-2013 identifies seven Core Tenets, three of which deal with identifying, understanding, and managing risk. The seventh deals with design consideration, which could be reflected in codes and standards:

Security and resilience should be considered during the design of assets, systems, and networks. *As critical infrastructure is built and refreshed, those involved in making design decisions, including those related to control systems, should consider the most effective and efficient ways to identify, deter, detect, disrupt, and prepare for threats and hazards; mitigate vulnerabilities; and minimize consequences. This includes considering infrastructure resilience principles.*

As will be evident from the discussion of Frameworks for Resilience below, the establishment of specific performance goals and objectives will be a critical first step in the process of pursuing Community or Disaster Resilience. NFPA has both documents and processes that could be applied for defining these goals and objectives.

The *Disaster Resilience Framework* being developed by the National Institute of Standards and Technology (NIST) catalogs performance objectives specific to buildings, based on how they need to function during and after an event. These categories will help inform design criteria and also emergency planning.

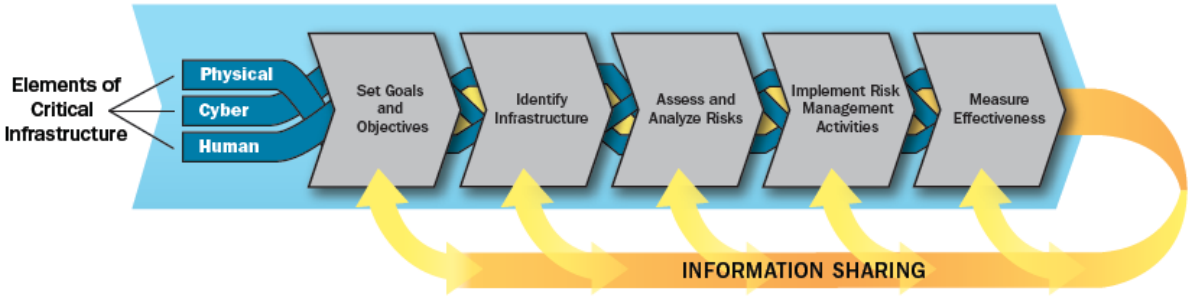
*Category A – **Safe and operational**: Essential facilities such as hospitals and emergency operations centers*
*Category B – **Safe and usable during repair**: "shelter in place" residential buildings, neighborhood businesses and services and buildings needed for emergency operations*
*Category C – **Safe and not usable**: The minimum needed to save lives. These Facilities may be repaired or replaced as needed to restore the economy*
*Category D – **Unsafe- partial or complete collapse**: damage that will lead to casualties*

Frameworks for Resilience

As referenced above with FEMA's NDRF, the concepts of *frameworks* for developing or enhancing resilience are common in the literature. Because of the complexity and interconnection of the many elements identified in the definitions outlined above, *frameworks* are presented to provide a means of facilitating successful interactions. Four references are discussed here. The first is NIPP-2013. The framework provided in Section 5, *Collaborating to Manage Risk,* of this reference focuses on a general approach to making risk-informed decisions.

> *This section is organized based on the critical infrastructure risk management framework, introduced in the 2006 NIPP and updated in this National Plan. The updates help to clarify the components and streamline the steps of the framework, depicted in Figure 3 below. Specifically, the three elements of critical infrastructure (physical, cyber, and human) are explicitly identified and should be integrated throughout the steps of the framework, as appropriate. In addition, the updated framework consolidates the number of steps or "chevrons" by including prioritization with the implementation of risk management activities. Prioritization of risk mitigation options is an integral part of the decision-making process to select the risk management activities to be implemented. Finally, a reference to the feedback loop is removed and instead, the framework now depicts the importance of information sharing throughout the entire risk management process. Information is shared through each step of the framework, to include the "measure effectiveness" step, facilitating feedback and enabling continuous improvement of critical infrastructure security and resilience efforts.*

Figure 3 – Critical Infrastructure Risk Management Framework



The need for flexibility and the connection to the *Comprehensive Preparedness Guide (*CPG) 201 is also addressed in NIPP 2013:

> *The critical infrastructure risk management framework is designed to provide flexibility for use in all sectors, across different geographic regions, and by various partners. It can be tailored to dissimilar operating environments and applies to all threats and hazards. The risk management framework is intended to complement and support completion of the Threat and Hazard Identification and Risk Assessment (THIRA) process as conducted by regional, SLTT, and urban area jurisdictions to establish capability priorities. Comprehensive Preparedness Guide 201: Threat and Hazard Identification and Risk Assessment, Second Edition cites infrastructure owners and operators as sources of threat and hazard information and as valuable partners when completing the THIRA process.*

The second reference is *CPG 201: Threat and Hazard Identification and Risk Assessment,* Second Edition referenced in NIPP 2013. The guide describes a four-step process for developing a risk assessment. These four steps are as follows:

1. ***Identify the Threats and Hazards of Concern****. Based on a combination of experience, forecasting, subject matter expertise, and other available resources, identify a list of the threats and hazards of primary concern to the community.*
2. ***Give the Threats and Hazards Context****. Describe the threats and hazards of concern, showing how they may affect the community.*

3. ***Establish Capability Targets***. *Assess each threat and hazard in context to develop a specific capability target for each core capability identified in the National Preparedness Goal. The capability target defines success for the capability.*
4. ***Apply the Results***. *For each core capability, estimate the resources required to achieve the capability targets through the use of community assets and mutual aid, while also considering preparedness activities, including mitigation opportunities.*

CPG 201 also refers to five preparedness missions that reflect the concepts of resilience identified above:

> ***Prevention****: Prevent, avoid, or stop an imminent, threatened, or actual act of terrorism.*
> ***Protection****: Protect our citizens, residents, visitors, and assets against the greatest threats and hazards in a manner that allows our interests, aspirations, and way of life to thrive.*
> ***Mitigation****: Reduce the loss of life and property by lessening the impact of future disasters.*
> ***Response****: Respond quickly to save lives; protect property and the environment; and meet basic human needs in the aftermath of a catastrophic incident.*
> ***Recovery:*** *Recover through a focus on the timely restoration, strengthening, and revitalization of infrastructure, housing, and a sustainable economy, as well as the health, social, cultural, historic, and environmental fabric of communities affected by a catastrophic incident.*

Although Community Resilience is only listed as a core capability under Mitigation in CPG 201, all of the preparedness missions are integral to both Community Resilience and Disaster Resilience as defined above.

The third framework appears in the *NDRF*. As the name indicates, this framework focuses on the Recovery aspects of resilience. The document is intended for broad application across diverse stakeholders. Of particular relevance to NFPA codes and standards is the emphasis on pre-planning:

> *Recovery begins with pre-disaster preparedness and includes a wide range of planning activities. The NDRF clarifies the roles and responsibilities for stakeholders in recovery, both pre- and post-disaster. It recognizes that recovery is a continuum and that there is opportunity within recovery. It also recognizes that when a disaster occurs, it impacts some segments of the population more than others.*
>
> *The ability of a community to accelerate the recovery process begins with its efforts in pre-disaster preparedness, mitigation and recovery capacity building. These efforts result in a resilient community with an improved ability to withstand, respond to and recover from disasters. Timely decisions in response to disaster impacts can significantly reduce recovery time and cost.*
>
> *The NDRF describes key principles and steps for community recovery planning and implementation. It promotes a process in which the impacted community fully engages and considers the needs of all its members. A key element of the process is that the impacted community assumes the leadership in developing recovery priorities and activities that are realistic, well-planned and clearly communicated.*

This pre-planning is reiterated under Core Principles in the NDRF:

> *The speed and success of recovery can be greatly enhanced by establishment of the process and protocols prior to a disaster for coordinated post-disaster recovery planning and implementation. All stakeholders should be involved to ensure a coordinated and comprehensive planning process, and develop relationships that increase post-disaster collaboration and unified decision making. Another important objective of pre-disaster recovery planning is to take actions that will significantly reduce disaster impacts through disaster-resilient building practices….*

NDRF includes several informative concepts for the codes and standards process. First, in its description of the Recovery Continuum, NDRF provides an excellent guide for establishing priorities that could be addressed in NFPA documents. The figure titled Recovery Continuum – Description of Activities by Phase identifies four phases of recovery, Preparedness (Ongoing), Short-Term (days), Intermediate (Weeks-Months), and Long-Term (Months-Years). The importance of health care, sheltering, and mitigation activities as immediate Short-Term priorities should influence the focus of NFPA activities. Likewise, the Long-Term emphasis on *Resilient Rebuilding* expands on the *disaster-resilient building practices* referenced above and identifies two items important to NFPA's mission:

> *The recovery is an opportunity for communities to rebuild in a manner which reduces or eliminates risk from future disasters and avoids unintended negative environmental consequences.*
>
> *Communities incorporate stronger building codes and land use ordinances. Vulnerable structures are retrofitted, elevated or removed from harm.*

The fourth framework is being developed by NIST. The President's Climate Action Plan of June 2013 included the NIST initiative described below:

> ***Boosting the Resilience of Buildings and Infrastructure:*** *The National Institute of Standards and Technology will convene a panel on disaster-resilience standards to develop a comprehensive, community-based resilience framework and provide guidelines for consistently safe buildings and infrastructure – products that can inform the development of private-sector standards and codes.*

Using a series of workshops with a cross section of stakeholders, NIST is developing *a* comprehensive *Disaster Resilience Framework for achieving community resilience that considers the interdependence of the community's physical and human assets, operations, and policies/regulations*. The expectation for this document is that it will include the following:

- *Define community-based disaster resilience for the built environment*
- *Identify consistent performance goals and metrics for buildings and infrastructure and lifeline systems to enhance community resilience,*
- *Identify existing standards, codes, guidelines, and tools that can be implemented to enhance resilience, and*
- *Identify gaps in current standards, codes, and tools that if successfully addressed, can lead to enhanced resilience.*

The emphasis of this effort parallels and supports those issues identified in NIPP 2013 for the *built environment.* The 25% draft of the framework provides placeholders for defining

Performance Levels, Hazard Levels, and Recovery Levels as parameters for evaluating building design requirements. The draft also introduces a sample resilience matrix that characterizes the hazard levels as *routine, expected, and extreme*. It also characterizes the time dependence of the response and recovery in three phases similar to the post event phases identified in the NDRF Disaster Recovery Continuum. This proposed framework also introduces a set of performance goals, *Categories*, as described above.

Role of Codes and Standards

Several of the references identified above discuss the design aspects of building resilient infrastructure. The built environment in the USA is significantly influenced by the development and enforcement of codes and standards. The NIPP 2013, in Core Tenet 7 quoted above, establishes the need to design and build *considering infrastructure resilience principles.* Likewise, NDRF encourages that *Communities incorporate stronger building codes.*

Perhaps the most explicit discussion of the role of codes and standards in disaster resilience is contained in the report of a conference, *Designing for a Resilient America: A Stakeholder Summit on High Performance Resilient Buildings and Related Infrastructure,* held on November 30 – December 1, 2010. The report discusses the role of codes and standards and makes recommendations for participation of codes and standards organizations:

> *Traditionally, building codes have regulated life safety issues. New building codes and standards should extend beyond life-safety aspects to include resilient design concepts in a performance-based approach as well as continuity of operations. They should rely on common and widely adopted methods of measurement, provide a flexible framework to address different facility types, address types of structures (from residential to large commercial and industrial structures), and recognize the differing levels of performance that are required. Uniform adoption of resiliency objectives by jurisdictions requires including resiliency requirements in the current model building codes, educating regulators and their constituents, and incentivizing the application, inspection, and regulation of resiliency approaches. This process begins with the development of criteria, codes, and standards that address resiliency objectives and the supporting tools and validation for their use. Given that state and local governments have jurisdiction over building codes, the role of the Federal Government is limited in mandating changes. Opportunities do exist, however, to effect changes in zoning, local planning, and urban planning requirements by providing guidance to communities and jurisdictions on how and where to design and locate buildings and infrastructure to encourage best practices for life safety, security, resiliency, and other objectives.*
>
> *Recommendations*:
>
> 7. *Relevant codes and standards organizations [e.g., the International Code Council (ICC), National Fire Protection Association (NFPA), and ASTM International (formerly known as the American Society for Testing and Materials) and others] should participate in an effort to support development of an integrated suite of standards, codes, and guidelines that support resiliency for buildings and infrastructure with clear guidance on design criteria and concepts.*
> 8. *The Interagency Committee on Standards Policy (ICSP) and the American National Standards Institute's Homeland Security Standards Panel (ANSI-HSSP) should coordinate the development of resiliency standards across various standards development organizations for facilities. These two organizations bring together a broad range of Federal agencies and standards development*

> *organizations necessary to ensure efficient alignment of goals and standard development responsibilities. Other groups such as the Federal Facilities Council (of the National Academies' National Research Council), and the Federal Real Property Council can provide effective venues for collaboration.*

It is important to note that these recommendations relate to what are characterized as *High Performance Resilient Buildings.* The *high performance* implies beyond current performance created by current codes and standards.

The 25% draft of the NIST Disaster Resilience Framework also identifies the role of codes and standards, first in Chapter 2:

> ***Codes, standards, administration, and enforcement***. *Strong local building codes are a key tool for building the right kind of physical infrastructure and requiring retrofit at opportune times. A community's history with the adoption, administration and enforcement of codes will have a significant influence on the degree of "inherent" resilience present in the physical infrastructure. There must be a commitment to funding these activities if the resilience plan is to ever have an impact.*

Chapter 5, Building Sector, discusses codes and standards at length, including the Risk Categories as they now appear in the *International Building Code,* and similarly in NFPA 5000.

<u>Other Parallel Approaches</u>

Other regulatory agencies in the USA offer insight into possible approaches to incorporating disaster resilience into codes and standards. Rather than providing a detailed discussion of these regulations, the common elements of analysis and performance criteria are summarized. Two of these approaches are from the United States Department of Energy (USDOE) and the United States Nuclear Regulatory Commission (USNRC). Both approaches require a detailed *safety analysis* to address internal (accidents and failures) and external (natural disasters) events. The goal of these analyses is to identify the engineered and administrative features in place to control (prevent or mitigate) the risks. In these cases the quantification of an acceptable maximum consequence as a performance goal is more easily defined than the application of a *resilience goal* to a wide variety of structures and systems. However, the valuable parallels are as follows:

1. Performance objectives must be established against which to measure designs and operations,
2. Performance objectives must be risk-informed,
3. Safety (or resilience) strategies must not depend on a single element (Redundancy, Defense-in-depth), and
4. Not all structures or systems are of equal importance to achieving the performance objectives.

Another useful comparison can be found in the terminology, or jargon, applied to characterize the decision process. The USNRC refers to the built environments in terms of *Structures, System and Components (SSCs).* The safety function of these SSCs is used to catalog their importance and hence their required performance. In terms of resilience, the need for the SSCs to perform their intended function before, during, and after an event, whether internal or external, establishes its design criteria. SSCs that are characterized as *safety related* or *safe shutdown* must demonstrate the ability to withstand disaster at a higher functionality than

balance of plant SSCs. Similarly, the USDOE characterizes SSCs with safety functions as *Safety Class* or *Safety Significant.* Those terms are used to establish design criteria including continuity of safety functions as necessary during and after external events (natural disasters).

Likewise, both the USNRC and the USDOE address elements other than SSCs. These include administrative controls, staffing, operating procedures, training, and emergency response. Recognizing the need for personnel to act in support of or in place of engineered features places emphasis on these *Administrative, Operational and Programmatic (AOP)* activities. In conjunction with the engineered features and the administrative features, these regulations identify *Limiting Conditions of Operation* and *Compensatory Measures. Limiting Conditions of Operation* and *Compensatory Measures* could have a parallel application in the recovery phase of *disaster resilience.* A critical question is raised by the proposed NIST Categories: What are the minimum requirements for *Category B* – ***Safe and usable during repair***? The concept of *Limiting Conditions of Operation* could establish the conditions of structures, system, and components necessary to allow use of a facility. The concept of *Compensatory Measures* could establish activities to be added or curtailed until all systems are back to pre-event conditions.

Similar in approach but broader in application is the Occupational Safety and Health regulation, OSHA 1910.119, *Chemical Process Safety*. The requirements for a process safety analysis and the characterization of engineered and administrative controls are useful in assessing how disaster resilience could be achieved. OSHA also identifies the importance of Emergency Operations and Emergency Planning and Response.

Another approach (non-regulatory) to resilient designs is *ASCE/SEI 7-10*, *Minimum Design Loads for Buildings and Other Structures.* This standard provides guidance for determining dead and live loads (soil, flood, snow, rain, atmospheric ice, earthquake, and wind). These loads are to be incorporated into the building codes. The standard uses the concepts of Risk Category and Importance Factor to discriminate performance requirements for structural and non-structural components. Chapter 13 of the standard addresses seismic criteria for non-structural components. This chapter also incorporates two *Importance Factors* of either 1.0 or 1.5 for use in calculating loading. One of the changes in the 2010 edition was to designate egress stairs as having an importance factor of 1.5.

Risk-informed Criteria

Both the PPDs and the implementing activities at DHS recognize that resources to achieve resilient infrastructure or community disaster resilience are not inexhaustible. Therefore the approaches recommended all emphasize risk as the basis for decisions. NIPP 2013 identifies understanding risk as its *National Plan's* first core tenet:

> *Risk should be identified and managed in a coordinated and comprehensive way across the critical infrastructure community to enable the effective allocation of security and resilience resources.*

Central to the framework outline by the NIPP is *Assess and Analyze Risk.* This is not a new concept to the NFPA. In March 2007, the Fire Protection Research Foundation published *Guidance Document for Incorporating Risk Concepts into NFPA Codes and Standards.* Although the contexts of this guidance document revolves around fire as the primary risk, the general concepts and the discussions of example methodologies apply very well to the broader applications of *resilience.*

Other Relevant Bibliographies

In addition to the selected references discussed above, there is an excellent compilation of references related to infrastructure by Melanie Guttmann, Publication Editor at George Mason University's Center for Infrastructure Protection and Homeland Security entitled, *Library of Critical Infrastructure Reading.* Another useful collection of references has been assembled by *TISP* in its *Best Practices for Building Resilience-Annotated Bibliography.* A third is available online from American Planning Association, *Post-Disaster Annotated Bibliography.*

Codes and Standards Mapping

This section is intended to provide an overview of existing NFPA codes and standards as related to the *Resiliency Frameworks* discussed above. Many of the NFPA documents currently address *resiliency*, but focus on fire as the disruptive event. Although the *resiliency* terminology may not be familiar to the technical committees, the concepts of prevention, protection, mitigation, response, and recovery related to fire are well understood and incorporated into NFPA activities.

The first part is a simple discussion of the interaction between NFPA codes and standards. NFPA publishes more than 300 consensus documents. These are either written in mandatory requirements language for codes and standards, or advisory, non-mandatory language for guides and recommended practices. The official NFPA definitions of these terms as they appear in the *NFPA Glossary of Terms* are provided below:

> *Code: A standard that is an extensive compilation of provisions covering broad subject matter or that is suitable for adoption into law independently of other codes and standards.*
>
> *Guide: A document that is advisory or informative in nature and that contains only nonmandatory provisions. A guide may contain mandatory statements such as when a guide can be used, but the document as a whole is not suitable for adoption into law.*
>
> *Recommended Practice: A document that is similar in content and structure to a code or standard but that contains only nonmandatory provisions using the word "should" to indicate recommendations in the body of the text.*
>
> *Standard: A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the Manual of Style for NFPA Technical Committee Documents.*

NFPA Technical Committees currently produce 34 documents that carry the title of Code, as listed below:

> NFPA 1 *Fire Code*
> NFPA 2 *Hydrogen Technologies Code*
> NFPA 30 *Flammable and Combustible Liquids Code*
> NFPA30A *Code for Motor Fuel Dispensing Facilities and Repair Garages*

NFPA 30B *Code for the Manufacture and Storage of Aerosol Products*
NFPA 42 *Code for the Storage of Pyroxylin Plastic*
NFPA 52 *Vehicular Gaseous Fuel Systems Code*
NFPA 54 *National Fuel Gas Code*
NFPA 55 *Compressed Gases and Cryogenic Fluids Code*
NFPA 57 *Liquefied Natural Gas (LNG) Vehicular Fuel Systems Code*
NFPA 58 *Liquefied Petroleum Gas Code*
NFPA 59 *Utility LP-Gas Plant Code*
NFPA 70 *National Electrical Code®*
NFPA 70A *National Electrical Code® Requirements for One- and Two-Family Dwellings*
NFPA 72 *National Fire Alarm and Signaling Code*
NFPA 85 *Boiler and Combustion Systems Hazards Code*
NFPA 99 *Health Care Facilities Code*
NFPA 101 *Life Safety Code®*
NFPA 301 *Code for Safety to Life from Fire on Merchant Vessels*
NFPA 400 *Hazardous Materials Code*
NFPA 432 *Code for the Storage of Organic Peroxide Formulation*
NFPA 434 *Code for the Storage of Pesticides*
NFPA 490 *Code for the Storage of Ammonium Nitrate*
NFPA 495 *Explosive Materials Code*
NFPA 900 *Building Energy Code*
NFPA 909 *Code for the Protection of Cultural Resource Properties - Museums, Libraries, and Places of Worship*
NFPA 914 *Code for Fire Protection of Historic Structures*
NFPA 1122 *Code for Model Rocketry*
NFPA 1123 *Code for Fireworks Display*
NFPA 1125 *Code for the Manufacture of Model Rocket and High Power Rocket Motors*
NFPA1127 *Code for High Power Rocketry*
NFPA 5000 *Building Construction and Safety Code®*

As can be seen from the titles, these codes address a variety of subjects. Some are hazard specific, such as LNG, LPG, Hydrogen, etc; some are occupancy/building related such as building, life safety, and health care facilities codes; and others are system related such as the electrical and fire alarm codes. It is a risk to generalize, but some conclusions can be made for the use of the term Code to describe these documents. First, they all contain **engineered features** to reduce risk (primarily the risk of fire and explosion). Second, they are all intended to be adopted into law. Therefore, these documents are an appropriate starting place to evaluate *Disaster Resilience* provisions.

Each of the NFPA documents listed above has a chapter that includes a scope and purpose statement (NFPA 2, as yet, has not documented its scope and NFPA 59, as yet, has not documented its purpose). The paradigm expressed in most of these scopes and purposes is *to prescribe minimum requirements*. Another paradigm expressed in most of these scopes and purposes is *fire and life safety* and *hazards of fire and explosion.* These paradigms should not be viewed as a weakness but as a strength of NFPA's long history of standards development. Incorporating disaster resilience into these Codes may require a shift in these paradigms, however.

Since, by NFPA's official definition, these codes are intended to stand alone, they should be complete and comprehensive enough to accomplish their objectives. How those objectives support *disaster resilience* or could be adjusted to do so is a useful question to examine. For

the purposes of this report, this examination is referred to as mapping. It is intended to provide some benchmarking and a pathway, or map, to incorporating *disaster resilience* concepts.

NFPA 5000 is an appropriate place to start this mapping. As typical of building codes, its purpose is:

> *…to provide minimum design* regulations to safeguard life, health, property and public welfare…

As such, building codes address design loads and safety objectives other than fire. Chapter 4 of NFPA 5000 identifies Goals and Objectives of the code as follows:

- Safety
  - Fire
  - Structural Failure
  - Building Use
  - Hazardous Materials
- Health
  - Interior Environment
  - Surface Water Entry
  - Control of Contaminants
  - Lighting
  - Sanitation
  - Uncontrolled Moisture
- Usability
  - Accessibility
  - Barrier-Free Use
- Public Welfare
  - Energy Efficiency
  - Cultural Heritage
  - Mission Continuity
  - Environment

Most, if not all, of these Goals and Objectives interact with the goals and objectives of *disaster resilience*. The most obvious of these interactions is Structural Failure. Chapter 35 addresses loads for wind, snow, ice, flood, and earthquake. The connection to the safety goal of structural failure is very clear. The connection to the other goals is only implied in Table 35.3.1, *Risk Categories of Buildings and Other Structures for Wind Snow and Earthquake.* Section 35.3.1 requires buildings and other structures to be classified on the basis of risk to *human life, heath and welfare.* This portion of NFPA 5000, with its reference to ASCE/SEI 7-10, attempts to achieve risk-based resilience by adding the *Importance Factor* discussed above.

The next document important to *resilience* is NFPA 101, *Life Safety Code*®. Section 1.1.2 specifically addresses the fire focus of this document by highlighting that its features are *necessary to minimize danger to life from the effects of fire…* However, Section 1.2 reminds that, *its provisions will also aid life safety in similar emergencies.* This concept is expanded on in Section 4.1.2 which discusses comparable emergencies. The requirements for the size and location of means of egress apply for any event requiring evacuation. Likewise the requirements for emergency lighting and notification can be applied to any emergency requiring evacuation.

NFPA 99, *Health Care Facilities Code*, provides a good example of risk-informed criteria in its Chapter 4, Fundamentals. This chapter identifies four building system categories based on potential for injury to patients and caregivers and requires these categories be determined by a risk assessment. The framework outlined in NFPA 99 lends itself to application to improve *disaster resilience.* Once the importance of the structures or systems is established, the performance objective and design criteria for withstanding or recovering from external events can be developed.

NFPA 909, *Code for the Protection of Cultural Resource Properties - Museums, Libraries, and Places of Worship,* explicitly addresses external events such as severe weather, flood, and earthquake in discussing a protection plan. The planning flow chart in Figure 5.3.1 could apply to any facility and any resilience goals. Likewise the potential threat assessment sheet in Figure 5.3.5.2 provides an excellent screening tool for all occupancies and all threats. However, NFPA 909 is more specific in its guidance for emergency operations than for the design of new facilities. Chapter 9, *New Construction, Additions, Alterations, Renovations and Modification Projects,* focuses much of its attention on fire risks.

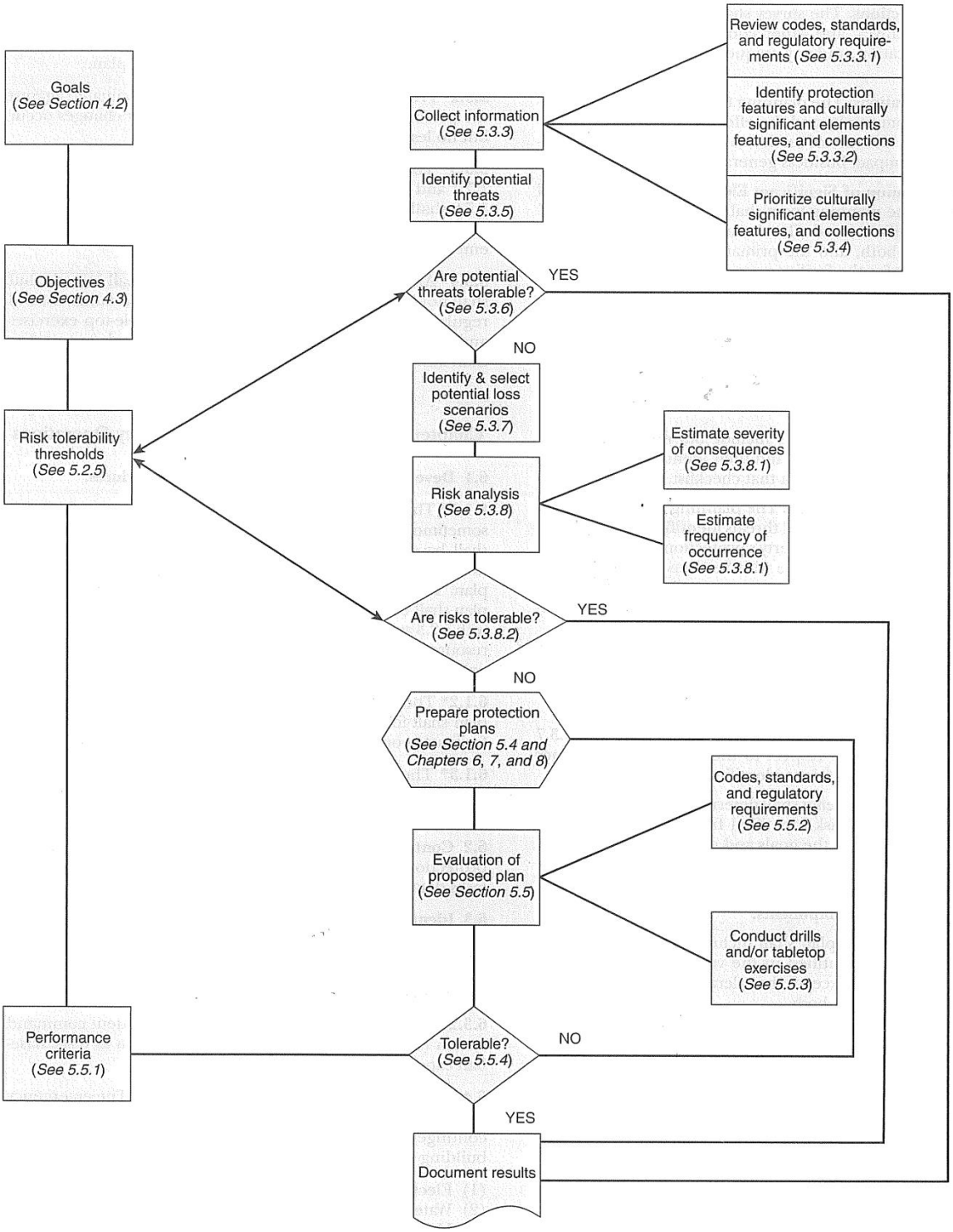


FIGURE 5.3.1 Planning Flow Chart.

POTENTIAL THREATS ASSESSMENT

		Likelihood of Occurrence			Potential Severity		
	N/A	Low	Moderate	High	Low	Moderate	High
Unintentional Act							
Fire/explosion	❑	❑	❑	❑	❑	❑	❑
Health emergency	❑	❑	❑	❑	❑	❑	❑
Hazardous material spill or release	❑	❑	❑	❑	❑	❑	❑
Transportation accident	❑	❑	❑	❑	❑	❑	❑
Intentional Act							
Terrorism	❑	❑	❑	❑	❑	❑	❑
Cyber attack	❑	❑	❑	❑	❑	❑	❑
Arson	❑	❑	❑	❑	❑	❑	❑
Theft	❑	❑	❑	❑	❑	❑	❑
Vandalism	❑	❑	❑	❑	❑	❑	❑
Sabotage	❑	❑	❑	❑	❑	❑	❑
Civil disturbance, public unrest, mass hysteria, riot	❑	❑	❑	❑	❑	❑	❑
Strike	❑	❑	❑	❑	❑	❑	❑
System Failure							
Loss of electricity	❑	❑	❑	❑	❑	❑	❑
Water leak	❑	❑	❑	❑	❑	❑	❑
Building collapse/structural failure	❑	❑	❑	❑	❑	❑	❑
Fuel shortage	❑	❑	❑	❑	❑	❑	❑
Communications system interruption	❑	❑	❑	❑	❑	❑	❑
Air/water pollution contamination	❑	❑	❑	❑	❑	❑	❑
Water control structure, dam, or levee failure	❑	❑	❑	❑	❑	❑	❑
HVAC system failure	❑	❑	❑	❑	❑	❑	❑
Loss of protection systems	❑	❑	❑	❑	❑	❑	❑
Geological							
Earthquake	❑	❑	❑	❑	❑	❑	❑
Tsunami	❑	❑	❑	❑	❑	❑	❑
Volcano	❑	❑	❑	❑	❑	❑	❑
Landslide/mudslide	❑	❑	❑	❑	❑	❑	❑
Biological							
Pandemic disease	❑	❑	❑	❑	❑	❑	❑
Animal or insect infestation	❑	❑	❑	❑	❑	❑	❑
Meteorological							
Flood, flash flood, seiche, tidal surge	❑	❑	❑	❑	❑	❑	❑
Drought	❑	❑	❑	❑	❑	❑	❑
Wild fire (forest, range, urban)	❑	❑	❑	❑	❑	❑	❑
Snow, ice, hail, sleet, avalanche	❑	❑	❑	❑	❑	❑	❑
Windstorm, tropical cyclone, hurricane, tornado, water spout, dust/sand storm	❑	❑	❑	❑	❑	❑	❑
Extreme heat/cold	❑	❑	❑	❑	❑	❑	❑
Lightning	❑	❑	❑	❑	❑	❑	❑

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FIGURE 5.3.5.2 Potential Threats Assessment.

Those codes cataloged above regarding hazards, such as NFPA 30, 54, 55, and 59 have limited reference to external events. NFPA 30 addresses the problems associated with flooding for below ground and above ground storage tanks. NFPA 55 addresses *falling objects*, which could be considered as including those resulting from an earthquake. These codes reference ASME B31.3, *Process Piping,* which addresses wind and earthquake as loads. In some cases these codes reference ASCE/SEI 7-10 (or older edition ASCE/SEI 7-05). Other explicit discussions or requirements for engineered features for external events are not addressed.

Not all occupancy or hazard documents are developed as codes. Many of these are standards and a few are recommended practices. Since these occupancy and hazard documents are the starting place to input performance goals regarding **engineered features** for disaster resilience, the distinction between code and standard becomes less important.

NFPA 70 and 72 are systems documents that do not mandate the systems but establish requirements on how they should by designed, installed, and maintained. These types of documents are most often standards in the NFPA process. In the case of system standards, the requirements for having the system typically appears in another code or standard, or they may be the choice/need of the owner. Many of these documents address fire protection features, such as fire suppression systems and fire alarm systems. NFPA 13, *Standard for the Installation of Sprinkler Systems*, is one of these system documents that addresses earthquake. Again, it does not mandate that a system must be protected from an earthquake but states, that when a system is required to be protected against an earthquake, here is how it should be done. NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* addresses earthquake protection by stating, if it is required to follow NFPA 13. NFPA 22, *Standard for Water Tanks for Private Fire Protection* addresses design loads including wind and earthquake and references following of the local code requirements. NFPA 72, *National Fire Alarm and Signaling Code*, has numerous elements of reliability and robustness which can improve disaster resilience, but this document does not address specific external events such as flooding, wind, or earthquake. Circuit redundancy and survivability are design features that can be prescribed, but these are not specific to natural disaster. Survivability of notification circuits is related to fire events for which the notification must be available. The same survivability requirements could be established for other events for which the notification system is expected to be needed. NFPA 110, *Standard for Emergency and Standby Power Systems,* is a document that addresses disaster resilience. The event that requires the alternate power supply is irrelevant to the requirements for how the systems should be designed, installed, and maintained. The purpose of the standard identifies that other NFPA standards will establish when such systems are required. NFPA 110 addresses earthquake protection in its section on protection, but it does not address flood or wind.

These examples are somewhat anecdotal of the **engineered features** addressing disaster resilience in NFPA documents. How the considerations of disaster resilience could be incorporated into the standards process and ultimately into the standards will be discussed below, under **Gap Analysis**. It is important to note that many NFPA documents address **administrative features,** exclusively or in addition to **engineered features**. Virtually all of the references on resilience, whether critical infrastructure, community, or disaster, identify *prepare for, plan for, respond to,* and *recover from* as essential elements. These elements are largely **administrative features**. Emergency planning is vital to resilience. It supplements **engineered features** and allows adaptation to changing circumstances far quicker. Many of the occupancy and hazards documents addressed above require emergency planning. NFPA 101, in Chapter 4 requires Emergency Plans and identifies what elements should be incorporated into the plans.

NFPA 99 provides an excellent disaster resilience requirement in Chapter 12, Emergency Management:

> *12.1.1.1 This chapter shall provide those with responsibility for emergency management in health care facilities with the criteria to assess, mitigate, prepare for, respond to and recover from emergencies of any origin.*

The chapter goes on to provide specific requirements for program elements to incorporate into the management plan. Likewise, as stated above the NFPA 909 protection plan incorporates **administrative features** necessary to achieve the protection goals.

Most of the NFPA hazard-based documents also incorporate **administrative features**, including operating procedures, training, and emergency planning. For example, NFPA 55, *Compressed Gases and Cryogenic Fluids Code,* outlines requirements for an Emergency Plan in Chapter 4. NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)*, requires emergency procedures in Chapter 14. Whereas, NFPA 59, *Utility LP-Gas Plant Code,* requires operating procedures in Chapter 11, but does not specifically reference emergency planning. The explicit reference to external causes of problems, such as natural disasters, is not contained in most of these documents.

One excellent disaster resilience document is NFPA 1600, *Standard on Disaster/Emergency Management and Business Continuity Programs.* The purpose of the standard describes the very concept of disaster resilience:

> ***1.2 Purpose****. This standard provides the fundamental criteria to develop, implement, assess, and maintain the program for prevention, mitigation, preparedness, response, continuity and recovery.*

NFPA 99 references the requirements of NFPA 1600 as a basis for developing its emergency plan. A new proposed standard, NFPA 1616, *Standard for Mass Evacuation and Sheltering*, addresses key elements in the NDRF Continuum of Disaster Recovery. The scope of the committee is stated as *This Committee shall establish a common set of criteria for mass evacuation and mass sheltering programs, hereinafter referred to as the program,* and primarily addresses **administrative features**. NFPA 1620, *Standard for Pre-Incident Planning,* provides requirements for developing emergency response plans around specific properties. Although the implied emphasis is fire protection, the information about construction, hazards, and water supply can be very useful in responding to other emergencies, especially rescue type responses.

NFPA is a vital source for standards on planning, organizing, training, equipping, and protecting for emergency response. In addition to the fire response implied in the Association's name, topics are as diverse as technical rescue, confined space entry, and hazardous material incidents. A good place to start the discussion regarding emergency response is NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*. Included in the purpose in paragraph 1.2.2 is the broad role of emergency responders as, *those involved in rescue, fire suppression, emergency medical services, hazardous materials operations, special operations and related activities.* The standard addresses administration and organization, training, personal protective equipment, and emergency operations. It also references many other NFPA standards on these related topics. The chapter on emergency operations addresses incident command, communications, accountability, and other issues germane to the response aspects of disaster resilience.

There is another group of NFPA standards that address qualification or performance testing. These standards include fire test methods and acceptance criteria for a variety of materials and assemblies. One paradigm to point out regarding the acceptance criteria of some of these tests is that the test measures their ability to perform a fire safety function but makes no assessment for suitability of use after the event; withstand but not recover. One example is NFPA 252, *Standard Methods of Fire Tests of Door Assemblies,* which states in paragraph 1.3.5, *These tests shall not be construed as determining the suitability of fire door assemblies for continued use after exposure to real fires.* Similar statements appear in other fire test standards.

It should be considered that some, if not all, of the *disaster resilience* concepts will be difficult to prescribe as universally mandated features. In such cases, NFPA recommended practices and guides could play a valuable role. These types of documents often define processes to making risk-informed decisions rather than prescribing minimum requirements. One noteworthy example is NFPA 550, *Guide to the Fire Safety Concepts Tree.* This document describes a systematic approach to selecting or evaluating fire safety strategies. The figure titled*, Manage Exposed Branch of Fire Safety Concepts Tree*, applies equally well to any initiating event creating a risk to exposed populations. The top options of *defend exposed in place* or *move exposed* and the lower tier requirements to achieve either of these objectives are excellent tools to inform *disaster resilience* decisions.

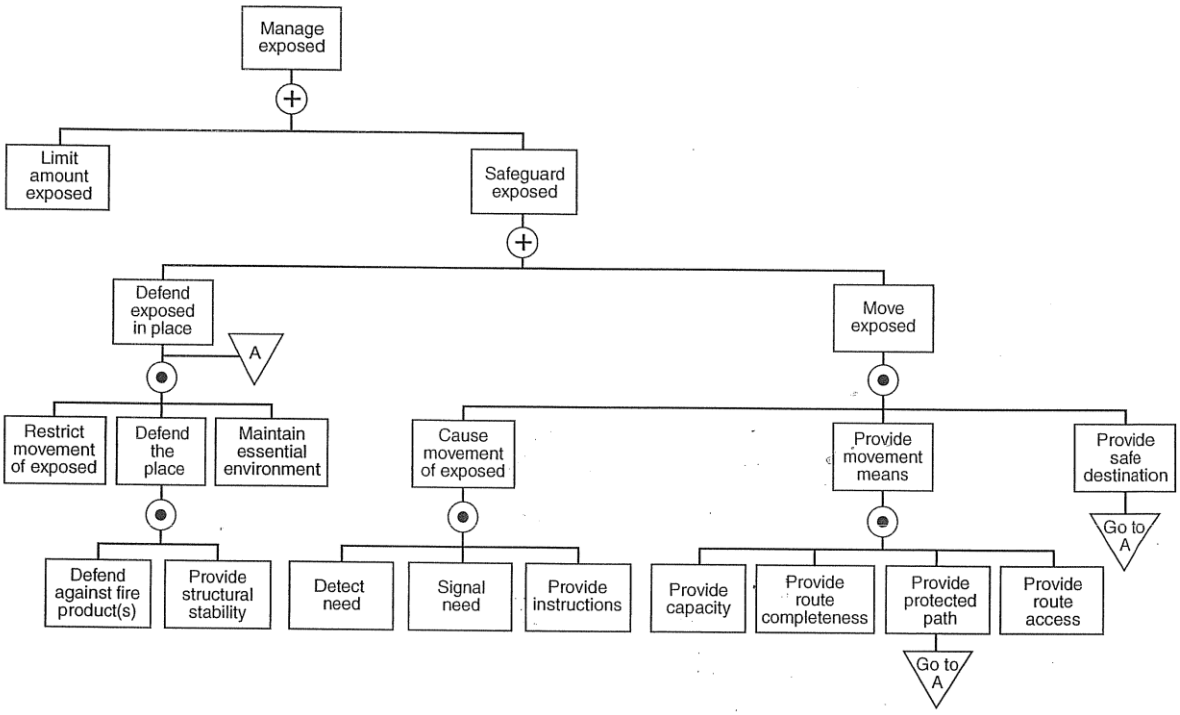

FIGURE 4.5.2.1 "Manage Exposed" Branch of Fire Safety Concepts Tree.

As a further mapping of NFPA codes and standards, the primary issue of Performance Goals addressed in the NIST framework and the five preparedness missions of CPG 201 can be used to highlight the role of existing documents.

Performance Goals

The clearest statements of performance goals appear in NFPA 99, NFPA 101, and NFPA 909. In many cases, particularly in fire protection systems documents, means of establishing goals are presented but the goals themselves are left to the stakeholder (designers, owners, AHJs). With regard to *Disaster Resilience* and *Community Resilience* performance goals may be established outside the codes and standards arena. However, establishing the performance objectives and criteria (design or operational) to achieve the established goals will be an important role for NFPA codes and standards.

Preparedness Missions

Single word missions sometime create confusion, because the context of the mission is lost. Therefore the specific language from the CPG 201 is repeated here.

1. ***Prevention****: Prevent, avoid, or stop an imminent, threatened, or actual act of terrorism.*

NFPA documents emphasize preventing fires from igniting. Preventing a natural event such as wind, ice, snow, flood, and earthquakes is obviously beyond the role of codes and standards. However, the roles of security and mass notification could influence the capability to detect and thwart acts of terrorism. NFPA 730, *Guide for Premises Security,* and NFPA 731, *Standard for the Installation of Electronic Premises Security Systems,* could play a role in meeting established performance goals. Likewise, NFPA 72's discussions of emergency communication and mass notification plays a role, which could be expanded.

2. ***Protection****: Protect our citizens, residents, visitors, and assets against the greatest threats and hazards in a manner that allows our interests, aspirations, and way of life to thrive.*

NFPA codes and standards excel in this mission. From the aspects of **engineered features,** all of the codes and standards developed related to occupancies, hazards, and systems address protection of building, contents, people, and operations from fires and explosions. Again the references to other events in NFPA documents as described above is a starting point and provides a useful platform to launch additional resilience concepts. From the aspect of **administrative features**, existing NFPA standards on planning, organizing, training, and equipping for emergency response already consider the response and recovery aspects of resilience and can reflect changing or expanding performance goals developed by *Community Disaster Resilience* efforts.

3. ***Mitigation****: Reduce the loss of life and property by lessening the impact of future disasters.*

As with the second mission, both the NFPA documents and the NFPA system for developing and amending documents focus on this Mitigation mission. It is a companion with the Protection mission.

4. ***Response****: Respond quickly to save lives; protect property and the environment; and meet basic human needs in the aftermath of a catastrophic incident.*

This is a primary emphasis of NFPA documents addressing **administrative features**. Moving forward, the emergency response role of facilities, such as shelters and health care (see FEMA's Recovery Continuum – Description of Activities by Phase in NDRF), may influence

engineered features to incorporate additional performance requirements into other NFPA codes and standards.

5. ***Recovery:*** *Recover through a focus on the timely restoration, strengthening, and revitalization of infrastructure, housing, and a sustainable economy, as well as the health, social, cultural, historic, and environmental fabric of communities affected by a catastrophic incident.*

NFPA 1600 and NFPA 909 contain effective strategies to help with recovery from disasters. Likewise, NFPA 99 incorporates recovery aspects into it emergency management requirements. Appendix A provides a further mapping using some graphics to show how NFPA codes and standards interact to provide both **engineered features** and **administrative features** for fire protection and life safety. If the role of emergency responders is expanded to a more defined *disaster recovery* role, the NFPA standards on planning and operations can play an important role in standardizing these approaches.

As the examples above indicate, *resilience* concepts are currently being addressed, but not in a systematic way. It is clear that NFPA codes and standards currently excel in the ***Protection*** and ***Response*** missions. The platforms and Technical Committee expertise exists within NFPA to increase emphasis on *disaster resilience* as deemed necessary by the Board and Standards Council.

Gap Assessment

The role that NFPA codes and standards could play is easier to identify than is the role that NFPA codes and standards should play. The following section attempts to identify some gaps in both the existing codes and standards and potential barriers to incorporating *resilience* concepts.

Paradigm Shift

The greatest number of NFPA codes and standards focus on fire and life safety, (*danger to life from the effects of fire,* or *fire and life safety* and *hazards of fire and explosion).* This is a strength of NFPA that can be readily expanded to address the role of other events on current requirements. Applying many of the concepts of *resiliency* to fire related incidents would introduce some new language, but would not radically change the fire safety requirements. It could, however, require more explicit definitions of performance objectives. Applying the concepts of *Disaster Resiliency* to NFPA documents will require developing a new set of performance objectives for response to other disruptive events. As outlined in the Mapping above and in Appendix A, a small minority of NFPA codes and standards currently address non-fire disruptive events. While not necessarily a paradigm shift for NFPA, it is a cultural transition.

One paradigm regarding the requirements in NFPA codes and standards is that they are intended to be those minimums necessary to achieve a consensus based level of fire safety. As stated above, the provision of minimum requirements does not lend itself to providing *High Performance* when desired. Perhaps a clearer expression of this paradigm shift is that not all minimums are created equal. As referenced above in *Designing for a Resilient America: A Stakeholder Summit on High Performance Resilient Buildings and Related Infrastructure,* Recommendation 7 calls for an *integrated suite of standards, codes, and guidelines that support resiliency for buildings and infrastructure with clear guidance on design criteria and concepts.* Implementation of resilience concepts throughout all NFPA documents would likely require

guidance documents rather than codes and standards and may need to focus on process first, rather than specific **engineered features**. That process must support the risk-informed, performance-based criteria for the continuity of functionality for critical structures, systems, and components.

In some cases, the current NFPA concept of suitability after exposure may not be sufficient for resiliency. Structures, systems, and components may be required not only to survive the event, but to remain functional after the event. The most obvious examples of this are the elements that make up means of egress. As stated in the NFPA 550 figure referenced above, moving the exposed requires a protected path. That means door assembles, stairs, ramps, and other exit access must be operable after the event. The new minimum must focus on continuity of function and on defining what those functionalities must be. Translating these site specific or facility specific criteria into prescriptive standard language could be problematic.

Fire Protection Systems

With the limited exception of some seismic support requirements, NFPA standards do not adequately address the role of the fire protection system during and after natural disasters, or other disruptive events. Defining this role is an important element to *disaster resilience.* As implied by the four categories identified in the proposed *Disaster Resilience Framework,* the role of structures and their supporting systems should influence the resilience of its design. Categories A-D address facility use in general, but this concept can be applied to the systems covered by NFPA codes and standards. The following questions help to focus on the *disaster resilience* mission of these systems.

1. Does the NFPA prescribed system's failure from or during the disaster increase the risk to the safety and health of the occupants and/or emergency responders?
    a. Will the failed system block means of egress elements?
    b. Will the failed system create a mechanical hazard (pressure vessel failure, cylinder rocketing)?
    c. Will failure of the system produce a hazardous atmosphere (gaseous agents)?
2. Does the NFPA prescribed system have a required role during or after the disaster?
    a. Does the event cause an immediate need for the system (a fire)?
    b. Can the damage to the system be readily repaired to allow reuse?
    c. If the facility is to be under continuous use through and after the event, is the system required to remain fully functional?
        i. Does the fire risk change – up or down – with the post event use?
        ii. Can the risk be managed without a fully functional system?

Answering these or similar questions could lead to additional requirements regarding location and support of these facilities. These questions can also inform the emergency planning and response activities as well.

Hazard Standards

NFPA codes and standards devoted to specific hazards (flammable liquids, gases, LNG, LPG) address some external events such as floods or earthquakes but not in a comprehensive way or at least not apparently so. As with the fire protection systems above, the questions regarding the effect of a disaster on the fire and explosion risk may lead to additional **engineered features** to mitigate those risks.

Risk Categories

NFPA 5000 requires buildings to be classified based on *the risk to human life, health, and welfare associated with their damage or failure by the nature of their occupancy or use.* This risk category is then used to apply structural provisions for flood, wind, snow, earthquake, and ice. The Table identifying these risk categories mixes dissimilar goals of reducing risk to human life and health with the critical need for the facility. The reference to ASCE/SEI 7-10 introduces the use of *Importance Factor* to structure and non-structural components as well. Both of these prescriptive approaches fall short of the performance goal approach outlined in the proposed NIST framework. The risk to people during the event creates a different set of performance requirements than the post-event use (Category A or Category B).

Recovery

Disaster recovery may require the occupation or reoccupation of facilities that have not been fully restored to their pre-disaster functionality. NFPA codes and standards require many features to achieve an acceptable level of fire safety. Certificates of Occupancy are provided to building owners when they have satisfied the Authority Having Jurisdiction (AHJ) that these codes requirements are completed. The process for allowing temporary use of a facility with deficiencies or impairments is less well defined. The NDRF and the NIST framework will require implementing concepts such as limiting conditions of operation and compensatory measures, as discussed above in conjunction with the parallels of the USDOE and USNRC. To facilitate rapid recover, while still managing the risks associated with occupying a building, enforcement questions will arise, such as: When and under what conditions (limiting conditions of operation) can a facility be reoccupied; How long can the facility remain occupied until repairs are implemented; What additional temporary precautions (compensatory measures) are needed to manage fire and life safety risks in the interim?

Path Forward

All of the referenced quotes above emphasize that the path to better community and infrastructure resilience must be risk-informed and performance-based. That means more flexible guidelines may be required to achieve a mix of **engineered features** and **administrative features** to fit a wide variety of facilities and communities. In response to Recommendation 7 in *Designing for a Resilient America: A Stakeholder Summit on High Performance Resilient Buildings and Related Infrastructure,* a new document, initially presented as a guide or a recommended practice, could be developed on High Performance Buildings. This could separate the roles of immediate risk to occupants during the event and continuity of use after the event for establishing design criteria. Likewise, additional training and planning documents could be developed to support emergency response. To facilitate both efforts, a *Disaster Resilience Concepts Tree* or similar decision tool could be developed. Some overarching guidance to existing committees would be helpful in implementing the concepts of resilience into the many NFPA activities.

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Appendix A
Codes and Standards Mapping

NFPA codes and standards address a wide variety of subjects, but with some common themes. Introducing new jargon to characterize these themes can create confusion. However, the mapping of the documents is useful to identify where a resiliency concept may apply. This attempt will introduce two mapping criteria. The first criterion addresses the concepts identified in the section on Parallel Approaches as ***engineered features*** and ***administrative features****.* To reduce the confusion, the use of ***engineered features*** in this context means such synonyms as: the Build Environment; Structures, Systems and Components; physical realm; or Hardware. Whatever choice of words, the intent is to characterize documents that address how facilities should be designed and built. Similarly, the use of ***administrative features*** means those features intending to address those human responses to work in concert with, or in place of, ***engineered features****.* Using this first "road sign," one wishing to identify those documents that address (or could address) resilient structures and systems would choose the ***engineered features*** path. Conversely, one wishing to identify those documents that address (or could address) resilient emergency preparedness and response would choose the ***administrative features*** path.

The second criterion addresses the nature of the requirements contained in the documents. Again, two general paths can be identified: 1) Documents that identify ***What (When and Where)*** requirements and 2) Documents that identify ***How (How much)*** requirements. Using this second "road sign," one can identify the appropriate location for requirements addressing the broader needs for resiliency and those that provide details of how those needs could be met. As discussed in the body of the report, those documents that are considered occupancy or hazard tend to lean more toward the ***What (When and Where)*** pathway and often reference other NFPA documents for the ***How (How much)*** requirements. It should be noted that many of the ***What (When and Where)*** documents also contain some ***How (How much)*** requirements.

An example of these pathways was addressed in the body of this report. Selecting NFPA 5000, *Building Construction and Safety Code®*, the first path to take would be for ***engineered features****.* The second pathway would be ***What (When and Where)***. Selecting NFPA 13, *Standard for the Installation of Sprinkler Systems,* the first path to take would also be for ***engineered features***, however the second pathway would be ***How (How much)****.* NFPA 13 does not require a sprinkler system to be installed but establishes how these systems should be designed and installed when they are required by other codes or my owners. In the case of some of the hazard documents (e.g., NFPA 30) and some of the occupancy documents (e.g., NFPA 409 or NFPA 418), ***How (How much)*** requirements, such as protection design criteria, are included with the ***What (When and Where)***, although NFPA 13 and NFPA 11 are also referenced. This is less common since the 1999 edition of NFPA 13, when the specific design requirements of more than 40 other NFPA documents were incorporated into NFPA 13.

To explain how this mapping can be useful in applying disaster resilience concepts, assume that it was desirable to develop guidance documents for a facility classified as Category A under that proposed NIST framework. The first step would be to develop those criteria that are to be used to establish the category. The second step would be to establish the performance objectives for the structures, systems, and components to achieve the *continuity* required for the facility. The third would be to establish design criteria based on the risk profiles (severity and likelihood of events) to achieve the necessary level of performance. This approach is virtually identical to the

performance-based design approach used for fire protection and other designs today. It is obvious that the first pathway would be toward ***engineered features***. The second would be toward ***What (When and Where)*** to document those classification criteria and performance objectives. The next pathway would be toward ***How (How much)*** to provide the methods and design criteria to achieve the performance objectives. The mapping assists the selection process of which type of NFPA document would be an appropriate choice.

These mapping concepts are not rigid, in that some NFPA documents include all four pathways. However, the pathways are useful in understanding the intended purposes and scopes of NFPA codes and standards. Continuing the road map analogy, some of the documents are secondary roads, some are primary roads and a few are super highways.

Table A-1 catalogs NFPA documents that emphasize ***engineered features***. The occupancy based documents are listed first, followed by the hazard based documents in the ***What (When and Where)*** column. For those cases of documents that follow multiple pathways, the documents appear in its primary columns.

A similar mapping can be done for the ***administrative features*** documents. Some of the occupancy documents provide requirements, ***What (When and Where),*** to provide ***administrative features***. Many more of the codes and standards provide details of how those requirements should be implemented, ***How (How much)***. Table A-2 attempts to catalog these documents. As part of this convention, those documents establishing qualifications are listed as ***What (When and Where)***, where as training standards are listed as, ***How (How much)***.

Additional mapping of these documents is warranted, specific to disaster resilience. Using the definition of *National Preparedness* as it appears in PPD 8, the NFPA codes and standards can be mapped by their scopes and purposes as ***Plan, Organize, Equip, or Train*** for emergencies. Table A-3 further catalogs the ***administrative features*** documents by these preparedness goals.

These tables are not all-inclusive. Documents on subjects, such as Fire Testing and Inspection, Testing and Maintenance (ITM), are not included in the tables, although they play an important role in achieving the goals and objectives of other NFPA codes and standards. Figure A-1 is intended to summarize the mapping discussed above.

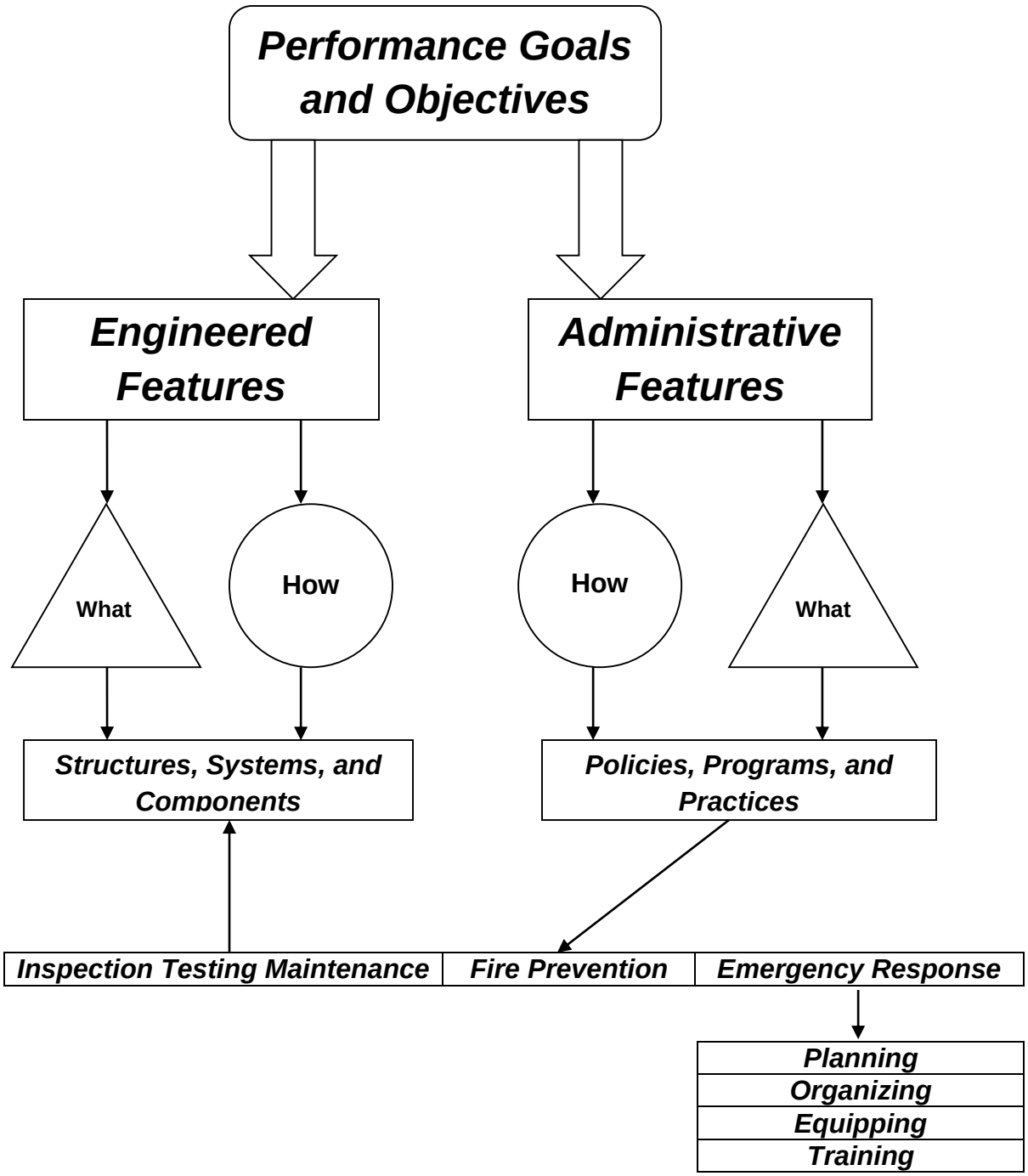

Figure A-1
Codes and Standards Mapping

Table A-1
Engineered Features

What (When and Where)		*How (How much)*	
	Occupancy		**System/Component**
30A	Code for Motor Fuel Dispensing Facilities and Repair Garages	10	Standard for Portable Fire Extinguishers
30B	Code for the Manufacture and Storage of Aerosol Products	11	Standard for Low-, Medium-, and High-Expansion Foam
32	Standard for Drycleaning Plants	12	Standard on Carbon Dioxide Extinguishing Systems
36	Standard for Solvent Extraction Plants	12A	Standard on Halon 1301 Fire Extinguishing Systems
45	Standard on Fire Protection for Laboratories Using Chemicals	13	Standard for the Installation of Sprinkler Systems
76	Standard for the Fire Protection of Telecommunications Facilities	13D	Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes
88A	Standard for Parking Structures	13E	Recommended Practice for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems
99	Health Care Facilities Code	13R	Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies
99B	Standard for Hypobaric Facilities	14	Standard for the Installation of Standpipe and Hose Systems
101	Life Safety Code®	15	Standard for Water Spray Fixed Systems for Fire Protection
101A	Guide on Alternative Approaches to Life Safety	16	Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems
120	Standard for Fire Prevention and Control in Metal/Nonmetal Mining and Metal Mineral Processing Facilities	17A	Standard for Wet Chemical Extinguishing Systems
122	Standard on Motion Picture and Television Production Studio Soundstages, Approved Production Facilities, and Production Locations	18	Standard on Wetting Agents
130	Standard for Fixed Guideway Transit and Passenger Rail Systems	18A	Standard on Water Additives for Fire Control and Vapor Mitigation
140	Standard on Fire and Life Safety in Animal Housing Facilities	20	Standard for the Installation of Stationary Pumps for Fire Protection
150	Fire Protection Standard for Marinas and Boatyards	22	Standard for Water Tanks for Private Fire Protection
303	Standard for the Protection of Semiconductor Fabrication Facilities	24	Standard for the Installation of Private Fire Service Mains and Their Appurtenances
307	Standard for the Construction and Fire Protection of Marine Terminals, Piers, and Wharves	51	Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes
318	Standard for the Protection of Semiconductor Fabrication Facilities	53	Recommended Practice on Materials, Equipment, and Systems Used in Oxygen-Enriched Atmospheres
409	Standard on Aircraft Hangars	68	Standard on Explosion Protection by Deflagration Venting
415	Standard on Airport Terminal Buildings, Fueling Ramp Drainage, and Loading Walkways	69	Standard on Explosion Prevention Systems
418	Standard for Heliports	72	National Fire Alarm and Signaling Code
423	Standard for Construction and Protection of Aircraft Engine Test Facilities	75	Standard for the Fire Protection of Information Technology Equipment
501	Standard on Manufactured Housing	77	Recommended Practice on Static Electricity

501A	Standard for Fire Safety Criteria for Manufactured Home Installations, Sites, and Communities	80	Standard for Fire Doors and Other Opening Protectives
801	Standard for Fire Protection for Facilities Handling Radioactive Materials	80A	Recommended Practice for Protection of Buildings from Exterior Fire Exposures
803	Standard for Fire Protection for Light Water Nuclear Power Plants	82	Standard on Incinerators and Waste and Linen Handling Systems and Equipment
804	Standard for Fire Protection for Advanced Light Water Reactor Electric Generating Plants	85	Boiler and Combustion Systems Hazards Code
805	Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants	86	Standard for Ovens and Furnaces
806	Performance-Based Standard for Fire Protection for Advanced Nuclear Reactor Electric Generating Plants Change Process	87	Recommended Practice for Fluid Heaters
820	Standard for Fire Protection in Wastewater Treatment and Collection Facilities	90A	Standard for the Installation of Air-Conditioning and Ventilating Systems
850	Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations	90B	Standard for the Installation of Warm Air Heating and Air-Conditioning Systems
900	Building Energy Code	91	Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids
909	Code for the Protection of Cultural Resource Properties - Museums, Libraries, and Places of Worship	92	Standard for Smoke Control Systems
914	Code for Fire Protection of Historic Structures	96	Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations
1141	Standard for Fire Protection Infrastructure for Land Development in Wildland, Rural, and Suburban Areas	105	Standard for the Installation of Smoke Door Assemblies and Other Opening Protectives
1194	Standard for Recreational Vehicle Parks and Campgrounds	110	Standard for Emergency and Standby Power Systems
5000	Building Construction and Safety Code®	111	Standard on Stored Electrical Energy Emergency and Standby Power Systems
	Hazard - Based	115	Standard for Laser Fire Protection
2	Hydrogen Technologies Code	204	Standard for Smoke and Heat Venting
30	Flammable and Combustible Liquids Code	211	Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances
30B	Code for the Manufacture and Storage of Aerosol Products	225	Model Manufactured Home Installation Standard
33	Standard for Spray Application Using Flammable or Combustible Materials	232	Standard for the Protection of Records
34	Standard for Dipping, Coating, and Printing Processes Using Flammable or Combustible Liquids	496	Standard for Purged and Pressurized Enclosures for Electrical Equipment
35	Standard for the Manufacture of Organic Coatings	497	Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas
36	Standard for Solvent Extraction Plants	505	Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations
37	Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines	720	Standard for the Installation of Carbon Monoxide(CO) Detection and Warning Equipment
40	Standard for the Storage and Handling of Cellulose Nitrate Film	730	Guide for Premises Security

51A	Standard for Acetylene Cylinder Charging Plants	731	Standard for the Installation of Electronic Premises Security Systems
54	National Fuel Gas Code	750	Standard on Water Mist Fire Protection Systems
55	Compressed Gases and Cryogenic Fluids Code	780	Standard for the Installation of Lightning Protection Systems
58	Liquefied Petroleum Gas Code	1145	Guide for the Use of Class A Foams in Manual Structural Fire Fighting
59	Utility LP-Gas Plant Code	1150	Standard on Foam Chemicals for Fires in Class A Fuels
59A	Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)	1221	Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems
61	Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities	1231	Standard on Water Supplies for Suburban and Rural Fire Fighting
70	National Electrical Code®	2001	Standard on Clean Agent Fire Extinguishing Systems
75	Standard for the Fire Protection of Information Technology Equipment	2010	Standard for Fixed Aerosol Fire-Extinguishing Systems
77	Recommended Practice on Static Electricity		
102	Standard for Grandstands, Folding and Telescopic Seating, Tents, and Membrane Structures		
115	Standard for Laser Fire Protection		
214	Standard on Water-Cooling Towers		
232	Standard for the Protection of Records		
400	Hazardous Materials Code		
484	Standard for Combustible Metals		
495	Explosive Materials Code		
654	Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids		
655	Standard for Prevention of Sulfur Fires and Explosions		
664	Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities		
853	Standard for the Installation of Stationary Fuel Cell Power Systems		
1144	Standard for Reducing Structure Ignition Hazards from Wildland Fire		

Table A-2
Administrative Features

	What (When and Where)		***How (How much)***
1	Fire Code	51B	Standard for Fire Prevention During Welding, Cutting, and Other Hot Work
2	Hydrogen Technologies Code	329	Recommended Practice for Handling Releases of Flammable and Combustible Liquids and Gases
99	Health Care Facilities Code	402	Guide for Aircraft Rescue and Fire-Fighting Operations
101	Life Safety Code®	405	Standard for the Recurring Proficiency of Airport Fire Fighters
130	Standard for Fixed Guideway Transit and Passenger Rail Systems	412	Standard for Evaluating Aircraft Rescue and Fire-Fighting Foam Equipment
403	Standard for Aircraft Rescue and Fire-Fighting Services at Airports	414	Standard for Aircraft Rescue and Fire-Fighting Vehicles
472	Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents	422	Guide for Aircraft Accident/Incident Response Assessment
473	Standard for Competencies for EMS Personnel Responding to Hazardous Materials/Weapons of Mass Destruction Incidents	424	Guide for Airport/Community Emergency Planning
600	Standard on Industrial Fire Brigades	704	Standard System for the Identification of the Hazards of Materials for Emergency Response
601	Standard for Security Services in Fire Loss Prevention	1142	Standard on Water Supplies for Suburban and Rural Fire Fighting
801	Standard for Fire Protection for Facilities Handling Radioactive Materials	1221	Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems
804	Standard for Fire Protection for Advanced Light Water Reactor Electric Generating Plants	1401	Recommended Practice for Fire Service Training Reports and Records
805	Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants	1402	Guide to Building Fire Service Training Centers
850	Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations	1403	Standard on Live Fire Training Evolutions
909	Code for the Protection of Cultural Resource Properties - Museums, Libraries, and Places of Worship	1404	Standard for Fire Service Respiratory Protection Training
914	Code for Fire Protection of Historic Structures	1407	Standard for Training Fire Service Rapid Intervention Crews
1000	Standard for Fire Service Professional Qualifications Accreditation and Certification Systems	1410	Standard on Training for Initial Emergency Scene Operations
1001	Standard for Fire Fighter Professional Qualifications	1451	Standard for a Fire and Emergency Services Vehicle Operations Training Program
1002	Standard for Fire Apparatus Driver/Operator Professional Qualifications	1452	Guide for Training Fire Service Personnel to Conduct Dwelling Fire Safety Surveys
1003	Standard for Airport Fire Fighter Professional Qualifications	1581	Standard on Fire Department Infection Control Program
1005	Standard for Professional Qualifications for Marine Fire Fighting for Land-Based Fire Fighters	1582	Standard on Comprehensive Occupational Medical Program for Fire Departments
1006	Standard for Technical Rescuer Professional Qualifications	1583	Standard on Health-Related Fitness Programs for Fire Department Members

1021	Standard for Fire Officer Professional Qualifications	1584	Standard on the Rehabilitation Process for Members During Emergency Operations and Training Exercises
1026	Standard for Incident Management Personnel Professional Qualifications	1600	Standard on Disaster/Emergency Management and Business Continuity Programs
1031	Standard for Professional Qualifications for Fire Inspector and Plan Examiner	1620	Standard for Pre-Incident Planning
1033	Standard for Professional Qualifications for Fire Investigator	1670	Standard on Operations and Training for Technical Search and Rescue Incidents
1035	Standard for Professional Qualifications for Fire and Life Safety Educator, Public Information Officer, and Juvenile Firesetter Intervention	1801	Standard on Thermal Imagers for the Fire Service
1037	Standard for Professional Qualifications for Fire Marshal	1851	Standard on Selection, Care, and Maintenance of Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting
1041	Standard for Fire Service Instructor Professional Qualifications	1852	Standard on Selection, Care, and Maintenance of Open-Circuit Self-Contained Breathing Apparatus (SCBA)
1051	Standard for Wildland Fire Fighter Professional Qualifications	1855	Standard for Selection, Care, and Maintenance of Protective Ensembles for Technical Rescue Incidents
1061	Professional Qualifications for Public Safety Telecommunications Personnel	1901	Standard for Automotive Fire Apparatus
1071	Standard for Emergency Vehicle Technician Professional Qualifications	1906	Standard for Wildland Fire Apparatus
1081	Standard for Industrial Fire Brigade Member Professional Qualifications	1911	Standard for the Inspection, Maintenance, Testing, and Retirement of In-Service Automotive Fire Apparatus
1143	Standard for Wildland Fire Management	1912	Standard for Fire Apparatus Refurbishing
1201	Standard for Providing Emergency Services to the Public	1917	Standard for Automotive Ambulances
1250	Recommended Practice in Fire and Emergency Service Organization Risk Management	1925	Standard on Marine Fire-Fighting Vessels
1405	Guide for Land-Based Fire Departments that Respond to Marine Vessel Fires	1931	Standard for Manufacturer's Design of Fire Department Ground Ladders
1500	Standard on Fire Department Occupational Safety and Health Program	1932	Standard on Use, Maintenance, and Service Testing of In-Service Fire Department Ground Ladders
1521	Standard for Fire Department Safety Officer Professional Qualifications	1936	Standard on Powered Rescue Tools
1561	Standard on Emergency Services Incident Management System and Command Safety	1951	Standard on Protective Ensembles for Technical Rescue Incidents
1710	Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments	1952	Standard on Surface Water Operations Protective Clothing and Equipment
1720	Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations and Special Operations to the Public by Volunteer Fire Departments	1961	Standard on Fire Hose
		1962	Standard for the Care, Use, Inspection, Service Testing, and Replacement of Fire Hose, Couplings, Nozzles, and Fire Hose Appliances
		1963	Standard for Fire Hose Connections
		1964	Standard for Spray Nozzles
		1965	Standard for Fire Hose Appliances
		1971	Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting

		1975	Standard on Station/Work Uniforms for Emergency Services
		1977	Standard on Protective Clothing and Equipment for Wildland Fire Fighting
		1981	Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services
		1982	Standard on Personal Alert Safety Systems (PASS)
		1983	Standard on Life Safety Rope and Equipment for Emergency Services
		1984	Standard on Respirators for Wildland Fire Fighting Operations
		1989	Standard on Breathing Air Quality for Emergency Services Respiratory Protection
		1991	Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies
		1992	Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies
		1994	Standard on Protective Ensembles for First Responders to CBRN Terrorism Incidents
		1999	Standard on Protective Clothing for Emergency Medical Operations
		2112	Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire
		2113	Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for Protection of Industrial Personnel Against Short-Duration Thermal Exposures

Table A-3
Emergency Preparedness

Planning	***Organizing***	***Equipping***	***Training***
1-Fire Code	402-Guide for Aircraft Rescue and Fire-Fighting Operations	10- Standard for Portable Fire Extinguishers	1401-Recommended Practice for Fire Service Training Reports and Records
2-Hydrogen Technology Code	403-Standard for Aircraft Rescue and Fire-Fighting Services at Airports	412-Standard for Evaluating Aircraft Rescue and Fire-Fighting Foam Equipment	1402-Guide to Building Fire Service Training Centers
99- Health Care Facilities Code	405-Standard for the Recurring Proficiency of Airport Fire Fighters	414-Standard for Aircraft Rescue and Fire-Fighting Vehicles	1403-Standard on Live Fire Training Evolutions
101- Life Safety Code®	422- Guide for Aircraft Accident/Incident Response Assessment	1801- Standard on Thermal Imagers for the Fire Service	1404-Standard for Fire Service Respiratory Protection Training
130-Standard for Fixed Guideway Transit and Passenger Rail Systems	450-Guide for Emergency Medical Services and Systems	1851-Standard on Selection, Care, and Maintenance of Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting	1407-Standard for Training Fire Service Rapid Intervention Crews
424- Guide for Airport/Community Emergency Planning	472-Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents	1852-Standard on Selection, Care, and Maintenance of Open-Circuit Self-Contained Breathing Apparatus (SCBA)	1410-Standard on Training for Initial Emergency Scene Operations
704- Standard System for the Identification of the Hazards of Materials for Emergency Response	473-Standard for Competencies for EMS Personnel Responding to Hazardous Materials/Weapons of Mass Destruction Incidents	1855-Standard for Selection, Care, and Maintenance of Protective Ensembles for Technical Rescue Incidents	1451-Standard for a Fire and Emergency Services Vehicle Operations Training Program
909- Code for the Protection of Cultural Resource Properties - Museums, Libraries, and Places of Worship	600-Standard on Industrial Fire Brigades	1901-Standard for Automotive Fire Apparatus	1452-Guide for Training Fire Service Personnel to Conduct Dwelling Fire Safety Surveys
1201- Standard for Providing Emergency Services to the Public	601-Standard for Security Services in Fire Loss Prevention	1906-Standard for Wildland Fire Apparatus	1584-Standard on the Rehabilitation Process for Members During Emergency Operations and Training Exercises
1500- Standard on Fire Department Occupational Safety and Health Program	1000-Standard for Fire Service Professional Qualifications Accreditation and Certification Systems	1911-Standard for the Inspection, Maintenance, Testing, and Retirement of In-Service Automotive Fire Apparatus	
1584- Standard on the Rehabilitation Process for Members During	1001-Standard for Fire Fighter Professional Qualifications	1912-Standard for Fire Apparatus Refurbishing	

Emergency Operations and Training Exercises			
1600-Standard on Disaster/Emergency Management and Business Continuity Programs	1002-Standard for Fire Apparatus Driver/Operator Professional Qualifications	1917-Standard for Automotive Ambulances	
1616-Standard for Mass Evacuation and Sheltering	1003-Standard for Airport Fire Fighter Professional Qualifications	1925-Standard on Marine Fire-Fighting Vessels	
1620-Standard for Pre-Incident Planning	1005-Standard for Professional Qualifications for Marine Fire Fighting for Land-Based Fire Fighters	1931-Standard for Manufacturer's Design of Fire Department Ground Ladders	
	1006-Standard for Technical Rescuer Professional Qualifications	1932-Standard on Use, Maintenance, and Service Testing of In-Service Fire Department Ground Ladders	
	1021-Standard for Fire Officer Professional Qualifications	1936-Standard on Powered Rescue Tools	
	1026-Standard for Incident Management Personnel Professional Qualifications	1951-Standard on Protective Ensembles for Technical Rescue Incidents	
	1031-Standard for Professional Qualifications for Fire Inspector and Plan Examiner	1952-Standard on Surface Water Operations Protective Clothing and Equipment	
	1033-Standard for Professional Qualifications for Fire Investigator	1961-Standard on Fire Hose	
	1035-Standard for Professional Qualifications for Fire and Life Safety Educator, Public Information Officer, and Juvenile Firesetter Intervention	1962-Standard for the Care, Use, Inspection, Service Testing, and Replacement of Fire Hose, Couplings, Nozzles, and Fire Hose Appliances	
	1037-Standard for Professional Qualifications for Fire Marshal	1963-Standard for Fire Hose Connections	
	1041-Standard for Fire Service Instructor Professional Qualifications	1964-Standard for Spray Nozzles	
	1051-Standard for Wildland Fire Fighter Professional Qualifications	1965-Standard for Fire Hose Appliances	
	1061-Professional Qualifications for Public Safety Telecommunications Personnel	1971-Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting	
	1071-Standard for Emergency Vehicle Technician Professional Qualifications	1975-Standard on Station/Work Uniforms for Emergency Services	
	1081- Standard for Industrial Fire Brigade Member Professional Qualifications	1977-Standard on Protective Clothing and Equipment for Wildland Fire Fighting	

	1405-Guide for Land-Based Fire Departments that Respond to Marine Vessel Fires	1981-Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services	
	1521-Standard for Fire Department Safety Officer Professional Qualifications	1982-Standard on Personal Alert Safety Systems (PASS)	
	1561-Standard on Emergency Services Incident Management System and Command Safety	1983-Standard on Life Safety Rope and Equipment for Emergency Services	
	1581-Standard on Fire Department Infection Control Program	1984-Standard on Respirators for Wildland Fire Fighting Operations	
	1582-Standard on Comprehensive Occupational Medical Program for Fire Departments	1989-Standard on Breathing Air Quality for Emergency Services Respiratory Protection	
	1710-Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments	1991-Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies	
	1720-Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations and Special Operations to the Public by Volunteer Fire Departments	1992-Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies	
		1994-Standard on Protective Ensembles for First Responders to CBRN Terrorism Incidents	
		1999-Standard on Protective Clothing for Emergency Medical Operations	