RESILIENCE CERTIFICATION FOR COMMERCIAL BUILDINGS: A STUDY OF STAKEHOLDER PERSPECTIVES

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Abstract

Infrastructure resilience has become a primary objective for homeland and national security organizations over the past decade. Recent initiatives have focused on resilient building design, and one approach under consideration is a voluntary resilience certification program for commercial buildings. The intent of this program would be to encourage the adoption of resilient design practices in construction and planning of the buildings. While resilience may be a frequently discussed concept within the security communities, its level of awareness within the construction, design, insurance, and building owner communities is not well known. Given the voluntary nature of the certification program under consideration, program development requires a comprehensive understanding of resilience as defined by the commercial building stakeholders. Toward this end, Sandia National Laboratories conducted a study of stakeholder perspectives on resilience to ascertain factors that would serve as motivation for participation in the resilience certification program. This paper describes how Sandia performed the study and the resulting conclusions. One of the key conclusions that the study found is that the term resilience is unfamiliar to many and inconsistently defined across the industries. Those familiar with the term frequently linked it to sustainability concepts. The study also found that increased participation in the resilience certification program is very likely affected by demonstrable returns on resilience investments and a public-private partnership model for program administration.

Introduction

The year 2011 set a record for natural disasters in the United States. The National Oceanic and Atmospheric Administration (NOAA) reported 14 weather- and climate-related disasters that each caused more than $1 billion in damages (NOAA 2012). Many people, including NOAA Administrator Jane Lubchenco, view 2011 as an indicator of an increasing trend in U.S. and global disasters. This opinion is consistent with the observation that the frequency of man-made and natural disasters has steadily risen over the last 40 years (Swiss Reinsurance Company Ltd 2011). Additionally, the worldwide cost of natural disasters in 2011 was $435 billion, the costliest year on record (Aon Benefield 2012).

The impact of these disasters on private businesses frequently goes beyond the direct economic losses. Businesses may lose customers, market shares, and competitive edges. Some businesses may close after a disaster, which affects not only the employees, but also the community they support. Communities sustain damage and then frequently lose revenue needed to recover from damages. The federal government and charitable organizations provide some support, but current economic conditions limit the funds available for both public and private disaster recovery support.

Traditional U.S. critical infrastructure protection policies focus primarily on physical protection and prevention. Unfortunately, this focus had little if any effect on preventing the $1 billion-plus disasters. Over the past decade, infrastructure protection has developed a broader focus; the concept of resilience has become a prominent component

of national, homeland, and infrastructure security policies. The recent Presidential Policy Directive 8 (PPD-8, Obama 2011) on national preparedness defines resilience as "the ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies." The inclusion of resilience in policy indicates that the federal government accepts that not all assets can be protected from all threats at all times. The nation must be prepared to respond to disruptive events, whether these events are malevolent, accidental, or natural.

The Homeland Security Advisory Council's (HSAC) Critical Infrastructure Task Force (CITF) recommended in 2006 that the U.S. Department of Homeland Security (DHS) focus on critical infrastructure resilience as its top-level strategic objective (HSAC 2006). Following that recommendation, federal and local governments initiated resilience-related activities. For example, the National Infrastructure Protection Plan now emphasizes protection and resilience equally (U.S. Government Accountability Office 2010), and the DHS Sector Specific Plans written for critical infrastructure systems frequently cite resilience as a primary goal. For example, see the *Transportation Systems Sector Specific Plan* (DHS 2010).

One recent idea under consideration to enhance the resilience of businesses, infrastructures, and their surrounding communities is the development of a voluntary resilience certification for commercial buildings. Similar to the Energy STAR and Leadership in Environmental Design (LEED) programs through which a building can be certified as energy efficient, this new program is intended to promote the adoption of resilient design features in buildings through a resilience certification program.

In the context of a disruptive event, certified resilient buildings are expected to be less susceptible to physical damage, to be repaired more quickly and cost-effectively, and to maintain key building functionality either throughout the disruptive event or to attain a targeted operation level more quickly after the disruptive event. Several beneficiaries exist for such a building. The owner of the building will incur less property and business interruption losses. The surrounding communities may benefit as well since commercial facilities and businesses, such as banks and grocery starts, frequently serve important roles in the community recovery activities. The continued operation or quick recovery of these businesses will facilitate recovery and sustenance of the surrounding community. In some cases, certified resilient buildings may even be able to serve dual purposes. Under normal conditions, it would perform its typical business function, and in times of crises, it could become a safe, community gathering place. Ultimately, the objective of the program is to create resilient communities and a more resilient nation, one building at a time.

While resilience may be a frequently discussed concept within the national, homeland, and infrastructure security communities, its level of awareness within the construction, design, insurance, and building owner communities was not well known. [4] Given the voluntary nature of the certification program, program development requires a

[4] For the sake of brevity, the remainder of the paper will refer to the group of commercial building construction, design, insurance, and owner communities as the commercial building stakeholders.

comprehensive understanding of resilience as defined by the commercial building stakeholders.

Toward that goal, Sandia National Laboratories (Sandia) conducted a study of commercial building stakeholders. The goal of the study was to improve understanding of the following issues:

- **Awareness:** How do the stakeholders define resilience? Do they use the term in their professional activities? If so, in what ways do they do so?

- **Motivation:** What factors exist that would make stakeholders more/less likely to participate? What types of incentives might encourage participation?

- **Development:** In the development of the program, do the stakeholders have any opinions about key program features that need to be included or developed?

This paper describes the study and how it was designed and implemented, as well as the resulting recommendations.

A Brief Introduction to Resilience

Though the concept of resilience is relatively new to the security and commercial building communities, it has been studied and researched for several decades in other contexts. Material scientists first defined resilience as a thermodynamic property of solid materials more than one hundred years ago (Trautwine 1907; Park et al. 2012). C. S. Holling is widely credited with introducing the concept into complex systems studies in 1973 when he wrote about resilience for ecological systems. Over the following four decades, resilience research has spread far beyond these initial areas of study. To provide some context for the environment in which the study was conducted, we provide a brief summary of some recent advances in resilience research from the complex systems, risk, and disaster management communities. (For a more complete discussion, see Park et al.'s (2012) and Rose's (2007) discussions on the growth of resilience research, proposed definitions of resilience, and how resilience differs from related concepts.)

The complex systems, risk, and disaster management communities have provided some of the most recent advances in resilience thinking. Madni and Jackson (2009) formulated a conceptual framework for "resilience engineering." Under this framework resilience engineering is characterized as "the ability to build systems that are able to circumvent accidents through anticipation, survive disruptions through recovery, and grow through adaptation." The framework uses disruption characterization; system attribute analysis; ongoing use of several risk, safety, and other analysis methods for monitoring and tradeoff analysis; and resilience metrics and indicators.

In a review of three recent disasters, Park et al. (2011) describe how traditional risk management methods proved inadequate in each of the incidents. The authors call for a "resilience-based design and management paradigm" to address low probability, high-

consequence events and to complement risk management approaches. Park et al. (2012) further distinguish between risk and resilience management. The authors note that risk analysis has fundamentally different assumptions, objectives, and methods than are necessary for resilience analysis. Whereas risk analysis focuses on managing known hazards, resilience is a dynamic, emergent property that must be continually managed and is characterized by a lack of certainty. They rightly note that classic risk analysis methods are not sufficient for resilient design and that a departure from traditional design practices is needed.

Madni and Jackson's (2007) and Park et al.'s works are generally applicable to complex systems, but much work has been done that focuses on specific areas of application. Rose (2007) has led much of the resilience research for economic applications. The Multidisciplinary Center for Earthquake Engineering Research (MCEER) has focused on the development of technologies to make communities more resilient to earthquake events (Bruneau et al. 2003). Fiksel (2006) has developed a systems-based approach for examining the resilience and sustainability of industrial, social, and ecological systems, and with the increasing concerns about cyber security, cyber resilience has become an area of active research (Bodeau and Graubart 2011, Goldman 2010).

Only recently has the concept of resilience started to gain some attention in the building and construction communities. In 2010, the National Building Museum organized a conference focused on designing buildings and communities to deal with disasters (National Building Museum 2010). One of the key recommendations resulting from the conference was call for increased "planning and building for resilience", which could be achieved in part the standardization of resilience in building codes. Additionally, the conference recommended that resilience incorporated into design curricula so that resilience becomes a core design consideration at the beginning of a building's lifecycle. Following the 2010 conference, several others have been held that specifically focus on incorporating resilience concepts into building planning, design, and construction (McGraw Hill Construction 2011, The Infrastructure Security Partnership 2012, National Institute of Building Sciences 2013).

The inclusion of resilience concepts into building design and construction may seem a bit puzzling at first, given the inherent systemic nature of resilience. However, the aforementioned conferences note buildings themselves can be considered systems. The building envelope; electrical; heating, ventilation, and cooling (HVAC); communications and other systems must all integrate effectively for a building to sustain safe operations during disruptive events. Code standards typically focus on structural integrity and safety; they do not necessarily address continuity of operations. "Resilient buildings" are often thought of as structures that exceed minimum code requirements so that the key building systems continue to function, enabling the continued operation of the building.

Many of the general resilience attributes considered in complex systems can be applied in the building context. A building's "avoidance" resilience attribute can be enhanced by siting it in a less hazard prone area. Adaptation can be facilitated by installing telecommunications equipment that enable remote access when physical access is not

possible. Rapid recovery can be enabled by the selection of certain construction materials.

Outside of these conferences, though, the awareness and acceptance of resilience in the building community is not well known. Even less well understood is what incentives and program features might motivate individuals and businesses to participate in a resilience certification program.

Methodology

The goal of this research was to determine a framework of factors that would motivate individuals to participate in a resilience certification program. The task was accomplished through the following process:

1. Identify key stakeholder categories.
2. Select stakeholders within those categories for interviews.
3. Develop the interview questionnaire.
4. Contact interviewees and conduct interviews.
5. Analyze the interview results.

This section details those steps and analysis findings.

Stakeholder Categories

The research team identified the following four categories of stakeholders for representation in the interview process:

1. **The construction, planning, and design community**. These individuals and organizations represent the professional community that could supply resilience-certified buildings; thus understanding this group's views on the requirements to build a resilient building is important to the program.
2. **Owners, occupants, and marketers of building.** These stakeholders represent the potential demand group for resilient buildings. This group represents the program's target audience of individuals and businesses that could apply for building certification. Understanding their needs and motivations for participating in the program are critical to encouraging program success.
3. **Insurance and financial-sector organizations.** When planning this project, the research team hypothesized that reduced insurance premiums or loan rates could be incentives to participate in the program. In addition, the insurance and financial industries are well versed in risk analysis—a concept closely related to resilience.
4. **Organizations with certification program experience.** Many green building certification programs are currently operating. Leveraging lessons learned from those programs could assist in the marketing of the resilience certification program and expedite efficient development of the program.

Selection and Prioritization of Interview Candidates

The research team developed a list of more than 40 interview candidates from across the four stakeholder categories. Because both schedule and budget were constrained, the candidates were prioritized for interviews into High, Medium, and Low groups according to the following criteria:

- **Expected knowledge of the program issues.** Interviewing people with knowledge across several categories was a priority.
- **Years of experience and status in the professional community.** An experienced person who is recognized as a leader in the professional community was expected to represent the views of colleagues better than an individual with less experience.
- **Representation across the four stakeholder categorie**s. Each prioritization grouping included stakeholders from all four categories.
- **Existing relationships between the potential interviewee and Sandia or potential program sponsor.** An existing relationship increased the likelihood of participation and thereby reduced the effort required to contact and persuade someone to participate in an interview.

Develop the Interview Questionnaire

The research team developed a questionnaire to answer the following questions:

1. How is the concept of resilience perceived by the interviewees?
2. Is the concept of resilience actively considered and implemented within the professional activities of the interviewee? If so, how and where?
3. What factors might motivate participation in a building resilience certification program?

Sandia researchers designed the questions to be open-ended, so that stakeholders had the freedom to expand upon the initial questions posed. Because the program sponsor had already decided to start development of the certification program, the questionnaire did not ask such yes-or-no questions as "Should such a program be developed and implemented?" The complete questionnaire is shown in Appendix A.

Contact and Interview Stakeholders

Starting with the interview candidates designated as High priority, Sandia attempted to contact approximately 30 potential interview participants. When contacting a stakeholder, a project team member generally made initial contact to explain the analysis objectives (i.e., collect perspectives and understand motivations to participate in the resilience certification program) and to obtain verbal consent to participate in accordance with Sandia National Laboratories Institutional Review Board requirements. The project team member would then send a follow-up email that contained the interview questionnaire, an informed consent form, and some additional information about the process.

Interviews were usually conducted through a telephone conversation. The project team took the following steps to ensure consistency in the interview process:

- Two team members conducted 80% of the interviews. Both team members are formally trained to conduct interviews and analyze results of the interviews.
- The project developed a script for conducting the interviews. By following this script, the interviewers ensured that each stakeholder was provided the same information, thus limiting bias that could be introduced by the interviewer.

Interviews were either audio-recorded (with the interviewee's consent) or interviewees completed the questionnaire and submitted it by email. Interviews generally lasted 30 to 45 minutes. When necessary, follow-up contacts were made with interviewees to clarify responses.

Analyze the Interview Results

The project team selected the Grounded Theory Method to analyze the interview results. The Grounded Theory Method, originally developed by Glaser and Strauss (1967), is a qualitative process used to ensure that the perspectives and concerns of experts in industry are addressed when making recommendations for designing a new program that holds the potential to affect them. Grounded Theory Method is a heuristic approach that enables the researcher to make sense of the participants' world through interpretation of data gathered through interviews. The findings are based on discovery of concepts that emerge from constant comparison of respondent's interviews. Since its initial development, the method has been extended beyond social science applications and has been applied to diverse areas such as the business environment (Goulding 2002), information systems (Orlikowski 1993), human behavior studies (Charmaz 1991), and total quality management (McAdam et al. 2008).

Figure 1 illustrates the Grounded Theory Method process. In this process, analysis is performed as the team gathers data. Because resilience is a relatively new concept to the building industry, the program sponsor identified potential interviewees that were individuals or businesses that were likely familiar with resilience or that were addressing resilience in their industry. The Sandia team supplemented this list of individuals with other industry representatives as needed to have adequate representation of each industry. This process for selecting interview candidates is consistent with the Grounded Theory Method since, unlike statistical design methods, Grounded Theory Method does not require randomization of the individuals from whom the data will be collected.

Analysis of each interview is conducted by means of constant comparison of the data gathered from the proceeding interview. The comparisons provide direction for identifying the next interview candidate and data gathering step. The analyst reviews the interview transcripts and identifies an initial theme for each respondent. The analyst then uses the process of coding to identify, name, categorize, and descibe phenomena found in the responses. After each interview is coded, the codes are then compared to previous interview findings. The interviews are compared to identify repetitive responses. Repition within the responses indicates saturation, i.e., the responses sufficently similar across

enough interviews to conclude that no more information is required to investigate the specific issue. If saturation is not reached, additional interviews are performed. When saturation is achieved, no additional interviews are necessary and responses are analyzed to establish common categories of responses.

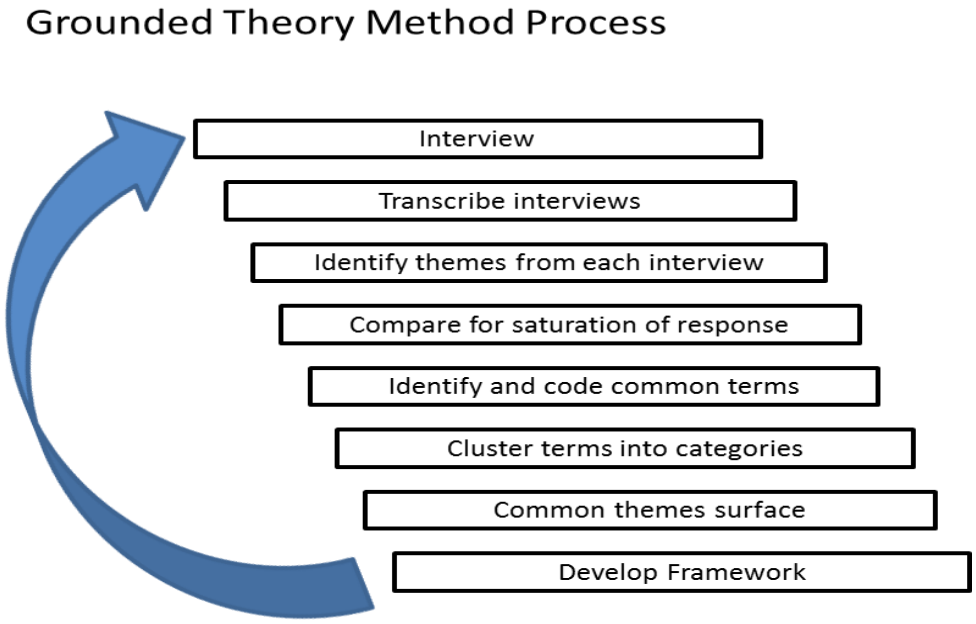

Figure 1. Grounded Theory Method Implementation Process

In the Grounded Theory Method, the analyst constantly compares and reviews the information received to determine whether it is repetitive. Findings are substantiated when the responses gathered reflect similar opinions. The method enables an inductive process to extend the possibility of more findings; the analyst either alters the questions asked or selects an individual to interview. For this project, open-ended questions were included in the interviews, so rather than alter the original research questions, the analyst conducting the interview would invite the respondent to add to their previous responses. Broader representation was gathered when additional interviewees were culled from another category of operation within the industry.

The Grounded Theory Method is a good match for this project because the research was to be conducted without *a priori* knowledge. Hence, the research team did not define a research hypothesis at the beginning of the project. Rather, researchers were able to discover the findings without contributing influence. The Grounded Theory Method is nearly a reverse approach to traditional analysis in that the data gathered directs the theoretical conclusion rather than the findings being used to prove or disprove an existing theory.

The qualitative nature of the method is a strength of the approach, but it is also a potential source of criticism. Hence, the project team took action to ensure consistency and to limit potential introduction of bias through the subjective steps. Specifically:

1. A single team member, the coder, performed the coding step for all interviews. This ensured the consistency of the coding process.
2. Additional team members independently coded two interviews and then compared their results to the coder's results. This step ensured that the coder's result were complete and unbiased.
3. Five team members each performed cross-interview comparisons on groups of four interviews. Consequently, five interviews were analyzed by multiple team members. This duplicate analysis provided triangulation of the data: i.e., cross verification of the information by two sources to ensure the validity of the analysis. This cross-verification further ensured the analysis is unbiased.

Findings

The 15 interview participants represented architects, planners, developers, insurance providers, commercial property brokers, and similar programs and institutions focused on presentation of building practices to the public. If potential interviewees did not respond to the initial contact attempt, Sandia made additional efforts to establish contact using telephone calls and emails. Only one organization directly declined to participate. The remaining potential participants did not respond to any of Sandia's queries. Figure 2 shows the distribution of interviewed stakeholders by category and priority.

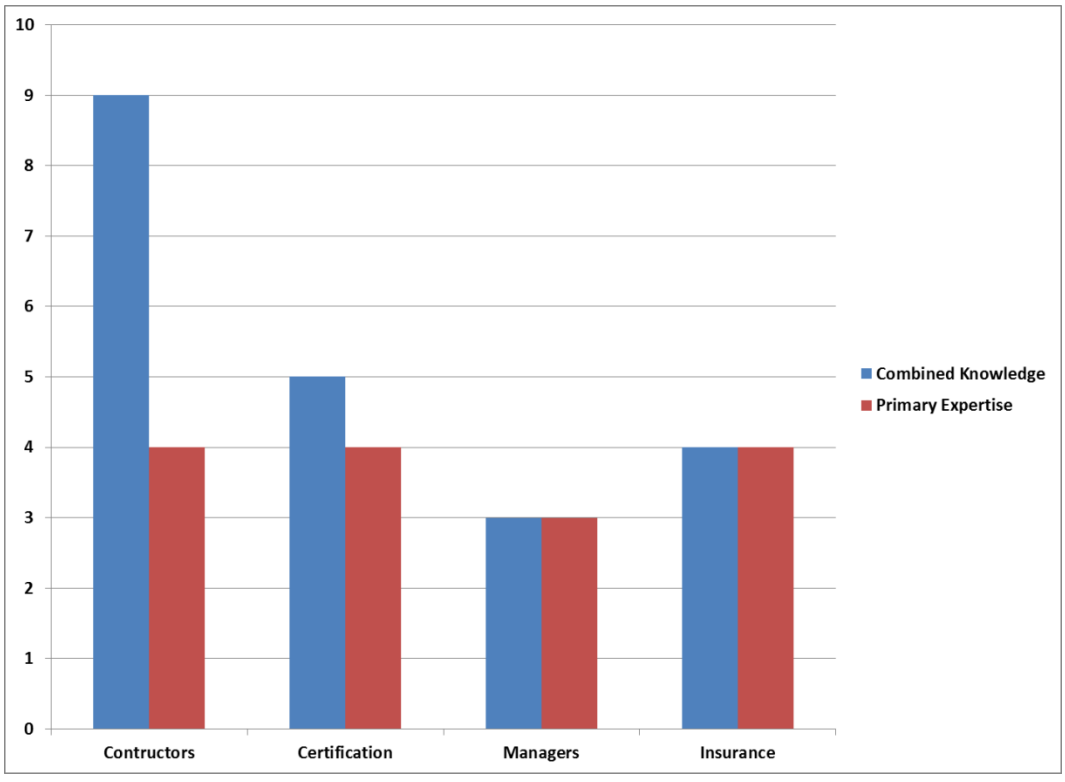

Figure 2. Interviewees, by Primary Expertise (red) and Across All Categories (blue)
(Constructors=construction community, Certification=certification program experience, Managers=managers, owners, and marketers, Insurance=insurance and finance industry)

Seven primary findings emerged from the stakeholder interviews (Table 1). The findings are not listed in any particular order of priority. The following paragraphs provide additional detail on these findings and along with quotes from the interviewees related to the findings.

Table 1. Theoretical Framework of Stakeholder Interview Findings

Interview Findings
1. There is either a lack of consensus on the definition of the term 'resilience' or unfamiliarity with the term.
2. A successful program will require an education and training component.
3. Participation in resilience depends directly on costs versus benefits and a demonstrated return on investment.
4. Optimally, resilience should be initiated in the design process and considered throughout the entire building lifecycle.
5. Definitions of resilience tend to vary by industry. For example, the insurance sector strongly ties resilience to 'risk' and 'risk management,' while planners expressed the need for 'recovery' and 'continuity of operations' after an event or disaster.
6. Building resilience extends beyond maintaining the building envelope and includes dependence upon the infrastructure required to operate the business conducted in the building.
7. Interviewees mentioned that a public-private sector partnership model is important to the success of the program.

The first finding was that among the interviewees, there was either a lack of consensus on the definition of resilience or unfamiliarity with the term. One interviewee indicated,

> "We typically have not used the word resilience broadly …As this field [resilience] gets additional momentum because of the increase in the magnitude and severity of losses that is concurring across the world, I think the… insurance industry and the whole field in general, needs to come to terms with."

For some people, resilience meant continuity of operations or risk management. For others, it meant adaptation, recovery, flexibility, or preparedness. It appeared the use of the term was correlated to the stakeholder's industry.

In general, respondents did not use the term resilience in their industry unless their work had brought them into contact with DHS or other agencies that commonly use the term. When asked to define resilience, one interviewee responded, "You mean that term that DHS made up?" There was consensus that although the terminology differed, industry does include concepts related to resilience, such as preparedness and risk management, in general business practices. One interviewee stated:

> "We typically use the words loss prevention; property loss prevention; mitigation; response planning; emergency response planning would tend to fall into what is kind of the recovery period. We also use the words that are more focused on businesses, such as mitigating business interruption, which is how quickly businesses can be back in business after something happens"

In the world of land use and planning, sustainability was the operating term because the term sustainability already appears in building standards and codes at the local level of government. Of all the responses, resilience seemed to be most strongly tied to the concept of sustainability. Despite the many different responses, most respondents generally agreed that resilience is a desirable trait for buildings and other areas.

The second finding is a corollary to the first finding; respondents generally agreed that the program would require an education and training component to be successful. Respondents indicated that new programs benefit from educational outreach to familiarize the public and stakeholders with a new concept. Respondents spoke of the need for education to explain why resilient buildings are necessary and their associated benefits. Said one respondent with previous experience in green building programs:

> "Training is key to success. Training of the proper techniques would be paramount. Education about the appropriate products for the area. Training has been key to the success of sustainable building. Awareness of new products, training of the how-to… [will] make it all a bit easier to certify."

Another interviewee responded similarly:

> " …. you have to teach people why this is important. Like driving, people like to drive SUVs because they enjoy the power, until they see the price of gas, $4 or $5 a gallon, then you want a hybrid. This is why education should be part of the project so you can teach people to do this for the future, for their children…When people don't have the concept then they don't think about it, but if you see something on TV or on a flyer or at school, then you might think about it more."

Participation in the proposed program will be voluntary, so several interview questions explored motivating participation. The interviewer asked respondents to identify what would encourage them to participate. Our third finding indicated that, overwhelmingly, that demonstration of cost effectiveness and a positive return on investment for resilient design features is essential to attracting program participants. When that demonstration

can be made, a demand for them will occur. Then, as one reposndent commented, "Much like the awareness of "green" buildings and sustainability has redefined many building practices…the market will similarly demand it [resilient buildings] and developers and designers will follow."

The fourth finding resulted from respondents generally agreeing that it is ideal to incorporate resilience practices and principles in the initial building design stages and to continue consideration of resiliency throughout the building lifecycle. Respondents indicated that including resilient design features in the initial design stages would result in maximal effectiveness of the design features. When asked at what point in a building's lifecycle resilience should be considered, one interviewee stated "I would say right at the beginning." Another respondent felt strongly that resilience must be considered in all stages of a building's lifecycle:

> "In terms of sound risk management in preventing losses as well as recovering from losses, that [resilience] has got to be a factor through all of those phases. Through initial planning because it affects the sighting and the hazards that commercial industrial property could be exposed to; in the design to again mitigate any potential losses or build a robust building that reduces the possibility for hazards, whether its fire explosions or given the exposure to hazards. [If] they are being located in the wind zone, reducing the vulnerability to those hazards; construction practices have to follow the standards that are laid out in the design, so there's got to be some due diligence in terms of insuring that the construction practices are followed to meet the intent of the design and that the materials are used to meet the performance specifications required as well."

Furthermore, implementing the features during building construction would be more economical than retrofitting features to improve building resilience. At later stages in a building's lifecycle, design features may require continued maintenance (e.g., backup generators need to be tested and maintained) or the building's surrounding environment could change, necessitating additional resilience design features or modifications to existing ones. While respondents indicated that including resilience in the design stage was ideal, they noted that retrofitting existing structures was still important.

The fifth finding was an industry-specific observation. Insurance industry respondents strongly tied resilience to the concept of risk management, while planners expressed the need for 'recovery' and 'continuity of operations' after an event or disaster. This difference stemmed from the planners' acceptance that, despite the best attempts to prevent and decrease hazard probabilities, realistically, not all hazards can be identified and prevented. Hence, designing for recovery and continued operations in challenging situations is necessary to facilitate resilience. Conversely, insurance representatives generally felt that employing risk management approaches that preventing the occurrence of hazard events, was the most cost effective means for enhancing resilience. As one insurance representative stated "it will be necessary to demonstrate that resilient building practices will result in less damage and therefore decreased average annual risk." The

planners' conceptualization is similar to Park et al.'s (2012) position that resilience requires preparing for the unexpected minimizing the consequences of "failure", while the insurance respondents' comments seem to be inconsistent with Park et al.'s (2012) conceptualization of resilience.

The sixth finding indicated that while maintaining the integrity of the building envelope was important, ensuring building resilience included other considerations. For example, incorporating resilience into a building's essential systems, such as power, heating, telecommunications, etc., would minimize building disruptions caused by infrastructure outages. A building that has backup power generation or backup communication systems should be considered more resilient than a comparable building without those systems. In addition, building resilience should consider the length of time required to repair building damage and the degree to which business operations are impacted. Buildings that are more easily and quickly repaired and have shorter business interruptions should be considered more resilient than comparable buildings that experience longer, more expensive repair work and business interruptions. In essence, the stakeholders agreed with the resilience definition previously put forth in PPD-8, which states, a building's resilience includes its ability to "adapt to changing conditions and withstand, and rapidly recover quickly from a disruption due to emergencies" (Obama 2011).

Finding seven was the result of the respondents' recommendations for a public-private partnership model for program implementation. Reasons for recommending an approach ranged from providing access to organizational members to leveraging private sector resources to leveraging experiences gained through other building certification programs. One respondent stated "There is also a need for partnership between various stakeholders, such as the government and the private industry, such as insurance industry, so that the program can be widely announced and made acceptable." Another similarly stated that "For the long-term success of the program, partnerships between government and private sector will remain critical."

Finally, the stakeholders were asked whether they thought a number of potential incentives might motivate individuals to participate in a resilience certification program for buildings. Table 2 lists those incentives and the stakeholder responses. Incentives related to how resilient design features result in decreased damages and business interruptions were considered the strongest incentives. Respondents generally considered marketing the *inclusion of resilient design features as the 'right thing to do'* as a weak, ineffective incentive.

Table 2. Responses to Interview Question: "Would any of the following reasons encourage adoption of resilient design practices?"[5]

INCENTIVE	YES	NO	MAYBE

[5] **Note:** Number of responses for each question do not sum to 15 because some respondents declined to provide opinions on some questions.

1. Increased revenue from ability to continue/return to business operations in the event of a disruption	10	0	2
2. Competitive edge from being able to continue/return to business operations in the event of a disruption	9	1	1
3. Quicker, cheaper recovery following a disruptive event	9	1	1
4. Ability to charge higher lease rates due to increased attractiveness of the building to tenants (as a result of 1, 2, and 3)	5	4	3
5. Decreased insurance premiums	8	1	3
6. Tax incentives	7	3	0
7. Increased chance of receiving financing or lower finance rates	5	1	3
8. It is 'the right thing to do'	3	4	4

The respondents were generally supportive of the need for resilience in commercial buildings; however, they differed in how they identified resilience and thus how it would prove valuable in their industry. The consensus of these industry representatives was that they believed people would participate if they could benefit from return on investment, decreased business interruptions, decreased building damages, and enhanced risk management.

Upon completion of the interview analysis, Sandia compared these results to the National Infrastructure Advisory Council (NIAC) report, "Critical Infrastructure Resilience: Final Report and Recommendations" (2009). The NIAC recommended cooperation between public and private sector entities on efforts to enhance infrastructure resilience. They also recommended "encouraging resilience through appropriate market incentives" such as tax incentives, procurement practices, financial disclosure requirements, insurance-based incentives, and increased funding for repair and maintenance. These two recommendations closely resemble two of the seven findings from Sandia's study. The similarities between these two independently developed reports support and validate the findings.

Program Development Recommendations

The project team used these findings as the basis for a set of five program development recommendations to the certification program's potential sponsor. The recommendations are:

1. **Use a public-private partnership model for the program.** This recommendation is consistent with analysis of the stakeholder interviews and NIAC recommendations. Partnering with industry leaders can provide industry-

driven guidance during program development and increase the private sector's trust in the program. The manner in which the information technology (IT) sector worked with the U.S. Environmental Protection Agency during the initial development of the Energy STAR program is an example of the positive impact a public-private partnership model can have.

2. **Include a training and education program**. Another key finding from the stakeholder interviews is that the building community generally does not use the term 'resilience' in its professional activities. A lack of consensus existed on a definition of resilience. To overcome this challenge, the project team recommended the creation of an education and training component in the program to answer the following questions for building owners and managers:

    a. What is resilience and why should one invest in it?

    b. What are the essential components of the program?

    c. Who is eligible to participate in the program and how can they get started?

    For the construction and design community, the following questions should be answered:

    a. What are building features that create resilience?

    b. What criteria need to be met for certification?

    c. What are the benefits gained by providing resilient building services to owners?

3. **Develop a strategy for government-based incentives.** Monetary incentives, such as tax credits and rebates, were viewed by stakeholders as potentially effective incentives for program participation. NIAC recommended the Federal government provide these and other incentives to encourage adoption of resilient practices by the private sector. However, some stakeholders indicated that the complexity associated with understanding, applying for, and receiving tax credits was so daunting that many did not bother trying to receive them, even though the credit amounts were frequently larger than easy-to-obtain rebates. The project team recommended that the program sponsor identify which incentives will be provided by the government and then take steps to ensure that these incentives are user-friendly. This may require coordination between the program sponsor and the Internal Revenue Service and other entities. Education efforts should ensure that these incentive programs are understood and easy to navigate.

4. **Develop a cohesive resilience story across the Federal government's multiple resilience efforts**. As the public becomes more aware of resilience and its importance to national security, it will realize that the U.S. government has a large number of resilience-related initiatives, including the Private Sector Preparedness Program (PS-Prep), the Community Resilience Project, etc. The number of efforts may cause some confusion, and people may start to question why another resilience program is needed or wonder about the differences between the many projects. Consequently, the project team recommends that the Federal government develop a cohesive resilience story– similar to the Homeland Security Advisory

Council's Community Resilience Task Force Report from June of 2011 (HSAC 2011)– that describes the different roles each program plays. Specifically, the Federal government should communicate the important role this program plays in the larger national security strategy. The DHS has a Resilience Integration Team (RIT) that coordinates the Federal government's resilience-related initiatives. This team is a ready-made vehicle that would be ideal to perform this action.

5. **Collect historical resilience stories and images**. Several interviewed stakeholders stated that people (and businesses) who had experienced a disaster event were more likely to make mitigation investments than those who had not, even if they were at equal risk levels. Based on this insight, Sandia recommends the program sponsor collect historical stories and images that convey the benefits and impacts of resilience in the context of disaster events, to the purpose of motivating people to invest in resilience without having to experience disasters themselves. The prioritization of resilience in the security communities has made finding these kinds of stories easier, with Sheffi (2006), Lanahan (2011), Factory Mutual Insurance (2005), and California Seismic Safety Commission (1999) providing excellent examples.

Summary

This study examines potential participation in a resilient building certification program through the analysis of the opinions and expertise shared by stakeholders in the following industries: construction, planning and design communities, owners, occupants and marketers of buildings, insurance and financial sector and organizations with certification program experience. The factors that emerged as motivation for these stakeholders to participate in a resilience certification program are related to the benefits that can be obtained through implementation of such a program and the ease of which implementation can be achieved. Although the term resiliency is not widely or consistently used within building communities, each of these stakeholders currently employs some form of resilience in their business plans or building designs. The respondents, who were representative of the industries that crosscut the community of stakeholders, generally thought well of the proposed resiliency program and opportunities exist to build national resilience as a result. Hence, motivating participation in the program greatly depends on the sponsor's ability to effectively communicate the benefits (e.g., return on investment) of the program.

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Citations

Aon Benefield. 2012. Annual Global and Climate Catastrophe Report. http://thoughtleadership.aonbenfield.com/ThoughtLeadership/Documents/20120110_if_annual_global_climate_cat_report.pdf, accessed May 7, 2012.

Bodeau, D., and Graubart, R. (2011). *Cyber Resiliency Engineering Framework* (MITRE Technical Report MTR1-10237). Bedford, MA: MITRE Corporation.

Bruneau, M., S. E. Chang, R. T. Eguchi, G. C. Lee, T. D. O'Rourke, A. M. Reinhorn, M. Shinozuka, K. Tierney, W. A. Wallace, and D. von Winterfeldt. 2003. A Framework to Quantitatively Assess and Enhance the Seismic Resilience of Communities. *Earthquake Spectra* 19(4): 737-738.

California Seismic Safety Commission. 1999. "Earthquake Risk Management: Mitigation Success Stories."

Charmaz, K. 1991. *Good days, bad days: The self in chronic illness and time*. New Brunswick, NJ: Rutgers University Press .

DHS (U.S. Department of Homeland Security). 2010. "Transportation Systems Sector-Specific Plan: An Annex to the National Infrastructure Protection Plan." http://www.dhs.gov/xlibrary/assets/nipp-ssp-transportation-systems-2010.pdf, accessed September 12, 2012.

Factory Mutual Insurance Company. 2005. "Protecting Value Through Risk Improvement." http://www.fmglobal.com/assets/pdf/P0541b_OceanSpray.pdf, accessed May 7, 2012.

Fiksel, J. (2006). "Sustainability and Resilience: Toward a Systems Approach," *Sustainability: Science, Practice, and Policy*, 2(2), pp.14-21.

Glaser, B., and Strauss, A. 1967. "The discovery of grounded theory: Strategies for qualitative research." Chicago: Aldine Publishing Co.

Goldman, H. (2010). *Building Secure, Resilient Architectures for Cyber Mission Assurance* (MITRE Technical Report 10-3301). Bedford, MA: MITRE Corporation.

Goulding, C. 2002. "Grounded Theory: a practical guide for management, business and market researchers." Thousand Oaks, CA: Sage.

Holling, C.S. 1973. Resilience and Stability of Ecological Systems. *Annual Review of Ecology and Systematics* 4: 1-23.

HSAC (Homeland Security Advisory Council). 2006. "Report of the Critical Infrastructure Task Force." Washington, D.C.

HSAC (Homeland Security Advisory Council). 2011. "Community Resilience Task Force Recommendations." Washington, D.C.

Lanahan, Lawrence (2011) "The Disaster Tab". One Magazine, Fall/Winter 2011. Johns Hopkins Carey Business School. Baltimore, MD.

Madni, A. Am., and S. Jackson. (2009). "Towards a Conceptual Framework for Resilience Engineering," *IEEE Systems Journal*, 3(2), pp. 181-191.

McAdam, R., Leonard, D. J., Henderson, J., and Hazlett, S. 2008. "A grounded theory research approach to building and testing TQM theory in operations management." Omega, Elsevier, vol. 36(5), pp.825-837.

McGraw Hill construction. 2011. "Recommendatiosn to Congress, the Administration, and the Private Sector to Mitigate Impacts of Disasters by Planning and Building for Resiliency," http://construction.com/market_research/FreeReport/Mitigating_Impacts/Natural_Disaster_Mitigation_White_Paper_2011.pdf , accessed February 8, 2013.

National Building Museum. 2010. "Designing for Disaster: Partnering to Mitigate the Impact of Natural Disasters, Insights Drawn from the National Building Museum's Industry Council for the Built Environment," Washington, D.C., National Building Museum.

National Infrastructure Advisory Council. 2009. "Critical Infrastructure Resilience: Final Report and Recommendations." Washington, D.C.

National Institute for Building Sciences. (2013). "Building Innovation 2013," http://www.nibs.org/?page=conference, accessed February 8, 2013.

National Oceanic and Atmospheric Administration (NOAA). 2012. "Extreme Weather 2011: A year for the record books." http://www.noaa.gov/extreme2011/, accessed April 9, 2012.

Obama, B. (2011). "Presidential Policy Directive 8: National Preparedness." http://www.dhs.gov/presidential-policy-directive-8-national-preparedness, accessed July 9, 2012.

Orlikowski, W. 1993. CASE tools as organizational change: Investigating incremental and radical changes in systems development. *Management Information Systems Quarterly, 17*(3), pp.309-340.

Park, J., T. P. Seager, P. S. C. Rao. (2011). "Lessons in Risk-Versus Resilience-Based Design and Management," *Integrated Environmental Assessment and Management*, 7(3), pp. 396-399.

Park, J., T. P. Seager, P. S. C. Rao, M. Convertino, and I. Linkoz (2012). "Integrating Risk and Resilience Approaches to Catastrophe Management in Engineering Systems," *Risk Analysis*, doi: 10.1111/j.1539-6924.2012.01885.x.

Rose, A. (2007). "Economic resilience to natural and man-made disasters: Multidisciplinary origins and contextual dimensions," *Environmental Hazards*, 7(4), pp. 383-398.

Sheffi, Yosef (2005) The resilient enterprise: overcoming vulnerability for competitive advantage. Cambridge, MA: MIT Press.

Swiss Reinsurance Company Ltd. 2011. "Natural Catastrophes and man-made disasters in 2010: a year of devastating and costly events." Zurich, Switzerland.

Trautwine, J. C. (1907). The Civil Engineer's Pocket-Book. New York: John Wiley and Sons.

The Infrastructure Security Partnership (TISP). 2012. "Resilient Building Workshop," http://tisp.org/index.cfm?cdid=12795&pid=10231, accessed February 8, 2013.

U.S. Government Accountability Office. 2010. "Critical Infrastructure Protection: Update to National Infrastructure Protection Plan Includes Increased Emphasis on Risk Management and Resilience." Washington, D.C.

Appendix A: Stakeholder Questionnaire

1. How do you identify resillience in your industry?

2. What does resilience mean to you in the context of commercial buildings?

3. Does it include?
    a) Energy conservation yes/no
    b) Safety yes/no
    c) Security yes/no
    d) Cost/benefit yes/no
    e) Something else?

4. Do you use the word resilience in your commercial building codes, general planning or other activities? (Can you give some examples?)

5. Can you share the document or information that refers to resilience with me (land use, codes, redevelopment plan), or provide me a reference?

6. What programs are you aware of that exist related to resilience?

7. How do the developers discuss resilience?

8. How do developers support resilience efforts? Can you provide some examples?

9. How do planners discuss resilience?

10. What do you see as a motivation to build using resilient technology?

11. What would motivate customers in your industry to build or re-engineer to resilient standards? Would any of the following reasons encourage adoption of these practices:
    a. Increased revenue from ability to continue/return to business operations in the event of a disruption
    b. Competitive edge from being able to continue/return to business operations in the event of a disruption
    c. Quicker, cheaper recovery following a disruptive event
    d. Ability to charge higher lease rates due to increased attractiveness of the building to tenants (as a result of a, b, and c)
    e. Decreased insurance premiums
    f. Tax incentives
    g. Increased chance of receieving financing or lower finance rates
    h. It is “the right thing to do”
    i. Other?

12. In addition to structural integrity of the building, what support systems might be essential to ensuring building resilience? e.g., heating systems, power, and telecom and cyber connections.

13. In looking at the resilience of a building, how much would one need to look at the surrounding environment including other infrastructure?

14. Where would resilience be introduced? Initial planning, design, construction, operations, etc?

15. Is there anything that I missed?

16. Are there any comments that you would like to add to this interview?