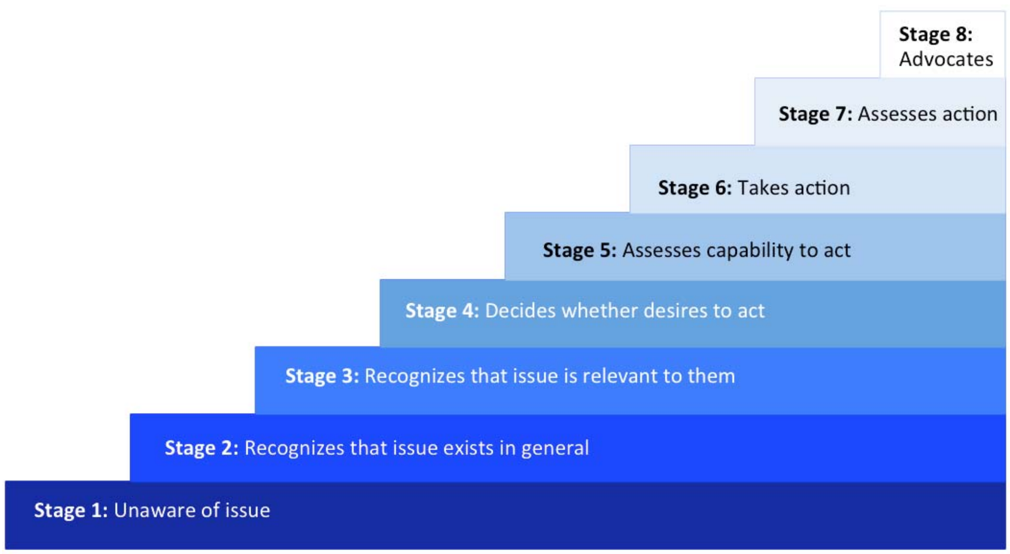
ATC 58-6

Recommendations for communicating seismic performance considerations in design decision-making



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Cover illustration: Illustration of eight-stage process for how stakeholders change their behavior.

ATC-58-6

Recommendations for Communicating Seismic Performance Considerations in Design Decision-Making

by

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Preface

In 2001, the Applied Technology Council (ATC) was awarded the first in a series of contracts with the Federal Emergency Management Agency (FEMA) to develop Next-Generation Performance-Based Seismic Design Guidelines for New and Existing Buildings. These would become known as the ATC-58 series of projects. The overall program was separated into two major phases of work: (1) Phase 1: Developing a Methodology for Assessing the Seismic Performance Assessment of Buildings; and (2) Phase 2: Developing Performance-Based Seismic Design Procedures and Guidelines.

Development of the Phase 1 assessment methodology was completed in 2012 with the publication of the series of volumes collectively referred to as FEMA P-58, *Seismic Performance of Buildings, Methodology and Implementation*:

- FEMA P-58-1, *Seismic Performance Assessment of Buildings, Volume 1 – Methodology* (FEMA, 2012a)
- FEMA P-58-2, *Seismic Performance Assessment of Buildings, Volume 2 – Implementation Guide* (FEMA, 2012b)
- FEMA P-58-3, *Seismic Performance Assessment of Buildings, Volume 3 – Supporting Electronic Materials and Background Documentation* (FEMA, 2012c)

In the FEMA P-58 methodology, performance is measured in terms of the probability of incurring casualties, repair and replacement costs, repair time, and unsafe placarding. Since its initial development, the methodology has been expanded to include the probability of generating environmental impacts, including additional embodied energy and carbon.

Upon completion of Phase 1, work began on Phase 2. Designated the ATC-58-2 Project, the purpose of this next phase of work is to: (1) develop products that assist stakeholders in selecting appropriate performance objectives for buildings of different occupancies; and (2) assist design professionals in efficiently developing building designs that meet these objectives.

This report was developed by the ATC-58-2 Stakeholder Products Team to summarize background information that was developed to determine necessary guidance products for complementing the detailed engineering products being developed by other teams.

The FEMA P-58 series of products is the result of the collaborative effort of more than 200 individuals, across all phases, involved in the development of the underlying methodology and subsequent products and reports. ATC is particularly indebted to the Phase 2 leadership of Ron Hamburger (Project Technical Director), John Gillengerten (Performance Products Team Leader), John Hooper (Products Update Team Leader), Laura Samant (Stakeholder Products Team Leader), and the members of the Project Management Committee, including Bill Holmes (Steering Committee Chair), Steve Mahin, Jack Moehle, Khalid Mosalam, and Steve Winkel.

ATC would also like to thank the members of the Project Steering Committee, the Performance Products Team, the Products Update Team, the Stakeholder Products Team, and the many consultants who assisted these teams as part of the Phase 2 work effort. The names of individuals who served on these groups, along with their affiliations, are provided in the list of Project Participants at the end of this report.

ATC also gratefully acknowledges Michael Mahoney (FEMA Project Officer) and Robert Hanson (FEMA Technical Monitor) for their input and guidance in the conduct of this work, and Carrie Perna for ATC report production services.

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Executive Summary

The ATC 58-2 Stakeholder Products Team is charged with developing guidance products that motivate stakeholders to use a performance-based approach to seismic risk decision-making and enable stakeholders to effectively use the FEMA P-58 methodology. These guidance products will cover non-engineering topics, and will complement detailed engineering guidance being developed by other teams.

This report explores how to produce non-engineering guidance products for stakeholders of the FEMA P-58 methodology that will be effective, useful, and appealing to their target audiences. Through workshops, interviews, literature reviews, and professional experience, the report gathers insights, including the following:

- Guidance products should focus on two critical audiences: building owner representatives, especially those who are concerned about post-earthquake recovery and functionality, and the structural engineers who work with them. Architects and other professionals involved in building design and construction teams could also benefit from guidance materials.
- Guidance products should specifically target likely early users of the FEMA P-58 methodology—building owners and design professionals concerned with earthquakes—because the successful use of the FEMA P-58 methodology by this group will promote further use of the methodology.
- Relevant stakeholders exist simultaneously in different stages of making a decision about whether to use a new approach, such as the FEMA P-58 methodology, at any given time. The stages involved in changing behavior can be modeled as illustrated in Figure ES-1. Products should target stakeholders with varying knowledge and in a range of stages of becoming aware of performance-based decision-making and deciding to use the FEMA P-58 methodology.
- Products will be most effective if they each deliver consistent but tailored and accessible messages in the context of where, when, and how these stakeholders are already working.

Based on these insights and others that appear throughout the report, as well as guidance from project reviewers, four products have been selected to provide non-engineering guidance to stakeholders of the FEMA P-58 methodology. Table ES-1 presents these four products and indicates the target audiences for each. These products and their intended audiences and outcomes are described in greater detail in Chapter 7 of this report.

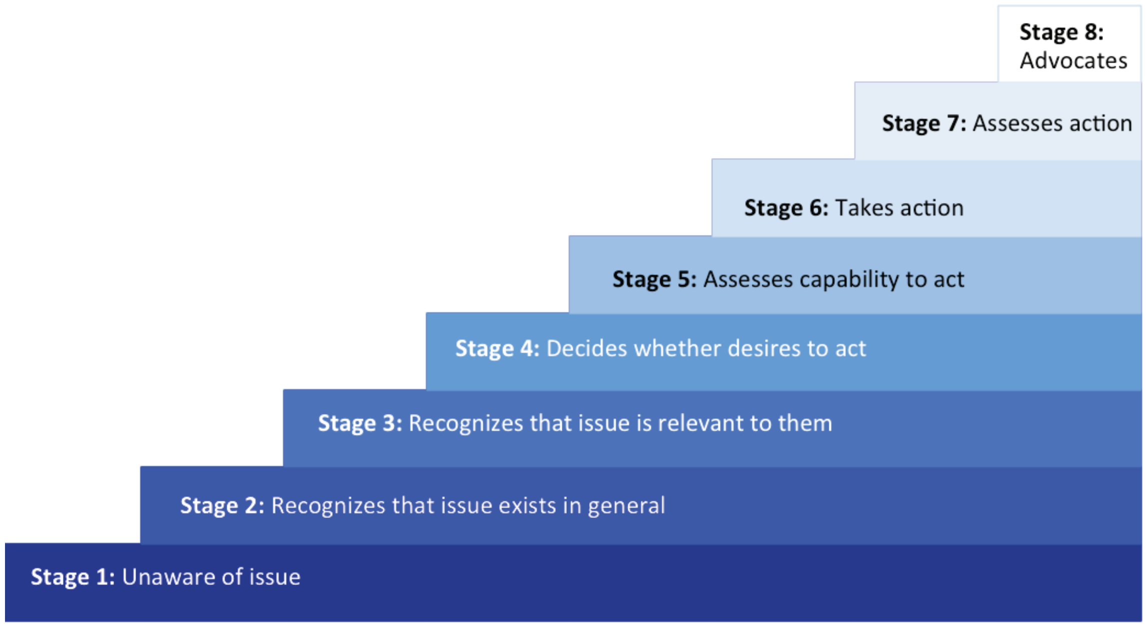

Figure ES-1 Illustration of eight-stage process for how stakeholders change their behavior.

Table ES-1 Selected Stakeholder Guidance Products

Guidance Product	Target Audience
Checklist/Quiz: Would Your Project Benefit from Performance Based Design?	Building owner representatives
Guideline: Practical Aspects of Using FEMA P-58 for a Project	
Graphic and Pamphlet: Communication of Performance Objectives	All stakeholders
Website Framework: Dissemination of FEMA P-58 Technical and Stakeholder Guidance Information	

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Chapter 1

Introduction and Report Orientation

Earthquake engineering is in the midst of an evolution. This evolution, which has been underway for several decades, is resulting in a range of approaches for earthquake-resistant building design and analysis, from a prescriptive code-based approach to a performance-based approach. The recent development of the FEMA P-58 methodology (FEMA, 2012) is a milestone in this evolution because it enables engineers to rigorously quantify structural and nonstructural damage and their consequences for a single building. This is the information needed for performance-based decision-making.

The ATC 58-2 Stakeholder Products Team is charged with developing guidance products that motivate stakeholders to use a performance-based approach to seismic risk decision-making and enable them to effectively use the FEMA P-58 methodology when that is the appropriate tool for their task (see Appendix A for more background on the project and its history). For this report, stakeholders are broadly defined as people who make or influence decisions related to the seismic risk of buildings: this list of people can include building owners and investors, tenants, lenders, insurers, building officials, design professionals, among others.[1] The Stakeholder Products Team is focused on developing products that provide non-engineering guidance to these stakeholders.

This report builds a case for and recommends guidance products to be produced for stakeholders. This first chapter begins by examining the evolution of performance-based earthquake engineering, which creates the need for guidance as stakeholders are faced with new ways to approach seismic risk decisions for buildings. Then, the chapter presents goals for what guidance products should seek to accomplish. The chapter ends by summarizing the structure of the rest of the report and how it identifies recommended guidance products to achieve the project's goals.

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[1] A more detailed definition and discussion of stakeholders as used in this report appears in Appendix B.

1.1. Evolution of a Performance-Based Approach

Building codes present a series of rules or procedures for designing building structural systems. When designing a building, a structural engineer needs to demonstrate that his or her design meets these rules. Applying the code-specified procedures is deemed to achieve an acceptable level of safety in the largest earthquakes likely to affect a building and to reduce property damage and economic loss in more frequent, moderate earthquakes. However, code-compliant buildings can vary widely in the actual amount of damage they experience in an earthquake. An engineer is not required to evaluate what amount of damage is expected of the building he or she is designing; instead, he or she is required to check that the design meets the rules of the code. Not only is the expected damage to new, code-designed buildings variable, it is also unknown to many stakeholders: engineers typically discuss buildings as "meeting code" and are not explicit about what that means in terms of expected building damage in earthquakes.

A performance-based approach is different. Performance-based design begins with defining how much damage is acceptable to the building owner and other decision-makers, which is referred to as building performance. Then, an engineer makes a preliminary design, checks the design's performance capability against the desired performance and, if needed, makes adjustments to the design until the desired performance is achieved. A building designed in this way may or may not meet the rules of the building code, but the expected performance might be equivalent to or better than that obtained using prescriptive design approaches. In fact, many early users of performance-based design wanted to use innovative or more efficient designs than those allowed by the code, and then sought regulatory approval by demonstrating that their design met the performance goals of the building code.[2]

The shift to performance-based thinking began in the mid-1980s when there began to be recognition that most of the risk of damage to buildings in earthquakes in the United States was concentrated in older buildings that were designed according to outdated building codes or before codes were enacted. Building owners began to ask engineers what would happen to a specific building if an earthquake occurred and how much that damage would be reduced through a seismic retrofit. These are fundamentally different questions than whether the building complies with the rules of the building code, and engineers did not have the analysis tools to answer these

[2] This practice is at the discretion of local building departments. Some large cities allow this, but not all jurisdictions are comfortable with the practice.

questions well. In response, the Federal Emergency Management Agency (FEMA) sponsored a series of projects to develop analysis approaches to answer these questions. The ASCE/SEI 41-13 standard, *Seismic Evaluation and Retrofit of Existing Buildings* (ASCE, 2014), and the outgrowth of these projects, defines today's practice of performance-based earthquake engineering.

ASCE/SEI 41 provides a menu of discrete options to help a structural engineer decide upon the desired building seismic performance with a building owner or other decision maker. A performance objective combines decisions about how much damage is acceptable to a building's structural system and non-structural components (referred to as building performance levels) when exposed to a specific level of ground shaking. Each building performance level—"Operational," "Immediate Occupancy," "Life Safety," and "Collapse Prevention"—qualitatively describes a range of building damage that relates to important consequences.

The performance-based procedures of ASCE/SEI 41 have been widely embraced by the structural engineering community, with the recognition that they have some important shortcomings, including the following:

- Performance is expressed qualitatively, not quantitatively, and expected damage to specific building components is not clearly identified.
- Performance is expressed in ways that are not always meaningful to decision-makers. The performance levels used by ASCE/SEI 41 (e.g., Immediate Occupancy, Life Safety, etc.) conflate the different types of losses caused by earthquakes: dollar losses, deaths, and downtime. The titles of each performance level can be misleading because they refer to only one type of loss and obscure uncertainty.
- The performance of nonstructural components, a major source of economic loss, could be addressed more rigorously.
- The uncertainty associated with the actual attainment of performance goals is not articulated.
- The acceptance criteria in ASCE/SEI 41 are rigid: if one building element of marginal importance does not meet the acceptance criteria for a performance state, the entire building is considered to not meet that performance.

The ASCE/SEI 41 methodology is a major shift from a code-based approach. It requires explicit decisions about performance objectives. However, the shortcomings listed above indicate the need for a more direct approach for performance-based design and decision-making.

1.2. The FEMA P-58 Methodology: A Milestone

The FEMA P-58 Methodology, released in 2012 after years of development, is the state-of-the-art approach to performance-based earthquake engineering. It directly calculates damage to structural and non-structural components of a building and the consequences of this damage, including casualties, cost of building repair, time for building repair, and damage tag color. The FEMA P-58 methodology uses sophisticated mathematical modeling techniques and state-of-the-art fragility functions. It is based on the best research currently available. The methodology was developed with a companion computer program, the Performance Assessment Calculation Tool (PACT), which enables users to make calculations according to the FEMA P-58 methodology.[3] The ATC 58-2 team is currently working to add quantification of building lifecycle environmental impacts to the FEMA P-58 methodology.

In a macro-sense, the overall approach for performance-based decision-making is the same using first generation ASCE/SEI 41 procedures and the next generation FEMA P-58 methodology: an engineer and a building owner agree upon a performance objective, the engineer checks whether a building or a building design meets that objective, and then changes are made to make the building performance and performance objective align. However, the FEMA P-58 methodology provides greater rigor in understanding building performance and offers more flexibility in making design decisions that reflect the priorities of a property owner. Using the FEMA P-58 methodology, a building could be designed to have an expected 30 days of repair time after the design level earthquake shaking, with a specified amount of uncertainty. This is a big technical advance over the grouped, qualitative performance objective options in ASCE/SEI 41.

1.3. Goals for Stakeholder Guidance Products

The ultimate goal of the ATC 58-2 stakeholder guidance products is to encourage a performance mindset among stakeholders. This means that all parties involved in making and shaping decisions that affect the earthquake risk of buildings consider the issue in terms of how much damage and disruption is acceptable to their buildings and the activities that take place within them. Spreading and deepening awareness about what performance-

[3] In the future, commercial developers are expected to develop alternate software packages that enable calculations using the FEMA P-58 methodology in a user-friendly fashion.

based design is and can do is fundamental to increasing acceptance, demand for, and repeated use of the FEMA P-58 methodology.

Specifically, stakeholder guidance products will:

- Motivate stakeholders to use a performance-based approach to seismic risk decision-making; and
- Enable them to effectively use the FEMA P-58 methodology when that is the appropriate tool for their task.

A performance mindset goes beyond the structural engineer and the design of the structural system. For example, the architect and other design and construction professionals need to consider how the elements they control, such as cladding or selection or installation of mechanical systems, relate to performance.

The larger goal of FEMA's efforts to advance performance-based earthquake engineering, including the development of the FEMA P-58 methodology, is to provide stakeholders with tools to make better-informed decisions about buildings and, over time, to improve the earthquake resilience of the building stock of the United States. In some cases, the FEMA P-58 methodology will be the most appropriate way to consider performance in design choices and analysis, but it will not be appropriate for all users or in all situations. Prescriptive codes will remain important to guide the design of most buildings. In time, the FEMA P-58 methodology is expected to improve the quality and consistency of building code provisions, increasing their ability to articulate and meet performance goals, which will directly improve general practice even for those stakeholders who never use the FEMA P-58 methodology first-hand.

Guidance products could take many forms; they could include publications, online resources, mobile applications, presentations, videos, training curricula, or other materials. The way those guidance products are presented, their appeal and design, and how they are released and distributed contribute to their effectiveness. A coordinated campaign, in which a series of products that complement each other are distributed over time, can be most effective.

These products could focus on a variety of audiences. Numerous types of organizations could benefit from the use of the FEMA P-58 methodology. These include corporate, institutional, and private building owners and tenants, design professionals, building departments, and other government agencies, to name a few. Appendix B presents a list of the variety of types of stakeholders considered for this project. Within each of these organizations, various people with differing backgrounds, levels of expertise, types of authority, and roles might participate in decisions regarding construction, renovation, purchasing, and leasing buildings. These stakeholders include high-level organization leadership, mid-level management, risk managers, in-house facilities managers, and outside service providers that work with these organizations, including design professionals, lenders, and insurers. Some stakeholders are currently using performance-based decision making for structural design and analysis, whereas others continue to use a code-based approach. Products targeted to each of these audiences need to reflect the needs, knowledge, interests, and motivations of the audience.

1.4 Report Structure

The remainder of this report focuses on analyzing how to meet the project's goals—to develop products that motivate stakeholders to use a performance-based approach to seismic risk decision-making and enable them to effectively use the FEMA P-58 methodology when that is the appropriate tool for their task. The report is organized as follows:

Chapter 2 summarizes the methods used by the project team to collect, synthesize, and analyze information about stakeholders and how to provide meaningful guidance to them. These methods include reviewing academic literature, conducting workshops, and conducting a series of in-depth stakeholder interviews. At each stage, insights emerged from the varied backgrounds and experience of the Stakeholder Products Team members.

Chapter 3 lays out a theoretical framework that explains how stakeholders decide to adopt new ways of doing things. Effective guidance products will recognize and enhance this process.

Chapter 4 presents and analyzes information about how stakeholders currently make decisions related to building seismic risk. This includes assessing the factors that are important to different types of stakeholders, describing how various stakeholders work together, explaining the key criteria used to make decisions, and elaborating on how the process varies based on the different types of decisions stakeholders make related to buildings. This chapter also examines the current status of performance-based decision-making among likely early users of the FEMA P-58 methodology.

Chapter 5 presents and analyzes information about how to communicate information about the earthquake risk of buildings for stakeholder decision-making. This includes a review of relevant literature on risk communication, as well as reporting insights that was shared with the Stakeholder Products Team on the types of information that is most meaningful to them and communication approaches that have been successful in the past. This chapter also presents detailed reactions of stakeholders to specific visuals that were shown during stakeholder interviews. In addition, this chapter provides information about current stakeholder perceptions of the FEMA P-58 methodology and perceived barriers to its use.

Chapter 6 offers a compilation of all of the recommendations from preceding chapters that should shape stakeholder guidance products. This chapter also summarizes the process used to transform these insights into a list of recommended guidance products.

Chapter 7 recommends specific stakeholder guidance products that should be considered for production. The products focus on a range of stakeholders in various stages of deciding to adopt a performance mindset.

Appendices provide background information supporting the findings in the report. Lists of references and project participants are provided at the end of this report.

Chapter 2

Methods to Collect and Analyze Information Relevant to Stakeholder Guidance Products

This chapter presents the specific data collection and analysis activities that the Stakeholder Products Team undertook to derive the findings and recommendations in this report. In brief, the methods included reviewing the existing relevant social science knowledge base, convening workshops, conducting a series of in-depth stakeholder interviews, and drawing on the considerable and diverse knowledge bases and experience of Stakeholder Products Team members. The activities took place from summer of 2013 to spring of 2015. For efficiency of presentation, as much as possible of the background and details are presented in Appendices C through F.

2.1 Academic Literature Review

A wealth of social science evidence exists that can inform the development of FEMA P-58 Stakeholder guidance materials. This report reviews existing knowledge about how people and organizations change beliefs and behaviors. Specifically, this work explores what is already known about what motivates people to do new things in general, to adopt new risk reduction behaviors specifically, and how successful new ideas, habits, or behavioral norms are born and spread in a modern, technology-driven society.

The literature review topics examined in this report, presented in Chapters 3 through 5, are:

- social-cognitive theories of behavior change;
- diffusion of innovation;
- qualitative methodologies for understanding individual and organizational decision-making;
- individual, building owner, and organizational-level earthquake risk reduction behavior; and
- best practices in disaster risk communication.

As part of this work, team members performed brief literature searches and summarized relevant theories and evidence for the group. The literature review enabled the team to create a theoretical framework to drive the recommendations in this report, and helped inform the decision to conduct interviews as well as shaping how those interviews were done (as described in Section 2.3 below).

2.2 Stakeholder Workshop

The first data collection effort undertaken for this project was to organize a FEMA sponsored stakeholder workshop in September of 2013. This workshop mirrored a similar workshop that was conducted in 2002 during the development of the FEMA P-58 methodology. The purpose of the 2013 workshop was to revisit, via direct conversation, the decision-making needs of various stakeholder groups, and to better understand how the seismic performance information produced by the FEMA P-58 methodology might best be used in decision-making processes. Workshop attendees represented a broad range of stakeholders involved in building development and management decision-making, including building owners and developers; lenders and insurers; institutional, civic, and corporate building managers; building officials; and design professionals.

This workshop stimulated in depth discussion between stakeholders and triggered ideas for further exploration. Specifically, the workshop provided a forum for interaction among these different stakeholder groups as to how various seismic risk-related decisions are currently made, and how seismic performance assessment results could be effectively used as part of the building design and procurement process. The types of decisions explored included those associated with: (1) new building design; (2) existing building retrofit; (3) lending and financing; (4) insuring; (5) purchasing; (6) renting; and (7) emergency preparedness/risk planning activities.

Specific insights that emerged from the workshop are documented in the ATC-58-4 report, *Proceedings of FEMA-Sponsored Workshop on Communicating Seismic Performance Metrics in Design Decision-Making* (ATC, 2014a). The present report also incorporates these insights in Chapters 4 and 5.

2.3 Stakeholder Interviews

From April to September 2014, the Stakeholder Products Team conducted, recorded, and transcribed a series of in-depth interviews with stakeholders both in person (when possible) and over the telephone. The purpose of these interviews was to better identify appropriate audiences for FEMA P-58 stakeholder guidance products, and understand what types of guidance would be most useful to and used by those audiences. The interviews sought insights into how organizations within different stakeholder groups currently make risk decisions (such as the process used and individuals involved when constructing or renovating a building), as well as how and when the FEMA P-58 methodology might be used (or not) and by whom. Interviewees were also asked to react to various presentations of information about earthquake risk and to comment on clarity, usefulness, and preferences. Appendix C presents the set of interview guides and presentation graphics used.

2.3.1 Rationale for Using Qualitative Methods

The team decided early on to conduct guided, semi-structured, in-depth interviews, which allow the interviewer to capture a wide a range of perspectives on a consistent set of topics with a moderate time commitment on the part of both interviewer and interviewee.

Qualitative methods are especially suited to contexts where people are encountering new or hypothetical information, objects, or concepts about which they have not yet formed conscious or cohesive beliefs or opinions. This fits the case for the FEMA P-58 methodology, a new technical method for analyzing earthquake risk, and for seismic risks in general, given the infrequent, unfamiliar, and abstract nature of earthquake events for many people. Further discussion of the merits and limitations of using a qualitative interview approach are provided in Appendix F.

2.3.2 Identifying Interview Respondents

The Stakeholder Products Team focused on finding stakeholders who were judged by the team to be likely early users of the FEMA P-58 methodology, because early users represent the group most likely to respond to initial guidance products.[4] Early users of a new approach influence stakeholders that are slower to adopt new approaches, either positively or negatively, and thus are frequently the focus of guidance materials.

For this kind of project, it is not feasible or desirable to randomly select a statistically representative sample of potential users. Such a sample would likely under-represent engineers and end-users with performance-based earthquake engineering experience in selected geographic areas with high seismicity. Instead, the project team chose a *purposive sample*, one that purposefully included a set of participants that represents a pre-determined

[4] In particular, the team sought to interview likely *innovators, early adopters* and *early majority* users of the FEMA P-58 methodology. This concept, from diffusion of innovation, is discussed more in Chapter 3.

range of perspectives. Specifically, the team recruited interviewees from members of two groups:

- Building Owner Representatives—defined as building owners and occupants from private companies (high-tech, manufacturing, real estate, and other businesses sensitive to downtime after an earthquake), local government, universities, utilities, and cultural institutions.
- Structural Engineers—defined as persons having direct experience in assessing earthquake damage to structures or in designing structures for earthquake resistance, including a couple of known critics of the FEMA P-58 methodology.

In addition, two interviews were conducted with other types of stakeholders (referred to as Other Stakeholders), specifically a building official and a person in the finance industry.

By September 2014, the team had completed 21 interviews representing thirteen building owners, six structural engineering experts, and two other stakeholders. Table 2-1 below shows a breakdown of interviewees.

These respondents worked predominantly in San Francisco, Los Angeles, and Seattle. The team chose to focus on interview subjects in these locations because these are the cities in the United States most likely to experience the

Table 2-1 Interviewees by Stakeholder Category and Organization Type

Stakeholder Category	*Organizational Type*	*# of Interviews Conducted*
Building Owner Representatives	Corporation sensitive to downtime	3
	Cultural institution	1
	Local government entity	5
	Academic institution	2
	Utility/Lifeline	2
	Building Owner Representative Subtotal	13
Structural Engineers	Critic	2
	User/potential user	4
	Structural Engineer Subtotal	6
Other Stakeholders	Building official	1
	Architect	0
	Financial industry	1
	Other Stakeholder Subtotal	2
	Overall Total	**21**

destructive effects of earthquakes, and accordingly have the largest population of stakeholders who have a legitimate interest in the subject.

Candidate subjects were identified by word of mouth and through contacts within the personal networks of the project team. Additionally, at the end of each interview, individuals were asked to suggest other potential interviewees. There was special effort put into recruiting divergent opinions, especially among the Structural Engineers group. Among the Building Owner Representatives group, many of the organizations represented are innovators, and some are already participating in the FEMA P-58 methodology development process.

Interviewees were assured that care would be taken to keep any information they shared anonymous, with no use of identifying names or information in any final public products. All but one interview was audio recorded with prior permission of the participants.

The most difficult target group to identify and recruit for an interview was corporations sensitive to downtime. A number of potential interviewees in this category declined to be interviewed.

Throughout the report the purposive sample of interviewees are referred to as *earthquake-concerned stakeholders*, because the individuals interviewed were selected based on their existing interest in making sound earthquake risk management decisions. The building owner representatives and engineers interviewed are a select and knowledgeable group. In general, they already are aware of performance-based approaches and are presumed to be potential early adopters of the FEMA P-58 methodology.

2.3.3 Overview of the Interview Process

Once the sample was identified, the following process was used to conduct the stakeholder interviews:

- The team prepared an interview guide (Appendix C), which is a rough script of general topics, specific questions, and possible follow-up prompts for the interviewer to use.
- The team prepared sample visual outputs (Appendix C) to be presented and discussed during each interview, consisting of two- or three-pages with five visuals showing hypothetical results produced by the FEMA P-58 methodology.
- For Round One interviews, six interview respondents were identified from a range of sectors to test the interview guide and to evaluate the

effectiveness of the interviews at producing valuable information. Those interviews were recorded and professionally transcribed.

- Team members reviewed the first six written transcripts and decided to conduct additional interviews using an updated set of visuals and interview guides.
- The team conducted fifteen additional interviews in Round Two, with each team member completing about five interviews each. These interviews were also audio recorded and transcribed.

2.3.4 Analysis Process for Interview Data

All team members read and annotated the interview transcripts and identified recurring messages and important insights using their judgment. These observations were summarized in key points that were shared and discussed with other team members, essentially a set of opportunities and challenges to be considered when preparing guidance materials and the dissemination strategy.

The interview transcripts were also systematically analyzed using Atlas.ti 7.5,[5] a Computer-Aided Qualitative Data Analysis (CAQDA) software program. CAQDA helps researchers uncover, document, and meaningfully depict complex phenomena hidden in unstructured data. The program provides tools that let the user locate, code, and annotate information in primary data material, to weigh and evaluate their importance, and to identify patterns, themes, or relationships between them.

The analysis process begins by defining key themes that relate to the various topics of discussion raised during the interviews, such as building codes, life safety concerns, or factors in renovation decision-making. For example, all quotes relating to the process interviewees use when making decisions about acquiring a building were tagged with the key theme *acquire decision process.* Appendix D describes this process in more detail and lists all key themes and their definitions.

Following the analysis process, Atlas.ti was used to produce descriptive reports summarizing which types of stakeholders mentioned which concepts and how often. Also, the team used Atlas.ti to assemble sets of quotations that related to key research questions, and then distributed among the team the responsibility of combing through the quotes for common and contrasting themes and insights.

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[5] Further information available from: http://www.atlasti.com/

2.4 Performance Products Team Workshop

The ATC 58-2 Performance Products Team held a workshop with structural engineers on August 14, 2014 in San Francisco. This workshop was primarily intended to provide the Performance Products team insight into the archetypes that should be used to benchmark the performance of code-conforming buildings. However, the workshop also provided an opportunity for structural engineers to comment on the way they work with building owner clients, and the products that could help them better work with those clients. This workshop provides some insights from the perspective of practicing structural engineers that are relevant to guidance products for stakeholders, which have been incorporated into the recommendations in this report. This workshop is documented in the ATC-58-5 report, *Proceedings of FEMA-Sponsored Workshop on Design Guidance and Tools to Implement Next Generation Performance-Based Seismic Design* (ATC, 2014b).

2.5 Development of Evaluative Criteria to Prioritize and Plan Guidance Product Development Activities

Using all of the sources of information described in the preceding sections, the team used the following steps to agree on key findings, implications, and recommendations:

- Identified and summarized key concepts that emerged about stakeholders and building decision-making in Chapters 3, 4, and 5.
- Identified key implications and take-away points for each topic, presented as tables at the end of each section in Chapters 3, 4, and 5 and succinctly summarized in Chapter 6.
- Developed a comprehensive list of possible guidance products for stakeholders (Appendix G).
- Performed a rapid evaluation of each proposed guidance product idea, identifying target audience, targeted stage(s) of behavior change, and making judgments on effectiveness, order-of-magnitude cost to produce, and feasibility to produce.
- Identified a short list of top candidate guidance product ideas for further investigation, which was reviewed by a broader group to finalize products to be produced, presented in Chapter 7.

Chapter 3

Theoretical Foundations for Behavior Change

The FEMA P-58 methodology is new and its use by stakeholders requires a change in behavior. Not surprisingly, the academic literature from the social sciences contains many insights on how and why individuals and organizations adopt new approaches and change the way they make decisions, and the types of information and information delivery approaches that are likely to be more or less effective at facilitating change.

The project team set out to understand and consider how to apply existing best practices about how, when, and why organizations and individuals change their behaviors, and what types of information and presentation formats most readily promote change. Two general social science concepts were found to be particularly compelling: stage-based theories of behavior change and sociological theories of how innovations diffuse in a populace and evolve over time. This chapter presents the theoretical framework the project team created for approaching this charge.

3.1 Social-Cognitive Multi-Stage Theories of Behavior Change

Multi-stage theories of behavior change describe a step-like process where a person or organization gradually becomes aware, interested, motivated, capable, and committed to taking action and then finally follows through (Armitage and Conner, 2000). A key prediction from stage theories is that different communication messages will be more effective for users at different stages of the behavior change process. The starting point is identifying current beliefs and practices of the audience for which behavior change is desired. Then, interventions can be matched to the behavior stage of the target audience. By doing so, products can be designed that better address information needs or barriers to change that are specific to persons in that stage, as well as avoiding discussion of barriers that are only relevant to different stages (Weinstein et al., 1998).

Stage-based theories suggest an intuitive sequencing for information delivery to different audiences and chart intermediate progress towards the ultimate goal of action-taking. It indicates that belief and behavior change efforts should be designed for and targeted to certain audiences and specifically tell each group how they can figure out how the issue relates to themselves and what next steps are available. Individuals who already perceive they are at risk are natural early targets.

At different stages, different types of information and forms of presentation are most effective at changing behavior. In the early behavior change stages, emotion is an important attention-getter and motivator. Evoking surprise, outrage, curiosity, and a search for more information is a key factor in motivating someone to do something new. At first, people tend to discount or ignore new information that invalidates their existing beliefs. People are often most influenced by observing the behaviors of others.

Behavior change is driven by more than scientific and technical facts. Beliefs about the recommended behavior might matter as much or more than beliefs about the underlying risk or threat. People want to know not only that an option to manage a risk exists, but that pursuing that strategy will not harm their social standing. People will be more likely to try a new approach if they feel they will experience either tangible benefits (e.g., competitive edge), personal identity enhancements (e.g., perceived as prudent, responsible, a leader, or cautious), or social status benefits from doing so. Appraisals of psychological and social implications can be important motivators, or de-motivators.

3.1.1 The Stakeholder Products Team's Stage-Based Framework

This section presents an eight-stage process—from ignorance to awareness to execution to advocacy—developed by the project team to model how an organization proceeds to change the way it does things. This eight-stage process is used to categorize stakeholders with varying levels of knowledge and differing concerns, and to target appropriate messages to each audience. This model is presented in Figure 3-1 and described in the text that follows.

- **Stage 1 – Unaware of issue.** Potential decision makers are not aware that building performance in earthquakes is an important concern for society, much less for themselves specifically.
    - In this stage, people are highly unlikely to actively seek information and highly likely to discount any new information they accidently encounter. Evoking surprise and appropriate outrage through credible sources can be effective ways to reach people in this stage.

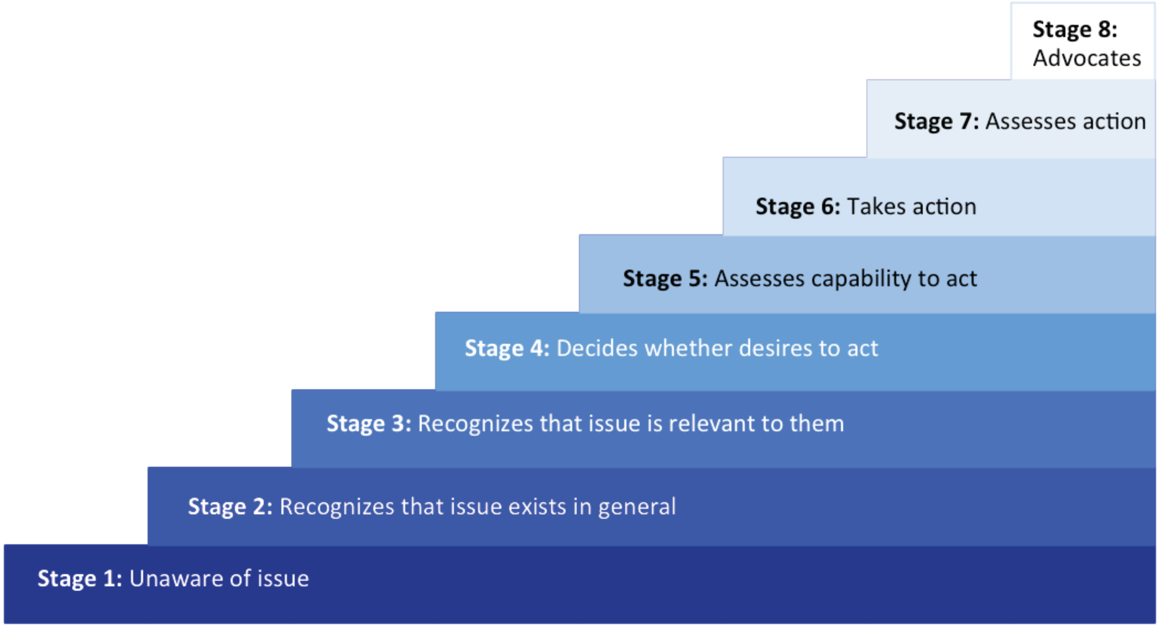


Figure 3-1 Illustration of eight-stage process for how stakeholders change their behavior.

- **Stage 2 – Recognizes that issue exists in general.** Potential decision makers are aware that building performance in earthquakes is an important concern for society, but have not considered how it relates to themselves specifically.
  - In this stage, target audiences are most in need of information about simple, low-cost steps to help them determine whether they might be in a higher than average risk category and the potential consequences of being at high risk.
  - Persons in this stage benefit from encountering new information through channels that they already use and pay attention to, such as print, TV, or online media. Information from people they consider to be peers or similar to them can be especially effective at changing opinions.
- **Stage 3 – Recognizes that issue is relevant to them.** Potential decision makers are aware that building performance in earthquakes might affect them and consider it an important issue relative to their own situation and goals. They understand that it is possible to make decisions about buildings by considering building performance and generally think this is a good thing to do.
  - In this stage, target audiences are most in need of personally relevant information about the likelihood, magnitude and types of risks they currently face.

- At this stage, it is important to instill a general sense that feasible, cost-effective actions exist that could help them, if they find the risk to be severe enough to warrant action. Referrals of experts and examples of successful action-taking by people or organizations they perceive as peers can be particularly powerful ways to do this.

- **Stage 4 – Decides whether desires to act.** Having concluded that it may be in their best interest, decision-makers in this stage are actively seeking out information as part of considering whether and how to incorporate earthquake performance into their building decisions.
  - The potential user needs to assess that the advantages of using a new approach exceed the potential downsides of trying something new, and that others whose opinions they value (or compete against) are using it.
  - People in this stage need expert advice and will need to form new relationships in order to obtain it. They need information from neutral third parties that helps them find trustworthy candidate experts to potentially work with.
  - In this stage, people need to know the steps involved in potential remedies. These steps and their benefits are best explained by neutral, trusted sources, such as more experienced peers, government institutions, and respected professional organizations.
- **Stage 5 –Assesses capability to act.** Potential users, having decided that they want to make performance-based decisions for the earthquake risk of their buildings, now assess whether they are capable of doing so.
  - Capacity to take action includes a number of dimensions that may vary in importance to different potential users:
    - **Personal.** Believing that they have the duty, authority, will, support from others, and/or self-efficacy to advocate for and carry out such a project.
    - **Technical.** Believing that their staff or consultants are qualified to use performance-based decision-making appropriately and successfully.
    - **Financial.** Believing that they can afford to use it and that it will be financially justifiable to persons whom they are accountable to, and ultimately worth the costs.
    - **Practical.** Believing a performance-based approach will work within the timelines and processes their organization uses for

decisions related to buildings (or that they can change their process to accommodate the use of performance-based decision-making), as well as within other logistical constraints (e.g., relocating tenants during construction period).

  - In this stage, decision-makers may especially need support for advocating for a change in approach to their superiors or among other design team members.

- **Stage 6a – Takes action.** Stakeholders are in the process of making decisions about the earthquake risk of a specific building project using a performance-based approach.
  - The goals of guidance materials or communications at this stage should be to ease the path from project start to finish, minimize the costs of use, grow the competence and confidence of users, and maximize the potential success of each project application.
  - In this stage, decision-makers can benefit from support in actually carrying out their projects, such as technical assistance in finding and using appropriate tools or navigating difficult trade-offs that unfold during the course of their projects.
  - Non-expert, third party, peer-to-peer assistance, or user-driven networks, "FAQs," blogs, call-in lines, or other information sharing, learning systems, or best practice evaluation and collection systems can be of help at this stage.
- **Stage 6b – Decides not to act.** Decision-makers in this stage have consciously considered adoption of a performance-based approach but have decided it is not appropriate for their own particular circumstances or a specific project.
  - In terms of communicating with decision-makers in this stage, the most important thing is to admit that there are a variety of legitimate reasons not to adopt a performance-based approach in many situations.
  - Communicating widely that there are valid reasons why people might make this decision can be effective in helping other potential users decide whether or not the tool is for them. Importantly, it separates the issues of whether or not a methodology has merit from whether or not a methodology is appropriate for a particular person, organization, or decision context. Also, it promotes trust in the guidance communication system.

- **Stage 7 – Assesses action.** Users have completed at least one performance-based project or application of performance-based decision-making.
  - After using a new approach, a user may assess, either informally or formally, whether the new approach was an improvement over their previous approach and whether its benefits exceeded the costs and effort of using it. This judgment can be driven by many factors, such as the quality of the output of the new approach, the effort required to use it, the opinions or interest of colleagues about using the new approach, and perceptions about projected versus actual costs, among many others.
  - It is also possible that a user will have mixed feelings or decide that use in this particular case was not successful. In the latter case, the person may revert to Stage 6b.
  - Persons in this stage will likely have opinions about the contexts when use of the methodology would be most and least useful, and how they might do things differently for their next project.
  - This is an ideal group from whom communicators can seek to learn about user experiences in ways that will help customize and improve the tool over time and better understand the most viable and beneficial contexts of use.
- **Stage 8 – Advocates.** Adopters feel that the use of performance-based decision-making was successful and intend to use it again. These persons are willing to participate in spreading knowledge of the need, desirability, and feasibility of performance-based decision-making.
  - If early adopters find that performance-based decision-making was successful for their organization, this will do more to spread the use of the approach than anything else. These early adopters can be a powerful influence on others who are receptive to or want to try the approach.
  - People in this stage might benefit from formal public recognition of their actions and other social rewards for their success.
  - People in this stage can be recruited to speak publicly about their experience or contribute to case studies that can be used in future motivational or guidance materials.

Table 3-1 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 3-1 Implications for Guidance Products from Multi-Stage Theories of Behavior Change

Key Findings	*Relevance to Guidance Products*
People go through distinct stages as they decide to change their behavior.	Different information is relevant at each stage. Products should target a specific stage or stages and present the information relevant for that stage.
Information that triggers specific feelings and reactions can be effective at motivating change; at some stages this is more effective than presenting facts.	Guidance products should build on known motivators: • Evoke emotion, including surprise, outrage, and curiosity in products targeted to early stages. • Show how actions could produce tangible benefits, improve social standing, and result in other positive consequences. • Provide opportunities for people to learn about or observe behavior of respected peers (e.g., case studies, testimonials).

3.2 Diffusion of Innovation

The theory of diffusion of innovations—long relied upon by marketers and sociologists alike to explain how new technologies and ideas penetrate populations—posits that people and organizations adopt new approaches at different rates and for different reasons. A small number, sometimes called *innovators*, like to try new things early and require little encouragement and guidance to try a new approach. The second group to try something new, often called *early adopters*, is also inclined to try new things. Early adopters are more mainstream than innovators and are highly influential among their peers. The next group, called *early majority*, wait to decide to use a new approach until after they see others, primarily early adopters, use it successfully. Other groups adopt innovations later, again, mostly after they observe its successful use (Rogers, 2003).

The theory of diffusion of innovations marries well with the theory of stage-based behavior change. When faced with a new approach, a variety of stakeholders will exist in each of the various stages of behavior change. The pace and ease with which they shift their stages of behavior will vary, and will be influenced by observing others. Some stakeholders adopt change quickly; others never do.

The factors that affect decisions to try something new vary, but most people are influenced by observing the experiences of others. Many successful social improvement efforts target guidance at early adopters: their willingness to try new things and their influential social standing make them highly influential change agents (unlike innovators, who are seen as outside of the mainstream and less relevant). Ideally, a new approach will eventually reach a tipping point, at which the innovation has sufficient momentum to spread on its own (Rodgers, 2003; Gladwell, 2002).

Early adopters often help shape and refine a new approach. Innovations achieve greater use over time in part because early adopters point out flaws and demand high value refinements. Furthermore, with increased demand, economies of scale can reduce production costs that further expands the market. When early adopters reject a new innovation, this can be a serious setback that can take years to overcome (Rodgers, 2003).

Table 3-2 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 3-2 Implications for Guidance Products from Diffusion of Innovations Theory

Key Findings	*Relevance to Guidance Products*
Successful new technologies and ideas follow a pattern starting with a few early, sophisticated, eager users towards an eventual tipping point where the new approach becomes the norm.	Guidance products should be designed to support and accelerate natural patterns and known social and economic processes related to uptake, spread, and evolution of a new product or idea. In particular, guidance products should focus on early adopters.
Early adopters often seek to refine and shape innovations.	Guidance products should anticipate that the FEMA P-58 methodology itself might need to be refined and adapted over time in response to different kinds of users, as the diffusion process takes place.
Early adopters influence other users to try, or not try, a new approach.	It makes sense to invest resources to ensure that early adopters have a positive experience.

Chapter 4

How Stakeholders Currently Make Decisions Related to Buildings and Seismic Risk

Understanding the current beliefs and practices of stakeholders is a key first step in changing the way they do things. Thus, this chapter presents insights collected from a range of sources on how stakeholders currently consider seismic risk in their decision-making for buildings. It begins by presenting findings from academic literature on decision-making related to earthquake risk. Then, the chapter discusses what this project has learned about the aspects of earthquake risk that are of most concern to stakeholders. This is followed by an examination of how stakeholders consider seismic risk when new buildings are designed and existing buildings are renovated. Finally, the chapter explores the way stakeholders incorporate earthquake risk into decisions to purchase, lease, finance, or insure buildings.

4.1 Academic Literature on Building Owner and Organizational-Level Seismic Preparedness

A number of studies provide insights into business and organizational practices and decision-making around earthquake risk that are relevant to the goals of this report. Overall, this research suggests that preventative action about disasters in general and earthquakes in particular ends up relatively low on organizational priority lists—earthquakes are not and will never be the primary or even a large source of overall risk for many people or organizations. Even leaders that consider earthquake mitigation both desirable and possible have difficulty justifying putting earthquake risks ahead of other pressing issues on the agenda.

Studies show that numerous other concerns—both important and seemingly trivial concerns—can impede seismic mitigation goals. Leading researchers in this arena recently used qualitative methods to document and analyze the struggles of acute care hospitals in California and the state agency overseeing the program to assess and upgrade hospital facilities to meet state-wide seismic safety minimums (Alesch et al., 2012). Their principal finding is that institutional factors, including the culture, resource constraints, internal and external incentives, and a program's complexity, impeded progress towards the universally appealing aim of improved seismic safety in hospitals. Even in the context of a popularly supported public mandate, budgetary, political, and other organizational realities can delay mitigation progress for decades.

Research consistently shows that attitudes and behaviors about earthquakes are highly variable and driven by social context. For example, Olson and colleagues conducted one of the earliest efforts to use interviews to investigate the sociology of seismic safety in their assessment of public attitudes and policymaking in the Cities of Oakland and Los Gatos before and after the Loma Prieta earthquake (Olson et al., 1999). They found that cities with similar levels of seismic hazard and building vulnerability might adopt very different risk preparedness approaches based on their social, political, and economic histories and realities. There is no such thing as a "rational" risk assessment process that leads to consistent risk management decisions in different communities, organizations, or individuals. Context—including the geographic location, past and current conditions of the building stock, cultural history, socio-political context, demographic make-up of the community, whether the community has experienced a disaster in recent years, and so forth—is a critical driver of risk decisions.

Another qualitative study explored how building owners think about structural mitigation (Egbelakin et al., 2011). These New Zealand based researchers interviewed 35 real estate stakeholders in four communities with different levels of earthquake hazard and policy proactivity; about 15 of the respondents were building owners. In assessing barriers to motivating building owners to retrofit existing hazardous structures, the authors found that owners fear the cost implications of retrofits (owners equate high seismic performance with high cost) and have low levels of trust in the recommendations of engineers. In regions of low to medium risk, passive governmental approaches to the problem reinforce beliefs that earthquakes are not a large problem. In high hazard areas, study participants were highly concerned about the risk but skeptical whether losses could actually be mitigated. Finally, owners that had carried out retrofits were interested in receiving more recognition for their efforts.

Researchers, when looking at how organizations approach risk, find that risk decisions are shaped by key individuals within an organization, constrained by the cultural norms and procedural rules of the organization. In general, risk is considered in binary terms (something is *at risk* or *not at risk*), with an overemphasis on the upfront costs of reducing risk and a minimization of the future benefits of reducing risk. Often, organizations are more concerned about unacceptable costs than unacceptable risks. Organizations are most likely to take action to reduce risk when they perceive that the risk could lead to insolvency. When they do act, organizations seek simple decision rules, not complex analyses of risk. Details of risk management decisions are often in the hands of mid-level internal employees or consultants, but the big picture rules that shape decisions are frequently determined or reviewed by top-level leaders. Organizations sometimes assume that engineers are biased, seeking to err on the side of overemphasizing risk or reducing risk too much rather than too little. The language that organizations use to discuss risk matters. Posing decisions in terms of "acceptable safety" instead of "acceptable risk" can lead to higher safety goals (May, 2001).

Table 4-1 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 4-1 Implications for Guidance Products from Literature on Organizational Preparedness

Key Findings	*Relevance to Guidance Products*
Social context is a critical driver of risk decisions.	Guidance products need to reflect the importance of social context in stakeholder decisions, including organizational culture, incentive structure for individuals within an organization, past experience with earthquakes, and financial climate.
Barriers to action include assumptions that seismic issues involve high costs.	Be transparent about true costs of performance-based decision-making and use of the FEMA P-58 methodology, as well as potential cost savings.
Barriers to action include low levels of trust in engineering recommendations.	Build trust in the methodology and advise engineers how to build trust in their recommendations. Engage building owners in decisions about acceptable performance.
Barriers to action include skepticism about solutions and a perception of lack of clear benefits to action.	Show how quantification enabled by the FEMA P-58 methodology builds better understanding of solutions and options.
Barriers to action include lack of recognition for owners that address seismic risks.	Position performance-based decision-making as an approach taken by the most sophisticated stakeholders. Provide acknowledgment for trailblazing stakeholders.
Barriers to action include other higher priorities.	Link earthquake risk to other priorities. In particular, insolvency drives action.
Barriers to action include lack of personalized information on likelihood and consequences of earthquakes.	Show how to produce personalized information on the likelihood and consequences of earthquakes.
Choice of language can alter decisions.	When possible, pose decisions in terms of positive priorities (e.g., safety, functionality, profitability) instead of negative consequences (e.g., risk).

4.2 Aspects of Earthquake Risk that Concern Stakeholders

During the interviews and workshops, the project team asked decision-makers to describe their concerns about earthquake risk and building performance. A full description of the concerns is summarized in Table 4-2. Decision-makers are nearly unanimous in their concern for ensuring the safety of building occupants in an earthquake. Interviewees were also highly

Table 4-2 **Summary of Decision-Makers' Earthquake Risk Concerns**

Area of Concern	*Aspects of Concerns*
Safety	Primary concern of most organizations Defined by some as collapse risk Defined by some as safe evacuation post-earthquake Some acknowledge role of nonstructural building contents Sensitive topic for some stakeholders given potential for misinterpretation or distress of staff or public
Business continuity and downtime	Secondary concern of many organizations Defined by most as time to resume building occupancy Some acknowledge role of nonstructural items in downtime Relevant only to facilities that house core business activities Terminology is confusing Consideration of downtime after an earthquake when undertaking a building project is relatively new to some organizations
Building damage and repair costs	Appears to be of low concern among stakeholders interviewed Costs of nonstructural damage can be as or more important than costs of structural damage
Environmental issues	Earthquake risk and carbon impacts not currently linked in minds of stakeholders interviewed LEED certification is sought by many Hazardous materials are a concern to some
Liability	Significant concern for a small number of organizations; not mentioned by others

concerned with ensuring business continuity by enabling re-occupancy and limiting downtime. While these concerns were widely expressed by the interviewees, there was variation in how decision-makers act on them, which is described in the sections that follow. Other areas of concern, such as direct financial losses due to damaged buildings and equipment, environmental issues, and liability, were mentioned in the interviews; however, there was less consensus on these topics amongst stakeholders.

4.2.1 Importance of Safety

Safety was mentioned in 15 interviews, including by 10 building owner representatives. Nearly every building owner representative interviewed stated that having safe buildings was their unambiguous top concern with respect to earthquakes. As stated by one, "Our number one priority…is life safety…We do not want to be putting our [staff], visitors, contractors at further risk by being in structures that we don't feel would sustain our design earthquake." Several building owner representatives described how decision-makers were willing to close buildings, move businesses, or spend more on a retrofit upon learning that their buildings or infrastructure might be unsafe in an earthquake. One interviewee stated:

"Life safety is obviously the top risk. ...If there's a building that we think will collapse and put people's lives at risk or in serious jeopardy, then we would be recommending that that building be closed. That's the top priority, the thing we look at most."

A number of aspects of earthquake risk that affect safety were mentioned by interviewees. On the less demanding end of the spectrum, safety was perceived as the ability of building occupants to evacuate safely. One building owner representative summed this up with, "A building has to stand long enough for everyone to get out. That has to be first." Other interviewees acknowledged the risk posed by non-structural elements of a building. One building owner representative related the following anecdote from the Kobe earthquake:

"[I had a client who had] all their filing…in binders, and the binders were in these seven-foot-high steel bookshelves, and the steel bookshelves were on a raised floor and had not been tied to the structural slab. Those things fell over and crushed the office furniture, and the only reason there weren't mass casualties in that building was that the earthquake happened at 5:00 in the morning."

Concerns about safety clearly drive stakeholder decisions about when and how to take action on the seismic risk of their buildings. As discussed in sections that follow, safety concerns play a key role in motivating seismic retrofits of buildings and in establishing performance objectives for new construction, existing building renovations, and decisions to purchase or lease buildings. One building owner representative declared, "That is the primary driver on everything we do." A structural engineer related an anecdote to show how safety concerns trump other issues:

"That boss, when he was told that his building was a threat to life safety, vacated 2,000 people in 30 days. ….I'm telling you, first and foremost, this guy, I could have said anything I wanted to about loss of function, he would have dealt with it some other way. But when I said, "You have a threat to the safety of your people," it overrode the loss of function issue."

However, one building owner representative stated that they do not consider seismic issues in terms of safety because, "it is extremely volatile as a subject in our organization." He stated that the emotional distress that is caused by discussing safety concerns had previously led to a situation where, "people …didn't want to come to work." In response, his organization made a decision to eliminate safety concerns from the organization's decision process and "pull the emotion out of it, and make it wholly business-focused."

The term *life safety* is problematic because it appears to mean different things to structural engineers than it connotes to others. Appropriate language to discuss safety concerns and performance objectives that address safety is explored in the next chapter of this report (Section 5.2.2). This report only uses the term *life safety* when specifically referring to the ASCE/SEI 41 defined performance level, or when quoting an interviewee, who might or might not use the term as defined in ASCE/SEI 41.

Table 4-3 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 4-3 Implications for Guidance Products from Safety Concerns

Key Findings	*Relevance to Guidance Products*
Safety is a clear and universal concern that can drive quick action, such as vacating a building, possibly more than other factors	Guidance products should help identify major safety concerns that warrant quick action, perhaps through comparisons to "acceptable" levels of safety such as current code.
The issue of seismic safety, especially building collapse risk, can be sensitive and problematic for organizations to discuss publicly.	Balance the importance of safety with sensitivity to this topic.

4.2.2 Importance of Business Continuity and Downtime

The importance of business continuity or preventing extensive downtime was mentioned by 16 of 21 interviewees, including 12 of 13 building owner representatives. Several respondents ranked it as their second most important performance goal, after safety. As stated by one building owner representative:

> *"Following [safety], we're now starting to look toward a new goal of resiliency, which gets into downtime and replacement costs, how long it takes you to recover, how much it costs you to recover, so that we can have business continuity. That's been our secondary goal, and we're now starting to focus on that in much more detail."*

The concept of maintaining business continuity or limiting downtime is defined in different ways by different stakeholders and has multiple dimensions. It encompasses the ability of a building to be occupied quickly after an earthquake, which means the structure must be safe to withstand aftershocks. It also relates to the ability of the building to be used for its pre-earthquake function. Functionality is dependent on the structure, nonstructural elements in the building, and external infrastructure such as roads, transportation systems, water lines, gas lines, and sewer systems. The dependence on these factors varies by stakeholder. For example, one building owner representative noted a critical nonstructural system particular to his organization:

> *"There are certain things we just can't do. For example, our security systems, we can't operate without those being operational… There's a lot of things we can work around, but there're certain things we just can't function without, it's impossible."*

Certain types of stakeholders, namely government institutions, can have an even broader definition of functionality: societal well-being. As stated by one interviewee:

> *"We've seen some of these major disasters where major portions of the population leave the city, such as New Orleans or other places. …we'll be thinking about the economic impact of losing some of these structures and what that does to the entire community and how that impacts the city on a long-term basis."*

The ability of an organization to remain functional after an earthquake has an indirect relationship with the functionality of individual buildings because certain types of activities can be successfully relocated temporarily after an earthquake and others cannot. The process of identifying which buildings are critical to an organization's operations is unique to each organization, and includes such factors as the mission of the organization or business, its core activities that support this mission, and its investments in human resources and other non-structural equipment and materials, amongst others.

Many of the institutions interviewed had clearly put a lot of thought into defining what made a building critical from their perspective. A representative of a university stated, "If students stopped coming here, or if researchers took their research somewhere else, that's what would impact our reputation." Another building owner representative explained the thinking behind the desire to keep a particular facility functional after an earthquake: "Our fleets maintenance building, this building is where all the work is done to keep… vehicles operational. …We will need those vehicles to work after an earthquake. That building needs to be up and running after an earthquake." A third interviewee described how his organization identifies buildings for which they seek to prevent or minimize downtime in the wake of an earthquake:

> *"Generally, things like office buildings and amenity projects like cafeterias and maybe fitness centers, things like that, general storage*

warehouses, we might just say, "If that building goes down for a period of time, we can just move the people over here to do their work. There's no real income impact to the business." So we would say that's generally the baseline code required design. But if it is a facility that has potential to have an income impact to the business, if it were to incur some downtime, then… we'll focus on an elevated level of design in terms of performance. Do we want this building to come back online instantly? Can we incur a day's downtime, a week, a month? We'll target an area of performance based upon that magnitude income impact, and then we'll… design around that targeted area."

The three quotes presented above illustrate some of the issues that go into decisions about which buildings matter most for a particular organization's resiliency—reputation, fulfilling duties, and maintaining revenue streams.

Thinking about earthquake risk in terms of business continuity and downtime is new to some businesses and organizations. Perhaps this is related to growing awareness that the length and cost of downtime has been devastating to building owners in past disasters. An anecdote related by a structural engineer shows the type of experience that might have contributed to this awareness:

> *"I remember after the Northridge earthquake, people were shocked at how long their buildings were down to get fixed. We were fixing somebody's hotel for them down there, and they were just flabbergasted and said, 'This is a great outcome that this thing didn't fall down, but it's a financial disaster.'"*

The many terms used to describe this concept—business continuity, downtime, resilience—each have their own nuances and might be understood differently by different organizations. The relationship each of these concepts have to *repair time* as calculated by the FEMA P-58 methodology is not straightforward (this is discussed further in Section 5.2.3). One structural engineer involved in the development of the REDi™ rating system (Almufti and Willford, 2013) uses the terms *reoccupancy* and *functional recovery* because he believes these to be most meaningful to decision-makers. Reoccupancy and functional recovery do not always mean that the building has no damage or is completely repaired. Rather, the goal is to achieve a certain level of functionality that allows the business or organization to operate.

Several interviewees recommended that guidance products for the FEMA P-58 methodology highlight the business continuity issue. As stated by one interviewee:

> *"I really think you should spend your time on… business resiliency in terms of business continuity. Don't spend the time talking about dead bodies… because the code thinks it's doing a good job [at achieving safe buildings]."*

Table 4-4 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 4-4 Implications for Guidance Products from Business Continuity Concerns

Key Findings	*Relevance to Guidance Products*
Business continuity is a clear secondary concern for the stakeholders interviewed that drives actions and decisions. Organizations that value business continuity seem ready to consider performance improvements.	Highlight business continuity impacts and the ability to quantify some of these impacts.
Business continuity is dependent on different factors for different organizations.	Guidance products should be flexible, given various factors that drive business continuity.
Organizations can have subtle and highly varied objectives across their different properties for business continuity.	Be flexible to respond to different objectives for different types of buildings and organizations.
Considering this issue as part of design and renovation decisions is a relatively new concern to some stakeholders.	Some stakeholders need to be educated about how to consider this concept in decision-making.
Varied terminology is used.	Terminology should be clear, defined, and accurate, and it should be unambiguous what the FEMA P-58 methodology does and does not calculate.

4.2.3 Importance of Building Damage and Repair Costs

In the past, the results of earthquake loss analyses have often been presented as the amount of direct dollar losses in terms of the costs to repair structural damage. Communication with stakeholders for this project indicates that while this issue is of some concern to stakeholders, it is not a top concern of stakeholders interviewed and is typically not a primary driver of decision-making about how much to invest in the earthquake resilience of their buildings.

In the interviews, stakeholders were asked what issues concern them most about earthquake risk. As part of this discussion, none of the interviewees specifically brought up the direct cost of damage to their structure as a top concern. However, during the interview conversations, the topic of building replacement and repair costs did come up in some discussions, and the topic seems to influence decisions in some cases. One building owner representative had investigated this issue and found some buildings for which it was a concern. She stated, "We have one building that cost $5 million to build and if it got flattened, it would cost us $36 million to replace it." Others noted that the costs of nonstructural damage could be significant to them. One interviewee stated that direct cost of non-structural damage influences his organization's performance objective decisions: "Part of this is to protect our investments as well. We've put some very expensive systems in here." A couple stakeholders who are most concerned about investments in nonstructural equipment also noted that their equipment was unique to their industry and unlikely to be included in the FEMA P-58 methodology fragility databases.

Several structural engineers interviewed specifically discussed how, in their experience, estimates of the cost of direct structural damage were not meaningful or motivating to building owners. One structural engineer stated that he thinks direct cost of damage to the structure is dwarfed by the other types of financial risk building owners face: "When you tell people you have a 15% loss [of the value of the structure], that sounds awesome. It's like, 'That's nothing, that's great.' …It seems negligible, actually."

Perhaps this finding is affected by the choice to interview earthquake-concerned building owner representatives and the engineers who work with them. It is possible that the direct cost of damage to a structure is of higher concern to other types of building owners for whom these structures represent a higher percentage of their total assets. Further, this measure might be of particular importance to the insurance and lending industries, which were largely excluded from the interview sample.

Table 4-5 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 4-5 Implications for Guidance Products from Damage Cost Concerns

Key Findings	*Relevance to Guidance Products*
Costs of direct structural damage are not a primary driver or motivator of the decision makers interviewed.	Present this topic to decision-makers, but it should be given less prominence than some other issues.
Cost of direct damage to nonstructural components can have equal or more importance than damage of structural components of a building.	Emphasize the inclusion of nonstructural impacts in FEMA P-58 results when costs of direct damage are mentioned.

4.2.4 Importance of Environmental Issues

Environmental concerns were only obliquely referred to, and earthquake impacts on hazardous materials were mentioned as the chief environmental concern. Possibly this is because the concept of embedded carbon in building materials is still new to decision makers as a disaster related issue. For example, one structural engineer interviewed said:

> *"Most of my clients are not concerned about carbon in terms of green… [or] carbon footprint in the work, [or] using recycled concrete versus regular concrete, because concrete is one of the biggest carbon footprint you can ever imagine, none of my clients even go there. Don't even understand it. It's not buggin 'em at all."*

This view was reiterated by a building owner representative who, when asked if his organization was concerned about the carbon impacts of replacing an existing building, stated, "I don't think we've really made that connection."

Unprompted, multiple interviewees mentioned the importance of LEED certification, a green building certification program[6], to their organization. One building owner representative stated that for his organization, "Now all of our [new] buildings have to be LEED gold." Another building owner representative stated that in building renovation projects, her organization "work[s] very hard on being LEED certified." A couple of structural engineers also noted that LEED certification matters to their clients.

The interviews and workshops did not probe the importance of carbon reduction, environmental sustainability, or LEED ratings to stakeholders. A couple of interviewees who are not building owners did express that this could be an important capability to add to the FEMA P-58 methodology. They felt that this information could be compelling because owners could use it to improve a LEED assessment, which is something that many building owners want and will pay for.

Table 4-6 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 4-6 Implications for Guidance Products from Environmental Concerns

Key Findings	*Relevance to Guidance Products*
Most building owners have not linked earthquakes with carbon impacts.	Establish this link.
LEED certification is important to some stakeholders, suggesting environmental impacts are an important concern, probably a higher ranking concern than earthquake risk.	Adding the capability to quantify carbon impacts of earthquakes within the FEMA P-58 methodology is of potential value to stakeholders, particularly if it can improve a LEED rating.

[6] Information on the LEED certification program is available at http://www.usgbc.org/leed.

4.2.5 Liability Concerns

Two building owner representatives identified liability concerns as a key factor that played a significant role in shaping their organization's approach to earthquake risk issues. For example, one described being prevented from studying seismic risk due to decision makers fearing the legal implications of finding a problem:

> *"We struggled early on with the legal aspects of the seismic program. I know a lot of other companies do as well…. That was our biggest hurdle. It wasn't the money, it was the fear [that] if we started doing seismic studies, that somehow we would be held liable if we didn't act on them. We worked about two years with our lawyers before I could actually even study anything."*

Another mentioned that minimizing legal risk was a primary driver of their organization's retrofit program: "We had to understand whether there had been things done over the life cycle of the building to make it more vulnerable to a seismic event and whether we had a legal risk there. That was our first priority." This interviewee also noted that, after concern of some employees about risks to safety, decisions related to seismic risk were made in the presence of an attorney so that they could be kept confidential. He stated,

> *"We put everything we did under attorney-client privilege, with the corporate attorney in the room, to capture and hold all of our notes and control the distribution of that information in the organization. ...It was very important to us to keep control of what went out of the room and what didn't in terms of communication."*

Table 4-7 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 4-7 Implications for Guidance Products from Liability Concerns

Key finding	*Relevance to Guidance Products*
Liability is a key concern for some but not all stakeholders.	Clearly address liability concerns and what is known about whether better knowledge of risk and risk reduction options affects liability.

4.3 How Decisions are Made about Designing and Renovating Buildings

A significant focus of the interviews and workshops was understanding how decision-making about the earthquake risk of buildings currently happens within organizations. The goal was to understand the decision-making processes that organizations currently use, the people who currently participate in decision-making, and the factors that currently drive decisions, so that changes needed to incorporate the use of the FEMA P-58 methodology could be identified. The sections that follow present the findings.

4.3.1 Competing Concerns

When building owners undertake projects to build new buildings or renovate existing buildings, seismic risk is generally low on their list of concerns. As stated by one representative of a building owner, "While earthquake is a piece of it, that's a pretty small piece… that never, unfortunately, drives the conversation." Issues that do drive project decisions include the way the space will be used, aesthetics, building location, environmental sustainability (including LEED certification), all balanced with costs. There are many secondary factors that also contribute to design and construction decisions, including history, acoustics, fire risk, flood risk, circulation, preferences of occupants, and preferences of neighbors. Earthquake risk generally ranks among these secondary concerns. The exception is when an existing building is known to have seismic risk issues, and a seismic retrofit is the key motivator of a renovation project (this is discussed more in Section 4.3.7).

For some building owners, seismic risk is not on their list of concerns at all. There appears to be a widespread perception that the building code provides adequate seismic performance, although it is not clear that many building owners understand the performance provided by building codes. Some building owners actively avoid discussions of seismic risk. As stated by one structural engineer:

> *"Ostensibly sophisticated clients don't always… want to know what the problems are or how to fix them… They don't really want seismic corrections to be something they have to deal with on a fundamental level in the middle of what seems to them to be a project to get them from A to B."*

For building owners that do not hold properties for long terms, seismic performance seems to be a low concern. In the Stakeholder Workshop of 2013, participants indicated that developers who build and quickly sell buildings have as their key priorities limiting construction and design costs while meeting minimum regulatory requirements.

However, the types of earthquake-concerned building owner representatives interviewed for this project do consider seismic risk issues among the many other issues of concern to them when undertaking construction of new buildings and renovation of existing buildings. Indeed, as explained in Chapter 2, the building owner representative stakeholders interviewed were selected particularly because earthquakes were known to be of concern to them. Even among this group, however, it is important to recognize that earthquakes are one of many decision factors. Owners do not necessarily see decisions about seismic risk issues as different from other types of decisions they make during building projects. As stated by one building owner representative:

> *"The structural systems are just the same as any other system, just the same as sustainability concerns or aesthetic concerns. All of those things are to explore options and choices, understand the impacts and the risks and the costs of those choices, and to make a smart decision."*

Table 4-8 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 4-8 Implications for Guidance Products from Competing Concerns

Key Findings	*Relevance to Guidance Products*
Earthquake risk is important for some stakeholders, but not all. Some stakeholders might never care about this issue and will seek minimum code compliance.	Focus on stakeholders who have some level of interest in minimizing seismic risk, or the potential for future interest.
Earthquakes are one of many concerns of building owners, and typically not the top concern.	Draw links between earthquake risk and other priorities.

4.3.2 Cost/Performance Tradeoff

At the heart of the decisions that building owners make about seismic risk for new building and retrofit projects is the inherent trade-off between what you spend and what you get. Cost is the major issue mentioned by all of the interviewees as affecting design choices relating to seismic risk. As stated by one building owner, "We could never afford to have every building we own be a super-seismic structure." However, it is clear that the types of earthquake-concerned owners interviewed for this project, in certain cases, are willing to pay for better seismic performance than the minimum required by the building code. As stated by one building owner representative, "Understanding what you're getting for that extra dollar is really important."

Many of the interviewees discussed a process where different structural options are presented, along with their associated costs and their expected performance during an earthquake. These options are presented to a decision-maker, which is sometimes a group and sometimes one person, who weighs the costs and benefits of various options according to their own decision calculus, which as stated above, involves many other factors that may overshadow any seismic concerns. As stated by one building owner representative, "We're putting the choices very clearly on the table and we're consciously deciding which way to go."

Some of the organizations interviewed clearly find it challenging to spend extra money on reducing seismic risk. One building owner representative stated:

> *"We're in a very cost-constrained environment right now, and we're in a very competitive environment. We're a publicly traded company and everyone knows all about our business… The facility cost has gotten pushed down and pushed down to whatever lowest possible place."*

Others noted that it is challenging to spend more on seismic risk issues than the minimum required because there is no short-term economic value to this. As stated by one building owner representative, "Seismic isn't going to be revenue-generating, so [decision-makers] don't see necessarily a payback on it."

Other organizations have a culture in which it is easier to spend more on reducing seismic risk. One building owner representative described the decision-making process this way:

> *"A big lab building…costs over a quarter billion dollars, so it's easy to get people to say, "Gee, if we're going to plug a quarter billion dollars in, and the additional structure is so minor, and the performance improvement is so large for that additional investment,"…that's kind of a no-brainer."*

Another building owner representative described the mindset at the organization that drives investment in seismic risk reduction, "What makes us different is that we build something for 40 or 50 years. That's our mantra.…We have to look at the total value of that structure from cradle to grave."

Numerous institutions described a process in which buildings are designed to meet a minimum standard, such as the building code or a performance level defined in ASCE/SEI 41, and then additional resilience is added if affordable. This was clearly articulated by one building owner representative as, "We're going to meet code and ensure life safety, and then make choices as to what else we can afford." Another building owner representative put it this way, "It's all about how much more than life safety you're going to do …and that's all bucks."

Some of the building owners interviewed recognized that achieving better earthquake performance in their buildings did not necessarily require significant additional expenses. One building owner representative stated, "Much of it is in paying clever engineers to do more work so that the design can be better tuned." Another building owner representative summed up their approach as, "We don't spend a whole lot more money on our facilities. We're smarter about our buildings."

A few stakeholders noted that the value of what is inside the building can be as or more important than the value of the building itself in making cost-performance trade-off decisions. For example, one building owner representative recommended discussing the risk to businesses-critical equipment to help convince decision makers to design buildings to a higher standard:

> *"That's really where—if I was going to convince someone to spend a little bit more money… [I would say:] "I put in the fragility of your $50 million each [essential piece of manufacturing equipment], and when I do it the old way, these things are thrashed, and when I do it the new way, with the base isolation, these are saved." Suddenly the loss equation tips."*

Table 4-9 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 4-9 Implications for Guidance Products from Cost/Performance Trade-Off

Key Findings	*Relevance to Guidance Products*
Understanding what extra investment produces is important.	Emphasize that FEMA P-58 can quantify this better than previous tools. Demonstrate how to effectively show investments versus performance gains.
There is a common perception that earthquake risk improvements are not revenue generating.	Seismic improvements generally do not generate revenue in the short term. Emphasize the longer-term economic benefits of investments in seismic risk reduction.
Performance improvements do not always mean significantly higher construction costs.	Clearly state this and illustrate it, perhaps with case studies.

4.3.3 Relationships with Design Professionals

According to structural engineers, typically, when designing a new building, the structural engineer is a sub-consultant to the architect, and the structural engineer might interact with a direct representative of the building owner only rarely or indirectly. In the workshop documented in ATC-58-5, the structural engineer attendees were asked for what percentage of their projects were they retained by the building owner rather than the architect. As shown in Figure 4-1, the replies ranged from 30 percent of projects to 70 percent of projects in which the structural engineer worked directly for the owner, with an average answer of just under 50 percent. It is important to note that the structural engineers who participated in this workshop are among the most sophisticated designers practicing today, and are therefore presumably more likely to interact directly with building owner representatives than other structural engineers.

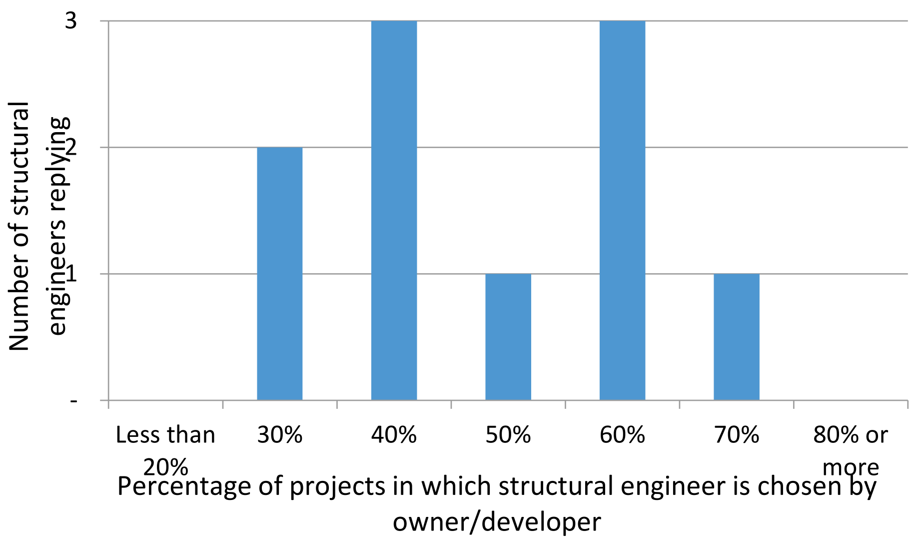


Figure 4-1 Reported percent of projects where leading structural engineer is selected by the building owner or developer, rather than the architect (from ATC-58-5).

The relationship between the building owner and the structural engineer matters because it affects the communication to the building owner regarding design choices that affect seismic risk. According to some structural engineers interviewed, architects are not generally interested in seismic risk issues unless they know this issue to be of importance to the building owner. As stated by one structural engineer:

> *"Normally when we talk about seismic risk, we're talking to the owners. They're the ones who are really interested in this, and in as much most of the work we do is consulting with architects, they're usually the least interested. Not to vilify them. They're doing what they have to do."*

The architect can act as a gatekeeper to discussions about seismic risk. As stated by one structural engineer, who was referring to projects in which he is retained by an architect, "You're not going to go around your client to the owner, typically." One engineer noted that he "gave up years ago" trying to convince architects to make large-scale changes that affect seismic risk, but continues to make efforts to explain to them that, "things won't necessarily look like your last building looked." Further, performance-based design can frequently result in higher consulting fees for the structural engineer. While this might lower the cost of the construction of the structure or reduce the cost of repairs to the structure after an earthquake, it could also cut into the architect's fee if the project has a fixed fee for design work, thus disincentivizing the architect to encourage performance-based decision-making.

However, again, the select group that participated in the interviews and workshops does not reflect common practice; the project team actively sought out institutions known to be concerned about seismic risk issues. For the group of building owners interviewed, communication between a representative of the building owner and the structural engineer was typical and robust. Out of thirteen organizations interviewed, eleven had a staff member whose job description included (and in some cases largely consisted of) managing the earthquake risk of new and/or existing facilities (the role of this person is discussed more in Section 4.3.5). For construction projects of new buildings and rehabilitation of existing buildings, all of these organizations worked with structural engineering consultants.

The various ways that the representative of the building owner organization interacted with the structural engineer during these projects included the following, with some organizations pursuing one of these strategies and other organizations pursuing several:

- Convening meetings of the entire design team to discuss all aspects of performance, often multiple times during the project.
- Reviewing structural plans prepared by consultants multiple times during a project.
- Having a standing committee review structural plans throughout a project.
- Developing a long-term relationship with one structural engineering consultant, who either does all structural design work or oversees the design work of other consultant engineers to ensure they meet the organization's needs.
- Setting in-house standards that structural engineering consultants need to meet (see Section 4.3.5 for more discussion on this topic).

Based on the relationships described by stakeholders, Figure 4-2 illustrates the apparent relationship of the building owner representative to the structural engineer and other members of the design team, comparing a *typical* process with the *interconnected* process that was used by many of the organizations interviewed for this project, as relayed in the project interviews and workshops. Key differences are that earthquake-concerned stakeholder organizations have staff members and consultants focused on risk, and lines of communication are more varied.

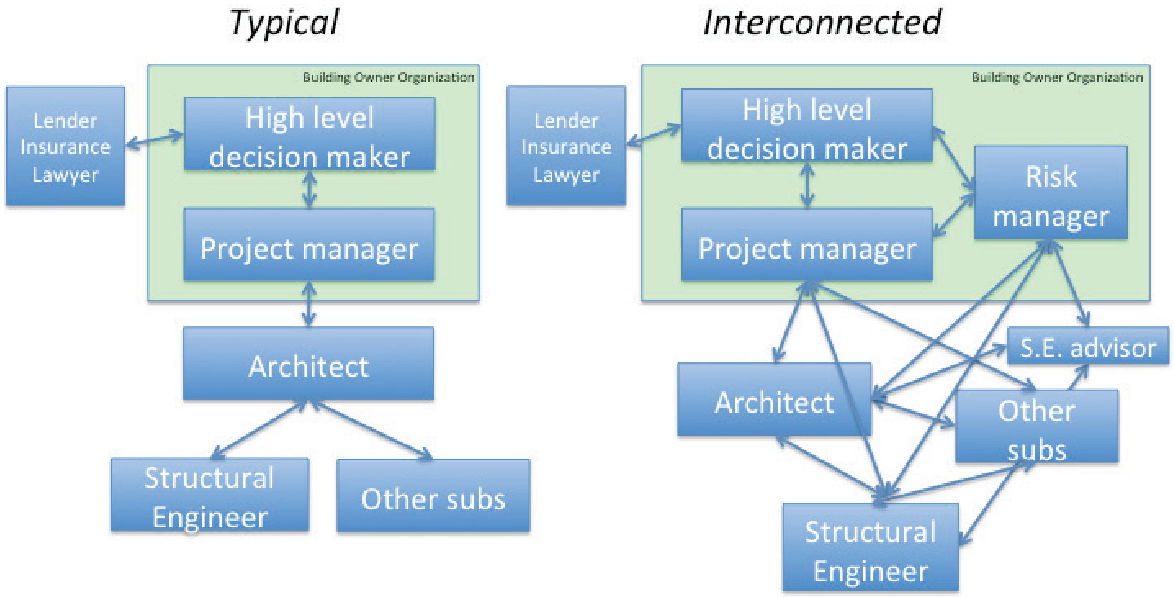


Figure 4-2 Schematic of relationships between building owner organizations and members of the design team for new buildings and rehabilitation of existing buildings, for *typical* and *sophisticated* building owners.

A number of the organizations interviewed had long-standing relationships with structural engineers who helped them define approaches to seismic risk decisions, including their seismic performance goals, and were viewed as important resources by the staff members in the institution. A number of the building owner representatives interviewed were originally trained as structural engineers (5 out of 13; an additional 3 were familiar with structural engineering concepts).

The structural engineer can be a powerful advocate for seismic risk issues and plays a major role in shaping the way that organizations approach seismic risk issues. The engineers seemed to view themselves as initiators of and advocates in conversing about performance-based design. There were clear themes among the main ideas that engineers were trying to get across. The first was trying to get persons within the organization to understand the true risks they face, including the many different types of consequences and potential impacts on the organization's own goals. The second was to get persons within the organization to understand that there are feasible options for dealing with these issues. As stated by one engineer, "That's one of my goals, to try to let them understand not just what the code says, but some things beyond the code, so they can make decisions." In essence, these aims illustrate the altruistic side to engineers' efforts to empower informed decision-making for their organizations or clients.

Even in those cases when the structural engineer has limited access to the building owner, or the building owner does not place a high priority on seismic risk issues, the structural engineers interviewed sought to maximize seismic performance. As stated by one, "It's kind of up to the engineer trying to figure out a way to squeeze in something more than code."

Table 4-10 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 4-10 Implications for Guidance Products from Relationships with Design Professionals

Key Findings	*Relevance to Guidance Products*
Structural engineers are key advocates for seismic risk issues.	Assist structural engineers to be effective advocates.
Some engineers build long-term relations and are trusted advisors to building owners. They can shape an organization's approach to seismic risk decisions.	These engineers are influential. Demonstrate how they could incorporate use of the FEMA P-58 methodology in decision-making. Target materials to these engineers.
Earthquake-concerned stakeholders already communicate directly with structural engineers through a variety of approaches.	Develop materials useful for each of the contexts identified in which owners and engineers communicate.
Typical owners do not frequently communicate directly with the structural engineer, and their communication is routed through the architect, who can be a barrier. Architects address this issue when it is of interest to the owner.	Materials could target architects to make them more receptive to performance issues. Materials could target owners; architects respond to the priorities of their owner clients.
Engineers seek to communicate the true risk owners face.	Assist engineers with communicating this message effectively.
Engineers present options to address risk.	Use options and comparisons in guidance products.
Some engineers seek to improve seismic resilience even when this is not an owner priority.	Guidance products should help engineers maximize performance in incremental ways.

4.3.4 Parties Involved in Decision-Making

Within an organization, numerous parties participate in the decisions related to constructing new buildings and renovating existing buildings. These include layers of management, committees, lawyers, and others for whom seismic risk might not be a top concern. Legal, financial, and insurance actors might deter or de-incentivize action. Large hierarchical organizations might not effectively communicate risk to decision-makers and other building users and occupants. As a result, some individuals that would otherwise support risk prevention might not voice their concerns.

In some organizations, the number of parties who participate in decision-making is voluminous. One public-sector stakeholder mentioned the following parties that participate in building-related decisions: the engineers, project managers, capital planning committee, finance department, people who will be occupying the building, working groups or committees, and the mayor's office. Private sector organizations can also involve many voices, as noted by one building owner representative, "Our procedures…involve six different groups to provide input and data into the process, and two of those are external consultants."

Within an organization, internal advocates for earthquake risk management need to promote and continually justify expenses related to seismic risk reduction. As stated by one building owner representative, "I need to try to sell that idea to those who are higher up who have financial decision-making abilities. If a [structural] system will be cheaper but I feel it's not as good, then my role is to try to convince them that a different system would be better." Another building owner representative, referring to an internal group within his organization that makes spending decisions, stated, "I need them because they're the funding mechanism. I have no signature authority, so I can't make the stuff happen. I need them."

In some institutions, established internal standards get questioned. One building owner representative described the effort to maintain these standards: "Even the importance factor, the I = 1.5, we have had to defend over and over again to people who don't even want to do that. …there are plenty of people in this company who think that's a total waste of money."

Sometimes, decisions to invest in seismic resilience get overruled by higher-level decision makers with different priorities. This decision can be affected by personalities. One building owner representative noted, "It really depends on the project manager… so depending on which project manager I get, I can have more influence than with another project manager." One building owner representative shared a strategy for advocating internally within his organization, "Sometimes I engage a strong personality structural engineer to really make the case."

There are external parties that play key roles in decision-making. In some cases, government regulators need to be convinced about performance-based designs. An anecdote by one building owner representative addresses this:

"The [regulatory agency] wasn't extremely sophisticated in their approach to performance. They thought that they could get this kind of operation by using really strict drift requirements. ...We tried to explain to them ...that that isn't going to give the performance you want because you will really destroy the operations ...and that the accelerations up there might even begin to damage your electronic equipment ...They finally came to grips with that."

Public sector organizations noted that they also have external groups they need to convince about the benefits of investing in seismic risk reduction, in addition to the internal decision-makers within their organization. Public sector organizations might need to conduct public hearings to get feedback directly from the public that affect design and location choices. Sometimes, public sector agencies need to convince voters to fund a project. One public sector building owner representative shared this experience, "We tried in 2002 and lost by something like two percentage points, and in 2004 we got it. Two-thirds vote, by the way. …An agency cannot advocate for or against a bond measure, but they can educate. So we created an education program."

Table 4-11 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 4-11 Implications for Guidance Products from Parties Involved in Decision-Making

Key Findings	*Relevance to Guidance Products*
One use of the FEMA P-58 methodology is internal advocacy within an organization. Different actors within an organization have differing priorities and motivations.	Address concerns and perspectives from a variety of voices, so advocates within and outside of organizations can speak effectively to their concerns. Emphasize that the FEMA P-58 methodology is a tool that can help organizations better achieve their objectives. It's not a tool "for" engineers; it's a tool engineers can use to help others do their jobs better and get better results.
Another use is external advocacy, which includes outreach to the public by public sector organizations.	Anticipate the information needed to communicate to the public.
External advocacy can include educating government regulators about performance-based decision-making.	Target materials at code officials or on how to communicate with code officials

4.3.5 Existing Approaches to Integrate Performance into Build/Renovate Decision Making

Unsurprisingly, many of the earthquake-concerned stakeholders interviewed have been thinking about the seismic performance of their buildings for a while, and have developed systems, approaches, and metrics to integrate performance concerns into decision-making for their buildings. They are aware of the deficiency of current building codes for achieving the kind of performance their organizations seek and, in a variety of ways, do more than the minimum required. None of the building owners interviewed, however, currently have used the FEMA P-58 methodology to make decisions about their buildings.

One of the key ways that the organizations interviewed consider seismic performance currently is by having a full-time staff member whose duties include thinking about earthquake risk issues for the organization's buildings, existing and new. As shown in Table 4-12, out of thirteen building owner representatives interviewed, nine organizations have a full-time staff member who clearly is responsible for considering earthquake performance issues for their buildings; two organizations had a staff member that does consider these issues but the function seems less institutionalized (i.e., it appears be driven by the interest of the staff member, not the organization); and the remaining two institutions have only considered seismic performance issues at the time of a relevant construction or renovation project. The role, duties, and influence of this staff member vary among the organizations interviewed. Sometimes, this person has a structural engineering background. Those without structural engineering backgrounds report relying heavily on the advice of trusted structural engineering consultants in shaping their program and approach.

Table 4-12 Number of Organizations Interviewed with a Staff Member Focused on Seismic Risk Issues

Role	*No. of organizations with staff member in this role*
Clearly responsible for considering earthquake performance issues for buildings	9
Staff member does consider these issues but the function seems less institutionalized, driven by personal interest	2
Only considered at time of building/renovation projects	2
Total	**13**

All of the organizations interviewed had thought about their buildings in terms of desired seismic performance in some way. A number of the organizations had articulated desired performance goals or building performance categories that they use when constructing new buildings or retrofitting existing buildings. Often, these performance goals varied by the use of the building and its importance to the organization. For some organizations, this also related to an in-house rating scheme that they use to understand and manage the risks of their entire portfolio of buildings (discussed more in Section 4.3.6). Table 4-13 summarizes the performance goals/categories as shared by some of the interviewed organizations. It is important to note that interviewees were not consistently asked to explicitly state their organization's performance goals or building performance categories, so the information is incomplete.

Table 4-13 Seismic Performance Categories Used by Interviewees

*Performance goals**	*How goals are met*
<u>*Organization 1*</u>	
Three levels	
A – critical to production, goal is 2 to 4 weeks of downtime in code design earthquake	A – Same as Level C plus importance factor of 1.5 and peer review
B – buildings containing hazardous materials, goal is no release of materials in code design earthquake	B – Same as Level C plus importance factor of 1.5
C – all other buildings	C - In-house selection of structural system, in-house guidelines
<u>*Organization 2*</u>	
Projects valued at >$1 million: must have positive rating in 500-year earthquake shaking; rating is an internally developed formula that considers risk (probability and cost of repairs, business downtime) and cost to design/construct structural and non-structural systems.	Projects valued at >$1 million: sometimes use performance-based design, sometimes use an importance factor (if project only addresses non-structural, then use importance factor).
A different standard for projects valued at <$1 million.	Projects valued at <$1 million: a chart relates function of building to the importance factor to use.
<u>*Organization 3*</u>	
Hardened facilities that are not lost to use through contamination, immediate occupancy under wide-ranging commonsense earthquake scenarios.	A Seismic Review Board defines in structural engineering language how this will be accomplished for each project All projects use in-house structural and nonstructural standards
<u>*Organization 4*</u>	
(Class 1 was not discussed)	(Differences in meeting different classes not discussed)
Class 2 – critical function, resume operations quickly Class 3 – well-designed code building	In all projects, limit irregularities, design reviewed by Seismic Advisory Committee, detailed peer review, internal design guidelines
<u>*Organization 5*</u>	
Critical to operability – operable at defined levels of shaking	Critical to operability – in-house standards developed by chief engineer
Not critical – life safety/non-collapse	Not critical - code
<u>Organization 6</u>	
A few buildings: continual operations	Uses ASCE/SEI 41
Most buildings: life safety	Most buildings: code level shaking, importance factor 1.25, regular design, symmetrical lateral system, in-house review of drawings
<u>Organization 7</u>	
In-house rating system: S1 to S6	Appears that ASCE/SEI 41 is used
S3 = safe, typically what this organization seeks	Approach developed and implemented by a consultant
S4 is lower performance	
This organization typically purchases and upgrades existing buildings, does not do much new construction.	

* Organizations are numbered rather than named to maintain confidentiality.

Many of the organizations interviewed have developed internal guidelines or requirements for how consultants address seismic performance issues. These include requirements for using a higher Importance Factor, *I*, than required by code for some or all types of buildings; limiting or controlling which types of structural systems could be used for design; controlling the layout of structures to limit irregularities or ensure redundancy; and requirements for non-structural components. Organizations have also identified which of these requirements need to be met for buildings with specific performance goals.

A number of interviewed organizations have developed a process to ensure the quality of structural engineering and overall design. Several organizations require structural engineering peer review for some or all projects. Others seek to hire structural engineers they believe to be high quality (although some interviewees are constrained for a variety of reasons in their ability to hire the engineer of their choice; this relates to internal decision-making within their organization). One interviewee's organization developed a design process that brings the structural engineer, architect, and all other members of a design team together early and often to discuss performance issues of all kinds (not limited to seismic) to ensure that all team members are knowledgeable about the needs and limitations of other team members.

Table 4-14 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 4-14 Implications for Guidance Products from Existing Approaches

Key Findings	*Relevance to Guidance Products*
Earthquake-concerned stakeholders articulate individualized earthquake performance goals unique to their needs and priorities and meet them in a variety of ways. The ways they meet their goals are approximate and could be improved.	Help stakeholders to define updated individualized performance objectives and to meet those performance objectives using the FEMA P-58 methodology.
ASCE/SEI 41 is widely used.	Clarify how ASCE/SEI 41 and the FEMA P-58 methodology are different, when the FEMA P-58 methodology can be used in conjunction with ASCE/SEI 41, when FEMA P-58 is a better choice, and how to transition from ASCE/SEI 41 to the FEMA P-58 methodology.
Safety is a performance goal that is seen as a minimum acceptable goal by many and seen as aligning with the code.	Clearly show what performance the code provides.

4.3.6 Managing a Portfolio of Buildings

Many of the earthquake-concerned building owners interviewed for this project have a large number of buildings that they manage. During discussions with stakeholders, many of them mentioned the process they use to manage the earthquake risk of their portfolio of buildings: how they understand the risk of their existing buildings, communicate that risk to decision-makers within their organization, and make performance decisions considering the overall risk of all of their buildings and the operations within them.

A number of organizations had worked with consultants to develop their own system of categorizing or ranking the earthquake risk of their buildings and to apply it to all or some of their building portfolio. These scales mostly grouped buildings in categories with simple definitions. For example, one building owner representative summed up their rating system as, "Our scale is S1 to S6. S3 is safe." Another building owner representative described their rating system as, "A *one* means that it'll be completely usable without any issues right away. A *four* means that there is some collapse potential."

Organizations used these rating schemes to make both long-term and short-term decisions about their buildings. In the short-term, some building owner representatives reported that each new building purchased or leased was given a rating. That rating was used to make decisions about whether the transaction would go through, whether the building would need a retrofit, and how that building would be used by the organization. In the long-term, organizations used these rating systems to understand and make decisions about the overall risk of their building stock and prioritize projects to upgrade buildings.

In addition to the simple categories used by the rating systems, several organizations reported that the results are presented in a red-yellow-green format to upper level decision-makers. One structural engineer noted, with some sarcasm, that even technically knowledgeable clients like to see results in these terms: "This client has requested that all these answers… be presented with the very sophisticated red, green, and yellow…and I'm telling you, you couldn't get a client more sophisticated than this one."

These rating schemes are a long-term investment, and numerous organizations reported that understanding and upgrading their portfolio of buildings was a lengthy process. One building owner representative described their program this way, "It just keeps plodding along. Every year we try to do a couple studies. I try to do one retrofit a year, but that has not really worked out."

Some organizations reported that they currently use alternate approaches in concert with their seismic rating systems to help them understand the risk of their portfolio, in particular FEMA HAZUS was mentioned by several interviewees. It is important to note that the FEMA P-58 methodology is intended to be used to analyze the risk of individual buildings, and the level of rigor and accuracy built into the FEMA P-58 methodology reflects this. When analyzing the overall risk of a portfolio of buildings, less accuracy is required because errors in the risk assessment of one building will likely be counterbalanced by errors in another.

Table 4-15 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 4-15 Implications for Guidance Products from Managing a Portfolio of Buildings

Key Finding	*Relevance to Guidance Products*
Earthquake-concerned owners frequently own many buildings and have a need to understand the overall risk of their building stock and relative risks within it.	Discuss whether, when, and how the FEMA P-58 methodology can be used in this way.

4.3.7 How Decision-making Process Differs for New Construction and Renovation

Nearly all building owner representatives interviewed reported that their process to construct a new building and to renovate an existing building is essentially the same. However, there are clearly a few differences that relate to seismic risk considerations. Most notably, building owners report that they are more likely to be concerned about seismic risk when undertaking work on an existing building than when constructing a new building. Presumably, this is because they know that buildings designed to outdated building codes can have significant seismic deficiencies. Sometimes, retrofitting seismic risk is the primary reason a project is undertaken, although typically the owner takes advantage of the construction on their building to make functional, aesthetic, or other changes, as well. As stated by one structural engineer interviewed, "Normally the owners are much more involved with existing buildings. I think a lot of it is because quite often they're motivated by seismic safety to start with."

In renovation projects, structural engineers report that a building owner representative is more likely to communicate directly with the project's structural engineer, and is less likely to route all communication through the architect. In some cases, the structural engineer is actually the primary consultant to the building owner, with the architect working as a sub-consultant.

Some building owner representatives reported that building a new building is perceived as more cost-effective than seismically retrofitting an existing building. As stated by one building owner representative, "It makes more sense to build a new one than to try to fix the old one. …it's just much more expensive to renovate." Another noted that their organization has decided to address the seismic risk in their building stock through eventual attrition rather than retrofits: "They made the decision that it was a lot cheaper to add a small percentage when the new buildings were built than it was to go back and try to make an old building into a hospital."

Another key difference between new building projects and renovations is that renovation projects have significantly more constraints. Will the retrofit affect the functionality of the space due to the location of new structural elements? Will the retrofit trigger other expensive work, such as compliance with the Americans with Disabilities Act or removal of hazardous materials? Does the retrofit affect the ability to lease the space, such as having a structural element blocking a retail display window? Will the space be usable during construction? Several building owners reported that having facilities non-functional during a retrofit was problematic for their organizations. As stated by one, "The most difficult part of our renovations is that we're having to maintain operations at the same time. We don't have the luxury of moving people out of buildings."

Table 4-16 saummarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 4-16 Implications for Guidance Products from New Construction versus Renovation

Key Findings	*Relevance to Guidance Products*
There is better communication between the engineer and some building owners during retrofit projects, compared to new construction.	Retrofit might be a somewhat more likely time when the FEMA P-58 methodology could be used, particularly for building owners who have not already built performance-based decision-making into their processes for new buildings. Target materials for this context.
Retrofits are seen as cost-prohibitive.	Clearly state that use of the FEMA P-58 methodology quantifies the implications of money spent on retrofits. Case studies of cost-beneficial retrofits could be valuable.

4.4 How Decisions are Made about Acquiring/Leasing/Financing/Insuring Buildings

When an organization decides to purchase or lease an existing building, this decision affects the organization's seismic resilience. These actions are an opportunity to proactively improve their organization's seismic resilience, or to increase their seismic risk, perhaps inadvertently. At these times, organizations commit significant funds and make important decisions relating to key assets, such as staff and equipment. Decisions about insurance and financing typically accompany these decisions and can influence them. The following sections examine how seismic risk currently plays into these decisions.

4.4.1 How Seismic Issues Are Considered When Leasing and Acquiring Space

Many of the earthquake-concerned stakeholders interviewed indicated that their organization sometimes or always conducts an assessment of the seismic risk of a building that they are considering purchasing or leasing. As summarized in Table 4-17, out of thirteen building owner representatives interviewed, seven stated that their organization always or sometimes conducts seismic evaluations when seeking to purchase or lease a building, one said their organization does not, one did not know, one interview did not discuss this topic, and three organizations do not purchase or lease buildings. As stated by one interviewee, "We call it the seismic blessing." The way that organizations do this varies: several interviewees mentioned ASCE/SEI 41 Tier 1 evaluations, and others mentioned in-house seismic rating schemes that were developed and applied by consultants. Some interviewees mentioned that evaluations were conducted only for buildings intended for uses critical to the organization's operations, or were conducted more rigorously for these types of buildings.

Table 4-17 Reported Approaches to Seismic Evaluations at Time of Purchase of Lease

Approach at time of purchase or lease	*No. of organizations*
Always or sometimes conducts an evaluation	7
Does not conduct evaluations	1
Interviewee did not know	1
Not discussed	1
Organization does not purchase or lease buildings	3
Total	**13**

For all of these organizations, it is clear that seismic risk is one of many factors considered when decisions about purchasing and leasing buildings are made, and is rarely the most important factor. Several interviewees noted that there have been occasions when evaluations raised seismic concerns, but buildings were purchased regardless, with the owner informed of the risks. As stated by one interviewee:

> *"We made it very clear to people early on that it was not a great seismic building. A lot of people thought it was because it was a former bank,*

but it's not. We had to be very clear that it… potentially could be red-tagged or at least yellow-tagged after an earthquake. We…went into that with our eyes open. Some people forget that now, but we went in it with our eyes open, so we knew that that's what we were paying for."

Others stated that they have identified a threshold of acceptable risk, and will not purchase or lease buildings with a seismic resilience that falls under that threshold.

A number of challenges were noted with considering seismic risk issues at the time of sale or lease:

- Stakeholders, both in interviews and in the Stakeholder Workshop in September 2013, noted that decisions to buy or rent space happen quickly. Any analyses or evaluations conducted need to fit into a short time frame.
- In a tight real estate market, it can be challenging to find any space within an organization's budget, much less space that meets rigorous seismic standards. As stated by one building owner representative, "It takes a lot of buildings off the market."
- One organization noted that the arm of the institution that dealt with real estate transactions appears to not be fully supportive of the seismic evaluations, which has led to some of those evaluations being of lesser quality than desired by seismic resilience advocates.

One building owner representative stated that their organization does not use leased buildings for purposes critical to business continuity. Therefore, less effort is put into managing the risk of leased properties.

It is interesting to note that out of only a small number of known instances to date in which a client paid a structural engineer to use the FEMA P-58 methodology, two of those instances were to assist building purchase decisions. In both cases, a large building or a stake in a large building was being considered for purchase, and the potential purchaser wanted an assessment of the building's risk that was as accurate as possible. The FEMA P-58 methodology was identified by their structural engineer as the appropriate approach to provide this information.

Table 4-18 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 4-18 Implications for Guidance Products from Purchase and Lease Decisions

Key Findings	*Relevance to Guidance Products*
The FEMA P-58 methodology has a role to play in purchase and lease decisions, and is already being used in this way.	Clearly show how to use the FEMA P-58 methodology for this purpose.
Many purchase and lease decisions happen within a short time frame.	Provide clear information about the time and cost of conducting an analysis using the FEMA P-58 methodology.
The FEMA P-58 methodology has been used to assist purchase decisions for large, valuable buildings.	Target people who are making decisions where a lot is at stake, warranting the cost and effort of an analysis using the FEMA P-58 methodology.

4.4.2 Use and Perception of PML, SEL, and SUL

Scenario Estimated Loss (SEL) and Scenario Ultimate Loss (SUL) are estimates of probable building repair cost expressed as a fraction of replacement value; these measures are widely used by commercial lenders and property investors when considering real estate transactions. Formerly, a measure called Probable Maximum Loss (PML) was used for this purpose, and the term PML is still frequently used when referring to seismic risk calculations required for obtaining financing for buildings. Typically, an SEL value of 20 % is required to obtain financing with favorable terms. ASTM E2026-07 and E2557-07 (2007a and b, respectively) are industry standards that define various levels of detail used to perform SEL and SUL calculations and the desired qualifications for persons performing these, but do not provide prescriptive guidance on how to calculate them. As a result, current practice is varied, and not rigorous or reliable.

Stakeholders reported in the interviews and the September 2013 Stakeholder Workshop that the current PML/SEL/SUL system is widely recognized by engineers as providing unreliable information about seismic risks. One structural engineer stated, “They’re abused. They’re so badly mangled.” Another stakeholder discussed problems with the ASTM methodology, “The loopholes were expanded last time so wide that you can drive trucks through them.” He continued by discussing the attitude of the financial industries that require PML, SEL and SUL evaluations with, “They can tell their board that, ‘We’re doing our industry’s best practices.’ That is really how it works. The way it works is, they have very high standards, and then we have very loose reports. Just terrible, absolutely awful.”

Interviewees stated that the consultants hired to obtain PML, SEL and SUL calculations do not always perform the service well. One interviewee stated, “The vast majority of the groups are what some of us…call the three-letter firms that will charge you $500 or $1,000 and give you something that’s not worth quite that much." Another interviewee stated that favorable outcomes are predetermined by building owners, "They want to know they'll get a favorable report. They'll ask that question before they hire the consultant." Another stakeholder noted that there was no oversight or quality control for PML, SEL and SUL calculations: "Those PML reports are not being reviewed by experts. They're being reviewed by title-type people who are very good at checklists."

The strong feelings expressed by knowledgeable stakeholders suggests that there is room for an improved tool for stakeholders who desire better quality information for financing and insurance decisions. However, the interviews did not indicate that members of the finance and insurance industries are dissatisfied with the current approach. Representatives from these groups were not interviewed.

Again, among only a small number of known cases where use of the FEMA P-58 methodology has been paid for by a client, two cases in which high-quality PML/SEL/SUL calculations were conducted were identified. This clearly shows that there is existing interest in some cases, and that the FEMA P-58 methodology can be used this way. One structural engineer noted that it took them awhile to confirm that the FEMA P-58 methodology could be used to comply with the appropriate ASTM standards and suggested that this information be easier to find in the FEMA P-58 reports.

Table 4-19 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 4-19 Implications for Guidance Products from Use of PML, SEL, and SUL

Key Findings	*Relevance to Guidance Products*
The PML/SEL/SUL system has problems known to structural engineers, but is widely relied upon by building owners, financiers, and insurers.	Inform building owners, financiers, and insurers of problems in the PML/SEL/SUL system.
It is unclear that the FEMA P-58 methodology can be used to comply with ASTM E2026-07 and E2557-07.	Clearly state that the FEMA P-58 methodology can be used to produce PML/SEL/SUL calculations, and present the costs and time of doing so.
The FEMA P-58 methodology has been successfully used for high-quality PML/SEL/SUL calculations.	Position the FEMA P-58 methodology as a gold-standard for clients who care about the right answer.
The PML/SEL/SUL calculation, and many of the firms that do this work, lack credibility, casting doubt on other methods and firms.	Clearly show that the FEMA P-58 methodology produces reliable and meaningful results and that it is very different from more commonly used approaches.

4.4.3 Influence of Tenants

Stakeholders expressed that tenants—their desires and beliefs—have the potential to shape the way some building owners make decisions about seismic performance. This issue was mentioned both in the Stakeholder Workshop in 2013 and in the interviews. As stated by one interviewee familiar with the world of lending, “The tenants are the base of everything. If the users want it, the landlords will want it, the lenders will want it, because we all—we don’t lend on buildings, we lend on leases. It takes the tenant.”

Interviewees report that, currently, potential tenants do not typically ask about seismic risk issues when considering leasing a space and there is no price premium for space in buildings that are more seismically-resistant. Again, this point was made both in the Stakeholder Workshop and in the interviews. One interviewee stated, “It’s a real challenge for property owners to exceed the code, because there’s really no value yet in society of a better building.” The perception is that it can cost more to build a higher performing building, but tenants are not willing to pay more to occupy one. One building owner representative interviewed works for an organization that owns multiple buildings, some of which they occupy themselves and others that are leased to tenants. This building owner uses performance standards higher than code minimums for the buildings they occupy themselves, but when asked about the performance standards preferred by their tenants, who must pay for building upgrades themselves, stated, “When they’re tenants, no, it’s code.”

Interviewees mentioned that a small number of tenants are different. For example, both the University of California and the federal General Services Administration have policies that require seismic evaluations of buildings prior to lease and establish minimum acceptable seismic performance goals. A few anecdotes were shared about particular tenants who had requested seismic analyses of buildings before leasing space. One interviewee summed up his observations as:

> *“We are starting to see tenants who are sophisticated asking for the PML of a building, a few of them, and making value judgments whether they want to be in that building, but it hasn’t so taken over the market that buildings are devalued or more valuable …when you have a tight market, it has almost no value.”*

Another interviewee stated that in Japan, tenant concerns about earthquake risk and business continuity drive investments in better seismic performance of buildings and expressed hope that could happen in the United States.

Table 4-20 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 4-20 Implications for Guidance Products from Influence of Tenants

Key Findings	*Relevance to Guidance Products*
Tenants can be highly influential to landlords. Some care about earthquake risk issues.	Earthquake-concerned tenants are a potential, but largely not current, user for seismic risk information. The FEMA P-58 methodology might be of interest to some tenants.

Chapter 5

Communication to Support Informed Decision-Making

This chapter presents and analyzes information about how to communicate information about the earthquake risk of buildings for stakeholder decision-making. This includes a review of relevant literature on risk communication, as well as reporting insights that stakeholders shared with the Stakeholder Products Team on the types of information that is most meaningful to them and communication approaches that have been successful in the past. This chapter also presents detailed reactions of stakeholders to specific visuals that were shown during stakeholder interviews. It concludes by presenting specific feedback that was given on the FEMA P-58 methodology.

5.1 Academic Literature on Risk Communication

Social scientists have been studying how people and groups perceive and respond to different types of risks and new information about those risks for decades. The latest research (Kano et al., 2008; Kano et al., 2009; Wood, et al., 2012) finds that preparedness behavior arises from both receiving information about what to do and observing what others are doing. Communications about what to do to reduce risk are important, and can launch an individual to initiate a search for more information and to interact with their peers to determine how to respond to the risk. The appropriateness of taking the precautionary behavior is then either supported or not; failure to find support for the behavior recommendation during social interactions can lead new information to be ignored or discounted. This implies that the social environment is pivotal to either enhancing or counteracting the effects of risk reduction advice.

Social science research also provides significant insights into how to communicate risk reduction advice most effectively (Covello, 2003; Mileti et al., 2004):

- Create concern by being clear about: (1) potential losses; (2) how likely they are in a relatively short time span; and (3) how they can be reduced.
  - Make information consistent across materials, audiences, and time.
  - Use simple words and great visuals; invest in graphic design.

- Spell out who exactly is at risk.
- Tell people what to do first (e.g., "find out how much an earthquake could harm you").
- Tailor information for special groups and/or locales; personalizing the risk makes people pay attention.

- Support people in their search for more information.
  - Make additional information easy to find, e.g., position it where the target audience already is or goes.
  - Partnerships are effective; leverage existing networks.
  - Put your best specialist communicators out front.
- Repeat information
  - Use a sequenced, varied stream of communications, so that messages complement and reinforce each other frequently; the audience should hear the same or similar messages from multiple, trusted sources.
  - Match communication approaches to audiences based on current information gathering habits.

It is important to keep the tone of communications positive. Negative threat appeals seldom work. Excessive "doomsday" portrayals of threats tend to disempower the audience and promote denial and avoidance. It is most effective to balance presentations of hazard and threat information with positive imagery and messages, such as the ability of people and communities to more effectively counteract and respond to those risks, and the feasibility of their own personal action-taking.

Risk communication approaches can be grouped into three styles (Granger et al., 2002). Different styles are most effective for different audiences and messages. The three styles are:

- Tell people what to do.
- Give people numbers and facts that will allow them to make their own choices about what to do.
- Educate and involve people so they can become a part of the overall societal dialogue about how to manage the risk.

Due to its complexity and the likely sophistication of users, use of the FEMA P-58 methodology and promotion of a performance-based mindset falls into a category of risk communication best suited to the second communication style, Type 2, and perhaps also Type 3 for some users. In general, heavy-handed recommendations should be avoided. It is often more effective to adopt a tone that is informative and open-ended, and "if-then," rather than prescriptive, providing an appropriate amount of well-chosen information to help the user wisely draw their own conclusions. Similarly, it generally works best to adopt a neutral, non-judgmental tone regarding what people currently do, and not state too strongly what stakeholders "should" be doing instead.

Social scientists group decision-making into two modes: associative and cognitive. In associative mode, people make quick, habitual, even "automatic" or subconscious judgments and actions. In cognitive mode, they tend to seek, assess, and weigh information. Different modes will be associated with different stages of the decision-making process.

Table 5-1 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 5-1 Insights for Guidance Products from the Risk Communication Literature

Key Findings	*Relevance to Guidance Products*
Personalized guidance is most effective.	Target guidance products to specific audiences. Research the particular concerns, questions, and interests of each audience so that the guidance can respond to their personal concerns.
Negative threat appeals seldom work.	Focus on positive steps people can take; do not dwell too much on negative consequences.
Sophisticated audiences benefit from being provided numbers and facts, rather than being told what to do.	Present information about the FEMA P-58 methodology and performance-based decision-making in a neutral way that allows the audience to make their own decisions, rather than overtly seeking to convince them the approach is right for them.

5.2 Stakeholder Insights Regarding Communication

This section shares key findings regarding communication practices and approaches reported by stakeholders as both successful and unsuccessful at relaying the complex nature of earthquake risk for making decisions related to individual buildings. This covers the style, language, completeness, graphics, and many other characteristics that contribute to whether the message communicated is understood and internalized as intended.

5.2.1 Hazard

Communicating earthquake hazard information in a manner that is accurate, understandable, and meaningful to a diverse audience is a challenge. There are numerous aspects of earthquake hazard, including the magnitude of the earthquake, the location of the earthquake hypocenter and epicenter, the fault rupture characteristics, the amount of ground shaking at a building site, and the probability of the earthquake occurring. To add complexity to this challenge, the term *hazard*, as understood by structural engineers, is jargon that might not be understood the same way by building owners or other stakeholders.

There are many different ways that are used to communicate hazard for a specific building. The list that follows includes a range of options, including some that are technically rigorous from an engineering perspective (ground motion at a specific site), and others that are used colloquially by non-engineers ("the big one"):

- peak ground acceleration with a specified probability of exceedence in a specified number of years (e.g., 10% probability of exceedence in 50 years)
- the Maximum Considered Earthquake or ground shaking
- the design level earthquake or ground shaking
- a 500-year earthquake or 500-year ground shaking
- a scenario earthquake with a specific probability of occurrence (e.g., a 50% chance of occurring in the next 30 years)
- a scenario earthquake without a probability of occurrence (e.g., a Magnitude 7.2 earthquake on the San Andreas Fault at 3pm), or the repeat of a historic event
- comparison to shaking experienced in a known event (e.g., shaking twice as strong as experienced in the Loma Prieta earthquake)
- magnitude, ranging from a more technical approach (e.g., M_w 7.0) to a more colloquial approach (e.g., a magnitude 7)

From the perspective of communication for decision-making, the key goal is to convey enough information to support good decisions, but not so much that decision-makers are overwhelmed or confused. Interviewees shared frequent experiences in which decision-makers sought simplicity. More than one interviewee referred to "eyes glazing over" when hazard is described in an overly technical manner to decision-makers.

The stakeholders interviewed had a variety of preferences for how to present earthquake hazard to decision-makers, but the most prevalent preference was for an earthquake scenario. Several interviewees held this as a strong preference, as exemplified by this statement from a structural engineer: "Scenarios are the only way to go." Scenarios were identified as something that decision-makers can understand and relate to. Many interviewees stated that non-technical stakeholders think in terms of magnitude, which can be related to a scenario. Interviewees repeatedly stated that, when facing design choices, decision-makers ask, "What sized earthquake can it withstand?" One interviewee summed up the advantages of communicating with scenarios with, "Scenarios bring you right into what the consequence would be, rather than trying to dilute it with a probability … you could have a really bad consequence and you would miss it because you diluted it with the probability."

Scenarios were defined and used in different ways by the interviewees. Some interviewees stated that they present multiple scenarios to their decision-makers, to illustrate the range of impacts earthquakes could cause. Another stated, "If you're explaining more than one scenario, you totally lose them." One interviewee recommended using a scenario that relates to a known earthquake: "The one thing I've learned is that everyone relates to an earthquake they know." Six interviewees reported relying on scenarios of a specific magnitude in a specific location, such as "the maximum Hayward event." Others reported using variations on a scenario, such as "a code-level earthquake" or "a 500-year event."

An acknowledged downside of scenarios is that they show one set of possible circumstances, and do not convey the wide range of other possible outcomes. Some interviewees provided strategies for addressing this, such as this anecdote from one building owner representative:

> *"We again kept it pretty simplistic. "Here's the earthquake scenario." We did of course say that there's uncertainty in it, without getting into any sort of detail. We just said, "Understand that this is our best estimate, given that these earthquakes do things differently. You're not going to get the same earthquake that we're modeling here, we know that." And I think that level gets across okay."*

One structural engineer recommended using a scenario, "But you can play the game with the scenario by putting another column just to the left of the scenario and put the annual probability or however you want to convey the likelihood of that particular scenario."

Many of the interviewees (both structural engineers and building owner representatives) have a structural engineering or other technical background and, as individuals, they preferred ways other than scenarios to communicate earthquake hazard, but found that other decision-makers within their organization desired scenarios. Engineers seem to feel that scenarios do not adequately convey all of the information about hazard that is important for making decisions. A number of the interviewees expressed frustration at the level of simplicity that decision-makers desired, and seemed to struggle with the balance of being accurate and technically responsible, and communicating clearly. This was articulated by one building owner representative with, “I’m more interested in the accelerations and the durations. But I think this helps us with our average stakeholders, because they always want to say, ‘What happens in a 7.0 earthquake?’” Some of these interviewees felt that it was their duty to educate less technical decision-makers within their organization. For example, one asserted, “As we talk with owners, we need to be focused on ground motion and not earthquakes.” Another stated:

> *“I usually say, “This earthquake has a 10% chance of happening in the building’s lifetime.” People actually get that. They’re like, “Oh, okay. It could happen.” It does convey the level of risk, where I think earthquake scenario doesn’t convey that level of risk at all.”*

Numerous interviewees cautioned against using probabilistic descriptions of seismic hazard. One stated, “When you start getting into 10%, and this size earthquake will generate this, you’ve lost them.” Another stated, “If you tell any client it’s a 2% in 50 chance and this is a 2% in 10, their eyes glaze over.” A third described his unsuccessful efforts to educate decision-makers within his organization: “We’ve told them several times that this is a 2% probability in 50 years, but it has no connotation to them at all.”

Table 5-2 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 5-2 Insights for Guidance Products on Communicating Hazard

Key Findings	*Relevance to Guidance Products*
Scenarios are meaningful to many people, with varying degrees of complexity.	Recommend scenario-based presentations of hazard, with variations that reflect the level of sophistication and needs of the decision-maker audience.
Accuracy is important in that decision-makers should understand the uncertain nature of hazard.	Include discussion of uncertainty in scenarios.
Probabilistic statements of hazard are not understood by many non-engineers.	Provide alternates to probabilistic statements that still communicate uncertainty.

5.2.2 Casualties

Communicating about casualties—deaths and injuries—was regarded as very problematic for some stakeholders, and important to others. Out of thirteen building owner representatives interviewed, six stated that casualty estimates were problematic for them, three stated that they were important to them, and four did not express an opinion. The reluctance to discuss casualty estimates is an interesting juxtaposition with the high priority stakeholders place on safety, as discussed in Section 4.2.1.

A number of interviewees were concerned about public reactions to casualty estimates. One building owner representative shared the view of his superiors: "They really, really, really don't want us going around saying, 'You might have 40 people die.' We don't say stuff like that. In a closed board session, we would probably talk to the board about it like that, but not to the public." Another stated that it could cause problems for politicians: "Knowing that there would be 40 casualties doesn't help. It might hurt politically. It could be perceived negatively, that the mayor signed off on a project that would have 40 casualties." One interviewee related an anecdote about a past effort in which casualty estimates had caused worry among employees:

> *"There was a point where people to some degree didn't want to come to work or were saying, "Why am I in this building and not that other building that's safer than this building?" …We had to completely pull back on the analysis…pull the emotion out of it, and make it wholly business-focused."*

Some stakeholders said that, while they address safety issues in earthquake risk discussions, they prefer to keep the discussion vague and unspecific. One stakeholder described his organization's approach with, "We didn't think we could not talk about it, but we made it pretty vague and pretty generic." This was expressed by another stakeholder with:

> *"We don't really quantify that at all. The moment you do quantify actual deaths, it gets murky. …We just talk in high confidence that we're retrofitting the building to meet life safety standards and that it's intended to get everybody out of the building alive. That's the extent of how we've communicated it*."

Some stakeholders felt it was important to include casualties because they are a real consequence of earthquakes. As stated by one building owner representative, "I believe that if we tiptoe around the issue, we're not getting people's attention. We're not trying to be alarmist, but at the same time, we've got to tell the truth." Two stakeholders, perhaps notably both from government entities, stated that knowledge of casualty risk was an important piece of information for making decisions and prioritizing risk reduction activities. Casualty numbers and degrees of injury also are needed for benefit cost evaluations that monetize death and injury avoidance.

Interviewees noted that the term *casualty* is ambiguous. The term *deaths*, while unambiguous, is off-putting. However, it is important that whatever term is used—deaths, injuries, fatalities, casualties, etc.—must be clearly defined.

Many interviewees used the term *life safety* when discussing safety issues, which has a specific technical definition according to structural engineering standards. In ASCE/SEI 41-13, designing a building to a *life safety* level of performance means that the building is likely to have some residual strength and stiffness left in all stories; it does not mean that risks of deaths and casualties have been eliminated (ASCE, 2014). The term *life safety* appears to be understood by some stakeholders as meaning a building will have no loss of life in earthquakes. One building owner representative made a strong statement about the need to reconsider the term *life safety*:

> *"A lot of lay people, when they hear life safety, they say, "That's what we want. We don't want to have anybody injured or hurt in this building," so they always say, "We want life safety." But you can also achieve that no injuries or greatly reduce injuries in a different damage state than just life safety. I don't like the term life safety, because I think it conveys something that means one thing for an engineer but could mean something different for a decision-maker."*

This opinion was not universal. Another building owner representative with a structural engineering background had made, he felt, a successful effort to educate his non-engineer colleagues about the term: "*Life safety*, we've explained many times what *life safety* means. They pretty much get it. They understand what it means when I say this building's not life-safe, this one's been upgraded or it needs to be upgraded, they've got that."

A number of interviewees questioned the accuracy of casualty estimates, noting that casualties will vary depending on how many people are inside a building when an earthquake occurs, which can vary dramatically by the time of day and date. It was not clear to them that the FEMA P-58 methodology takes this into consideration by considering actual occupancy 24 hours a day, seven days a week. Others, with more knowledge of loss modeling and the data that underlie it, noted that casualty estimates are based on weak epidemiological data linking damage with the degree of casualties under various situations. Estimates are based on limited data, have many embedded assumptions, and high uncertainty. They suggested that this is another reason to be careful about how casualty estimates are presented.

In the Stakeholder Workshop, participants asked whether casualty estimates could be made optional. Another suggestion is to calculate the probability of incurring casualty-causing damage, rather than the probable number of casualties, which might be both more useful and tasteful to decision-makers.

Table 5-3 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 5-3 Insights for Guidance Products on Communicating Casualty Information

Key Findings	*Relevance to Guidance Products*
Casualty estimates are a sensitive topic for many stakeholders.	Make calculating casualties optional. Add capability to calculate the probability of casualties or life-threating damage to the methodology. Present a range of ways to discuss casualties, which includes not discussing them. Casualty estimates might be most useful if they can be compared to some measure of acceptability, such as what current code provides, or another measure.
Casualty estimates often are misunderstood as predicting the real numbers of casualties.	Clarify that estimates are based on average occupancy over 24 hour, seven days-a-week, and might be probabilistic.
There are technical concerns about the accuracy of casualty estimates.	Clearly state the sophistication of the FEMA P-58 methodology to calculate casualties, but not overstate it. While the FEMA P-58 methodology is state-of-the-art, it remains highly imperfect.
The term casualties is unclear.	Use clearly defined and intuitive terms to discuss deaths and injuries.
The term life safety is understood differently by engineers and non-engineers.	Avoid the use of this term. Use clearly defined and intuitive terms.

5.2.3 Repair Time and Downtime

Interviewees indicated that maintaining business continuity and limiting downtime after an earthquake were of high importance to them, as discussed in Section 4.2.2. This would indicate that stakeholder guidance products should emphasize information on this topic. However, this topic appears to be one that is frequently interpreted in differing ways. Clear communication is essential.

The FEMA P-58 methodology calculates *repair time*, which is defined as the length of time necessary to conduct repairs (FEMA, 2012). Repair time is not synonymous with business downtime. Business downtime is a function of many other things, including but not limited to the time required to evaluate building damage; obtain financing to make repairs; design needed repairs; obtain permits; line up contractors, equipment, and tradespeople; procure items needed for repairs with varying lead times; conduct repairs; resume functioning of lifelines controlled by other entities including water, sewer, and power; and resume the ability of employees to travel to the building. Repair time is only one of these items. Further, the ability of the building to be in operation is not necessarily directly linked to repair time; some types of damage can be repaired while the building is in use, while other types of damage require the building to be vacant. The use of the building is also important. Some functions can be easily replicated in another building, while others require specialized equipment or other features linked to one particular building.

Many stakeholders do not seem to differentiate between the terms *repair time* and *downtime*, at least not without the difference being called to their attention. When shown example results from the FEMA P-58 analysis in the interviews, it appeared that some interviewees might be misinterpreting repair time as downtime. For example, when examining example results that included repair time, one building owner representative reacted with, "Repair time is good, too. Understanding …how long do you expect the building to be down." Another building owner representative reacted with, "We would take the repair time, and we turn that into business impacts. We'll refer to that as downtime for our business and what does that mean from a revenue standpoint." A third concluded that repair time of three months meant it "would take three months before the building was serviceable." Note that during some of the interviews, *repair time* was defined in a footnote of the first table of Visual #1 (see Section 5.3); this did not noticeably improve the understanding of this term.

Stakeholders who understood the difference between repair time and downtime noted that downtime was of more value to them. As stated by one building owner representative, "I think what would be more helpful is estimated days to reoccupy with acceptable levels of damage still in place. That's the biggest thing we're interested in, when you can get back in."

One structural engineer who has thought a lot about this issue stated his conclusion about the best way to communicate on this topic, "At the end of the day I think downtime is definitely the best indicator of resilience. It's intuitive, people get it. We talk about it in terms of reoccupancy and functional recovery, and that's even more intuitive, rather than downtime."

Table 5-4 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 5-4 Insights for Guidance Products on Communicating Repair Time and Downtime

Key Findings	*Relevance to Guidance Products*
Stakeholders confuse repair time and downtime.	Clearly state or show that the FEMA P-58 methodology calculates repair time, which is not synonymous with downtime.
Downtime or time until a building resumes functionality is of more interest to stakeholders than repair time.	Update the methodology to calculate downtime, if possible.
Stakeholders understand key terms differently.	Clearly define terms such as repair time, downtime, reoccupancy, and functional recovery.

5.2.4 Uncertainty

Uncertainty is embedded in earthquake risk. The timing and strength of the next significant earthquake to strike any particular location is uncertain, the impacts of a particular amount of ground shaking on a building are uncertain, and the economic and social consequences of various levels of damage are uncertain. All of these issues can only be accurately quantified as a range of possible outcomes with varying probabilities. The FEMA P-58 methodology rigorously quantifies the uncertainty of all of the results it produces.

Communicating about uncertainty is another important but problematic issue. When queried about how they tackle this communication challenge, some interviewees commented that they never or rarely mention variability in possible outcomes to decision-makers. Others said they feel communicating uncertainty is part of giving an honest and accurate estimate of what can happen.

Probabilistic uncertainty was mentioned as too complex a concept for some decision-makers. As relayed by one building owner representative, "Every time we talked about probabilistic to all of our media relations people, their eyes just glazed over. [laughs] 'Just make it simple for me, will you?' " One structural engineer stated, "If I start saying, 'This is with 50% confidence, this is with 90% confidence,' people's eyes will just glaze over. I usually say 'expected,' and when people hear that, they're like, 'Oh, OK.' "

Uncertainty can be viewed as undermining the value or credibility of information. One building owner representative stated outright, "We don't like uncertainty." One engineer lamented this issue:

> *"As a profession, it's kind of discouraging. It makes us look like a bunch of guessers. And as educated guessers, I would say, 'Look, it's not that we haven't spent a lot of time studying this problem and trying to get our heads around what can be known about it. But in fact, what is known*

and what has been proven over and over again is that it's not extremely predictable in any precision.'"

A number of interviewees stated that they mention uncertainty and they express it in simple terms but do not generally quantify it. Others recommended presenting results as a range, which indicates that there is uncertainty, identifies the magnitude of likely outcomes, and is relatively simple to understand. A number of building owner representatives interviewed were well-informed about the uncertainties inherent in earthquake loss estimates and were skeptical of results that did not include some information about level of confidence or uncertainty. One stated, "I do feel strongly that it's really a range and it should be conveyed as a range."

One structural engineer noted that the uncertainty associated with particular types of earthquake impacts is more challenging to communicate than other types of impacts. He stated:

> *"With downtime, it is more a binary thing, where you either damage this thing and once you damage it it's a huge amount of downtime because you've got to get the money to repair all that stuff. If you don't damage that thing, it's zero downtime. Let's call it functionality, full recovery. How do you communicate that?"*

Table 5-5 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 5-5 Insights for Guidance Products on Communicating Uncertainty

Key Finding	*Relevance to Guidance Products*
Probabilistic information is confusing to many non-engineers.	Use a minimum of probabilistic language. Presenting a range of possible outcomes can be a simple and effective alternative.
Earthquake-concerned stakeholders generally know that uncertainty exists and do not trust results where it is not acknowledged.	Acknowledging uncertainty is important for many stakeholders.

5.2.5 Terminology and Jargon

The complexity of the underlying hazard and the processes that are used to understand and address it can lead engineers to give too much information or to use excessive terms of art. As stated by one interviewee: "One of the challenges we structural engineers always have is that nobody understands what we're talking about. It seems clear as day in our minds, but everybody else's eyes glaze over and they have no idea." Another stakeholder stated, "Translation is a key need, and I think we can all learn to do it better."

A number of terms were mentioned in previous sections that were unclear to interviewees, including *hazard*, *repair time*, *repair costs*, *casualties*, *life safety, downtime,* and *reoccupancy.* In some cases, interviewees asked for definitions of these terms. In others, their responses to questions made it clear that they were defining terms in different ways than intended. A number of terms have a specific structural engineering definition, defined in codes or other documents, that are not known to other stakeholders, who interpret these terms as best they can given the commonly understood definitions of the words.

Table 5-6 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 5-6 Insights for Guidance Products on Terminology and Jargon

Key Finding	*Relevance to Guidance Products*
Different people use and understand the same words in different ways.	A variety of approaches can educate readers on the intended meaning of particular important terms or concepts, e.g., graphics, clear definitions, glossary.
Engineers have a professional technical lexicon for certain concepts (often linked to codes, methods, or ordinance language) that includes words and phrases widely perceived differently by non-engineers.	Eliminate structural engineering jargon and acronyms where possible from materials aimed at other types of stakeholders.
Language can be complex, confusing, and misinterpreted.	Adopt consistent and clear language across all guidance products to the degree possible, while also trying to match the language to the level of detail and audiences' levels of understanding.
Some engineers have a difficult time explaining technical concepts to stakeholders.	Provide advice, graphics, and a tutorial on communicating the concepts of the FEMA P-58 methodology.

5.2.6 Value of Comparisons

Comparisons were frequently cited as an effective communication tool. This includes comparisons of different options that could be pursued for a building, for instance leaving things "as is" versus rehabilitating a particular property to various degrees, or the difference in performance expectations for two different design options for new construction. For example, a structural engineer described a system his company uses to determine client performance preferences, "We'll lay out a whole…matrix of possibilities. …It shows them what end of the matrix is good performance and what end is poor performance, and you talk about everything in the middle and get them to lean one way or the other."

Many building owner representatives also described using comparisons of options as a tool for decision-makers within their organizations. During the interviews, several building owner representatives shared tables they had put together comparing options for their decision-makers. One interviewee described a table showing many possible projects his board was asked to consider pursuing with, "Every one of these was calibrated on what we knew they were worried about." His table was colored coded with red, yellow, and green based on an important parameter, and presented all information in terms of financial impact, the metric of choice for his board. Another interviewee described her organization's approach:

> *"We often take these to our board, where we say, "In order to meet class three, this is the cost of the building. If we wanted to meet class two, the incremental cost would be X. Is that something you want to do?" We're putting the choices very clearly on the table."*

It can also be powerful to compare one building to others in the neighborhood, others used in the same industry, "average" similar buildings, buildings that were damaged in specific earthquakes, or buildings that meet "current code". For example, one structural engineer described the importance of comparisons in educating clients, "A lot of the conversations with those owners is explaining to them what is probable compared to other buildings and then explaining this building as it compares to other buildings in that group, so that they can get a comparison." Another structural engineer stated, "For the most part, we try to characterize seismic risk on relative basis. We compare it with benchmark buildings in the same neighborhood."

Table 5-7 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 5-7 Insights for Guidance Products on Use of Comparisons

Key Finding	*Relevance to Guidance Products*
Comparisons are widely used to guide decision-making.	Identify useful comparisons for various types of decisions and decision-makers.

5.2.7 Visual Presentations

Stakeholders expressed that images, photographs, and other visual presentations are powerful ways to communicate. As expressed by one structural engineer:

> *"In fact, [images are] the only way we know to really communicate the risk, to literally show them lots of pictures of different things. "Here are all buildings that met code. They don't look so great. Here are buildings that had a half of a code earthquake and structurally they*

performed fine, but look what happened to the ceilings." Get them to look at that and that earthquakes at that level are 10 times more likely than the one you're designing for."

During the interviews, stakeholders responded well to the pie chart and bar charts they were shown (see Appendix C). Some comments include, "I thought that was extremely enlightening, to see that pie chart," "I love the pie chart," and "I prefer bar charts." Suggestions were made to replace tables and text with bar charts or other visual options. One suggested, "Anything graphical will be much, much better than just numbers. In fact, if there's a way to put it in there without seeing numbers but seeing pie charts with percentages shown rather than [written], so their mind doesn't have to relate…to percentages." Some stakeholders shared charts, diagrams, maps, and other visual presentations that they used within their own organizations that employed a variety of presentation techniques. Multiple interviewees mentioned the use of a red-yellow-green color scheme to represent varying levels of risk.

Table 5-8 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 5-8 Insights for Guidance Products on Visual Presentation

Key Finding	*Relevance to Guidance Products*
Visual presentation works better than textual presentations for many people; a variety of effective options exist.	Use visual presentations in addition to text whenever possible. Identify effective examples of ways to present the outputs of the FEMA P-58 methodology.
Visual presentations of damage illustrate conditions more clearly than numbers.	Provide photographs and sketches of typical damage to illustrate damage associated with estimates from the FEMA P-58 methodology.

5.2.8 Importance of the Communicator

Many aspects of communication and decision-making hinge on relationship and the degree to which the parties working together know each other, trust each other, and have a track record of working together successfully. This theme emerged both between consultants and clients, and between individuals working inside the same organization.

One building owner representative attributed his ability to make creative performance-based decisions to, "A lot of trust is put in myself" by individuals whom he reports to. He also emphasized that trust plays a key role in the entire process: "The only way we can get to those issues is by having this trusted collaboration where we're allowed to tap into the collective wisdom of an entire team."

A structural engineer attributed his efficient working relationship with a client to "a lot of trust and experience." A building owner representative described her trust in her structural engineering consultant with:

> *"I think the reason our program is so successful is because we have such a great partnership with [our engineering consultant]. I really appreciate that their interest is always our interest and they never—I always am very confident in the advice that they give and the direction and things like that."*

Table 5-9 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 5-9 Insights for Guidance Products on the Importance of the Communicator

Key Finding	*Relevance to Guidance Products*
Trust matters; better communication occurs when there is trust.	Identify trusted experts from both within and outside organizations who can clearly convey complex information and act as catalysts for the adoption of specific guidance products.
Frequency of contact and repeat business aids in forming strong relationships and trust.	Acknowledge that trust may be harder to achieve with user audiences that have less frequent occasion to interact with structural engineers. Consider other routes for establishing trust if or when these audiences are targeted.

5.2.9 Personalized Information

There will never be one best way to present the results of an analysis using the FEMA P-58 methodology. People differ in what information is most interesting and useful to them and the most effective way to present that information. This need for variety partly comes from varying personal preferences, but it also comes from the wide variety of audiences, with differing interest, available time, and levels of technical knowledge, to whom results of a FEMA P-58 analysis might be communicated.

A structural engineer who conducts an analysis using the FEMA P-58 methodology might need to communicate those results to other members of the design team—the architect, mechanical and electrical engineers, construction managers, for example—or to representatives of the client who owns the building. The client representative may, in turn, need to communicate those results to corporate leadership, Board of Directors, other departments, lawyers, or financial decision makers within their organization. Government entities seem to have even more audiences they need to coordinate with, serve the needs of, and convince, as discussed in Section 4.3.4.

Interviewees recommended that communicators figure out what their audiences' goals are or what they care about, so information could be presented in those terms. It also helps to use measures that relate directly to the particular clients' business objectives or responsibilities. One building owner representative summed this up with, "You have to read your decision-makers and say, 'What are the hot buttons for them?' And then hone in on those. Forget the other stuff."

The following issues would benefit from personalized communication:

- Who is the audience, and what is their level of technical knowledge, amount of time, visual presentation preferences, etc?
- What are the top priorities of this organization?
- What issues drive decision-making within this organization?
- Are particular types of information sensitive, such as casualty estimates, that should not be shown or that should be shown with great care?
- Are there any meaningful reference points of the audience (past earthquakes experienced, similar organizations, etc.) to compare to?

Table 5-10 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 5-10 Insights for Guidance Products on Personalized Information

Key Finding	*Relevance to Guidance Products*
Personalized presentations are most powerful.	Make guidance products flexible and adaptable. Include templates for providing information in understandable ways that are meaningful to varied decision-makers.
Structural engineers who use the FEMA P-58 methodology are in the best position to customize information outputs for different users.	Provide structural engineers with rationales, tools, and advice about how to communicate outputs differently to particular clients.

5.3 Specific Reactions to Sample Visuals

Interviewees were shown visuals of sample results of an analysis using the FEMA P-58 methodology for a hypothetical building (see Appendix C). This section summarizes how the respondents from Round 1 and Round 2 of the interviews responded to these visuals. Each section below replicates the visuals that were used during the actual interviews, followed by a summary of what the respondents said in terms of what they liked and did not like, what they understood and did not understand, and suggested changes. An overall summary of respondents' thoughts is below, in Table 5-11. Note that changes were made to the visuals between Round 1 and Round 2; several of the visuals had minor changes, and Visual 5 had a major change, described later.

Table 5-11 Effectiveness of Visuals for Communicating Risk of Building Damage*

Respondent Rating/ Visual #	*Effective, no reservations*	*Effective, with changes*	*Indifferent/ Uncertain*	*Ineffective, but harmless*	*Ineffective, mislseading*
Visual #1 (n=19)	16% (n=3)	63% (n=12)	5% (n=1)	0% (n=0)	16% (n=3)
Visual #2 (n=19)	37% (n=7)	58% (n=11)	0% (n=0)	5% (n=1)	0% (n=0)
Visual #3 (n=13)	31% (n=4)	46% (n=6)	8% (n=1)	8% (n=1)	8% (n=1)
Visual #4 (n=14)	21% (n=3)	29% (n=4)	36% (n=5)	7% (n=1)	7% (n=1)
Visual #5** (n=11)	9% (n=1)	27% (n=3)	9% (n=1)	55% (n=6)	0% (n=0)

* *n* = number of respondents
** The Round 2 version of Visual 5

5.3.1 Reactions to Visual #1: Expected Damage in Earthquakes of Various Sizes

Of 19 respondents who evaluated Visual #1, shown in Figure 5-1 and Figure 5-2, 15 found the visual to be an effective way to communicate the risk of building damage in an earthquake. The respondents appreciated how it summarized complicated information in a way that was easy for the general public to understand.

Expected Damage in Earthquakes of Various Sizes

Earthquake Return period	Repair Cost	Repair Time	Probability of Red Tag	Casualties
200 years	$4 million	40 days	14%	1
500 years	$10 million	90 days	36%	20
1,000 years	$36 million	180 days	72%	130

Figure 5-1 Round 1 Version of Visual #1.

Expected Damage in Earthquakes of Various Sizes

Earthquake Scenario	Repair Cost	Repair Time*	Probability of Red Tag	Casualties**
M 6.5	$4 million	40 days	14%	5
M 7.2	$10 million	90 days	36%	40
M 8.1	$36 million	180 days	72%	320

* Repair time only includes construction time. Additional time will be required to make decisions, obtain financing, receive insurance payments, engage design and construction professionals, obtain permits, etc.

** Casualties are defined as deaths and injuries requiring hospitalization.

Figure 5-2 The Round 2 Version of Visual #1.

They also believed that the visual presentation was attention-grabbing and would help them convince stakeholders of the degree of risk. As expressed by one building owner representative:

> *"It is kind of nice to have that data in your hip pocket before you express to somebody what's really going on. It does put a sense of reality of why we're doing what we're doing. One of the biggest challenges we have… is that there was a misconception of what it meant to say, "Our building meets code." To them, that meant it's completely earthquake-proof, zero damage, everybody gets out. It's been a struggle for me to say to people, "No, it's kind of a way of getting close to something where everybody might get out, but it has nothing to do with damage." This is nice, because it puts things more in the context of what we're talking about here."*

Three respondents, however, found Visual #1 to be misleading and expressed serious concerns about how it could be misinterpreted, and possibly misused, by non-technical individuals. It seems possible that the interview context strongly impacted these reactions. All or some of the negative reaction to Visual #1 as a whole comes from the artificial situation of being asked to react to hypothetical results for a made-up building during an interview with an unfamiliar person. These interviewees expressed concerns about whether the hypothetical results were realistic and were unable or unwilling to respond to whether this type of information and presentation, assuming it was based on sound analysis techniques, would be meaningful to them. This same general desire to understand and trust the methods behind the numbers was expressed by numerous other interviewees who were, nonetheless, able to share opinions on the visual assuming the results were sound. This lack of trust and the inability of some respondents to get beyond it is, in and of itself, an interesting result that points to the need to build credibility and trust at the outset.

A few interviewees also criticized the lack of information about the data sources. One respondent wondered whether the estimates were derived from average values following an earthquake and complained that this misrepresented how repair costs and times vary widely depending on the building type, the degree of earthquake impacts, etc.

Among the 15 respondents (89%) that viewed Visual 1 as effective, 12 expressed reservations about how the information was presented and believed it was necessary to make changes to avoid misinterpretation and misuse of the data. Their critiques were mostly concerned with refining vague terms and providing more details about how the estimates were produced. These comments and suggestions are summarized in Table 5-12 and described in more detail in the text below.

Table 5-12 Summary of Concerns and Suggestions for Visual #1

Topic of Concern	*Concern or problem*	*Suggestions*
Earthquake Hazard	Measures do not mention distance from epicenter or earthquake depth Measures do not describe the probability of the event occurring	Use "ground-shaking" or "acceleration" measures for appropriate stakeholders Insert column with the probability of the event occurring in next *n* number of years Clarify the location of scenario events
Repair Costs	What type of building is described? (size, steel or concrete, building code) What types of costs are included in total? Costs of being out of operation are equally or more important Example is unrealistic	Define type of building being discussed Clarify what is included in repair costs Provide estimate of cost for having building out of operation
Repair Time	What is included in this estimate? Example is unrealistic	Explicitly define repair time
Red Tag	How are red tags defined? Is the building partially operational? Yellow tags are as important as red tags Is the probability of red tag part of the repair cost or repair time value? Example is unrealistic	Define what a red tag is Explain how replacement cost and replacement time estimates relate to red tag Consider adding estimate of yellow tag
Casualties	Casualty estimates would change depending on if it is a weekday or weekend and building's use (e.g., office vs. warehouse) Information may be politically risky or seen as fear-mongering	Include building's use and day of week explanatory note about casualties May not be appropriate to use in some settings or political contexts

5.3.1.1 Earthquake Hazard

The majority of respondents (*n* = 9) were concerned by how the earthquake hazard was depicted and expressed reservations about both of the options they were presented. (The earthquake scenarios were represented by "Earthquake Return Period" in Round 1 and "Magnitude" in Round 2.) Several noted that magnitude of the earthquake was irrelevant if they did not know the epicenter and depth of the event. As stated by one interviewee:

> *"I'm a little skeptical of the earthquake scenario, the definition of what that is, and people understanding what that is… [A] 6.5 [earthquake] located with its epicenter 10 miles from us and 200 feet deep, it's going to be different from a 6.5 that's right under us and it's very shallow."*

Respondents were also concerned that the Earthquake Hazard category did not include a measure of the probability of the event occurring. Two respondents recommended adding a column to the table that described the probability of the event occurring during the building's lifetime or in the next *n* number of years (e.g, 30 years or 50 years).

Interviewees shared a range of opinions on the best ways to communicate seismic hazard. These are discussed in detail in Section 5.2.1.

5.3.1.2 Repair Costs, Repair Time, and Red Tag Probability

Five respondents were concerned by the lack of details available for understanding repair costs and expressed a desire to know what data the values were based on. These respondents wanted to know how the repair costs value was calculated and what types of costs it included. For example, several mentioned the need to define whether it included the cost of replacing equipment, inventory, and other internal investments in the building or if it strictly referred to the cost of repairing the structure. One respondent mentioned the need to describe the type of building represented in the graphic, including its size, the type of materials used to construct it, and the code it was constructed under.

Several respondents questioned whether the hypothetical results were realistic. One respondent, noting the high probability of a red tag in a high magnitude earthquake (72%), commented that the repair cost price tag did not reflect the higher cost of having to replace the entire building. This respondent recommended using asset replacement cost rather than repair costs. Two respondents made similar remarks about Repair Time. One individual remarked that if a building was red tagged, the repair time would go up significantly, and this did not seem to be reflected in the repair time estimate.

Despite the confusion about how the probability of a red tag was reflected in the repair costs and time estimates, several respondents were positive about including the red tag probability in the table. One structural engineer said: “[T]he probability of a red tag, I think that can wake people up a bit, or would. To see it in type on a piece of paper is better than to have me say it. I could give them these numbers and it would just drift by them. If you say it and it’s in front of them, ‘Whoa!’”

Lastly, one respondent mentioned the usefulness of providing an estimate of the cost of having a building out of operation during repairs. He said, “You’ve got repair costs. But there’s also a cost to having the building down. If it’s a jail, for instance, if a jail’s down for 90 days, it means you have to temporarily relocate prisoners for 90 days.”

5.3.1.3 Casualties

Five respondents were very critical of the casualties category and two stated outright that it should not be included. One respondent worried that engineers risked being accused of fear-mongering if they used it. Two others stated that the information might be politically risky to share publicly. The sensitivity around communicating casualty loss estimates is explored in depth in Section 5.2.2.

Two of the respondents also noted that the casualties data needed to include other details about the building and time of the earthquake, because the number of casualties would vary depending on if it were a work day or weekend and in buildings with different uses (e.g., office space vs. warehouses).

Table 5-13 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 5-13 Insights for Guidance Products from Visual #1

Key Findings	*Relevance to Guidance Products*
Visual #1 was largely viewed as effective, with significant and detailed suggestions on how to present specific items within it.	A visual similar to Visual #1 could be useful in guidance products, incorporating the advice and suggestions that are feasible. The diversity of opinions offered suggest that preferences vary.
Many respondents requested more contextual background and definitions in order to be able to understand, explain, and interpret the information relative to their own goals and decision-making purposes.	Context is critical. Provide guidance to help engineers or others who prepare visuals to adapt them appropriately to the context at hand. Consider ways to format additional information, such as definitions of terms, to accompany the graphic.

5.3.2 *Visual #2: Identify What Will Likely Cause the Most Earthquake Damage to your Buildings*

Reviews of Visual #2, shown in Figure 5-3, were nearly universally positive. Of the 19 reviewers, 18 found the visual to be an effective way to communicate the risk of building damage in an earthquake. The feature of the graphic that most pleased the respondents was the fact that it captured the nonstructural repair costs associated with earthquake damage. One respondent said: "It's an interesting chart to me because it says you're doing all this fine work, you're going to hold the building up, but your damage is going to come from elsewhere, not from the structure." Another stated that the detail represented in this graphic is "where the industry has to go regarding earthquake safety."

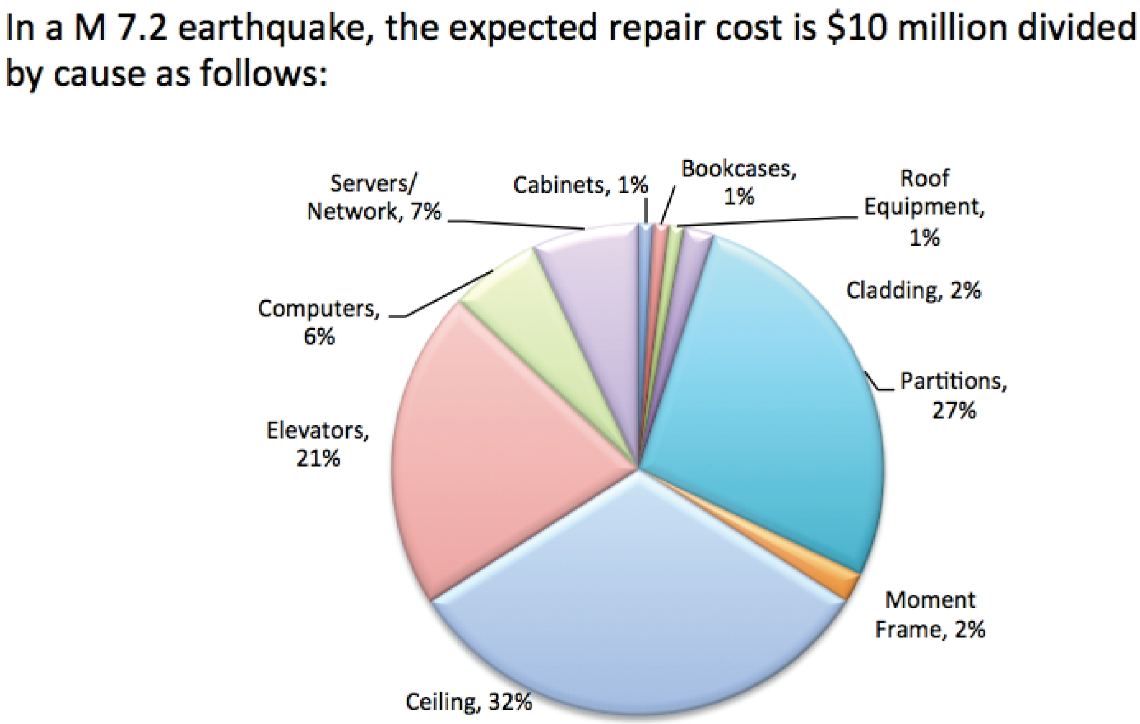


Figure 5-3 Visual #2 from Rounds 1 and 2.

The respondents said that this type of graphic would help them communicate to stakeholders the risks earthquakes posed to their businesses or organizations and the potential benefit of designing buildings to avoid these damages. One building owner representative said:

> *"That is one of the great things about [Visual #2], that ability to put in front of a decision-maker to say, "Look, this is where your potential damages are. We can fix this piece right here for pennies. We can fix this piece for pennies. If you want to fix this piece, we're going to have to spend some money, but look how much damage you'll get from that.*

This is where we can get you a lot of bang for your buck, by fixing this piece of damage, which will be very expensive to repair, and it'll cost you this much up front to fix it." Having that information to me is very useful."

Several respondents mentioned that this type of nonstructural repair cost information is something they would like to have access to so that they could help their business or organization make strategic investments and reduce potential repair costs and downtime after a disaster. As stated by one respondent:

"I thought that was a granularity that we had not had access to from an information standpoint. It really could help us understand where we might incur the most damage and where, if we wanted to be more specific about where we invested our money, that that would be quite helpful."

Another respondent echoed this sentiment, saying, "Anything that helps you spend your money in a smart way so you can attack the problem with the limited funds you have, that's bang for the buck to me, this type of thing."

Only one respondent found the visual to be ineffective, stating simply that the graphic would be of no use to his organization. This respondent also expressed doubts about the accuracy of the data and wanted to know more about its source and the types of buildings and businesses it was based on. These concerns were repeated by many of the respondents that were excited about the potential of the graphic.

While seven of the positive reviewers had no reservations about using the Visual as it was presented to them, 11 suggested certain changes to or questioned specific details of the visual, summarized below. Some respondents noted that the hypothetical results did not reflect the types of buildings used by their organization. For example, one respondent noted that for their business, servers were not an important item because they use the cloud. Others noted items that were missing from the list that they believed would be important to their own business or organization (for example, plumbing, waterlines, etc.) As articulated by one respondent, "[The chart] would be very useful, but maybe not all these particular elements on this pie chart, and there's other things that might be more important to us, but the idea is awesome." Some of the interviewees appeared not to understand that results of an analysis using the FEMA P-58 methodology would reflect the unique nature of each building and its contents.

Some respondents shared thoughts or desires about how this visual might alter decision-making. Some wanted links to a calculation of how much each nonstructural item contributed to business downtime post-disaster. For example, a business in a two-story building that is highly dependent on computers to carry out its productive activities would be more highly impacted by lost computers than the loss of elevators. One respondent worried that the low replacement costs of some items would lead stakeholders to make poor decisions and avoid investing in protecting items that had low replacement costs but high productive value–a decision the business will regret as the cost of downtime grows. Another respondent worried that the chart would lead decision makers to plan to avoid necessary repairs post-disaster: "It might be almost too much detail for some people. It's like, 'Let's not repair the ceilings and we'll save 30%.'" She concluded: "It's a nice chart maybe once you decide what you're going to do, but probably not a tool for making the decision."

Some respondents commented on the visual presentation and terminology in the graphic. Several respondents mentioned that they did not personally like pie charts. Some recommended experimenting with other types of chart, such as a bar graph. One respondent mentioned that an advantage of such a chart was that it would be able to fit data such as "contribution to downtime" and other details in. In addition, other respondents recommended eliminating technical terms such as "moment frame" from the presentation or providing their definition.

Table 5-14 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 5-14 Implications for Guidance Products from Visual #2

Key Finding	*Relevance to Guidance Products*
Visual #2 was positively received, with some suggestions for additions or changes.	A visual similar to Visual #2 could be useful in guidance products, incorporating the advice and suggestions that are feasible.

5.3.3 *Visual #3: Evaluate the Effectiveness of Options to Reduce Risk*

The reviews of Visual #3, shown in Figure 5-4, were largely positive, with 10 of 13 respondents (77%) finding the graphic to be an effective tool for communicating risk. The respondents appreciated the inclusion of retrofit design options and costs in the table. One structural engineer reacted with, "[T]his is definitely extremely useful," but noted that it would only be useful to, "the kind of client who can look at a table like this and make sense out of this array of numbers."

Of the 10 positive reviews, 6 respondents mentioned several changes they would like to see to the graphic, which largely echo the concerns and suggestions for Visual #1 (see Table 5-12). For example, respondents expressed reservations about the vague definition and potential misinterpretation of the terms, *earthquake return period*, *red tag*, and *casualties*. One respondent remarked that his confidence in the information would be higher if he knew that the results were based on solid research validated by actual earthquake damage. Another respondent reiterated a desire for data on loss of revenue due to the business being out of operation. A third respondent contributed a new suggestion that it would be helpful to add a column to the table that captured the return on investment of the retrofit schemes.

Retrofit Scheme	Expected Damage in M 7.2 Earthquake After Retrofit				Cost of Retrofit Scheme
	Repair Cost	Repair Time*	Probability of Red Tag	Casualties**	
Retrofit Scheme 1	$0.4 million	10 days	8%	negligible	$16 million
Retrofit Scheme 2	$1.3 million	25 days	21%	1	$7 million

* Repair time only includes construction time. Additional time will be required to make decisions, obtain financing, receive insurance payments, engage design and construction professionals, obtain permits, etc.
** Casualties are defined as deaths and injuries requiring hospitalization.

Figure 5-4 Visual #3 from Round 2. (Round 1 visual was very similar but did not contain explanatory notes under the table.)

The two respondents that found the visual to be ineffective were concerned with how it would be used by decision makers. The first commented that decision makers struggle when there are several different options and tradeoffs that need to be taken into consideration. The respondent was uncertain if the graphic effectively communicated the tradeoff between making the retrofit investment or risking the potential of costs associated with repairs and a red tag. The other respondent thought the numbers in the hypothetical example would be influential, but that they might give stakeholders a reason to avoid investing in retrofits. He stated:

> *"The numbers are convincing in the sense where your downtime will be much less and obviously you'll be able to function, because the red tag probability is much less. And yet on the other hand, the 25 days isn't so terrible. [laughs] Nine million bucks!… So I don't see, if I was the client, I'd say, "You're telling me to invest another $9 million to save*

$1 million in repair costs and two weeks of repair time." Kind of a tough sell with that matrix."

Table 5-15 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 5-15 Implications for Guidance Products from Visual #3

Key finding	*Relevance to Guidance Products*
Visual #3 was largely viewed as effective, with significant and detailed suggestions on how to present specific items within it.	A visual similar to Visual #3 could be useful in guidance products, incorporating the advice and suggestions that are feasible.
Many potential users want more standardization, simplification, and definitions.	Provide definitions and background information so those presenting the graphics can answer questions.
Some viewers would prefer fewer options or comparisons to be presented at the same time, or better explication of trade-offs.	Allow stakeholders to personalize resulting graphics.

5.3.4 *Visual #4: Compare Design Options in Meaningful and Measurable Ways*

Visual #4, shown in Figure 5-5, is an alternative version of Visual #3, shown in Figure 5-4. This discussion is short because respondents had less to say about Visual #4 and often repeated what they said about Visual #3. However, it should be noted that many respondents said that the addition of an additional scheme and the three bar charts to Visual #4 increased its quality over its predecessor, with the exception of one respondent, who argued that these additions muddled the graphic and made it hard to understand. Others recommended making cosmetic changes to the bar graphs so that they were easier to read.

Options		Cost
Option 1	Base isolation	$6.4 million
Option 2	Concrete frame	$3.2 million
Option 3	Steel frame	$2.8 million

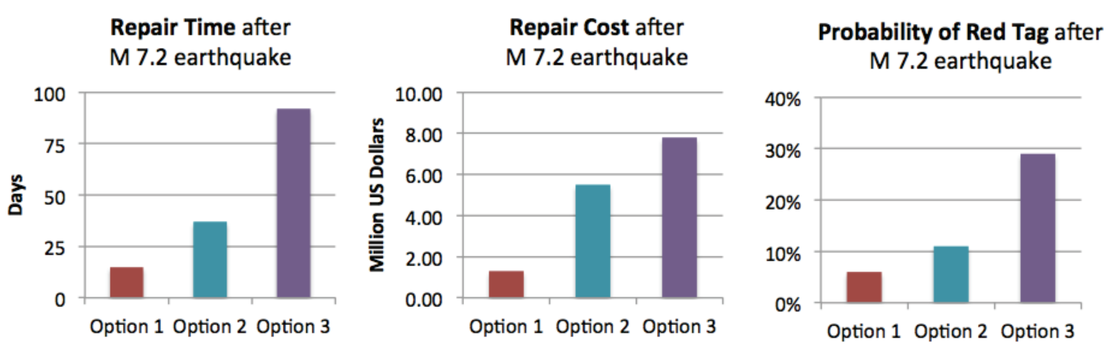


Figure 5-5 Visual 4, Round 2.

There were two more substantive recommendations made. One respondent recommended providing a more detailed description of what types of improvements and construction each retrofit scheme entailed. Another respondent was more critical and gave the graphic a poor review. This respondent, a structural engineer, was concerned about the red tag probability graph. He said: "If you're designing to a probable red tag, I don't think you're servicing the client very well. You need to be pushing it up to a higher standard than that."

Table 5-16 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 5-16 Implications for Guidance Products from Visual #4

Key Finding	*Relevance to Guidance Products*
Reactions to visual #4 were generally positive, although reactions were more cursory.	A visual similar to Visual #4 could be useful in guidance products, incorporating the advice and suggestions that are feasible.

5.3.5 Visual #5: Rating System

Interviewees in Round 1 and Round 2 were presented with two very different versions of Visual #5, as presented in Figure 5-6 and Figure 5-7. In Round 1, interviewees reviewed a set of graphics depicting the impact of three curtain wall installations on repair time, casualties, and red tag probability after a 500-year earthquake. Two respondents reviewed this option. One found it highly effective while the other was very confused by it and did not provide an opinion. In general, interviewees appeared to gloss over this graphic, possibly because it was very similar in appearance to Visual #4 from Round 1.

The Round 2 version of Visual #5, shown in Figure 5-7, was a Rating System that grouped repair costs, repair time, casualties, and red tag probability into five categories ranging from best to worst. This version of the visual was not popular: six of nine respondents disapproved of it. Three reviewers had a personal distaste for star-rating systems and complained that using one "dumbed down" what the FEMA P-58 methodology was trying to achieve by making it more like rating movies or restaurants. Another complained that it sounded too much like the environmental rating system for buildings (LEED Gold, LEED Silver, etc.) One structural engineer complained that the use of a rating system would limit the ability to engage decision makers in a strategic discussion of the retrofit options. He said, "The problem with that is, everybody wants to have platinum buildings, and if they're not, they don't want to know."

(2) Compare how specific design choices affect earthquake risk.

Three options for a curtain wall system:

Options	Cost
Option A	$890,000
Option B	$440,000
Option C	$390,000

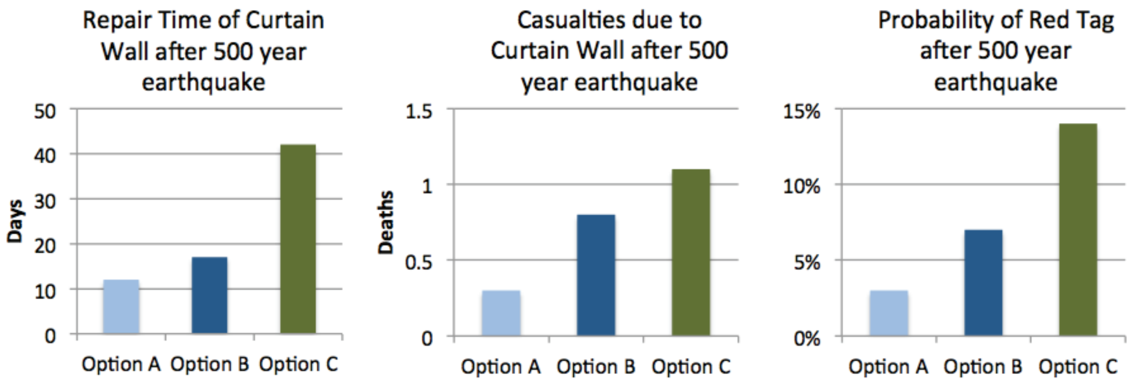


Figure 5-6 Visual #5 from Round 1.

Possible ways to categorize results			Expected impacts for an earthquake of specified size
Platinum	★ ★ ★ ★	A	**Repair Cost:** 0 to 3% of building value **Repair Time:** 0 to 7 days **Casualties:** negligible **Probability of Red Tag:** < 1%
Gold	★ ★ ★	B	**Repair Cost:** 3 to 10% of building value **Repair Time:** 7 to 30 days **Casualties:** negligible **Probability of Red Tag:** 1 to 10%
Silver	★ ★	C	**Repair Cost:** 10% to 25% of building value **Repair Time:** 1 to 6 months **Casualties:** negligible **Probability of Red Tag:** 10 to 25%
	★	D	**Repair Cost:** 25% to 50% of building value **Repair Time:** 6 to 12 months **Casualties:** < 5 **Probability of Red Tag:** 25 to 50%
		F	**Repair Cost:** > 50% of building value **Repair Time:** > 1 year **Casualties:** > 5 **Probability of Red Tag:** > 50%

Figure 5-7 Visual #5 from Round 2.

Some reviewers disliked how the visual included a heavy amount of text on the page and recommended including more graphics, like the previous visuals. The other concerns expressed by the respondents were echoes of ideas stated about the other visuals. One individual wanted more information about the data sources and their reliability. Others wanted more details about the type of building being impacted, the amount of ground-shaking it was exposed to, and what construction the different types of retrofit schemes entailed. One critic doubted the accuracy of the red tag probability in the FEMA P-58 methodology. One building owner representative stated, "I worry about false senses of security being given on the one hand, or over concern being caused on the other, just through a simple star rating system. It tends to break it down to a lowest common denominator."

Reviews were not completely negative, however. One respondent commented that similar rating systems had been undertaken by other groups and that such an effort might help businesses make decisions about purchasing buildings. Another reviewer commented on the power of a rating system to help stakeholders understand that "retrofit" is not a synonym for "earthquake proof." This respondent said: "You go in and say, 'Oh, this building's been retrofitted. We're good.' That doesn't mean anything. It would be wonderful to have some type of rating system. It would be a huge shake-up for so many people."

The rationale for including this graphic in the interview visuals was not to seek opinions on rating systems. Rather, it was included to see if respondent reacted positively to having the various types of earthquake consequences that can be estimated using the FEMA P-58 methodology grouped into categories rather than presented separately. This question arose because of the evolution from the ASCE/SEI 41 approach to the FEMA P-58 methodology. ASCE/SEI 41 performance levels qualitatively group together all of these types of earthquake impacts. Interviewers wondered whether having all of these types of losses calculated and presented separately would overwhelm decision-makers. Would grouping the quantitative results into a manageable number of categories be helpful? In many ways, this is like the individual rating systems that stakeholders have developed internally (see Section 4.3.6).

When viewing Visual #5, some interviewers specifically asked whether grouping the results would help decision-making. Respondents did not expect this to be helpful. While possibly this is because such groupings would not help decision-making, it is also possible that the specific options presented or the way they were presented (specifically, with a lot of text) inhibited understanding of the concept. Also, this question was asked at the end of the interviews; in many interviews, it was given only brief attention.

Table 5-17 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 5-17 Implications for Guidance Products from Visual #5

Key finding	*Relevance to Guidance Products*
Visual #5 was not well received overall.	A graphic similar to Visual #5 should not be used in guidance products. Graphics should use less text.
Visual #5 in the format presented might not have adequately encouraged discussion on grouped performance levels.	The value of grouped performance levels to stakeholders should be explored in other ways.

5.4 Reactions to FEMA P-58

Interviewees and workshop attendees were specifically asked for comments on the FEMA P-58 methodology. The FEMA P-58 methodology is new. Some of the stakeholders interviewed by the project and some of the stakeholders who attended project workshops were familiar with the methodology, and others were unfamiliar with it. Only a few of the stakeholders queried have deep familiarity with the methodology. The level of familiarity matters because the critique of the usefulness, problems, and value of the methodology is more valid when it comes from those who have thought about and considered the methodology for some time or have used it, and has less weight when it comes from someone who is providing off-the-cuff reactions to an idea that they have just been exposed to. The sections that follow present feedback received.

5.4.1 Perceived Value of the FEMA P-58 Methodology

Many of the stakeholders consulted found the concept of the FEMA P-58 methodology to be very valuable. Enthusiasm for the types of information that comes from an analysis using the FEMA P-58 methodology was expressed by both representatives of building owners and structural engineers, though the purposeful selection of whom to interview obviously influenced this finding.

Representatives of building owners expressed enthusiasm for the ability to communicate the impacts of spending decisions to decision-makers in their organizations. One representative of a building owner stated that the FEMA P-58 methodology provided a way to do something he had been seeking for some time: “I’ve been looking …to be able to go to an owner and say, ‘Look, here’s the three different systems that our engineers recommended. Even though this one's more expensive, look at the potential cost savings down the road if there's ever an event.'" They also saw potential for the methodology to help them make decisions when resources are limited. As stated by another building owner representative, "If we only have $3 million, what do we do?"

Many of the building owner representatives interviewed act as internal seismic resilience advocates for their organizations. They anticipated the methodology could help communicate the value of investing additional resources in upfront engineering design services. As stated by one building owner representative:

> *"Facility owners don't always understand that you could spend $10 on engineering and by doing that you hardly have to spend anything on retrofitting, because you've done a sophisticated analysis that shows your building's really good except for this one little thing here, where if you did a less sophisticated analysis, you'll have to do all these things to your building, and you're still not really going to know how it performs."*

A few stakeholders expressed that the FEMA P-58 methodology was unlikely to be useful to their particular group. In the September 2013 workshop, building developers, who construct a building and sell it quickly, thus holding the earthquake risk of that building for only a short time, stated that this methodology did not appear to be of great use to them. Other stakeholders speculated that the methodology had limited application to some other groups (although the stakeholders were not direct representative of those groups). For example, one technical stakeholder stated his belief that the FEMA P-58 methodology would not be of great interest to the insurance industry: "They need very little reliable data to make their estimates. …the industries run along working very well on these $25 to $50 per item assessments. So I'm not real hopeful that [FEMA P-58] is likely to have an influence on the insurance industry."

Most structural engineers in this study stated that the FEMA P-58 methodology was the future. In the words of one, "There's a lot of sincerity in the development of the theoretical underpinnings. It probably represents a good cutting-edge tool for doing as much as we can possibly do to characterize building seismic risk."

Table 5-18 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 5-18 Implications for Guidance Products from Perceived Value of Methodology

Key Findings	*Relevance to Guidance Products*
There is enthusiasm for the concept of the FEMA P-58 methodology both among the representatives of building owners and among structural engineers interviewed.	The earthquake-concerned stakeholders interviewed are potential users of the FEMA P-58 methodology.
Two stakeholder characteristics that seem to be associated with those less likely to be interested in the FEMA P-58 methodology are: Organizations who are highly interested in minimizing short term costs or who hold building risk for short periods of time (e.g., developers, leasees). Stakeholders who have a portfolio perspective and have a limited interest in individual buildings (such as insurers).	These groups should not be early targets for guidance materials for the FEMA P-58 methodology.

5.4.2 Questions Regarding Use of the FEMA P-58 Methodology

Building owner representatives shared some of their thought process about whether, when, and how they might use the FEMA P-58 methodology. As part of this, they posed questions that they need answers to before determining whether and how the methodology would be useful to their organizations.

Numerous building owner representatives asked about the cost, time, and effort to use the methodology, clearly showing that this information is of primary concern. The question asked by one building owner representative, "Is it a costly thing to run this?" was repeated by several others in very similar terms. Another building owner representative specifically requested information on how long the FEMA P-58 methodology takes to use: "If there's some general guidance for that, that would be good." Some stakeholders expressed concern about ease of use; in the words of one, "For this to be useful … it needs to be somewhat user-friendly."

Understanding the cost, time, and effort to use the FEMA P-58 methodology are part of answering a larger question about whether this approach would fit within the current decision making processes of their organizations, to either supplement or replace the way their organization currently addresses earthquake risk. Some building owner representatives articulated their thinking process about this. One mused:

> *"We'll need a certain level of information early on in concept design when we don't know a lot about the building and we're evaluating options. And then when we get into basic design, when we do know much more about the building, we can actually utilize this very deep analytical method. Is the process scalable in terms of iterating through the design as opposed to just a one-time shot?"*

Another shared internal considerations that would affect his use of the FEMA P-58 methodology:

> *"We're turning a lot to design-build for a lot of our structures, even some of our more complicated structures, and so unless I'm going to write something into our standards… I can see it as a tool for us when we're developing options for figuring out what our shells should look like and that sort of thing, but I'm not exactly clear on how this will be implemented."*

Table 5-19 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 5-19 Implications for Guidance Products from Questions about Use

Key Findings	*Relevance to Guidance Products*
Stakeholders want to know the cost and time to use the methodology.	Clearly state how long it takes to use the FEMA P-58 methodology, the level of input information required, the skill/knowledge level of the engineer who runs the analysis, etc. Include suggestions for instances in which the use of the FEMA P-58 methodology is likely to provide bang for buck.
Structural engineers desire a user-friendly interface.	Pursue a user-friendly interface.
Stakeholders need help understanding how use of the methodology could work within their decision-making process.	Clearly state whether and how the FEMA P-58 methodology can be used at different stages of the design process, for instance in conceptual design, detailed design, portfolio management, etc.

5.4.3 Concerns about Validation and Accuracy

Numerous stakeholders expressed concern about the credibility of the FEMA P-58 methodology, whether the results it produces are accurate and validated against actual performance of buildings in earthquakes. These concerns came in a detailed form from a couple of engineers who are deeply knowledgeable about earthquake loss estimation modeling. They also came from sophisticated building owner representatives who understand the complex nature of estimating the impacts of earthquakes on buildings.

Critiques from knowledgeable engineers focused largely on these topics:

- The data used to construct the fragility functions.
- One technical stakeholder expressed doubt that adequate data to build complex fragility relationships currently exists: "We're not collecting adequate data on which to make refined estimates of damageability. I'm really very, very skeptical of trying to get too many parameters in a model for developing damage." This concern also includes relying on data from component tests rather than real earthquake damage: "It's how

[the components] interact that ultimately will be the measure of what damageability you achieve."

- Overestimation of red tags and collapses, compared to observations in recent earthquakes.
- One engineer expressed frustration with results of the FEMA P-58 methodology with, "If we have all these collapses [in FEMA P-58 analysis results], how come such a small fraction of the buildings actually got a red tag [in the Northridge earthquake]? …When you tell me that you have half the design earthquake and you've got an 80% probability of red tag, would you please look at what happened in Northridge?"

Concerns from building owner representatives were less detailed but showed a clear need to know that the methodology was reliable and accurate before they would be comfortable using it. One building owner representative stated, "I want to know where that number comes from and what it represents. …Where did you get those numbers? Have these been tested anywhere?" Another asked, "What level of confidence is there that these numbers are good?" It was clear that establishing trust in the methodology was of primary importance to them, prior to considering its use.

Table 5-20 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 5-20 Implications for Guidance Products from Concerns about Validations and Accuracy

Key Findings	*Relevance to Guidance Products*
Some technical experts question aspects of the methodology.	Build trust of technical experts first. Others will look to them when deciding whether to use and trust the methodology. Build trust in the methodology through specific products that increase its technical transparency. Be transparent about any limitations in the evidence base from which the methodology operates. Acknowledge that the methodology has flaws and technical limitations, as does every technical approach. The FEMA P-58 methodology is a state-of-the-art approach that will continue to evolve and improve. Systematically identify and address technical concerns, aiming to validate and improve elements of the methodology whenever possible and encourage projects and research that can produce data to validate the methodology.
Some building owners question the validity of the methodology's results.	Clearly demonstrate the technical sophistication and reliability of the methodology. Show a successful track record of use, for instance through case studies. Present these case data through trusted sources, such as testimonials directly from the building owner, rather than solely by people who clearly have a stake in the reputation or success of the tool or in being paid to use it.

5.4.4 Specific Ideas for Improvement

Stakeholders had a number of suggestions on possible improvements to the FEMA P-58 methodology. These suggestions ranged from slight variations in the way output results are calculated to larger future directions for the methodology:

- Consider changes to life loss estimates.
- As discussed in Section 5.2.2, it could be beneficial to make casualty estimates optional, or to calculate the probability of life-threatening damage in addition to estimated casualties.
- Estimate business downtime.
- As discussed in Section 5.2.3, stakeholders are more interested in a building's downtime than its repair time. If the methodology can be altered to calculate downtime, or something closer to downtime, that would be beneficial.
- Add yellow tag estimate.
- Several building owner representatives noted that their key concern was whether they could occupy a building or not. Therefore, they felt that in addition to knowing the likelihood of a building receiving a red tag, it would also be helpful to know the likelihood of the building receiving a yellow tag. Both a yellow tag and a red tag would require them to discontinue use of the building. As stated by one building owner representative, "For us to be down, we're down. It doesn't matter if the building's yellow or red. If it's not in business, it's not in business."

One stakeholder who is familiar with the FEMA P-58 methodology had a vision for linking the FEMA P-58 methodology to HAZUS. In his words:

> *"HAZUS is a global tool and 58 is a local tool, if you will, and they ought to come together. They ought to be giving similar answers. In other words, if you took 58 and did a typical building, and then said, 'What if all of LA had that building?' and then you ran Northridge, you'd better get a reasonable answer. Same for HAZUS. If you've got better building modeling tools in 58, bring them into HAZUS, so that the two are compatible. Both FEMA products. Bring the two together."*

Table 5-21 summarizes key findings from this section and identifies their relevance to stakeholder guidance products.

Table 5-21 Implications for Guidance Products from Specific Ideas for Improvement

Key Findings	*Relevance to Guidance Products*
Method changes were suggested for calculating casualties.	Enable calculations of the probability of life threatening damage, and make calculations of the number of casualties optional.
It was suggested to add estimations for downtime and yellow tags.	Consider adding estimation of downtime and yellow tags.
FEMA P-58 and HAZUS could be linked.	Consider linking FEMA P-58 and HAZUS.

Chapter 6

Summary of Insights for Guidance Products

Chapters 3, 4, and 5 of this report contain detailed and wide-ranging insights on topics relevant to developing and deploying guidance products for stakeholders of the FEMA P-58 methodology. This chapter synthesizes, organizes, and summarizes those conclusions into six broad categories:

1. Guiding Principles
2. Use Contexts
3. Audiences
4. Content
5. Format, Style, and Delivery
6. Critique of Method

6.1 Guiding Principles

This section summarizes the underlying, theoretical approach that informed the identification and proposed creation of the guidance products. Key insights, as presented earlier in this document and illustrated in Figure 3-1, are:

- Decisions to adopt the FEMA P-58 methodology, which represent a change in behavior, are made in a staged approach, beginning with a complete lack of knowledge, and progressing through general knowledge, knowledge of aspects of personal relevance, desire to act, feeling capable of acting, acting, and assessing action.
- Different stakeholders are at different stages of making a decision about changing their behavior at any given time. It is important to recognize this, and to initiate guidance from an understanding of how a stakeholder currently acts and thinks, with respect for and in ways that are informed by how decisions are currently being made.
- Different types of information are most relevant at each stage in the decision-making process. Effective guidance products adapt content,

form, and delivery methods to reflect the needs at each stage of decision-making.

- An effective guidance strategy targets stakeholders in a variety of stages and over a period of time. An ongoing campaign that addresses multiple audiences at various stages in the decision change process in a consistent way is ideal.
- Successful new ideas diffuse from sophisticated, early users to an eventual tipping point where use becomes the norm. Guidance products should be designed to reinforce and accelerate this natural process. It makes sense to target early guidance products towards likely influential early users of the FEMA P-58 methodology, addressing their particular concerns and information needs. Successful adoption by influential users typically encourages additional users, and is a key component of reaching a tipping point for adoption, implementation, or broader social change.
- Information delivery format and wording matter. Graphic design and communication best practices regarding such things as appearance, tone, and level of language sophistication can enhance receptivity and understanding.
- Consistent messages from multiple, authoritative sources have greater impact than a message from only one source. Partnerships with organizations and media would enhance effectiveness.

6.2 Use Contexts

Guidance products can be used to support a variety of activities, such as designing a new building, retrofitting an existing building, managing a large portfolio of buildings, leasing or purchasing a building, or obtaining financing or insurance for a building.

- Performance-based decision-making and the FEMA P-58 methodology seem most likely to be used for the following purposes:
    - Preliminary and detailed design of new buildings, when the building is important to its owner for business continuity or other reasons.
    - Preliminary and detailed design of seismic retrofits for existing buildings, when the building is important for business continuity or other reasons.
    - In building purchase, lease, insurance and lending decisions where a lot of resources are at stake or the building is important for business continuity or other reasons.

- In support of building code improvements.
- To demonstrate code equivalence while minimizing costs by pursuing design approaches that do not conform with the code's prescriptive rules.
- To prepare for rapid damage evaluations relating to post earthquake occupancy and repair decisions. The City of San Francisco's Building Occupancy Resumption Program (BORP) is an example.
- Scholarly and applied research.

- Some building owners in the public and private sectors need information about the risk of their portfolio of buildings. The FEMA P-58 methodology focuses on single buildings, but some owners might be interested in using it to support or improve internal ranking systems.

6.3 Audiences

This section presents insights on potential audiences for the guidance products.

- The most receptive audiences for guidance products for non-engineering aspects of the FEMA P-58 methodology are likely to be structural engineers and building owner representatives who are concerned about post-earthquake recovery and functionality. Architects and other professionals involved in building design and construction teams could also benefit from guidance materials, but might be most motivated by learning that this is a priority of their building owner clients.
- The types of building owner representatives interviewed for this project represented organizations with a demonstrated interest in reducing seismic risk and/or concerns about business continuity. It seems likely that the types of individuals interviewed and the organizations they work for could be early users or early adopters of the FEMA P-58 methodology. Many of these organizations are in Stage 4 (deciding whether to try the FEMA P-58 methodology for a project) or above in performance-based decision-making. Some are in Stage 5 (assessing their capability to use the FEMA P-58 methodology). Many of these organizations have direct communications between the building owner representative and structural engineer consultants, easing communication about building performance.
- In many situations, architects act as a go-between for building owner representatives and structural engineer consultants. Architects typically respond to the priorities expressed by the owner, and might be a barrier

to performance-based decision-making if earthquake risk is not a priority of the owner. Materials that target building owner representatives, as described above, should aim to increase the likelihood that they will express this priority to their architect. Materials that target architects should aim to improve their receptivity to the concept when/if it is raised by a structural engineer. In this way, parties on both sides of the communication can become more inclined and empowered to adopt the methodology.

- Structural engineers with long-term relationships with organizations can exert substantial influence on an organization's approach to earthquake risk decision-making. They could be influential in the decision to adopt performance-based decision-making and the FEMA P-58 methodology.
- Innovative structural engineers and structural engineering firms are already testing the use of the FEMA P-58 methodology in-house and deciding whether and when it makes sense to pitch it to clients.
- Unlikely users of performance-based decision-making and the FEMA P-58 methodology appear to be organizations that are highly interested in minimizing short-term costs or who hold risk for short periods of time (e.g., developers, short-term leasers) and stakeholders with a portfolio perspective and limited interest in specific buildings (e.g., insurers, holders of mortgage securities).

6.4 Content

Different audiences will find different messages meaningful and convincing at different stages of the decision-making process, ranging from completely unaware (Stage 1) to acting and assessing the success of actions (Stages 6-8). This section and the subsequent tables summarize insights into the goals for what guidance products should aim to accomplish in each decision stage, and the information and subject matter that should potentially be covered by guidance products to accomplish these goals for all audiences, as well as the three key audiences introduced above: earthquake-concerned building owner representatives, structural engineers, and architects or other design professionals. This information is presented in Figure 6-1 through Figure 6-7.

Stage 1 *Unaware of issue*	→	Stage 2 *Recognize issue exists in general*

For all audiences:

1. Clarify actual performance of "code-level" buildings and their contents. In particular, emphasize that the Building Code provides widely varying performance and does not protect business continuity.
2. Give examples of past events where the public has been surprised at the actual performance that code level construction delivered (e.g., Christchurch, New Zealand). Explain possible resilience implications of this for the overall community.
3. State that alternate approaches for design and analysis of buildings exist that provide better information and options, and that some organizations, structural engineers, and design teams are currently using these approaches.

For building owner representatives:

4. Identify weaknesses with current PML/SEL/SUL system and explain how this can make businesses like theirs more vulnerable.

For structural engineers, architects, and other design team members:

5. Assert that some clients want better understanding of their buildings' seismic risks and might benefit from better seismic performance, and some engineers and design teams already provide this.
6. Share that some design choices provide markedly better seismic performance than others, and that long-term benefits of investing in seismic resilience can exceed costs.
7. State that performance-based approaches exist to better understand performance and design options; they are state-of-the-art.

Figure 6-1 Potential information to present to stakeholders to promote shift from Stage 1 to Stage 2 in decision change process.

Stage 2 → Stage 3

Recognize issue exists in general → *Recognize issue is relevant to organization*

For all audiences:

1. Show how seismic performance relates to other priorities, such as business downtime, safety, environmental impacts, financial risks, and getting value for money.
2. Show examples of how earthquake risks can be quantified and better understood.
3. State that a qualified structural engineer and design team can help organizations make choices to manage/reduce/understand these risks.

For building owner representatives:

4. Illustrate that performance-based decision-making is used by some of their competitors and peers.
5. Identify simple, low cost ways to identify buildings with higher than typical risk, particularly building types they are likely to occupy or own.
6. Clarify actual performance of "code-level" buildings of the building types they are likely to occupy or own.

For structural engineers, architects, and other design team members:

7. Identify specific types of clients who are most likely to be interested in better understanding and/or enhancing their seismic performance.

For structural engineers:

8. State that the FEMA P-58 methodology is a tool engineers can learn to use for design and analysis.
9. Identify easy, low cost first steps to become familiar with the FEMA P-58 methodology.
10. Underscore that the FEMA P-58 methodology is feasible (cost-effective, works within time constraints, etc.) for certain types of projects.

For architects and other design team members:

11. State that qualified structural engineers and other resources can help design teams to meet this need.
12. Note that numerous important seismic design decisions are made by architects and other design professionals, not structural engineers.

Figure 6-2 Potential information to present to stakeholders to promote shift from Stage 2 to Stage 3 in decision change process.

Stage 3 →	Stage 4
Recognize issue is relevant to organization	*Decide whether want to act*

For all audiences:

1. Acknowledge common concerns about the costs of reducing earthquake risk. Note that better seismic performance does not always mean significantly higher construction costs, and long-term benefits often exceed costs.
2. List ways that quantifying seismic performance is a valuable decision-making tool, benefiting the bottom line, safety, environment, etc. Emphasize the value of quantifying the benefits of higher performance and weighing those against construction and lifecycle costs.
3. Discuss the approximate range of costs involved in using performance-based decision-making, and when and why these costs are reasonable.
4. Showcase studies of use, emphasizing the overall outcomes and benefits achieved.
5. Identify specific types of situations in which use of the FEMA P-58 methodology might provide good value for money.
6. Provide information about circumstances in which use of performance-based decision-making may be less appropriate.

For building owner representatives:

7. State that cutting edge, responsible organizations use performance-based decision-making. Link performance-based decision-making with desired characteristics, such as competitive edge, social responsibility, wise leadership, etc. Identify known organizations that have benefited from earthquake risk management decisions. Highlight examples of successful past use by specific companies, competitors, or peers.
8. Illustrate how early use of FEMA P-58 can become a competitive advantage in the marketplace.

For structural engineers:

9. State that the standard-of-practice in structural engineering now involves discussing earthquake performance with certain clients and in certain situations, and that the FEMA P-58 methodology can provide the basis for these discussions.
10. Discuss that the FEMA P-58 methodology is state-of-the-art. Identify it as the most rigorous technical approach currently available, while acknowledging that it is not flawless.
11. Compare performance-based decision-making and the FEMA P-58 methodology to other known methods to address or quantify earthquake risk. Identify features that make the FEMA P-58 methodology unique, such as quantification of nonstructural damage.

Figure 6-3 Potential information to present to stakeholders to promote shift from Stage 3 to Stage 4 in decision change process.

Stage 4 *Decide whether want to act*	→	Stage 5 *Decide whether capable to act*

For all audiences:

1. Provide an outline of the overall process and next steps necessary to investigate using performance-based approach for a project. Acknowledge process difficulties they might encounter and offer tips.
2. Show that the time, cost, equipment, and personnel required to do this are known and feasible. Clearly identify the time typically required in various situations to use performance-based decision-making. Clearly state the financial costs of using performance-based decision-making, perhaps by identifying cost elements rather than estimating a number.
3. Show that others have used this approach successfully. Show case studies of use, emphasizing the mechanics of how organizations succeeded in using a new approach.

For building owner representatives:

4. State that a cadre of engineers and other design professionals know how to do this. Provide information to help building owners find qualified professionals that know how to use state-of-the-art performance-based decision-making.
5. Demonstrate that the benefits of this approach can be compellingly presented to other decision-makers within an organization. Identify strategies and information that can be used to persuade others within an organization to support performance-based decision-making.

For structural engineers:

6. Clearly identify the knowledge, skills, software, and equipment required to use performance-based decision-making and the FEMA P-58 methodology.
7. Present clear information and/or training on how to use FEMA P-58 for conceptual design, detailed design, PML/SEL/SUL, and other likely contexts of use.
8. Provide advice on how to clearly discuss with clients whether the costs are reasonable given the benefits.

For architects and other design team members:

9. Present clear information on how to work with a structural engineer on a performance-based project, for conceptual design, nonstructural systems, etc.

Figure 6-4 Potential information to present to stakeholders to promote shift from Stage 4 to Stage 5 in decision change process.

Stage 5 *Decide whether capable to act*	→	Stage 6 *Act*

For all audiences:

1. Explain performance options, and present ways to determine the "acceptability" of various performance choices.
2. Illustrate how to show benefits of higher performance along with the costs of achieving that performance.
3. Suggest effective ways to communicate findings to others within an organization, linking to key organizational goals, such as business resilience, environment, finances, etc. Present a menu of presentation options that users can select from and customize based on their needs and preferences in a variety of levels of detail and technicality for a range of types of audiences.

For building owner representatives:

4. Present specific information to seek from a design team, and questions to ask to achieve best results.
5. Provide template documents that can be used in performance-based projects, such as for bidding and specifications.

For structural engineers, architects, and other design team members:

6. Present advice on how to work with other design team members and the types of decisions other team members make that affect seismic performance.
7. Demonstrate how and why to reduce the use of technical jargon and buzzwords.

For structural engineers:

8. Show that the FEMA P-58 methodology can be used at different levels of rigor for different purposes, such as preliminary design, detailed design, PML/SEL/SUL calculations, etc. Clarify how to determine the appropriate level of rigor.
9. Provide step-by-step advice on input information required and decisions that need to be made for all of the typical ways that the FEMA P-58 methodology can be used. Identify when it makes sense to use default information, and when it makes sense to customize inputs. Provide clear information on how to conduct analysis.

For architects and other design team members:

10. Discuss details of the performance of nonstructural systems that are designed by team members other than the structural engineer, and present step-by-step guidance on how to make performance-based decisions for these elements.

Figure 6-5 Potential information to present to stakeholders to promote shift from Stage 5 to Stage 6 in decision change process.

Stage 6 → **Stage 7**

Act → *Assess action*

For all audiences:

1. Provide an approach to evaluate long-term benefits and short-term costs.
2. Provide a forum for users to share feedback on and share strategies for use of the FEMA P-58 methodology.
3. Emphasize that implementation was feasible and costs, schedule, personnel requirements were as expected.
4. Recognize building owner, engineers, and other design professionals with a responsible, forward-looking approach to seismic resilience.

For structural engineers, architects, and other design team members:

5. Provide an approach to show that the design team provided value to the client by using a performance-based approach.

Figure 6-6 Potential information to present to stakeholders to promote shift from Stage 6 to Stage 7 in decision change process.

Stage 7 → **Stage 8**

Assess action → *Decide action was success*

For all audiences:

1. Collect and disseminate case studies of use, such as the results of project or organizational case studies, focus group interviews, or satisfaction/feedback surveys.
2. Encourage users to share their stories with peers through conversation, conference papers, social media, etc. Develop a network of users that can be accessed in the event that people have questions, comments, or concerns about the methodology.
3. Provide a forum for user-generated advice on implementation, decision-making, and presentation.

Figure 6-7 Potential information to present to stakeholders to promote shift from Stage 7 to Stage 8 in decision change process.

6.5 Format, Style, and Delivery

This section presents insights into the way guidance content is best communicated. It discusses format, tone, wording, appearance, and how products reach the target audiences. Key observations include the following:

- Recommendations and guidance should be specific and tailored to different audiences, knowledge levels, and contexts of use.
    - Overly general advice is typically ineffective. Personalized information is most effective.
    - Make materials as relevant as possible to the unique situation of the intended audience, and identify ways for the audience to connect to their personal/organizational risk and risk management options.
- Guidance should be informative, non-judgmental, and allow users to draw their own conclusions. Avoid heavy-handed and overly prescriptive recommendations. Identify actions users *could* take, as opposed to ones they *should* take. Provide numbers and facts to help users make own their own choices. Identify "next steps" through offering resources and connections to experts who can help explain the process and mentor potential users.
- Emphasize positive outcomes, such as improving safety, increasing resilience, saving money, and improving long-term profitability. Overly negative communications, including threatening images, dire warnings, alarming colors like red, and focusing only on risk, are ineffective because they promote denial and avoidance.
- Use intuitive and clear language. Avoid structural engineering terms, jargon, and acronyms whenever possible. Define potentially confusing terms when their use is unavoidable. Keep the use of language as consistent as possible across different guidance products.
- Economize in length and breadth wherever possible to focus the viewer's attention on the most salient points. Don't try to convey everything a user might need to know in a single publication. Use short sentences, hierarchical ideas, and images. Use visual presentations wherever possible instead of or in addition to textual presentations.
- Recognize that safety issues are important and drive decision-making, but are also potentially sensitive. It can be difficult and problematic to talk about deaths and injuries, so treat these topics with care and respond to the needs and concerns of particular audiences.

- Provide alternatives for probabilistic statements because probabilistic information confuses and/or alienates many audiences. Many non-technical audiences respond well to scenario-based discussions of hazard, which can vary in complexity based on the audience.
- Acknowledge uncertainty in results, and note that all credible results have associated uncertainties. Present uncertainty in forms that can be understood by the widest possible audience, such as presenting a range of possible results. Note that uncertainty arises from multiple sources.
- Guidance products that target different stakeholders, use contexts, and stages should be consistent in terminology, style, and tone.
- The following approaches can help communication:
  - Case studies, particularly those of actual use, are an effective way to teach stakeholders about a new idea.
  - Testimonials from those who do not have a stake in the success of a new approach are particularly effective.
  - Options and comparisons are meaningful for many stakeholders; decisions about acceptable/appropriate choices and levels of risk are often relative.

In addition to the more general guidance above, it is important to remember that different forms of information might be more or less effective, depending on the stage that the user is in. The section below includes more specific guidance, organized by behavior change stage for potential users.

- In Stage 1 of behavior change, people respond to credible sources that evoke outrage and surprise. For example, stakeholders need to know that the building code might not provide the seismic performance that they expect.
- In Stage 2, information should come from familiar sources that emphasize impacts to peers or organizations/individuals that seem to have similar concerns. For example, information about performance-based decision-making and the FEMA P-58 methodology will be best received when it appears in respected journals, forums, conferences, and discussions with highly respected peers within a stakeholder's profession. Existing peer-to-peer networks can be used to share information.
- In Stage 3, increasingly personalized information from expert sources is useful. Materials that narrowly target the intended audience help them

realize the relevance of performance-based decision-making to their organization.

- In Stage 4, users will seek out expert advice, preferably from neutral sources without a financial stake in their decisions, such as experienced peers, government institutions, and professional organizations. This information should be easy to find and consistent.
- In Stage 5, users need detailed and practical information about how to implement a project and timely help troubleshooting obstacles as they come up.
- In Stage 6, users would benefit from step-by-step guidance from expert users or seasoned professionals, lists of Frequently Asked Questions, best practice compilations, etc.
- In Stage 7, users might want to share experiences. Users may appreciate having chances to voice their experiences (both favorable and negative) and give feedback, as long as they feel that information will be heard and used constructively.
- In Stage 8, users should be encouraged to share experiences and be given recognition.

6.6 Critique of Method

This section summarizes feedback received during the interviews about changes that should be considered to the FEMA P-58 methodology.

- Calculation of casualties could be made optional and it could be possible to calculate the probability of life-threatening damage in addition to or instead of casualties, which is likely to be less concerning to some stakeholders.
- Adding the capability to quantify carbon impacts of earthquake risk decisions is of potential interest to stakeholders.
- Downtime (the amount of time a building will not be functional) is of more interest to many stakeholders than repair time. Many stakeholders would find it valuable if the FEMA P-58 methodology could provide information relevant to quantifying downtime.
- Structural engineers desire a user-friendly interface to use the FEMA P-58 methodology.
- Some technical users would like access to the "guts" of the methodology, such as the fragility functions.
- Consider adding a calculation of the likelihood of a yellow tag.

- Anticipate that as the FEMA P-58 methodology is used by more people in more situations, errors and ideas for improvements will emerge. Providing a forum for feedback will help channel user concerns and could help improve the product in the future.

Chapter 7

Recommended Guidance Products for Stakeholders

The Stakeholder Products Team will produce four products for specific target audiences, as presented in Table 7-1. Ideally, a series of coordinated products will be developed and disseminated in a campaign that touches a wide range of potential stakeholders in a variety of stages of deciding to use a performance-based approach. This will lay the groundwork for a long-term transition to understanding and use of the FEMA P-58 methodology in appropriate situations.

Table 7-1 Selected Stakeholder Guidance Products

Guidance Product	*Target Audience*
Checklist/Quiz: Would Your Project Benefit from Performance Based Design?	Building owner representatives
Guideline: Practical Aspects of Using FEMA P-58 for a Project	
Graphic and Pamphlet: Communication of Performance Objectives	All stakeholders
Website Framework: Dissemination of FEMA P-58 Technical and Stakeholder Guidance Information	

This chapter discusses how these products were conceived of and selected, provides more information about each product, and presents products that were considered but not selected to be developed at this time.

7.1 Process to Identify Recommended Guidance Products

Considering all of the insights presented in this report, the project team used the following process to identify recommended guidance products for stakeholders of the FEMA P-58 methodology:

- Compiled a list of possible guidance product ideas from team members and advisors, presented in Appendix G.
- Discussed each idea and determined a subjective rating for three categories:
  - Effectiveness. The degree to which the product would help advance project objectives (i.e., motivate stakeholders to use a performance-

based approach for seismic risk decision-making and help them to effectively use the FEMA P-58 methodology when that is the appropriate tool for their task.) This includes the likely speed with which it will work; lasting impact/duration of effectiveness; and number and types of stakeholders reached.

    - Cost. The order-of-magnitude cost or potential cost range to produce and distribute the product.
    - Feasibility. The degree to which the necessary skilled personnel, information, and administrative capacity exist to create and disseminate the product.

- Identified highly ranked options. Note that a number of ideas ranked highly, but were identified as appropriate for consideration by other teams due to their technical nature.
- Selected top choices for consideration of project management, which are listed and explained in subsequent sections.
- These choices were critiqued and improved by project management and advisors. Four final products were selected, described in the next section.

7.2 Products Selected for Development

7.2.1 Checklist/Quiz: Would Your Project Benefit from Performance Based Design?

Performance-based design and the FEMA P-58 methodology are appropriate for some, but not all, projects. This product will help building owners figure out when and why a performance-based approach, and the use of the FEMA P-58 methodology in particular, would be beneficial.

Form. Short online quiz (e.g., ten questions), or online and paper checklist or flowchart. Materials will be developed so that they can be incorporated into a structural engineer's written and visual presentation materials for use with owners.

Target Audience. Building owner representatives, particularly project managers and risk managers in large organizations, who are in stages 2 through 4 (just learning about performance based design to actively evaluating whether they want to use it).

Description. A building owner would be guided through a series of questions to help determine whether performance-based design is likely to be beneficial to them for a specific project. Topics will include the use of the building, the value of contents and activities inside the building, the importance of post-earthquake business continuity, and related issues. Note that the goal is not to be a booster of the FEMA P-58 methodology, but to provide honest information about the situations in which use of the FEMA P-58 methodology would likely be advantageous.

Transmittal. The audience becomes aware of this product through references/links in other products (e.g., website). It might be brought to their attention by a member of a design team or another consultant.

Intended Outcome. Building owners will be made aware of the benefits that performance-based decision-making can provide and the situations when those benefits are most likely to be important. They will be prompted to learn more about performance-based design and analysis and figure out whether it is right for their needs at the time. In addition, this checklist/quiz would help establish norms for the situations in which cutting-edge building owners use the FEMA P-58 methodology. On its own, this is not expected to make someone decide to use the FEMA P-58 methodology for a project.

What it Needs to Be Effective. The questions need to be logical and carefully crafted. The quiz must be quick, easy, and appealing. The tone must be informative, not didactic or preachy.

7.2.2 Guideline: Practical Aspects of Using FEMA P-58 for a Project

The product will inform a building owner representative about the practical aspects of working with a design team on a performance-based project, particularly one that employs the FEMA P-58 methodology.

Form. A short (approximately 20 pages), easily navigable guidebook, printed and online, with attractive graphics. This guidebook will be made up of a series of short chapters focused on one particular topic, 1 to 3 pages in length. Many or all of these short chapters can also stand alone as a short pamphlet or pdf on the specific topic.

Description. This guidance product will discuss how using a performance-based approach and the FEMA P-58 methodology in a project will affect issues such as schedule, cost, requests for proposals, contractual documents, needed consultants, interactions with building officials, liability, and other aspects of implementing a project. It will provide guidance on the types of questions building owner representatives should ask their design team to achieve their performance needs.

Target Audience. Building owner representatives, particularly project managers and risk managers in large organizations, in stage 5. This means they would like to use performance-based design, but are considering whether and how it would work within their organizational/project management constraints.

Transmittal. In Stage 5, in which a building owner has already decided that a performance-based project or use of the FEMA P-58 methodology is a good thing but they are not sure it is feasible, they might actively seek out this product. It will be referenced/linked to in other products. It could be handed or emailed to a building owner representative by a consultant or design team member. It will appear on the website, as a complete document and as smaller pdfs focused on particular topics.

Intended Outcome. Building owner representatives will be convinced that it is feasible to use FEMA P-58 successfully in a project.

What it Needs to Be Effective. The guidebook must cover the actual feasibility concerns of building owner representatives in a meaningful way. It must be easy to understand, avoiding technical jargon. It should be polished, attractive, easy to flip through, and easy to locate online.

7.2.3 Graphic and Pamphlet: Communication of Performance Objectives

This product will help structural engineers, building owners, and other stakeholders effectively discuss and select desired performance goals for a project, given the flexibility and capabilities of the FEMA P-58 methodology.

Form. A short document (approximately 2 pages), rich with graphics. There will be two versions of this product: a version intended for structural engineers with appropriate language and technical references, and a version for building owners and other stakeholders, with the same content presented in less technical terms.

Target Audience. Structural engineers, building owners, and other design professionals, primarily in Stage 6, who are actively using or planning to use the FEMA P-58 methodology.

Description. This product will express options for performance goals in terms of the outputs of the FEMA P-58 methodology: deaths, dollar losses, repair time, probability of red tag, etc. It will balance the flexibility of the FEMA P-58 methodology—one of the method's strengths is that a continuum of options is available to meet the unique needs of any particular project—with the expressed desire of building owner representatives to have simple, grouped options for easy decision-making. It will also express the uncertainty associated with various choices in an accurate yet non-technical way. It will provide reference points to known options, such as "code" and the performance levels of ASCE 41.

Transmittal. Linked to or reproduced in other products, available as a pamphlet handout, available online.

Intended Outcome. Engineers, their clients, and other stakeholders will be able to select performance parameters that can be used for design and analysis with the FEMA P-58 methodology.

What it Needs to Be Effective. The presentation of performance goals needs to have the technical rigor required by engineers while communicating in clear and intelligible terms to non-engineers. The product needs to facilitate the decisions required for design and analysis.

7.2.4 Website Framework: Dissemination of FEMA P-58 Technical and Stakeholder Guidance Information

This website will serve as a central repository for all products related to the FEMA P-58 methodology. The website would be a "one stop shop" that users know is authoritative for all available information.

Form. A design for a website that includes recommended menus, submenus, content, and schematic design. The Stakeholder team would develop all text for webpages, and would identify all products that should be linked to the website.

Target Audience. All stakeholders, all stages.

Description. An easy-to-navigate website that makes it straightforward to find all the resources that are being created by all teams. The website will be designed to be welcoming to all types of stakeholders at all levels of knowledge, directing users to the appropriate content for them. This website will be an elegant way to access all of the materials that have been created through the FEMA P-58 development process. It could also include new content on topics of interest to stakeholders, depending on budget.

Transmittal. All products refer users to this website. The website should also come up in internet searches when users seek information about FEMA P-58. It will be linked to the ATC website and other sites.

Intended Outcome. Stakeholders will have one place to go to seek authoritative information on and resources for the FEMA P-58 methodology and performance-based design and analysis.

What it Needs to Be Effective. It should be easy to find the desired information, regardless of background or knowledge level. The website should appear prominently in internet searches for FEMA P-58.

7.3 Other Products Considered

The following additional products were identified by the Project Team as top candidates for development but are not being produced at this time, or are being produced by another project team, as noted.

- **Materials on how to Communicate Effectively with Non-Technical Audiences About Performance-Based Design.** This product would train structural engineers in the best ways to communicate the complex issues associated with performance-based design and analysis to stakeholders who are not structural engineers. It could be in written format, or as an online training video. The product would compellingly present best practices in communication, including how to cover complex technical topics such as uncertainty and probabilities in accurate yet clear ways. It would discuss word choices and how they are understood by different audiences, and would include recommendations on graphics, effective use of comparisons, etc. The intended outcome would be for structural engineers to communicate about performance issues more effectively with clients and potential clients, improving the decision-making and interest of building owners and other design team members.
- **Templates for Presenting Results of FEMA P-58 Analyses.** This product would provide a range of easy-to-use graphical templates to assist structural engineers to effectively present the outputs of an analysis using the FEMA P-58 methodology. These would cover a wide range of possible situations and preferences, ranging in level of detail, technical specificity, etc. The format would be a template that is easy to customize to produce polished presentation of analysis results. The intended outcome would be to allow structural engineers to easily transform the output results of analyses using the FEMA P-58 methodology into compelling graphics that communicate effectively to other types of stakeholders.
- **Non-Engineering Design Guidance for Performance-Based Design.** This guidebook would cover aspects of building design that are not

typically controlled by structural engineers. It will explain why and how they affect building seismic performance and broadly discuss approaches to improve seismic performance. It would identify important design choices, such as building configuration, cladding, sprinkler systems, etc., that can play a major role in building performance. For each topic, the book will explain how this system is affected by earthquake shaking, illustrated with photographs and drawings of earthquake damage from past events, and will present best practices for designing resilient buildings. It will point design professionals towards detailed resources for resilient building design. The intended outcome would be for architects and other design professionals to become aware of performance issues associated with systems they design, and to have the information and resources they need to work with a structural engineer to achieve performance goals for all building systems.

- **Specification Sheets for Performance-Based Design.** These specification sheets would provide seismic resilient design details for typical mechanical, electrical, HVAC, and other systems that reflect best practices in resilient building design. The intended outcome is for architects and other design professionals to easily be able to specify seismically resilient details for projects that use a performance-based approach. This product is being developed by another project team.
- **Article Introducing Performance-Based Design and Analysis.** This high-level series of related articles would introduce architects and other non-engineer stakeholders to the concept of performance-based design. Each individual article would target a slightly different audience but would cover similar content. The articles would be published in notable journals, with the content adjusted to suit the interests and knowledge of each group. The articles will be authored or co-authored by a prominent representative of the profession. The intended outcome would be for a wide audience of stakeholders to be exposed to the concept of performance-based design and be receptive to it when reintroduced to it at a later time.

Numerous other guidance product ideas were identified and evaluated, but not selected to appear on the Stakeholder Products Team short list. These product ideas covered a wider range of target stakeholder audiences, forms, and stages of decision-making. These product ideas, along with comments and the evaluation of the Stakeholder Products Team, appear in Appendix G.

Appendix A

Overview of the ATC 58-2 Project and its History

In 2012, the Applied Technology Council (ATC) completed a ten-year program under contract with the Federal Emergency Management Agency (FEMA) to develop a next-generation seismic performance assessment methodology for buildings. This program (Phase 1) was conducted under a series of projects known as the ATC-58/ATC-58-1 Projects. The resulting products, collectively referred to as FEMA P-58, Seismic Performance Assessment of Buildings, Methodology and Implementation (FEMA, 2012a; 2012b; and 2012c), describe a general methodology, recommended procedures, and new metrics for assessing and communicating the probable seismic performance of individual buildings based on their unique site, structural, nonstructural, and occupancy characteristics.

FEMA has since funded a subsequent phase of work (Phase 2), designated the ATC-58-2 Project. The purpose of this work is to utilize the recently completed methodology in developing performance-based seismic design guidance for engineers and stakeholders.

Phase 2 work is utilizing the FEMA P-58 series of products and supporting materials (developed under Phase 1) to develop performance- based design guidance to assist in the selection of appropriate systems, configurations, and structural characteristics for meeting selected performance objectives in varying regions of seismicity. It also includes working with stakeholders to determine effective methods of communicating seismic performance. This information will be used to shape the development of a series of products that:

- Assist decision-makers to select appropriate performance objectives for buildings of different occupancies;
- Assist design professionals to identify appropriate structural design strategies for buildings to achieve specific performance objectives;
- Assist design professionals to efficiently develop preliminary designs that will achieve specific performance objectives and require relatively little iteration during the design process;

- Quantify the performance capability of typical buildings designed to current prescriptive building codes to assist in development of code-equivalent performance objectives, identify inconsistencies in current prescriptive codes, illustrate the inherent limitations of prescriptive codes, and demonstrate the advantages of performance-based design; and
- Provide guidance on simplified design of buildings to achieve different performance objectives.

In addition, Phase 2 is designed to: (1) exercise the FEMA P-58 methodology and identify needed improvements, if any; (2) enhance the methodology to estimate environmental impacts and potential loss of function associated with earthquake damage; (3) interact with stakeholders to tailor design guidance to better suit current decision-making needs; and (4) develop training materials to assist in implementation.

In addition to the Stakeholder Products team, the project includes a Project Management Committee, Performance Products Team and Product Update Team. The Product Update team is responsible for tasks associated with updating the products developed in Phase 1 to include improvements and enhancements. The Performance Products Team is responsible for assessing the performance of typical code-conforming buildings and developing design guidance. The Project Management Committee coordinates the work of the three Product Teams, and the Project Steering Committee provides advice, review, and critique of the project's work.

Appendix B

Stakeholders of the FEMA P-58 Methodology

For this report, stakeholders are broadly defined as people who make or influence decisions related to the seismic risk of buildings. The following three categories of stakeholders of the FEMA P-58 methodology were considered for this work:

- Building owner representatives. Those with primary direct decision-making control over seismic design decisions. This includes the following:
    - Private companies (high-tech, manufacturing, real estate, and other businesses sensitive to downtime)
    - Local government
    - Universities
    - Utilities
    - Cultural institutions
- Structural engineers. This includes:
    - Practicing engineers who work on design projects
    - Research engineers who study seismic performance issues
    - Engineers who participate in code writing bodies
- Others stakeholders. This includes other professionals who play a role in decisions about seismic risk, such as the following:
    - Architects and other design professionals who can affect seismic performance in their design and construction choices, including geotechnical engineers, mechanical engineers, electrical engineers, HVAC professionals, etc.
    - Building officials within local government
    - Lawyers, financial officers, and other internal or external bodies within a corporation or other organization who affect decisions related to building risk and expenditures

- Financial interest groups including lenders, insurers, and securities packagers, with an indirect stake in seismic design decisions
- Construction materials suppliers and industry associations, with financial interest in the decision process as it affects the viability of their products and services

This broad definition of stakeholders was used conceptually in this project; however, data collection efforts such as stakeholder interviews and recommended target audiences ultimately focused on a subset of this group: those deemed most likely to be early adopters of the FEMA P-58 methodology.

Appendix C
Stakeholder Interview Guides and Example Graphics

C.1 Overview of the Interview Guides

Three stakeholder interview guides were developed and used for this project:

- Round One interview guide: This guide was used for the first six interviews.
- Round Two interview guide for building owner representatives: Prior to the second round of interviews, the team made edits to the interview guide based on an assessment of what had been most effective in the first-round interviews. This updated guide was used for ten interviews.
- Round Two interview guide for structural engineers: The team developed a related, updated interview guide specifically aimed at structural engineers, used in five interviews.

Each question in the interview guides was written in an open-ended format and meant to encourage the interviewees to speak at length. Having a common script helps assure that the responses of different interviewees to the same questions can be compared. However, interviewers were encouraged to deviate from the interview guide as needed, while generally staying within the structure and topics of the interview guide, to reflect the unique experience of each interviewee.

C.2 Round One Interview Guide

C.2.1 Introduction to the Interview

Thank you for meeting with me today.

As we discussed on the phone/email, I am a consultant working with the Federal Emergency Management Agency and the Applied Technology Council on a project designed to learn about how organizations like yours make decisions about earthquake risk for their buildings. Specifically, I would like to ask you a series of questions that, among other things, will focus on:

- Concerns related to earthquake risk;

- The processes and criteria you use to design and renovate buildings; and
- The types of materials that might be useful to your company/organization.

I'll also ask for your feedback on some materials that an organization like yours might use to make earthquake risk decisions. Some of these questions relate to a new, state-of-the-art method to evaluate earthquake risk developed by FEMA, called FEMA P-58.

The interview will last about one hour. And, if you agree, I would like to audio record the interview so that I can focus on you rather than trying to take notes the entire time. Is that okay?

Do you have any questions before we proceed?

C.2.2 Information about Interviewee

To begin, I'd like to learn a bit more about you.

Q1. What is your position and what are your primary responsibilities here at [insert company/organization name]?

Q2. Because this project is focused specifically on earthquake risk, can you describe your current work in this particular area?

C.2.3 Concern about Earthquake Risk

Now I would like to ask about earthquake risk concerns – especially in relation to your organizations' buildings and facilities.

Q3. When thinking about your buildings, what aspects of earthquake risk are of most concern to your organization? [Potential probes]

- Business downtime? If one or more of your buildings were unusable for weeks, months, or longer, what would this mean?
- Repair or replacement costs for buildings or their contents?
- Casualties or injuries?
- Environmental impacts? Damage might release hazardous liquids or gasses, and building a replacement building can be carbon intensive.

C.2.4 Process to Build and Renovate Buildings

Next I want to ask you some questions about how your organization makes earthquake risk decisions when you build a new building or renovate an existing building.

Q4. If your organization wants to build a *new* building, will you walk me through, step by step, the process that is followed? [Probes, to follow initial question]

- Do you construct your own facilities or contract with a developer to build to spec, or look for available space on the market?
- Who in your organization is involved in making decisions regarding structural design at various stages?
- Does your company interact with the structural engineer that designs the building structural system?
    - If yes, is the structural engineer typically a subconsultant to the architect?
    - If not, does your company discuss structural design and earthquake performance with the architect or other professionals?
- What design criteria or standards do you follow?
- When does your organization make decisions about what design criteria to follow, or how much damage is acceptable in earthquakes?

Q 5. When you are building a *new* building, do you typically consult with a structural engineer about how earthquake-resistant you would like the new building to be, or whether the building could be used following earthquakes?

- If yes:
    - When does this discussion happen or begin?
    - Who initiates it (probes: your company, the architect, the engineer, or some other party)?
    - Who participates in this conversation? Do you participate?
    - What kinds of concerns are raised?
    - What drives decisions about earthquake resistance?
    - Limiting business interruption?
    - Minimizing costs of damage? Etc.
    - Are decisions based on a benefit-cost analysis of the options, meaning that expenditures must reduce likely damage by an equal or greater amount?
- If not:
    - Does your organization typically build "to code"?

- Have there ever been discussions about whether the building code is adequate for your organization's purposes?
- Are earthquake performance decisions left to the design team, which is expected to stay within a budget?
- What performance do you expect from a new, code-compliant building?

Q6. Now I would like to ask a few questions about the process of *renovating* an existing building that needs a seismic retrofit?

- Has your company/organization ever seismically retrofitted a building? [If not, do not ask the following questions.]
- How is that process different from building a new building?
- Is the primary contact an architect or structural engineer?
- Is the interaction with the structural engineer different than it is for the design of a new building?
- How do you decide how much to retrofit a building (i.e., what performance is acceptable in future earthquakes)?

Q7. What if you are purchasing or leasing a building for use by your company?

- Would you analyze its potential earthquake damage as a consideration before deciding to purchase or lease it?
- If purchasing, would you expect that your lender or insurer would require an analysis?
- Are the following measures used by your organization?: Probable Maximum Loss (PML), Scenario Estimated Loss (SEL), or Scenario Upper Loss (SUL)?
    - If yes to one or more,
    - how much importance do you assign to each measure?
    - And to each measure relative to the others?

Q8. Might your organization be willing to pay an additional 5 to 10 percent for the cost of the structural system (approximately 2 percent of the total construction cost) to reduce future earthquake damage and business interruption?

- In what circumstances?
- How would this decision be made?

- By who?
- When?

C.2.5 Presentation of Decision Making Materials and Results

Next, I am going to ask you a few questions about FEMA's new initiative and show you a few examples of materials. I'll then follow up each visual with some questions.

Q9. Are you familiar with the concept of performance based earthquake engineering? And, have you heard of FEMA P-58?

- If yes,
    - In what ways might your organization use FEMA P-58 or performance based earthquake engineering in the future?
    - What concerns or questions do you have about using performance based earthquake engineering or FEMA P-58?
- If no, I will show you some examples of the types of information FEMA P-58 can produce.

Q10. Here are a few examples of the types of results your structural engineer could show you if she or he conducts an analysis of the expected earthquake performance of a building being designed or renovated using the newly developed FEMA P-58 .

[Show example result visuals, briefly explain, and then let interviewee look at them.]

- Which results would be most useful to you and other decision makers in your company/organization?
- In what situations would this type of information be useful to you?
- Is there anything confusing in these results? What is confusing?
- How could the presentation of these results be made more useful for your company/organization?
- If your structural engineer asks you to identify the "earthquake performance" that your company/organization desires for a new building project, would the information presented here help you define that?
    - What other information would help you define that?
    - Would it help to know the performance you get from a new building built to-code?

C.2.6 Trusted Sources of Information

Q11. What professionals or other sources of information do you rely on to learn more about managing the earthquake risk of your facilities? [Probes:]

- Insurance agent
- Architect
- Engineer
- Company risk manager
- Trade publications? (please list)
- Professional organizations? (please list)
- Conferences? (please list)
- Other? (please list)

C.2.7 Closing Questions

Q12. Is there anything else you want to add? And, finally, are there any questions you would like to ask me?

Q13. I am interviewing a number of people for this work. Could you refer me to any colleagues in other companies/organizations who you think would be appropriate and willing to be interviewed about this?

Thank you so much for your time.

C.3 Round Two Interview Guide for Building Owner Representatives

C.3.1 Introduction to the Interview

Thank you for meeting with me today.

As we discussed on the phone/email, I am a consultant working with the Federal Emergency Management Agency and the Applied Technology Council on a project designed to learn about how organizations like yours make decisions about earthquake risk for their buildings. Specifically, I would like to ask you a series of questions that, among other things, will focus on:

- concerns related to earthquake risk;
- the processes and criteria you use to design and renovate buildings; and
- the types of publications and other materials that might be useful to your company/organization.

I'll also ask for your feedback on some materials that an organization like yours might use to make earthquake risk decisions. Some of these questions relate to a new, state-of-the-art method to evaluate earthquake risk developed by FEMA, called FEMA P-58.

The interview will last about one hour. And, if you agree, I would like to audio record the interview so that I can focus on you rather than trying to take notes the entire time. Is that okay?

Do you have any questions before we proceed?

C.3.2 Information about Interviewee

To begin, I'd like to learn a bit more about you.

Q1. What is your position and what are your primary responsibilities here at [insert company / organization name]?

Q2. Because this project is focused specifically on earthquake risk, can you describe your current work in this particular area?

C.3.3 Concern about Earthquake Risk

Now I would like to ask about earthquake risk concerns – especially in relation to your organization's buildings and facilities.

Q3. When thinking about your buildings, what aspects of earthquake risk are of most concern to your organization?

- Business downtime?
- Repair or replacement costs?
- Deaths, injuries, worker displacement?
- Environmental impacts?
- Others?

C.3.4 Process to Build and Renovate Buildings

Next I want to ask you some questions about how your organization makes earthquake risk decisions when you build a new building or renovate an existing building.

Q4. If your organization wants to build a *new* building, will you walk me through, step by step, the process that is followed?

[Probes, to follow initial question as needed]

- Who in your organization makes decisions regarding structural design at various stages?
- What design criteria or standards do you follow for the structure?
- Does your organization interact directly with the structural engineer that designs the building structural system?

Q5. When you are building a *new* building, do you typically consult with a design professional about how earthquake-resistant you would like the new building to be, or whether the building could be used following earthquakes?

- If yes:
  - Tell me about how this process works when you do consult with such a professional.
- If not:
  - Have there ever been discussions about consulting with such a professional?
  - Any discussions about whether the building code is adequate for your organization's purposes?

Q6. Now I would like to ask a few questions about the process of *renovating* an existing building that needs a seismic retrofit?

- Has your company/organization ever seismically retrofitted a building?
- If yes,
  - How is that process different from building a new building?
  - Who was /is the primary contact? [architect or structural engineer?]
  - How do you decide how much to retrofit a building (i.e., what performance is acceptable in future earthquakes)?

Q7. What if you are purchasing or leasing a building for use by your company?

- Would you analyze its potential earthquake damage as a consideration before deciding to purchase or lease it?
- Are the following measures used by your organization?: Probable Maximum Loss (PML), Scenario Estimated Loss (SEL), or Scenario Upper Loss (SUL)?
  - If yes, how do you use these?

Q8. Might your organization be willing to pay an additional amount for an improved structural system to reduce future earthquake damage and business interruption?

[possible probes]

- Why or why not?
- What would help convince decision makers to do this? Would quantifying benefits help (e.g., 2% total cost increase to reduce downtime by 1 month)?
- What are constraints to paying more?

C.3.5 Presentation of Decision Making Materials and Results

Next, I am going to ask you a few questions about FEMA's new initiative and show you a few examples of materials. I'll then follow up each visual with some questions.

Q9. Are you familiar with the concept of performance based earthquake engineering? And, have you heard of FEMA P-58?

- If yes,
  - In what ways might your organization use FEMA P-58 or performance based earthquake engineering in the future?

Q10. Here are a few examples of the types of results your structural engineer could show you if she or he conducts an analysis of the expected earthquake performance of a building being designed or renovated using the newly developed FEMA P-58 .

[Show example result visuals, briefly explain, and then let interviewee look at them. Make sure and let the interviewee know you would like to discuss each handout independently and then get his/her overall thoughts on the three handouts in comparison to one another.]

- [For *each* section of this handout] Can you tell me if the information is clear and might be useful to your organization? How could the presentation be improved?
- What other information would help you communicate with decision makers in your organization about earthquake risk?
- How do decision makers in your organization prefer to see earthquake shaking of various sizes expressed? An earthquake scenario, ground shaking with a specific probability (like the building code), or some other way?

- How do you think information about deaths and injuries should be presented? Average number of deaths and serious injuries? Probability that damage could be life-threatening?

Q11. The example results in this handout are *average* results, and thus actual earthquake damage could be higher or lower. What would be the most effective ways to present the range of possible outcomes, and inherent uncertainty, to decision makers in your organization?

[Clarification probe, if needed]

- Do you prefer to see one average number (i.e., $4 million damage), as shown now, or would you prefer to see results that give you information about the uncertainty, such as a range of results of likely earthquake damage (i.e., 90% chance damage will be between $2.5 million and $6.2 million)?

C.3.6 Trusted Sources of Information

Q12. What professionals or other sources of information do you rely on to learn more about managing the earthquake risk of your facilities?

[If necessary, probe]

For example, do you rely on:

- Insurance agents
- Architects
- Engineers
- Company risk managers
- Trade publications? (please list)
- Professional organizations? (please list)
- Conferences? (please list)
- Other sources? (please list)

C.3.7 Closing Questions

Q13. Is there anything else you want to add?

Q14. Are there any questions you would like to ask me?

Q15. I am interviewing a number of people for this work. Now that you have a sense of the types of questions we are interested in, I wondered if you could refer me to any colleagues in other companies/organizations who make earthquake risk decisions for their organization's buildings and who might be willing to be interviewed about this?

[Collect name, organizational affiliation, contact information, if possible.]

Thank you so much for your time.

C.4 Round Two Interview Guide for Structural Engineers

C.4.1 Introduction to the Interview

Thank you for meeting with me today.

As we discussed on the phone/email, I am a consultant working with the Federal Emergency Management Agency and the Applied Technology Council on a project designed to learn about how engineers might use FEMA P-58 to help clients make decisions about earthquake risk for their buildings. Specifically, I would like to ask you a series of questions that, among other things, will focus on:

- The concerns your clients have related to earthquake risk;
- The processes and criteria you use to design and renovate buildings; and
- The types of support or assistance you might need to feel comfortable using P-58.

I'll also ask for your feedback on possible formats for communicating performance and loss information to clients.

The interview will last about one hour. And, if you agree, I would like to audio record the interview so that I can focus on you rather than trying to take notes the entire time. Is that okay?

Do you have any questions before we proceed?

C.4.2 Information about Interviewee

To begin, I'd like to learn a bit more about you.

Q1. What is your position and what are your primary responsibilities?

Q2. Because this project is focused specifically on earthquake risk, can you describe your current work in this particular area?

- Do you talk with clients about seismic risk? If so, what types of clients (e.g., architects, developers, building owners, tenants, others?).
- What tools do you presently use for estimating seismic risk?

- (If no, what prevents you from discussing seismic risk with clients?)

C.4.3 Concern about Earthquake Risk

Now I would like to ask about earthquake risk concerns and various considerations.

Q3. I'm going to move through a number of potential concerns that engineers often must address. Can you tell me whether you explicitly consider the following in designing or evaluating buildings?

(If you *sometimes* address them, for which types of clients and/or which types of projects or buildings types do you address them?)

- Business downtime?
- Repair or replacement costs?
- Deaths, injuries, worker displacement?
- Environmental impacts?
- Other concerns or factors that you typically consider?
- Which of these issues are your clients most concerned about?
- How do you tend to communicate with them about their primary concerns?

C.4.4 Process to Build and Renovate Buildings

Next I want to ask you some questions about how you advise clients (here meant as a shorthand term for those whom you, as an engineer, might work closely with). I'm also interested in learning how you assist them in making earthquake risk decisions when they build a new building or renovate an existing building.

Q4. I understand that engineers often work with many potential clients – including developers, architects, and so forth. But in general, if your client wants to build a *new* building, will you walk me through, step by step, the process that is followed?

[Probes, to follow initial question as needed]

- Do you discuss structural system selection with the architect? If so, do you present options? Do you quantify the expected performance?
- Do you discuss structural system selection with the owner? (If no, does the architect discuss system selection with the owner?)

- What design criteria or standards do you follow for design of the structure?
- If you are performing a code design, do you inform the client that the building may not be functional following a design earthquake and may not be financially viable to restore after a maximum considered event?
- How is this process different for different types of clients?

Q6. Now I would like to ask a few questions about the process of *renovating* an existing building that needs a seismic retrofit?

- Have you designed seismic retrofits?
- If yes,
    - How is that process different from designing a new building?
    - How do you decide how much to retrofit a building (i.e., how do you determine what performance is acceptable in future earthquakes)?
    - How is the client involved in this decision? And how do you communicate with the client in these retrofit instances? Does your communication differ based on the type of client, type of project or type of building? If so, how?

Q7. What if your client is purchasing or leasing a building?

- Do you evaluate the potential for earthquake losses? If yes, what tools do you use to estimate or describe losses?
- Are the following measures used by your organization? Probable Maximum Loss (PML), Scenario Estimated Loss (SEL), or Scenario Upper Loss (SUL)?
    - If yes, how do you use these?
    - Why are these meaningful to your clients?

Q8. Under what situations do you use more effort in design than would be required to simply satisfy the code? When do you feel that more design effort is warranted?

- Do you believe that additional design fee is required for use of performance based design? If yes, why? What percent increase might you expect?

C.4.5 Presentation of Decision Making Materials and Results

Next, I am going to ask you a few questions about FEMA's new initiative and show you a few examples of materials. I'll then follow up each visual with some questions.

Q9. Are you familiar with the concept of performance based earthquake engineering? And, have you heard of FEMA P-58? (Alternate: As we discussed when scheduling the interview, our team was really interested in speaking with you because of your knowledge of P-58. Now I'm going to ask you some questions about that.

- If yes,
  - Have you ever been to a presentation about P-58?
  - Have you attended a workshop?
  - Have you used it?
    - If yes, any feedback?
    - If no, why haven't you used it?

Q10. Here are a few examples of the types of results you could show your client using the newly developed FEMA P-58.

[Show example result visuals, briefly explain, and then let interviewee look at them.]

- Would any of these be useful to communicate with clients?
- What other information would help you communicate with decision makers in your organization about earthquake risk?
- When communicating with clients, what do you think is the most effective way to present earthquake hazard? Scenario earthquakes? Earthquake shaking with a specific probability? Some other way?
- Again, when communicating with clients, what do you think is the most effective way to communicate deaths and injuries? An average estimated number? The probability that damage could be life threatening?

Q11. The example results in this handout are average results, and actual earthquake damage could be higher or lower. How have you had the most success expressing uncertainty about earthquake impacts to clients?

C.4.6 Trusted Sources of Information

Q12. What sources of information do you rely on to understand and quantify earthquake risk?

[Probe if needed]

For example, do you:

- Attend seminars/webinars/conferences (please list)
- Read technical journals
- Use loss estimation software
- Rely on the code
- Talk with other Engineers
- Participate in professional organizations? (please list)
- Other sources? (please list)

C.4.7 Closing Questions

Q13. Is there anything else you want to add?

Q14. Are there any questions you would like to ask me?

Q15. I am interviewing a number of people for this work. Could you refer me to any colleagues in other companies/organizations who make earthquake risk decisions for their organization's buildings and who might be willing to be interviewed about this? Or, even more specifically, if you have colleagues who you know are familiar with P-58, would you be willing to share their information with me?

[Collect name, organizational affiliation, and contact information for other potential interviewees.]

Thank you so much for your time.

C.5 Overview of Example Output Visuals

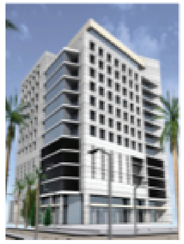
The team developed a graphical presentation of example results of analyses using the FEMA P-58 methodology. Prior to the second round of interviews, the team made edits to the visuals based on an assessment of what had been most effective in the first round interviews. The purpose of the visuals was to gain specific insights into which types of information seemed most interesting and useful to interviewees, what information was confusing or difficult to understand, and preferences about how information should be presented.

C.6 Round One Visuals

Example Results of FEMA P-58

FEMA P-58 Allows You to Analyze the Earthquake Risk of Existing Buildings

(1) Understand expected earthquake damage of buildings in meaningful and measurable ways.



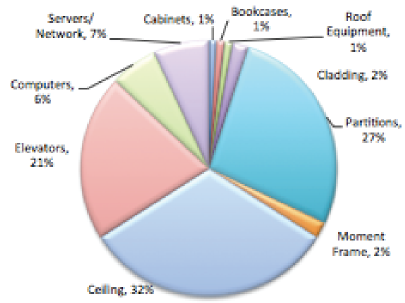
Expected Damage in Earthquakes of Various Sizes

Earthquake Return period	Repair Cost	Repair Time	Probability of Red Tag	Casualties
200 years	$4 million	40 days	14%	1
500 years	$10 million	90 days	36%	20
1,000 years	$36 million	180 days	72%	130

(2) Identify what will likely cause the most earthquake damage to your buildings.

Repair costs, divided by cause, for 500 year earthquake

Total = $10 million



(3) Evaluate the effectiveness of options to reduce risk.

Retrofit Scheme	Expected Damage After Retrofit in 500 Year Earthquake				Cost of Retrofit Scheme
	Repair Cost	Repair Time	Probability of Red Tag	Casualties	
Retrofit Scheme 1	$0.4 million	10 days	8%	< 1	$16 million
Retrofit Scheme 2	$1.3 million	25 days	21%	< 1	$7 million

Figure C-1 Round 1 Visuals 1, 2, and 3 (top to bottom).

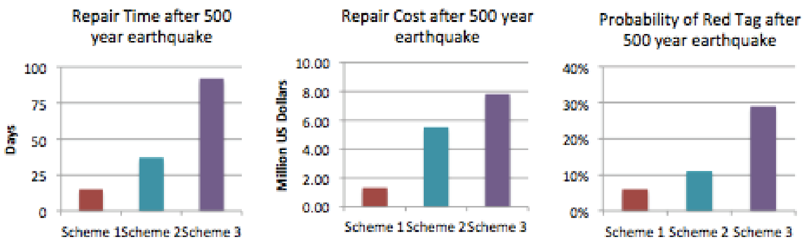
Example Results of FEMA P-58

FEMA P-58 Allows You to Compare Design Choices for New Buildings

(1) Compare conceptual design options in meaningful and measurable ways.

Three options for a basic structural system:

Scheme	Cost
Scheme 1	$6.4 million
Scheme 2	$3.2 million
Scheme 3	$2.8 million



(2) Compare how specific design choices affect earthquake risk.

Three options for a curtain wall system:

Options	Cost
Option A	$890,000
Option B	$440,000
Option C	$390,000

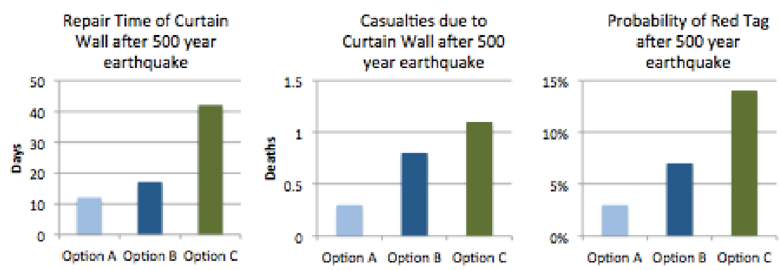
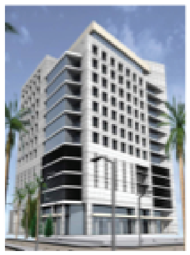


Figure C-2 Round 1 Visuals 4 and 5 (top to bottom).

C.7 Round Two Visuals

Possible Uses and Presentation of FEMA P-58 Results

Present expected earthquake damage of buildings in meaningful and measurable ways.



Expected Damage in Earthquakes of Various Sizes

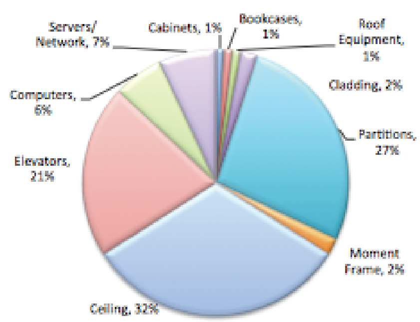
Earthquake Scenario	Repair Cost	Repair Time*	Probability of Red Tag	Casualties**
M 6.5	$4 million	40 days	14%	5
M 7.2	$10 million	90 days	36%	40
M 8.1	$36 million	180 days	72%	320

* Repair time only includes construction time. Additional time will be required to make decisions, obtain financing, receive insurance payments, engage design and construction professionals, obtain permits, etc.

** Casualties are defined as deaths and injuries requiring hospitalization.

Identify what will likely cause the most earthquake damage to buildings.

In a M 7.2 earthquake, the expected repair cost is $10 million divided by cause as follows:



page 1

Figure C-3 Round 2 Visuals 1 and 2 (top to bottom).

Possible Uses and Presentation of FEMA P-58 Results

Evaluate the effectiveness of options to reduce risk.

Retrofit Scheme	Expected Damage in M 7.2 Earthquake After Retrofit				Cost of Retrofit Scheme
	Repair Cost	Repair Time*	Probability of Red Tag	Casualties**	
Retrofit Scheme 1	$0.4 million	10 days	8%	negligible	$16 million
Retrofit Scheme 2	$1.3 million	25 days	21%	1	$7 million

* Repair time only includes construction time. Additional time will be required to make decisions, obtain financing, receive insurance payments, engage design and construction professionals, obtain permits, etc.
** Casualties are defined as deaths and injuries requiring hospitalization.

Compare design options in meaningful and measurable ways.

The earthquake performance of three options for a basic structural system can be quantified and compared.

Options		Cost
Option 1	Base isolation	$6.4 million
Option 2	Concrete frame	$3.2 million
Option 3	Steel frame	$2.8 million

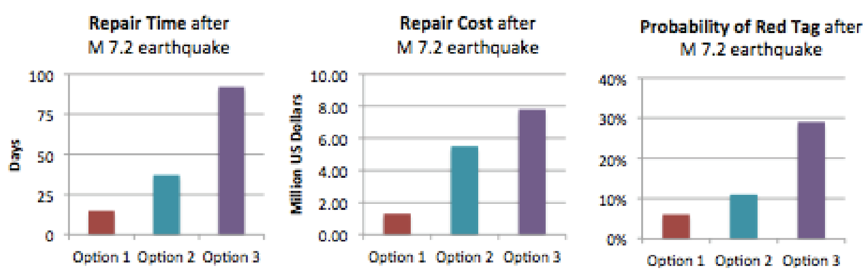


Figure C-4 Round 2 Visuals 3 and 4 (top to bottom).

Possible Uses and Presentation of FEMA P-58 Results

Analysis results could be categorized to help with decision making.

Possible ways to categorize results			Expected impacts for an earthquake of specified size
Platinum	★ ★ ★ ★	A	**Repair Cost:** 0 to 3% of building value **Repair Time:** 0 to 7 days **Casualties:** negligible **Probability of Red Tag:** < 1%
Gold	★ ★ ★	B	**Repair Cost:** 3 to 10% of building value **Repair Time:** 7 to 30 days **Casualties:** negligible **Probability of Red Tag:** 1 to 10%
Silver	★ ★	C	**Repair Cost:** 10% to 25% of building value **Repair Time:** 1 to 6 months **Casualties:** negligible **Probability of Red Tag:** 10 to 25%
	★	D	**Repair Cost:** 25% to 50% of building value **Repair Time:** 6 to 12 months **Casualties:** < 5 **Probability of Red Tag:** 25 to 50%
		F	**Repair Cost:** > 50% of building value **Repair Time:** > 1 year **Casualties:** > 5 **Probability of Red Tag:** > 50%

Figure C-5 Round 2 Visual 5.

Appendix D

Overview of Atlas.ti Analysis Process

About 125 key themes were initially proposed, arranged into nine families: Acquire, Build, Concerns, Communication, Interviewees, Methods, Renovate, Sources, and Visuals. Approximately 10 key themes were organically added and about 20% of the original key themes list was never used. The result is a final codebook with 108 active key themes. Table D-1 shows a list of all key themes used more than 70 times, broken down by stakeholder category. It is important to note that both the number of quotations assigned per transcript and the number of key themes assigned to each quote across all stakeholder categories are not equal.

Definitions for each of the family groups and key themes used appear in Table D-2. Table D-3 shows the number of quotes tagged with each key theme.

Table D-1 Highly Used Atlas.ti Key Themes (>70 times) by Stakeholder Category and Organization Type

		Building Owner Representatives					*Other Stakeholders*		*Structural Engineers*	
Top 50 Highest Use Key Themes (> 70 times)	*Total # Quote Links:*	*Private Corp.*	*Cultural Institutions*	*Local Gov't*	*University / Higher Ed*	*Utility Lifelines*	*Financial Sector*	*Building Officials*	*Critic*	*Structural Engineer Users*
renovate decision process	188	17	2	40	9	18	1	4	0	3
build decision process	182	16	8	29	14	6	10	4	0	4
renovate decision factors	158	12	2	29	10	14	0	5	1	6
build code	154	18	7	17	0	4	8	11	2	10
build decision factors	134	11	6	17	6	7	9	5	0	6
method current	128	13	0	13	3	1	4	6	19	5
method utility	120	5	6	24	1	7	4	4	8	1
communication practices	116	5	3	9	5	10	0	4	0	22
concern life safety	116	3	7	22	4	5	0	6	7	4
renovate earthquake	116	3	4	19	2	16	1	4	1	8
concern business continuity	106	13	0	15	4	3	5	1	9	3
communication obstacles	100	4	8	12	5	5	1	4	1	10
interviewee organization	98	6	0	24	3	6	5	4	0	1
method improvements	98	1	7	8	1	2	12	2	10	6
visual clarity	92	3	0	13	9	7	0	7	2	5
visual modification	86	1	0	12	9	5	2	4	3	7
concern buildings other	82	2	0	16	2	7	5	1	5	3
communication recommendations	80	0	9	10	3	9	0	1	0	8
method loss estimation	80	1	1	10	2	2	11	0	9	4
interviewee earthquake focus	74	3	1	10	5	3	0	6	4	5
sources external experts	74	3	2	3	8	5	7	3	2	4
build earthquake	70	3	4	13	2	6	2	3	0	2
visual 1_set 2	70	1	0	15	11	0	0	5	1	2

Table D-2 Definitions for Atlas.ti Family Groups and Key Themes

Family Group Name	*Key Theme Name*	*Definition*
acquire		This set of key themes captures the process involved in purchasing or leasing buildings or infrastructure.
	acquire challenges	Mentions of obstacles or barriers anticipated, encountered before, or during the process of acquiring a building, especially as those relate to seismic concerns or performance. These might be associated with dependencies, time, personnel, expertise, unexpected delays, etc. or how to finance investing in earthquake damage reduction. Any discussion of barriers associated with cost, time, personnel, expertise, etc. in terms of actually investing in earthquake damage reduction to properties they acquire.
	acquire code	Any description of the use or perceptions of the adequacy of building codes, trust in codes, use of codes when deciding to buy or lease, etc. References to criteria and standards consulted when deciding whether to buy or lease a new structure.
	acquire decision factors	Any description of factors in decisions about whether to acquire new buildings (necessary or desired features, location, timing, price points, etc.).
	acquire decision process	Any general descriptions of how decisions are made while acquiring new buildings. This could include: 1) what professionals and decision makers are involved in the decision-making surrounding building purchases and leases, 2) any description of roles, such as who has authority to make purchase or lease decisions, take actions, accountability, etc., and 3) any procedural steps or formal decision mechanisms involved, such as Board votes, negotiations, etc.
	acquire earthquake	Specific discussion of how earthquake risk or performance is factored into deciding whether to buy or lease a new building, and whether and how that is considered by an organization. If earthquake risk is not considered, that is also captured.
	acquire exceed	Any discussion of a stakeholder being willing to seek out buildings to purchase that exceed code to ensure high earthquake resistance.
	acquire internationally	Any discussion of acquiring buildings internationally.
build		This set of key themes should capture the process involved in building new buildings (new construction).
	build challenges	Mentions of obstacles or barriers anticipated, encountered before, or during the process of building, especially as those relate to seismic concerns or performance. These might be associated with dependencies, time, personnel, expertise, unexpected delays, etc. or how to finance investing in earthquake damage reduction. Any discussion of barriers associated with cost, time, personnel, expertise, etc. in terms of actually investing in earthquake damage reduction to properties they plan to build.
	build code	Any description of perceptions of the adequacy of building codes, trust in codes, use of codes, etc. or description of criteria and standards followed in building a new structure.
	build decision factors	Any description of factors in the making of decisions about whether to build new buildings (necessary or desired features, location, timing, price points, seismic performance goals, etc.). This includes descriptions of how costs play into decision-making or other desired features in new construction.

Table D-2 Definitions for Atlas.ti Family Groups and Key Themes (continued)

Family Group Name	*Key Theme Name*	*Definition*
build (continued)	build decision process	Any general descriptions of how decisions are made while buidling new buildings. This could include: 1) what professionals and decision makers are involved surrounding building design, financing, and construction, 2) any description of roles, such as who has authority to make decisions, take actions, accountability, etc., and 3) any procedural steps or formal decision mechanisms involved, such as consultation, peer review, etc.
	build difference	How is building a new building different from retrofitting an existing building or acquiring a building; this includes comparing the alternatives of whether to purchase, lease, or build.
	build earthquake	Specific discussion of how earthquake risk or performance is factored into designing or building a new building, and whether and how that is considered by an organization. If earthquake risk is not considered, that is also captured.
	build exceed	Any discussion of a stakeholder being willing (or unwilling) to seek out buildings to purchase that exceed code to ensure high earthquake resistance.
	build international	Any discussion or comparison of building in the U.S. versus internationally.
	build process	Any description of the physical process or steps involved in building or managing construction of a new building.
	build relationship engineer	Any discussion of how the structural engineer is or is not involved in various decisions, aspects, or stages of building a new building. This includes relationships with other professionals working on the design, such as consultants or architects, project managers, or organization leaders/decision-makers.
communication		This set of key themes should capture any specific statements from the interviewees about the nature of current practices and experiences of communicating about earthquake risks, whether or not they relate to FEMA P-58.
	communication obstacles	Any comments or observations related to obstacles faced when communicating risk.
	communication practices	Mentions of how respondents go about expressing the various aspects of risk, such as in probabilistic terms, in return intervals, as scenario events, and the results of analyses.
	communication recommendations	Any general recommendations interviewees have about how to communicate seismic risks or performance to decision makers. Additionally, statements about "what works" when communicating about risk with decision makers (scenarios, probabilistic statements, particular types of consequences like business interruption, repair costs, casualties, liability, etc.
	communication trust	Mentions of anecdotes or experiences of communicating risks to clients or the importance of relationships (long term, repeat business, past successful projects) to the stance or actions taken by decision-makers.
concern		This set of key themes should encompass any conversation regarding earthquake related concerns, especially in relation to the buildings and/or facilities that the respondent is responsible for in his or her daily work.

Table D-2	Definitions for Atlas.ti Family Groups and Key Themes (continued)	
Family Group Name	*Key Theme Name*	*Definition*
concern (continued)	concern awareness	Concern about peoples' lack of consciousness about their true earthquake risk, or that, despite their efforts, what is being done is still not enough to sufficiently prepared. Alternatively, this key concerns with how to increase awareness, which might include a desire to keep certain kinds of information back in some circumstances.
	concern buildings other	General concern that buildings (any specific type not mentioned else where, e.g., "high rise") will fall down or are at risk in some way.
	concern business continuity	Mentions of concerns about disruption of business operations and the consequences of that for the organization, such as not being able to access/occupy the premises, supply chain disruption, loss of key inventory or production equipment or contents, breakdown of mission- critical elements, and overall concern that an earthquake will cause so much business downtime that the organization will lose key customers, revenue, business or industry relationships. Concern about employees needing to work from home or in temporary office spaces post-earthquake.
	concern cost building damage	Concern that the cost of building damage or the costs to repair or replace buildings will be very high.
	concern cost building downtime	Concern that the costs of building downtime or loss of functionality will be very high.
	concern critical facilities	Concern that critical buildings such as hospitals, public works, schools, etc. will remain functional following an earthquake.
	concern critical infrastructure	Concern that bridges or roads will be impassable, will collapse, etc. or that public transportation will not function.
	concern earthquake philosophy	Any time the interviewee shows concern through a philosophical discussion about the nature of earthquakes or the moral or ethical dimensions of making performance choices.
	concern education	Concern that schools in the community will not be operational, or that students may be affected, including in ways that go beyond physical injury, namely disruption to their educational progress.
	concern environment	Concern (or lack thereof) that damage would lead to environmental impacts such as air or water pollution, hazardouswaste spills, toxic releases. etc.
	concern error	Concern that error or defect on the part of engineers or contractors contribute to level of damageability
	concern expertise	Concern that the level of expertise is not sufficient for proper seismic safety measures.
	concern fire	Concern that fires will occur associated with the earthquake.
	concern historic structures	Concern that historic structures will be damaged, destroyed, and/or demolished after an earthquake.
	concern insurance	Any discussion of the role or adequacy of insurance as an alternative way to handle earthquake risk.
	concern intensity	Concern regarding the intensity, size, depth, etc. of an earthquake, and uncertainties about how well they can be predicted.
	concern lack of enforcement	Concern about lack of enforcement of codes, regulations, and legislation, making these laws useless/void.

Table D-2 Definitions for Atlas.ti Family Groups and Key Themes (continued)

Family Group Name	*Key Theme Name*	*Definition*
concern (continued)	concern legal	Any mention of concern for legal ramifications of not following seismic codes or being held liable for study results that indicate a need for increased seismic safety.
	concern life safety	Any instance where the person discusses life safety, evacuation, or avoiding potential deaths as a performance goal.
	concern lifelines	Concern that utilities such as gas, electric, water, sewage or other critical lifelines will be damaged.
	concern liquefaction	Concern that parts of the city will experience liquefaction or that liquefaction has not been dealt with appropriately, lateral spread, or other ground failures.
	concern mandate	Concern about meeting fiduciary responsibilities and/or compliance with legislative or regulatory requirements
	concern non-ductile concrete	Concern about an older concrete structure.
	concern non-structural mitigation	Concern about the lack of non-structural mitigation (awareness of the distinctions as well as implementation of fixes). This could includes contents (e.g., books, shelving, computing, lab equipment, supplies) or non-structural fixed equipment (e.g., wine tanks, transport rails or pipes).
	concern politics	Concern that decision-making around seismic risk is highly political.
	concern recovery	Concerns about the plans for rebuilding the city and overall resumption of activities post-earthquake.
	concern response	Concern for the response capacity of the community/organization or lack thereof, the capacity of emergency services.
	concern social effects	Any mentions of concerns about the overall community or social impacts of earthquake damage, such as: decreases in the amount of affordable housing available; concern that there will be generalized chaos, disorder, or social breakdown; crime rates; displacement or flight from the area; negative psychological impact on community; overall public health and safety; impacts of vulnerable groups (homeless, disabled, etc.) will be harmed or killed.
	concern soft story building	Concern that this particular type of building will collapse and cause additional "ripple effects".
	concern soil	Concern that the soil or ground that they occupy (or will occupy) is not safe
	concern sustainability	Concern about whether it is more "green" or sustainable (e.g. in terms of carbon footprint or energy consumption) to either upgrade or demolish and rebuild a building.
	concern type of earthquake	Concern that earthquakes can come from all different directions with different levels of shaking which makes risk hard to estimate.
	concern unreinforced masonry buildings	Concern that this particular type of building will collapse.
interviewee		This set of key themes should capture key insights regarding the stakeholder interviewees' professional backgrounds, their actions, and abilities. Specifically, the intent of this set of key themes is to help characterize the professional backgrounds of the persons whom our team interviewed. These key themes may also provide insights in terms of the ways that FEMA may be better able to appeal to their potential target audience.

Table D-2 Definitions for Atlas.ti Family Groups and Key Themes (continued)

Family Group Name	*Key Theme Name*	*Definition*
interviewee (continued)	interviewee background	Information on the interviewees' background, professional training, education, etc.
	interviewee current responsibilities	Description of the interviewees current position, in general. Description of what the interviewee does in his or her current position, their title, or roles.
	interviewee early adopter	Any instance where the person perceives themselves (or we perceive them) as a potential "early adopter" of P-58 practices.
	interviewee earthquake focus	Any description of work specific to earthquake mitigation, risk reduction, response, recovery, etc.
	interviewee experience	Any discussion of their degree or level of experience carrying out similar types of analyses or using the outputs of similar analysis products or reports, or their willingness to try mew methods.
	interviewee organization	Any description of the nature of the organization for which the interviewee works, such as geographic reach, size, market focus, products, ways of doing business, standard operation procedures, etc.
	interviewee past responsibilities	Description of what the interviewee did in terms of past work experience, that may inform present position, outlook, etc.
method		This set of key themes captures any specific statements from the interviewees about the P-58 methodology; either how they have used the tool or their opinions on how FEMA could improve it.
	method barriers	Any specific obstacles mentioned that could impede adoption of the P-58 methodology or complaints expressed about the P-58 methodology that might deter use.
	method current	Any specific mentions of the methods of analysis currently in use, or use or comparisons to "predecessor," alternative," or "competitor" analytical tools, such as current ways (programs, processes) of doing performance assessments, projections, or analyses. Also, the assumed level earthquake used in an analysis; these could include: "design level" or Maximum Credible Event (MCE), and the importance factor.
	method dimensions	Any specific concerns or ideas related to the portrayal of each of the three dimensions of loss: deaths, dollars, and downtime (time until re-occupancy/resumption of use and functionality)
	method improvements	Any specific recommendations for revisions, refinements or additions to the methodology.
	method integrate	Advice about whether or how FEMA should make its product easy to integrate with already existing platforms.
	method loss estimation	Any specific discussion of loss estimation methodologies such as ASCE 31/41 or FEMA's HAZUS, or output measures of those methods such as PML (Probable Maximum Loss), SEL (Scenario Estimated Loss), or SUL (Scenario Upper Loss), as well as examples of their use in analysis or communication of analysis results
	method simplicity	Mentions about whether or how FEMA should offer analysis tools and information in simple, non-technical formats that can be easily understood.

Table D-2 Definitions for Atlas.ti Family Groups and Key Themes (continued)

Family Group Name	*Key Theme Name*	*Definition*
method (continued)	method trust	Discussion of general factors that promote or impede trust or confidence in the P-58 methodology; the degree to which it produces consistent, reliable, reproducible, verifiable results; and other things that affect how much the person trust/distrust the output information.
	method utility	Any mentions of specific benefits of using P58 over other analytical approaches. Also, reference to how much a user would be willing to spend on better analysis.
renovate		This set of key themes captures the process involved in renovating or retrofitting existing buildings or infrastructure.
	renovate amount	References about willingness to pay or how much the organization actually invests in earthquake risk reduction activities, how it obtains the funds it needs to do so, and its overall tolerance for spending on this type of work.
	renovate challenges	Mentions of obstacles or barriers anticipated, encountered before, or during the process of renovating, especially as those relate to seismic concerns or performance. These might be associated with dependencies, time, personnel, expertise, unexpected delays, etc. or how to finance investing in earthquake damage reduction.
	renovate code	Any description of perceptions of the adequacy of building codes, trust in codes, use of codes in renovations, etc.
	renovate decision factors	Any description of the factors or inputs to making choices about renovating or retrofitting an existing building or structure. This might include concern with meeting minimum code requirements, business interruption, repair costs, casualties, liability, cost benefit analyses, earthquake performance projections, trade-offs against concerns for other hazards such as sea-level rise, etc.
	renovate decision process	Descriptions of the general process of making renovation choices, such as who is involved and what their authorities or roles are, how recommendations are made, triggering events (what gets renovated, when, alternatives considered, etc.). This includes references to leadership, dependencies, and accountability among the professionals and decision makers involved in a renovation or retrofit process.
	renovate difference	How is renovating a building different from building a new building.
	renovate earthquake	Specific discussion of how earthquake risk is factored into renovating a new building.
	renovate exceed	Any discussion of a stakeholder being willing to exceed code or exceed set costs to build, purchase, or renovate to ensure the most earthquake resistance structure.
	renovate leader	Any description of who is in charge of renovation decisions, actions, etc. and what they do
	renovate retrofit performance	Any discussion of what performance is desired or perceived in a retrofitted building, and whether and how that is considered by an organization.
sources		This set of key themes should capture where the organizations/individuals represented in the sample are currently getting their information, products, or materials from.
	sources codes/standards	Any mentions of widely accepted codes referred to or used by interviewees.

Table D-2 Definitions for Atlas.ti Family Groups and Key Themes (continued)

Family Group Name	*Key Theme Name*	*Definition*
sources (continued)	sources credible	Any description of what makes the interviewee trust or believe in the accuracy of an information source. Also may refer to the importance of having access to credible or reliable data.
	sources external experts	Any discussion of engineers, academics, scientists, emergency managers, and others who advise agencies and provide information or data or attendance at professional conferences.
	sources government	Resources for earthquake preparedness advice or data provided by the government.
	sources insurance	Any discussion of what type of insurance their organization uses or where they get their coverage from.
	sources internal experts	Discussion of experts who are within an organization such as engineers, consultant, or architects, who provide essential information.
	sources past hazards	Mentions of information, resources, experiences, and/or lessons learned from past hazard events, including specific earthquakes and other hazard events, such as Hurricane Katrina.
	sources primary research	Any reference to learning based on their own research/data/testing/modeling.
	sources supplier	Any discussion of the source of supplies for the business, buildings, inventory, etc. especially as it relates to seismic safety.
	sources technical resources	References to knowledge or use of technical resources. These may include CDC data, HAZUS, USGS Shakemap, other analytical software, etc. or documents like scholarly journals, books, and other professional publications.
visual		This set of key themes should be used to capture the interviewees responses to the visuals.
	visual 1_set 1	Any positive or negative statements regarding visual 1 from the first set of visuals.
	visual 1_set 2	Any positive or negative statements regarding visual 1 from the second set of visuals.
	visual 2_set 1	Any positive or negative statements regarding visual 2 from the first set of visuals
	visual 2_set 2	Any positive or negative statements regarding visual 2 from the second set of visuals.
	visual 3_set 1	Any positive or negative statements regarding visual 3 from the first set of visuals
	visual 3_set 2	Any positive or negative statements regarding visual 3 from the second set of visuals.
	visual 4_set 1	Any positive or negative statements regarding visual 4 from the first set of visuals
	visual 4_set 2	Any positive or negative statements regarding visual 4 from the second set of visuals.
	visual 5_set 1	Any positive or negative statements regarding visual 5 from the first set of visuals
	visual 5_set 2	Any positive or negative statements regarding visual 5 from the second set of visuals.

Table D-2 Definitions for Atlas.ti Family Groups and Key Themes (continued)

Family Group Name	*Key Theme Name*	*Definition*
visual (continued)	visual clarity	Any statements about the understandability of the visuals, things the interviewees found to be particularly clear, compelling, convincing, or useful, OR, in contrast, confusing, unclear, or ambiguous.
	visual favorite overall	Overall evaluations of favorite visual(s), or comments about which one(s) are most useful.
	visual hazard	Any statements on how the earthquake hazard was presented or should be presented in terms of scenario, probability, magnitude, depth, ground shaking, etc.
	visual least overall	Overall evaluations of least favorite visual(s).
	visual missing	Any statements on things the interviewees felt were missing from the visual.
	visual modification	General recommendations for modifying the visual(s) to improve on what was presented.
	visual past experience	Any discussion of visuals or presentation methods that have been particularly effective with decision-makers in the past in an organization.
	visual uncertainty	Any statements on how uncertainty (or the range of possible uncertainties) were presented or could be presented most effectively.

Table D-3 Names and Counts of All Used Key Themes by Family, Presented in Order within each Family from Most to Least Number of Times Used

Family	*Key Theme Name*	*Total Times Used*
Acquire	acquire decision process	48
	acquire decision factors	34
	acquire earthquake	20
	acquire challenges	18
	acquire code	10
	acquire internationally	4
	Acquire Subtotal	**134**
Build	build decision process	182
	build code	154
	build decision factors	134
	build earthquake	70
	build relationship engineer	48
	build challenges	40
	build exceed	36
	build difference	22
	build process	8
	build international	2
	Build Subtotal	**696**

Table D-3 Names and Counts of All Used Key Themes by Family, Presented in Order within each Family from Most to Least Number of Times Used (continued)

Family	*Key Theme Name*	*Total Times Used*
Communication	communication practices	116
	communication obstacles	100
	communication recommendations	80
	communication trust	10
	Communication Subtotal	**306**
Concern	concern life safety	116
	concern business continuity	106
	concern buildings other	82
	concern critical facilities	28
	concern cost building damage	26
	concern critical infrastructure	24
	concern environment	16
	concern legal	14
	concern social effects	14
	concern soft story building	14
	concern non-ductile concrete	12
	concern recovery	12
	concern response	12
	concern historic structures	10
	concern politics	10
	concern type of earthquake	10
	concern unreinforced masonry buildings	10
	concern education	8
	concern expertise	8
	concern intensity	8
	concern sustainability	8
	concern earthquake philosophy	6
	concern error	6
	concern lack of enforcement	6
	concern liquefaction	6
	concern mandate	6
	concern fire	4
	concern lifelines	4
	concern soil	4
	Concern Subtotal	**1090**

Table D-3 Names and Counts of All Used Key Themes by Family, Presented in Order within each Family from Most to Least Number of Times Used (continued)

Family	*Key Theme Name*	*Total Times Used*
Interviewee	interviewee organization	98
	interviewee earthquake focus	74
	interviewee current responsibilities	62
	interviewee past responsibilities	28
	interviewee background	24
	interviewee experience	20
	interviewee early adopter	18
	Interviewee Subtotal	**324**
Method	method current	128
	method utility	120
	method improvements	98
	method loss estimation	80
	method barriers	52
	method simplicity	36
	method trust	32
	method dimensions	20
	method integrate	10
	Method Subtotal	**576**
Renovate	renovate decision process	188
	renovate decision factors	158
	renovate earthquake	116
	renovate challenges	68
	renovate code	68
	renovate retrofit performance	40
	renovate difference	38
	renovate leader	26
	renovate amount	24
	renovate exceed	14
	renovate process	12
	Renovate Subtotal	**752**
Sources	sources external experts	74
	sources codes/standards	50
	sources past hazards	44
	sources internal experts	24
	sources credible	10
	sources government	10

Table D-3 Names and Counts of All Used Key Themes by Family, Presented in Order within each Family from Most to Least Number of Times Used (continued)

Family	*Key Theme Name*	*Total Times Used*
Sources (cont'd)	sources insurance	10
	sources primary research	10
	sources supplier	2
	Sources technical resources	42
	Sources Subtotal	**276**
Visual	visual clarity	92
	visual modification	86
	visual 1_set 2	70
	visual 2_set 2	54
	visual missing	48
	visual 4_set 2	40
	visual hazard	40
	visual 5_set 2	38
	visual 1_set 1	36
	visual casualties	32
	visual 3_set 2	28
	visual uncertainty	22
	visual past experience	18
	visual 2_set 1	16
	visual 4_set 1	14
	visual favorite overall	14
	visual 3_set 1	10
	visual 5_set 1	8
	Visual Subtotal	**666**

Appendix E
Social-Cognitive Theories Related to Seismic Preparedness

Social-cognitive theories of behavior change can be categorized into three types: motivational (focusing on assessment of a hazard and the development of motivation to do something about it), behavior enaction (focusing on bridging the gap between motivations/intentions and action), and multi-stage theories (describing an overarching suite and sequencing of processes) (Armitage and Conner, 2000). The latter are usually the most complex, depicting belief and behavior change as a person or organization gradually becoming more aware, interested, motivated, capable, and committed to taking action and then finally following through.

A core principle of Social-Cognitive Theory is that people learn primarily by observing the behaviors of others and that behavior is not formulaic but rather highly variable and contextual; it is the joint-product of situation and person-specific factors (Bandura, 1977). Another Social-Cognitive Theory insight is that *beliefs* about the recommended behavior might matter as much or more than beliefs about the underlying risk or threat. *How hard is it to do? Is it likely to work as promised? Am I capable of carrying it out?* Individual appraisals of the social implications of their behavior matter, too. *What will people think of me if I behave in a new way?*

Social-Cognitive theories tend to frame behavior change campaigns as the co-product of individual factors such as personality traits, past history and experience, demographic and present circumstances and constraints. These are distinct from intervention factors, which are all the risk communication program design and implementation details both small and large (e.g., from the color and size of the font used on the program brochures to whether and how much of a financial incentive is offered). Both types of things can influence the behavioral outcomes of interest, either independently or through interactions. Ideally, program operators should understand the most relevant individual factors and then create materials that interact with those characteristics to raise the potential for action. Thinking this way also helps foster reasonable expectations as to the degree of behavior change that a guidance program can achieve, and facilitates targeting of resources toward the program features that have the most leverage on ultimate effectiveness.

Neil Weinstein's Precaution Adoption Process Model proposed five sequential stages of belief and behavior change (Weinstein, 1988). Figure E-1 presents this framework from an information campaign to motivate home radon testing (Weinstein and Sandman, 1992; Weinstein et al., 1998). The prediction from Weinstein's Precaution Adoption Process Model is that different communication messages will be most effective for users in different stages. Thus, it is vital to consider how to tailor and deliver specific, targeted messages to specific audiences.

Researchers have developed several other Social-Cognitive Theories to understand disaster preparedness behaviors specifically, most notably the Protective Action Decision Model (Lindell and Perry, 1992; Lindell and Perry, 2000; Lindell and Perry, forthcoming), and Protective Motivation Theory (Rogers, 1983; Mulilis and Lippa, 1990; Rogers and Prentice-Dunn, 1997).

The Precaution Adoption Process Model is a simpler stage-model (Lindell and Perry, 1992; Lindell and Perry, 2000; Lindell and Perry, forthcoming) that postulates a transition of a persons from: (1) threat awareness/perception (triggered by social, observed or experiential cues); to (2) conducting a low-cost search for appropriate solutions (that will not unnecessarily disrupt usual routines); to (3) a decision to act or not based on their assessment. It was originally formulated to explain evacuation behavior in response to warnings.

In some ways, it is difficult to draw analogies between structural mitigation for earthquakes and other types of protective action. One-time behaviors might be less difficult to influence via policies than someone's ongoing diet or exercise routines, which involve repeated cycling through initiation, follow-through, and maintenance behaviors. Mitigation happens essentially once and transforms a property into a new condition which will remains "permanent" until the next major renovation or quake. It involves large perceptual and financial barriers and potentially abstract, remote, and uncertain benefits. The nature of the threat and the recommended action suggest that many intermediate decisions have to be made, like whether and when to "buy" personalized risk information and how to respond to any new information received.

These features add additional layers to the challenge of explaining and predicting behavior that are not well-addressed in models that relate to commonly understood hazards. People with high general awareness of the threat may be totally unaware of the potential relevance of the problem to themselves. To be blunt, anyone can be an expert at low cost with regard to whether or not he or she is overweight or a smoker. This is not nearly as

	Stage 1 *Awareness*	*Stage 2* *Significance to Others*	*Stage 3* *Significance to Self*	*Stage 4* *Intention to Act*	*Stage 5* *Action Taken*
Example Diagnostic Belief Statement	"I have heard of the radon problem."	"Radon is a problem for quite a few people."	"There is a real chance that I could have a radon problem in my home."	"I plan to ventilate my home to reduce the radon level."	"I have added ventilation to reduce the radon level."
Example Counter-Indicating Belief Statement	"I have not heard of the radon problem."	"The number of people who have a radon problem is negligible."	"There isn't much of a chance that I have a radon problem in my home."	"I do not plan to ventilate my home to reduce the radon level."	"I haven't added extra ventilation."
Potential Determinants	communications about hazard personal experience with hazard know someone who's experienced hazard	credibility/clarity of communications regarding prevalence personal experience with hazard know someone who's experienced hazard	risk and susceptibility factor information relative to self personalized risk information personal experience with hazard	Beliefs about seriousness of threat: personal severity & susceptibility salience of short- vs. long-term threat aspects	Factors determining strength of intentions (all Stage 4 items plus…) complexity of precaution ease of obtaining information required to carry out
			information about peers' status on risk factors	behavior of others and communications implying seriousness	time, effort, and resources required by precaution
				personal capacity to act, resources	time until hazard noticeably fades/disappears opportunities that decrease costs of action reminders of threat
					reminders to take precaution

Figure E-1 A multi-stage framework for explaining the precaution adoption process, with example references to the problem of radon gas. Adapted from: Weinstein, 1988.

straightforward with earthquake hazards. As with many other environmental (e.g., radon gas, lead exposure) and health threats (e.g., cardiac disease, diabetes), even experts cannot just "tell" a person how at risk they are without a screening or diagnostic assessment that could be costly and create new risks (e.g., insurance status, fear of public disclosure, liability). Even an expert's assessment will still contain irresolvable uncertainties. Seismic assessments involve long chains of assumptions and predictions that even experts view as highly complex and uncertain, which exacerbates those challenges further.

Appendix F

Considerations in Using Qualitative Methods

The team concluded that the objectives of this project would benefit from the kind of human interaction and rich, comprehensive exploration of issues that interviews can provide. A one-on-one interview setting is open and flexible enough to let the conversation enter into unanticipated terrains and to let the respondent guide how much time is devoted to each topic depending on their own knowledge base or level of interest and comfort.

Despite the overall affordability compared to large sample size studies, qualitative methods have potential limitations such as the difficulty of identifying, gaining access to, and obtaining consent from respondents who must make an investment of time to discuss potentially personal matters. Qualitative studies also typically result in insufficient power to perform statistical tests. Qualitative investigations tend to raise more questions than they answer. However, the generation of new ideas or identification of information gaps for future study can be a contribution in itself.

The validity of the reported qualitative information depends on individual recollections, self-awareness, candidness, and ability to articulate motivations or predict future behaviors, possibly in unfamiliar contexts or in what may be politically- and emotionally-charged settings (e.g., their job performance or personal financial security might feel at stake). Rapport with the interviewer can be particularly influential to what is talked about and what gets said or not. Owing to a desire to please or assist the interviewer, or as a result of self-presentation concerns, actual behavior may systematically vary from that which is reported.

Even in research circles, some people doubt the ability of small N studies to produce systematic and testable observations. One key concept that enhances rigor in qualitative studies, and helps reduce some of the limitations described above, is *triangulation*. The highest quality studies use multiple, ideally independent data sources to investigate the same phenomena and interpret points that are heard about from three or more individuals as more important than isolated statements. *Saturation* is a natural process of diminishing receipt of new information with each additional interview completed. The saturation concept allows a qualitative researcher to iterate towards and have confidence in an appropriate sample size for understanding the particular phenomena being studied.

Appendix G

Long List of Guidance Product Ideas and Subjective Assessments

The project team developed a long list of possible guidance product ideas. Each of these ideas was discussed, categorized in terms of target audience and stage in the decision change process, and subjectively evaluated in terms of its effectiveness, cost, and feasibility. Table G-1 presents information on how the subjective assessments were made.

Table G-1 Information on Subjective Assessment Process

Title	*General Definition*	*Detailed Description/ Comments*	*Levels*
Effectiveness	The degree or amount of progress made on the projects objectives [e.g., (1) motivate stakeholders to use a performance-based approach, and (2) Enable them to effectively use the FEMA P-58 methodology]	Incorporates these qualities: reach (including the importance of those reached); speed with which it will work; lasting impact/duration of effectiveness; low need for updating over time; and how certain is the effectiveness.	1 through 4 (most effective)
Cost	The dollar cost or level of effort required.	Generally this requires setting specific goals and then comparing two or more products relative to the costs for each to achieve that goal.	1 through 4 (cheapest)
Feasibility	The degree to which the necessary skilled personnell, information, and administrative capacity exist to create and disseminate the product.	How much technical pre-work, data, or new research will be necessary before the product can be made? Are such efforts risky in any way? Are there sufficient skilled persons to carry out the product vision? What is the degree of dependence on outside parties who may have other agendas or constrained resources?	1 through 4 (highest)

Table G-2 presents the long list of possible guidance products and their assessments. In Table G-2, the targeted stakeholder audience is identified as building owner representative (BO), structural engineer (SE), other building professional (OBP).

Table G-2 Long List of Possible Guidance Products and Their Subjective Evaluation

Ref #	Guidance Product Concept	*Targeted Stakeholder Audience*				*Targeted Stages of Behavior Change*							*Evaluation Criteria*		
		BO	*SE*	*OBP*	*O*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*E*	*C*	*F*
1	2 - 4 page "Leave-Behind" brochure, intended for structural engineer to use during a pitch meeting with building owner client. (Engineer has the job, this backs up the proposal engineer has already put there.)	•							•	•	•		1	4	4
2	Promotional or training materials for building owner representatives (e.g., RIMs). Facility and risk managers would be the target audience so they can understand and explain concepts to other decision makers.	•			•	•	•						2	4	3
3	White paper/article for the insurance and/or finance industry on PML/SEL/SUL (i.e., describes problems with current systems, and how PBD gives better information)				•	•	•						1	4	4
4	A champion "owner" would write an article for a relevant publication with a success story of us of P-58/performance mindset	•				•	•						3	4	1
5	A champion architect would write an article in the AIA monthly magazine (e.g., conceptual, with a success story of use of P-58/performance mindset)			•		•	•						3	4	4
6	"TED Talk" introducing concept of performance-based decision-making. (Linked to YouTube idea #11.)	•				•	•						3	2	2
7	Brief (~10 pages) report for property appraisers, real estates sales agents, insurance underwriters, lenders on performance based engineering and capabilities to acquire better information on business continuity, loss estimates, etc. (Aimed at making performance information more relevant at the time of sale or lease. Perhaps a simplified performance "description.")			•		•	•						1	3	3
8	Project-specific materials to help engineers to discuss issues with architect. (e.g., at the conceptual design stage). Duplicate of #38.			•				•	•	•			3	4	4
9	A brochure on the SF Building Occupancy Recovery Program and the relevance of P58 loss modeling before and after earthquakes		•			•	•	•							

Table G-2 Long List of Possible Guidance Products and Their Subjective Evaluation (continued)

Ref #	Guidance Product Concept	*Targeted Stakeholder Audience*				*Targeted Stages of Behavior Change*							*Evaluation Criteria*		
		BO	*SE*	*OBP*	*O*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*E*	*C*	*F*
10	Training or guidance materials for architectural professionals (AIA course?). (Outreach to this audience is needed. Which is the best path? See education and training section below, e.g. #49.)			•		•	•	•					3	3	3
11	Short videos suitable for Youtube, generally introducing performance mindset concept, offering testimonials, how-to's.	•				•	•	•					3	2	2
12	A "champion" building official would present to building officials at the annual California Building Officials Organization about successful use of P-58			•		•	•	•					1	3	2
13	Spreading the word about businesses, government agencies, and other groups using P-58. If it becomes the industry standard these folks might see the value in being "early adopters" and leaders in this field.	•	•	•			•	•	•				2	4	1
14	Curriculum materials (e.g., modules, teaching cases and notes) for structural engineering students. (This would have to be carefully crafted to meet the needs of the professor and expand the audience of trained.)		•				•	•					2	4	4
15	Presentations by respected insider on PML/SEL/SUL at relevant conferences/meeting		•	•			•	•					2	4	2
16	Report documenting the expected performance of buildings designed in accordance with the current code		•				•	•	•				4	4	4
17	Updated ASTM standard for PML/SEL/SUL that acknowledges the FEMA P-58 methodology. (Involves consensus process to approve. It would be very useful but not within our control.)		•	•			•	•	•	•			4	4	1
18	Informational checklist or brochure for commercial real estate leasees to use when shopping for rental space.			•		•	•	•	•	•	•		1	4	2
19	Report and related presentation for building officials on the use of P-58 and code equivalency			•			•	•	•	•	•		1	4	3
20	Case Studies (five to ten pages) describing how target groups used and benefitted from the use of performance based engineering)	•						•	•				4	4	1

Table G-2 Long List of Possible Guidance Products and Their Subjective Evaluation (continued)

		Targeted Stakeholder Audience				*Targeted Stages of Behavior Change*							*Evaluation Criteria*		
Ref #	*Guidance Product Concept*	*BO*	*SE*	*OBP*	*O*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*E*	*C*	*F*
21	Written guidance (online reference?) for engineers explaining how to present and discuss performance decisions with non-technical audiences. (Written version of the "training" envisioned in #58, e.g., a Structure Magazine article.)		•					•	•			•	2	4	4
22	Quiz/checklist that helps owners identify situations in which use of the P-58 would be beneficial to them (i.e., "you might be a good candidate for P-58 if…")	•					•	•	•			•	3	4	4
23	Copies of simple method and output graphics available for use in a variety of publications or formats. Includes templates for a variety of communication uses. (Static / template graphic)	•						•	•	•		•	1	4	4
24	20 page booklet describing benefits of performance-based decision-making and FEMA P-58 methodology for the risk or facilities manager.	•					•	•					2	4	4
25	Library of photographs that can be used to illustrate to owners and architects some of the design choices they are faced with and the potential consequences. (Combine with existing photo databases and clearinghouse efforts?)	•		•				•	•	•	•		2	3	1
26	Definitions, glossary, or anthology of terms used in performance based engineering (online?) (Could be incorporated into several other products.)	•	•						•	•			2	4	4
27	Template/Canned PowerPoint presentations with talk outlines and speaker notes for a target audiences (there could be 10, 20, 30 and 45 minute versions) (Are these power point presentations meant for engineers to use to convince people to use this methodology?)	•	•	•					•	•			1	4	4
28	"Mini-PACT" program that can provide broad insights on how design choices affect performance. (a quick & dirty calculator)		•						•	•	•	•	2	2	3

Table G-2 Long List of Possible Guidance Products and Their Subjective Evaluation (continued)

		Targeted Stakeholder Audience				*Targeted Stages of Behavior Change*							*Evaluation Criteria*		
Ref #	*Guidance Product Concept*	*BO*	*SE*	*OBP*	*O*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*E*	*C*	*F*
29	Offer in person trainings that engineers could attend to become educated in what P58 is and how to use it (e.g., HAZUS)		•						•	•			3	3	4
30	Training materials or professional talks for other building subs (prior to giving them "specs" for a specific project; one-on-one is best or in small groups). This would include architects, mechanical engineers, plumbing, electrical, HVAC, elevators, process systems, equipment...			•		•	•	•	•				3	3	3
31	Presentations by structural engineers to peers on use of the FEMA P-58 methodology (at professional conferences)		•						•	•	•		4	4	4
32	Online FAQs to accumulate questions and provide answers about use of P-58 from a variety of user perspectives.	•	•	•	•				•	•	•	•	2	4	4
33	How-to guidance material for building owners/representatives to help them navigate how a project with P-58 is different from other projects.	•							•	•	•	•	3	4	3
34	Design guidance manual for architects. (Overlaps with #49.)								•	•	•	•			
35	The P-58-2 Stakeholder Guidance Product Year 3 report.	•	•	•					•	•	•	•	4	4	4
36	A brief report (20 to 40 pages) describing for structural engineers how to express performance based engineering concepts and advantages to architects, facility managers and owners and public bodies and to understand behavior change stages. (Duplicative to products focused respectively on Arhictects and Facilities Managers.)		•							•	•				
37	Sample scope of work (e.g., RFP language) for structural engineer undertaking FEMA P-58 analysis	•								•	•		2	4	4
38	Short brochure for engineers to use to discuss issues with architect (Duplicate of #8.)		•							•	•				
39	Equivalence guidance. (e.g., white paper discussing what would a process be to reconcile the scatter of code performance with more precise techniques)			•						•	•	•	3	3	3
40	How-to instructions for how to do a PML/SEL/SUL using P-58		•							•	•	•	2	4	4

Table G-2 Long List of Possible Guidance Products and Their Subjective Evaluation (continued)

Ref #	Guidance Product Concept	Targeted Stakeholder Audience				Targeted Stages of Behavior Change							Evaluation Criteria		
		BO	*SE*	*OBP*	*O*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*E*	*C*	*F*
41	Create a set of standardized performance specifications and then disseminate (through engineers) to architects, mechanical engineers and electrical engineers			•						•	•	•	3	3	4
42	Repository (website?) of workshops, tutorials, and other materials that can be widely disseminated through an "education and training" arm of P-58.		•	•						•	•	•	3	2	3
43	Develop a P58 curriculum, including a series of "lesson plans," power point files, tutorial videos, and other materials that would help educate a new user or develop the expertise/performance of a current user of P58.		•	•						•	•				
44	An app to manipulate and present performance data (previously calculated using PACT) in a variety of ways (losses and resumption times, probability and return period, …) Customizable, attractive presentation visuals that can be used to present results for a particular project.	•									•		3	3	3
45	Report collecting relevant information and analysis findings to guide code future development		•								•	•			
46	Online forum to collect user feedback about implementation, presentation, and decision-making using the FEMA P-58 methodology	•	•								•	•	1	4	4
47	Step by step design guidance for design structural engineer		•								•	•			
48	Design guidance manual for other building subs. (Duplicate.)			•							•	•			
49	Simplified design guidance available early in the design process for engineers to transmit to architects that illustrates performance-based principals (e.g., building configuration, materials, cladding) and other building subs (e.g., mechanical and electrical?) (Whole design team is on board with proceeding with P-58 and the engineer is in a position to educate and lead specific descisions to be made in the project.)			•						•			3	3	

Table G-2 Long List of Possible Guidance Products and Their Subjective Evaluation (continued)

Ref #	Guidance Product Concept	Targeted Stakeholder Audience: BO	SE	OBP	O	Targeted Stages of Behavior Change: 1	2	3	4	5	6	7	Evaluation Criteria: E	C	F
50	Design guide to assist engineers in selecting structural systems and indentifying acceptable drifts and accelerations for damage control. The emphasis would be "Designing to Protect Buildings from Earthquake Damage" or something like that.		•								•	•	4	3	4
51	Extranet or repository of technical and communications materials, available for active users. (Highly related to #42.)		•								•	•			
52	Online, easily searchable library of fragility functions (Part of #42)		•								•	•			
53	Online database/profiles of users of P58. This might help build a network of engineers and others who are using these materials. (Duplicate.)	•	•								•	•			
54	A champion architect would present at AIA meetings			•											
55	Description of problems with PML/SEL system for OWNERS and potential use of P-58														
56	Myth-Buster / "Sorry Folks" Message about code performance. (General public, media report).														
57	20 page booklet that explains why the public needs FEMA P-58 methodology				•	•	•								
58	Tip points, suggestions, materials, or other "trainings" intended for structural engineer to prepare for a pitch meeting with building owner client		•					•	•	•			3	2	3

BO: Building Owner Representative
SE: Structural Engineer
OBP: Other Building Professional

E: Effectiveness
C: Cost
F: Feasibility

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Applied Technology Council Projects and Report Information

One of the primary purposes of the Applied Technology Council is to develop engineering applications and resources that translate and summarize useful information for practicing building and bridge design professionals. This includes the development of guidelines and manuals, as well as the development of research recommendations for specific areas determined by the profession. ATC is not a code development organization, although ATC project reports often serve as resource documents for the development of codes, standards and specifications.

Applied Technology Council conducts projects that meet the following criteria:

1. The primary audience or benefactor is the design practitioner in structural engineering.
2. A cross section or consensus of engineering opinion is required to be obtained and presented by a neutral source.
3. The project fosters the advancement of structural engineering practice.

Funding for projects is obtained from government agencies and tax-deductible contributions from the private sector. Brief descriptions of completed ATC projects and reports are provided below.

ATC-1: This project resulted in five papers published as part of *Building Practices for Disaster Mitigation, Building Science Series 46*, proceedings of a workshop sponsored by the National Science Foundation (NSF) and the National Bureau of Standards (NBS). Available through the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22151, as NTIS report No. COM-73-50188.

ATC-2: The report, *An Evaluation of a Response Spectrum Approach to Seismic Design of Buildings*, was funded by NSF and NBS and was conducted as part of the Cooperative Federal Program in Building Practices for Disaster Mitigation. Available through ATC. (Published 1974, 270 Pages)

ATC-3: The report, *Tentative Provisions for the Development of Seismic Regulations for Buildings* (ATC-3-06), was funded by NSF and NBS. The tentative provisions in this report served as the basis for the seismic provisions of the 1988 and subsequent issues of the *Uniform Building Code* and the *NEHRP Recommended Provisions for the Development of Seismic Regulation for New Building and Other Structures*. The second printing contains proposed amendments prepared by a joint committee of the Building Seismic Safety Council (BSSC) and the NBS. Available through ATC. (Published 1978, amended 1982, 505 pages plus proposed amendments)

ATC-3-2: The project, "Comparative Test Designs of Buildings Using ATC-3-06 Tentative Provisions", was funded by NSF. It consisted of a study to develop and plan a program for making comparative test designs of the ATC-3-06 Tentative Provisions. The project report was intended for use by the Building Seismic Safety Council in its refinement of the ATC-3-06 Tentative Provisions.

ATC-3-4: The report, *Redesign of Three Multistory Buildings: A Comparison Using ATC-3-06 and 1982 Uniform Building Code Design Provisions*, was published under a grant from NSF. Available through ATC. (Published 1984, 112 pages)

ATC-3-5: The project, "Assistance for First Phase of ATC-3-06 Trial Design Program Being Conducted by the Building Seismic Safety Council," was funded by the Building Seismic Safety Council to obtain assistance in conducting the first phase of its program to develop trial designs for buildings in Los Angeles, Seattle, Phoenix, and Memphis.

ATC-3-6: The project, "Assistance for Second Phase of ATC-3-06 Trial Design Program Being Conducted by the Building Seismic Safety Council," was funded by the Building Seismic Safety Council to obtain assistance in conducting the second phase of its program to develop trial designs for buildings in New York, Chicago, St. Louis, Charleston, and Fort Worth.

ATC-4: The report, *A Methodology for Seismic Design and Construction of Single-Family Dwellings*, was published under a contract with the Department of Housing and Urban Development (HUD). Available through ATC. (Published 1976, 576 pages)

ATC-4-1: The report, *The Home Builders Guide for Earthquake Design*, was published under a contract with HUD. Available through ATC. (Published 1980, 57 pages)

ATC-5: The report, *Guidelines for Seismic Design and Construction of Single-Story Masonry Dwellings in Seismic Zone 2*, was developed under a contract with HUD. Available through ATC. (Published 1986, 38 pages)

ATC-6: The report, *Seismic Design Guidelines for Highway Bridges*, was published under a contract with the Federal Highway Administration (FHWA). Available through ATC. (Published 1981, 210 pages)

ATC-6-1: The report, *Proceedings of a Workshop on Earthquake Resistance of Highway Bridges*, was published under a grant from NSF. Available through ATC. (Published 1979, 625 pages)

ATC-6-2: The report, *Seismic Retrofitting Guidelines for Highway Bridges*, was published under a contract with FHWA. Available through ATC. (Published 1983, 220 pages)

ATC-7: The report, *Guidelines for the Design of Horizontal Wood Diaphragms*, was published under a grant from NSF. Available through ATC. (Published 1981, 190 pages)

ATC-7-1: The report, *Proceedings of a Workshop on Design of Horizontal Wood Diaphragms*, was published under a grant from NSF. Available through ATC. (Published 1980, 302 pages)

ATC-8: The report, *Proceedings of a Workshop on the Design of Prefabricated Concrete Buildings for Earthquake Loads*, was funded by NSF. Available through ATC. (Published 1981, 400 pages)

ATC-9: The report, *An Evaluation of the Imperial County Services Building Earthquake Response and Associated Damage*, was published under a grant from NSF. Available through ATC. (Published 1984, 231 pages)

ATC-10: The report, *An Investigation of the Correlation Between Earthquake Ground Motion and Building Performance*, was funded by the U.S. Geological Survey (USGS). Available through ATC. (Published 1982, 114 pages)

ATC-10-1: The report, *Critical Aspects of Earthquake Ground Motion and Building Damage Potential*, was co-funded by the USGS and the NSF. Available through ATC. (Published 1984, 259 pages)

ATC-11: The report, *Seismic Resistance of Reinforced Concrete Shear Walls and Frame Joints: Implications of Recent Research for Design Engineers*, was published under a grant from NSF. Available through ATC. (Published 1983, 184 pages)

ATC-12: The report, *Comparison of United States and New Zealand Seismic Design Practices for Highway Bridges*, was published under a grant from NSF. Available through ATC. (Published 1982, 270 pages)

ATC-12-1: The report, *Proceedings of Second Joint U.S.-New Zealand Workshop on Seismic Resistance of Highway Bridges*, was published under a grant from NSF. Available through ATC. (Published 1986, 272 pages)

ATC-13: The report, *Earthquake Damage Evaluation Data for California*, was developed under a contract with the Federal Emergency Management Agency (FEMA). It presents expert-opinion earthquake damage and loss estimates for industrial, commercial, residential, utility and transportation facilities in California. Included are damage probability matrices for 78 classes of structures and estimates of time required to restore damaged facilities to pre-earthquake usability. Available through ATC. (Published 1985, 492 pages)

ATC-13-1: The report, *Commentary on the Use of ATC-13 Earthquake Damage Evaluation Data for Probable Maximum Loss Studies of California Buildings*, was developed with funding from the ATC Endowment Fund. It provides guidance for using ATC-13 expert-opinion data for probable maximum loss (PML) studies of California buildings. Included are discussions of the limitations on the use of the ATC-13 expert-opinion data, and appendices containing information not included in the original ATC-13 report, such as model building type descriptions, beta damage distribution parameters for ATC-13 model building types, and PML values for ATC-13 model building types. Available through ATC. (Published 2002, 66 pages)

ATC-14: The report, *Evaluating the Seismic Resistance of Existing Buildings*, was developed under a grant from the NSF. It describes a methodology for performing preliminary and detailed seismic evaluations of buildings. A precursor to the eventual ASCE 31 Standard, *Seismic Evaluation of Existing Buildings*, it contains useful background information including a state-of-practice review; seismic loading criteria; data collection procedures; a detailed description of the building classification system; preliminary and detailed analysis procedures; and example case studies, including nonstructural considerations. Available through ATC. (Published 1987, 370 pages)

ATC-15: The report, *Comparison of Seismic Design Practices in the United States and Japan*, was published under a grant from NSF. Available through ATC. (Published 1984, 317 pages)

ATC-15-1: The report, *Proceedings of Second U.S.-Japan Workshop on Improvement of Building Seismic Design and Construction Practices*, was published under a grant from NSF. It includes state-of-the-practice papers and case studies of actual building designs and information on regulatory, contractual, and licensing issues. Available through ATC. (Published 1987, 412 pages)

ATC-15-2: The report, *Proceedings of Third U.S.-Japan Workshop on Improvement of Building Structural Design and Construction Practices*, was published jointly by ATC and the Japan Structural Consultants Association. It includes state-of-the-practice papers on steel braced frame and reinforced concrete buildings, base isolation and passive energy dissipation devices, and comparisons between U.S. and Japanese design practice. Available through ATC. (Published 1989, 358 pages)

ATC-15-3: The report, *Proceedings of Fourth U.S.-Japan Workshop on Improvement of Building Structural Design and Construction Practices*, was published jointly by ATC and the Japan Structural Consultants Association. It includes papers on postearthquake building damage assessment; acceptable earthquake damage; repair and retrofit of earthquake-damaged buildings; base-isolated buildings, Architectural Institute of Japan recommendations for design; active damping systems; and wind-resistant design. Available through ATC. (Published 1992, 484 pages)

ATC-15-4: The report, *Proceedings of Fifth U.S.-Japan Workshop on Improvement of Building Structural Design and Construction Practices*, was published jointly by ATC and the Japan Structural Consultants Association. It includes papers on performance goals and acceptable damage; seismic design procedures and case studies; seismic evaluation, repair and upgrade; construction influences on design; isolation and passive energy dissipation; design of irregular structures; and quality control for design and construction. Available through ATC. (Published 1994, 360 pages)

ATC-16: The FEMA 90 report, *An Action Plan for Reducing Earthquake Hazards of Existing Buildings*, was funded by FEMA and was conducted by a joint venture of ATC, the Building Seismic Safety Council and the Earthquake Engineering Research Institute. Available through FEMA. (Published 1985, 75 pages)

ATC-17: The report, *Proceedings of a Seminar and Workshop on Base Isolation and Passive Energy Dissipation*, was published under a grant from NSF. It includes papers describing case studies in the United States, applications and developments worldwide, recent innovations in technology development, and structural and ground motion issues in base-isolation and passive energy-dissipation. Also included is a proposed 5-year research agenda. Available through ATC. (Published 1986, 478 pages)

ATC-17-1: The report, *Proceedings of a Seminar on Seismic Isolation, Passive Energy Dissipation and Active Control,* was published under a grant from NCEER and NSF. Available through ATC. (Published 1993, 841 pages in two volumes)

ATC-18: The report, *Seismic Design Criteria for Bridges and Other Highway Structures: Current and Future***,** was developed under a grant from NCEER and FHWA. Available through ATC. (Published, 1997, 151 pages)

ATC-18-1: The report, *Impact Assessment of Selected MCEER Highway Project Research on the Seismic Design of Highway Structures***,** was developed under a contract with the Multidisciplinary Center for Earthquake Engineering Research (MCEER, formerly

NCEER) and FHWA. Available through ATC. (Published, 1999, 136 pages)

ATC-19: The report, *Structural Response Modification Factors* was funded by NSF and NCEER. Available through ATC. (Published 1995, 70 pages)

ATC-20: The report, *Procedures for Postearthquake Safety Evaluation of Buildings*, was developed under a contract with the California Office of Emergency Services (OES), California Office of Statewide Health Planning and Development (OSHPD) and FEMA. It provides procedures and guidelines for inspecting buildings that have been damaged in an earthquake, and making decisions regarding their continued use and occupancy. Written for volunteer structural engineers and building inspectors, it includes rapid and detailed evaluation procedures for posting buildings as "inspected" (apparently safe, green placard), "limited entry" (yellow) or "unsafe" (red). Available through ATC (Published 1989, 152 pages)

ATC-20-1: The report, *Field Manual: Postearthquake Safety Evaluation of Buildings, Second Edition*, was funded by Applied Technology Council. A companion to the ATC-20 report, the *Field Manual* summarizes postearthquake safety evaluation procedures in a concise format designed for ease of use in the field. Available through ATC. (Published 2004, 143 pages)

ATC-20-1 Bhutan: The report, *Bhutan Field Manual: Postearthquake Safety Evaluation of Buildings,* was developed in partnership with GeoHazards International and the Royal Government of Bhutan's Department of Engineering Services and Department of Disaster Management with funding from the ATC Endowment Fund and the World Bank's Global Facility for Disaster Reduction in Recovery. The *Bhutan Field Manual* is an adaptation of the postearthquake safety evaluation procedures described in ATC-20 to account for Bhutan's vernacular buildings, as well as Bhutan's cultural and governmental context. Available through ATC. (Published 2014, 246 pages)

ATC-20-2: The report, *Addendum to the ATC-20 Postearthquake Building Safety Procedures* was published under a grant from the NSF and funded by the USGS. It provides updated assessment forms, placards, and evaluation procedures based on application and use in five earthquake events that occurred after the initial release of the ATC-20 report. Available through ATC. (Published 1995, 94 pages)

ATC-20-3: The report, *Case Studies in Rapid Postearthquake Safety Evaluation of Buildings,* was funded by ATC and R.P. Gallagher Associates. Containing over 50 case studies using the ATC-20 Rapid Evaluation procedure, the report is intended for use as a training and reference manual describing how buildings are inspected and evaluated. Illustrated with photos and completed safety assessment forms and placards. Available through ATC. (Published 1996, 295 pages)

ATC-20-T: The *Postearthquake Safety Evaluation of Buildings Training CD* was developed in cooperation with FEMA. The 4½-hour training seminar includes photographs, schematic drawings, and textual information. Available through ATC. (Published 2002, 230 PowerPoint slides with Speakers Notes)

ATC-21: The FEMA 154 report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook*, *Second Edition*, was developed under a contract with FEMA. It describes a rapid visual screening procedure for identifying buildings that might pose serious risk of loss of life and injury in the event of a damaging earthquake. Available through ATC and FEMA. (Published 2002, 161 pages)

ATC-21-1: The FEMA 155 report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation*, *Second Edition*, was developed under a contract with FEMA. It provides the technical basis for the updated rapid visual screening procedure. Available through ATC and FEMA. (Published 2002, 117 pages)

ATC-21-2: The report, *Earthquake Damaged Buildings: An Overview of Heavy Debris and Victim Extrication*, was developed under a contract with FEMA. (Published 1988, 95 pages)

ATC-21-T: The report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards Training Manual, Second Edition,* was developed under a contract with FEMA. Training materials include120 slides in PowerPoint format and companion narrative coordinated with the presentation. Available through ATC. (Published 2004, 148 pages and PowerPoint presentation on companion CD)

ATC-22: The report, *A Handbook for Seismic Evaluation of Existing Buildings (Preliminary)*, was developed under a contract with FEMA in 1989. Based on the information originally developed in ATC-14, this report was revised by BSSC and published as the FEMA 178 report, *NEHRP Handbook for the Seismic Evaluation of Existing Buildings* in 1992, revised by ASCE and published as the FEMA 310 report, *Handbook for the Seismic Evaluation of Buildings – a Prestandard* in 1998. Currently available through the American Society of Civil Engineers as the ASCE 31 Standard, *Seismic Evaluation of Existing Buildings*.

ATC-22-1: The report, *Seismic Evaluation of Existing Buildings: Supporting Documentation*, was developed under a contract with FEMA. (Published 1989, 160 pages)

ATC-23A: The report, *General Acute Care Hospital Earthquake Survivability Inventory for California, Part A: Survey Description, Summary of Results, Data Analysis and Interpretation*, was developed under a contract with the Office of Statewide Health Planning and Development (OSHPD), State of California. Available through ATC. (Published 1991, 58 pages)

ATC-23B: The report, *General Acute Care Hospital Earthquake Survivability Inventory for California, Part B: Raw Data*, was developed under a contract with the Office of Statewide Health Planning and Development (OSHPD), State of California. Available through ATC. (Published 1991, 377 pages)

ATC-24: The report, *Guidelines for Seismic Testing of Components of Steel Structures*, was jointly funded by the American Iron and Steel Institute (AISI), American Institute of Steel Construction (AISC), National Center for Earthquake Engineering Research (NCEER), and NSF. Available through ATC. (Published 1992, 57 pages)

ATC-25: The report, *Seismic Vulnerability and Impact of Disruption of Lifelines in the Conterminous States*, was developed under a contract with FEMA. Available through ATC. (Published 1991, 440 pages)

ATC-25-1: The report, *A Model Methodology for Assessment of Seismic Vulnerability and Impact of Disruption of Water Supply Systems*, was developed under a contract with FEMA. Available through ATC. (Published 1992, 147 pages)

ATC-26: This project, "U.S. Postal Service National Seismic Program," was funded under a contract with the U.S. Postal Service (USPS), and resulted in the following interim documents:

ATC-26 Report, *Cost Projections for the U. S. Postal Service Seismic Program* (Completed 1990)

ATC-26-1 Report, *United States Postal Service Procedures for Seismic Evaluation of Existing Buildings (Interim)* (Completed 1991)

ATC-26-2 Report, *Procedures for Post-disaster Safety Evaluation of Postal Service Facilities (Interim)*. Available through ATC. (Published 1991, 221 pages)

ATC-26-3 Report, *Field Manual: Post-earthquake Safety Evaluation of Postal Buildings (Interim)*. Available through ATC. (Published 1992, 133 pages)

ATC-26-3A Report, *Field Manual: Post Flood and Wind Storm Safety Evaluation of Postal Buildings (Interim)*. Available through ATC. (Published 1992, 114 pages)

ATC-26-4 Report, *United States Postal Service Procedures for Building Seismic Rehabilitation (Interim)* (Completed 1992)

ATC-26-5 Report, *United States Postal Service Guidelines for Building and Site Selection in Seismic Areas (Interim)* (Completed 1992)

ATC-28: The report, *Development of Recommended Guidelines for Seismic Strengthening of Existing Buildings, Phase I: Issues Identification and Resolution*, was developed under a contract with FEMA. Available through ATC. (Published 1992, 150 pages)

ATC-29: The report, *Proceedings of a Seminar and Workshop on Seismic Design and Performance of Equipment and Nonstructural Elements in Buildings and Industrial Structures*, was developed under a grant from NCEER and NSF. It includes papers describing current practice, codes and regulations; earthquake performance; analytical and experimental investigations; development of new seismic qualification methods; and research, practice, and code development needs for nonstructural elements and systems. Available through ATC. (Published 1992, 470 pages)

ATC-29-1: The report, *Proceedings of a Seminar on Seismic Design, Retrofit, and Performance of Nonstructural Components*, was developed under a grant from NCEER and NSF. It includes papers on observed performance in recent earthquakes; seismic design codes, standards, and procedures for commercial and institutional buildings; design issues relating to industrial and hazardous material facilities; and seismic evaluation and rehabilitation of components in conventional and essential facilities. Available through ATC. (Published 1998, 518 pages)

ATC-29-2: The report, *Proceedings of Seminar on Seismic Design, Performance, and Retrofit of Nonstructural Components in Critical Facilities*, was developed under a grant from MCEER (formerly NCEER) and NSF. It includes papers on seismic design, performance, and retrofit of nonstructural components in critical facilities including current practices and emerging codes; seismic design and retrofit; risk and performance evaluation; system qualification and testing; and advanced technologies. Available through ATC. (Published 2003, 574 pages)

ATC-30: The report, *Proceedings of Workshop for Utilization of Research on Engineering and Socioeconomic Aspects of 1985 Chile and Mexico Earthquakes*, was developed under a grant from the NSF. Available through ATC. (Published 1991, 113 pages)

ATC-31: The report, *Evaluation of the Performance of Seismically Retrofitted Buildings*, was developed under a contract with the National Institute of Standards and Technology (NIST, formerly NBS) and funded by the USGS. Available through ATC. (Published 1992, 75 pages)

ATC-32: The report, *Improved Seismic Design Criteria for California Bridges: Provisional Recommendations,* was funded by the California Department of Transportation (Caltrans). Available through ATC. (Published 1996, 215 pages)

ATC-32-1: The report, *Improved Seismic Design Criteria for California Bridges: Resource Document,* was funded by Caltrans. Available through ATC. (Published 1996, 365 pages; also available on CD)

ATC-33: The project, funded under a contract with the Building Seismic Safety Council, was initiated by FEMA to develop nationally applicable, state-of-the-art guidance for performance-based seismic rehabilitation of buildings. Work resulted in the publication of:

FEMA 273, *NEHRP Guidelines for the Seismic Rehabilitation of Buildings* (Published 1997, 440 pages). Revised by ASCE and published as the FEMA 356 report, *Prestandard and Commentary for the Seismic Rehabilitation of Buildings* in 2000. Currently available through the American Society of Civil Engineers as the ASCE 41 Standard, *Seismic Rehabilitation of Existing Buildings*.

FEMA 274, *NEHRP Commentary on the Guidelines for the Seismic Rehabilitation of Buildings*. Available through ATC and FEMA. (Published 1997, 492 pages)

FEMA 276, *Example Applications of the NEHRP Guidelines for the Seismic Rehabilitation of Buildings*. Available through ATC and FEMA. (Published 1997, 295 pages)

ATC-34: The report, *A Critical Review of Current Approaches to Earthquake Resistant Design***,** was developed under a grant from NCEER and NSF. Available through ATC. (Published, 1995, 94 pages)

ATC-35: The report, *Enhancing the Transfer of U.S. Geological Survey Research Results into Engineering Practice* was developed under a cooperative agreement with the USGS. Available through ATC. (Published 1994, 120 pages)

ATC-35-1: The report, *Proceedings of Seminar on New Developments in Earthquake Ground Motion Estimation and Implications for Engineering Design Practice*, was developed under a cooperative agreement with USGS. It includes papers describing state-of-the-art information on regional earthquake risk; new techniques for estimating strong ground motions as a function of earthquake source, travel path, and site parameters; and new developments applicable to geotechnical engineering. Available through ATC. (Published 1994, 478 pages)

ATC-35-2: The report, *Proceedings: National Earthquake Ground Motion Mapping Workshop*, was developed under a cooperative agreement with USGS. It includes papers on ground motion parameters; reference site conditions; probabilistic versus deterministic basis; and the treatment of uncertainty in seismic source characterization and ground motion attenuation. Available through ATC. (Published 1997, 154 pages)

ATC-35-3: The report, *Proceedings: Workshop on Improved Characterization of Strong Ground Shaking for Seismic Design,* was developed under a cooperative agreement with USGS. It includes papers on identifying needs and developing improved representations of earthquake ground motion for use in seismic design practice and building codes. Available through ATC. (Published 1999, 75 pages)

ATC-37: The report, *Review of Seismic Research Results on Existing Buildings*, was developed in conjunction with the Structural Engineers Association of California (SEAOC) and California Universities for Research in Earthquake Engineering (CUREe) under a contract with the California Seismic Safety Commission (SSC). Available through the Seismic Safety Commission as Report SSC 94-03. (Published, 1994, 492 pages)

ATC-38: The report, *Database on the Performance of Structures near Strong-Motion Recordings: 1994 Northridge, California, Earthquake*, was developed with funding from the USGS, the Southern California Earthquake Center (SCEC), OES, and the Institute for Business and Home Safety (IBHS). Available through ATC. (Published 2000, 260 pages, with CD containing complete database).

ATC-40: The report, *Seismic Evaluation and Retrofit of Concrete Buildings*, was developed under a contract with the California Seismic Safety Commission. It provides guidance on performance objectives, hazard characterization, identification of deficiencies, retrofit strategies, nonlinear static analysis procedures, modeling rules, foundation effects, and response limits for seismic evaluation and retrofit of concrete buildings. Available through ATC. (Published, 1996, 612 pages in two volumes)

ATC-41 (SAC Joint Venture, Phase 1): The project, "Program to Reduce the Earthquake Hazards of Steel Moment-Resisting Frame Structures, Phase 1," was funded by FEMA and OES and conducted by a Joint Venture partnership of SEAOC, ATC, and CUREe. Under Phase 1 the following documents were prepared:

SAC-94-01, *Proceedings of the Invitational Workshop on Steel Seismic Issues, Los Angeles, September 1994*. Available through ATC. (Published 1994, 155 pages)

SAC-95-01, *Steel Moment-Frame Connection Advisory No. 3*. Available through ATC. (Published 1995, 310 pages)

SAC-95-02, *Interim Guidelines: Evaluation, Repair, Modification and Design of Welded Steel Moment-Frame Structures* (FEMA 267 report) (Published 1995, 215 pages; superseded by FEMA 350 to 353)

SAC-95-03, *Characterization of Ground Motions During the Northridge Earthquake of January 17, 1994*. Available through ATC. (Published 1995, 179 pages)

SAC-95-04, *Analytical and Field Investigations of Buildings Affected by the Northridge Earthquake of January 17, 1994*. Available through ATC. (Published 1995, 900 pages in two volumes)

SAC-95-05, *Parametric Analytical Investigations of Ground Motion and Structural Response, Northridge Earthquake of January 17, 1994*. Available through ATC. (Published 1995, 274 pages)

SAC-95-06, *Surveys and Assessment of Damage to Buildings Affected by the Northridge Earthquake of January 17, 1994*. Available through ATC. (Published 1995, 315 pages)

SAC-95-07, *Case Studies of Steel Moment Frame Building Performance in the Northridge Earthquake of January 17, 1994* (Published 1995, 260 pages, Available through ATC)

SAC-95-08, *Experimental Investigations of Materials, Weldments and Nondestructive Examination Techniques*. Available through ATC. (Published 1995, 144 pages)

SAC-95-09, *Background Reports: Metallurgy, Fracture Mechanics, Welding, Moment Connections and Frame systems, Behavior* (FEMA 288 report). Available through ATC and FEMA. (Published 1995, 361 pages)

SAC-96-01, *Experimental Investigations of Beam-Column Subassemblages, Part 1 and 2*. Available through ATC. (Published 1996, 924 pages, in two volumes)

SAC-96-02, *Connection Test Summaries* (FEMA 289 report). Available through ATC and FEMA. (Published 1996, 144 pages)

ATC-41-1 (SAC Joint Venture, Phase 2): The project, "Program to Reduce the Earthquake Hazards of Steel Moment-Resisting Frame Structures, Phase 2," was funded by FEMA and conducted by a Joint Venture partnership of

SEAOC, ATC, and CUREe. Under Phase 2 the following documents were prepared:

SAC-96-03, *Interim Guidelines Advisory No. 1 Supplement to FEMA 267 Interim Guidelines* (FEMA 267A report) (Published 1997, 100 pages; superseded by FEMA 350 to 353)

SAC-99-01, *Interim Guidelines Advisory No. 2 Supplement to FEMA 267 Interim Guidelines* (FEMA 267B report, superseding FEMA 267A). (Published 1999, 150 pages; superseded by FEMA 350 to 353)

FEMA 350, *Recommended Seismic Design Criteria for New Steel Moment-Frame Buildings*. Available through ATC and FEMA. (Published 2000, 190 pages)

FEMA 351, *Recommended Seismic Evaluation and Upgrade Criteria for Existing Welded Steel Moment-Frame Buildings*. Available through ATC and FEMA. (Published 2000, 210 pages)

FEMA 352, *Recommended Postearthquake Evaluation and Repair Criteria for Welded Steel Moment-Frame Buildings*. Available through ATC and FEMA. (Published 2000, 180 pages)

FEMA 353, *Recommended Specifications and Quality Assurance Guidelines for Steel Moment-Frame Construction for Seismic Applications*. Available through ATC and FEMA. (Published 2000, 180 pages)

FEMA 354, *A Policy Guide to Steel Moment-Frame Construction*. Available through ATC and FEMA. (Published 2000, 27 pages)

FEMA 355A, *State of the Art Report on Base Materials and Fracture*. Available through ATC and FEMA. (Published 2000, 107 pages; in print and on CD).

FEMA 355B, *State of the Art Report on Welding and Inspection*. Available through ATC and FEMA. (Published 2000, 185 pages; in print and on CD).

FEMA 355C, *State of the Art Report on Systems Performance of Steel Moment Frames Subject to Earthquake Ground Shaking*. Available through ATC and FEMA. (Published 2000, 322 pages; in print and on CD).

FEMA 355D, *State of the Art Report on Connection Performance*. Available through ATC and FEMA. (Published 2000, 292 pages; in print and on CD).

FEMA 355E, *State of the Art Report on Past Performance of Steel Moment-Frame Buildings in Earthquakes*. Available through ATC and FEMA. (Published 2000, 190 pages; in print and on CD).

FEMA 355F, *State of the Art Report on Performance Prediction and Evaluation of Steel Moment-Frame Structures*. Available through ATC and FEMA. (Published 2000, 347 pages; in print and on CD).

ATC-43: The reports, *Evaluation of Earthquake-Damaged Concrete and Masonry Wall Buildings, Basic Procedures Manual* (FEMA 306), *Evaluation of Earthquake-Damaged Concrete and Masonry Wall Buildings, Technical Resources* (FEMA 307), and *The Repair of Earthquake Damaged Concrete and Masonry Wall Buildings* (FEMA 308), were developed for FEMA under a contract with the Partnership for Response and Recovery, a Joint Venture of Dewberry & Davis and Woodward-Clyde. Available through ATC and FEMA. (Published, 1998 in print and on CD; *Basic Procedures Manual*, 270 pages; *Technical Resources*, 271 pages; *Repair Manual*, 81 pages)

ATC-44: The report, *Hurricane Fran, North Carolina, September 5, 1996: Reconnaissance Report*, was funded by the Applied Technology Council. Available through ATC. (Published 1997, 36 pages)

ATC-45: The report, *Field Manual*, *Safety Evaluation of Buildings After Wind Storms and Floods*, was developed with funding from the ATC Endowment Fund and the Institute for Business and Home Safety (IBHS). It provides rapid and detailed evaluation procedures for inspecting buildings that have been damaged in wind storms and floods, and making decisions regarding their continued use and occupancy. Presented in a concise format designed for ease of use in the field, it is intended for use by volunteer structural engineers and building inspectors in posting buildings as “inspected” (apparently safe, green placard), “restricted use” (yellow) or “unsafe” (red). Available through ATC. (Published 2004, 132 pages)

ATC-48 (ATC/SEAOC Joint Venture Training Curriculum): The training curriculum, *Built to Resist Earthquakes, The Path to Quality Seismic Design and Construction for Architects, Engineers, and Inspectors*, was developed under a contract with the California Seismic Safety Commission and prepared by a Joint Venture partnership between ATC and SEAOC. Available through ATC. (Published 1999, 314 pages)

ATC-49: The 2-volume report, *Recommended LRFD Guidelines for the Seismic Design of Highway Bridges; Part I: Specifications* and *Part II: Commentary and Appendices*, were developed under the ATC/MCEER Joint Venture partnership with funding from the Federal Highway Administration. Available through ATC. (Published 2003, *Part I*, 164 pages and *Part II*, 294 pages)

ATC-49-1: The document, *Liquefaction Study Report, Recommended LRFD Guidelines for the Seismic Design of Highway Bridges,* was developed under the ATC/MCEER Joint Venture partnership with funding from the Federal Highway Administration. Available through ATC. (Published 2003, 208 pages)

ATC-49-2: The report, *Design Examples, Recommended LRFD Guidelines for the Seismic Design of Highway Bridges*, was developed under the ATC/MCEER Joint Venture partnership with funding from the Federal Highway Administration. Available through ATC. (Published 2003, 316 pages)

ATC-50: The project, funded by the City of Los Angeles Department of Building and Safety, with support from the California Office of Emergency Services and the U.S. Department of Housing and Urban Development, was initiated because of high economic losses resulting from damage to single-family wood-frame dwellings in the 1994 Northridge earthquake. Work resulted in the publication of:

> ATC-50, *Simplified Seismic Assessment of Detached, Single-Family, Wood-Frame Dwellings* (Published 2002, revised 2007, 135 pages). Revised by FEMA and published as the FEMA P-50 report, *Simplified Seismic Assessment of Detached, Single-Family, Wood-Frame Dwellings* (ATC-71-3 Project).

> ATC-50-1, *Seismic Rehabilitation Guidelines for Detached, Single-Family, Wood-Frame Dwellings* (Published 2002, revised 2007, 141 pages). Revised by FEMA and published as the FEMA P-50-1 report, *Seismic Retrofit Guidelines for Detached, Single-Family, Wood-Frame Dwellings* (ATC-68-3 Project).

> ATC-50-2, *Safer at Home in Earthquakes: A Proposed Earthquake Safety Program* (Published 2002, revised 2007, 79 pages).

ATC-51: The report, *U.S.-Italy Collaborative Recommendations for Improved Seismic Safety of Hospitals in Italy*, was developed under a contract with Servizio Sismico Nazionale of Italy (Italian National Seismic Survey). Available through ATC. (Published 2000, 154 pages)

ATC-51-1: The report, *Recommended U.S.-Italy Collaborative Procedures for Earthquake Emergency Response Planning for Hospitals in Italy*, was developed under a contract with Servizio Sismico Nazionale of Italy (Italian National Seismic Survey, NSS). Available in English and Italian through ATC. (Published 2002, 120 pages)

ATC-51-2: The report, *Recommended U.S.-Italy Collaborative Guidelines for Bracing and Anchoring Nonstructural Components in Italian Hospitals*, was developed under a contract with the Department of Civil Protection, Italy. Available in English and Italian through ATC. (Published 2003, 164 pages)

ATC-52: The project, "Development of a Community Action Plan for Seismic Safety (CAPSS), City and County of San Francisco", was conducted under a contract with the San Francisco Department of Building Inspection. The following reports were prepared:

> ATC-52-1, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco: Potential Earthquake Impacts*. Available through ATC. (Published 2010, 78 pages)

> ATC-52-1A, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco: Potential Earthquake Impacts Technical Documentation*. Available through ATC. (Published 2010, 160 pages)

> ATC-52-2, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco: A Community Action Plan for Seismic Safety*. Available through ATC. (Published 2010, 92 pages)

> ATC-52-3, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco: Earthquake Safety for Soft-Story Buildings*. Available through ATC. (Published 2009, 60 pages)

> ATC-52-3A, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San*

Francisco: Earthquake Safety for Soft-Story Buildings Documentation Appendices. Available through ATC. (Published 2009, 206 pages)

ATC-52-4, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco: Post-Earthquake Repair and Retrofit Requirements*. Available through ATC. (Published 2010, 130 pages)

ATC-53: The report, *Assessment of the NIST 12-Million-Pound (53 MN) Large-Scale Testing Facility*, was developed under a contract with NIST. Available through ATC. (Published 2000, 44 pages)

ATC-54: The report, *Guidelines for Using Strong-Motion Data and ShakeMaps in Postearthquake Response*, was developed under a contract with the California Geological Survey. Available through ATC. (Published 2005, 222 pages)

ATC-55: The FEMA 440 report, *Improvement of Nonlinear Static Seismic Analysis Procedures*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2005, 152 pages)

ATC-56: The report, FEMA 389, *Primer for Design Professionals: Communicating with Owners and Managers of New Buildings on Earthquake Risk*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2004, 194 pages)

ATC-56-1: The report, FEMA 427, *Primer for Design of Commercial Buildings to Mitigate Terrorist Attacks – Providing Protection to People and Buildings*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2003, 106 pages)

ATC-57: The report, *The Missing Piece: Improving Seismic Design and Construction Practices*, was developed under a contract with NIST. It provides a framework for eliminating the technology transfer gap that has emerged within the National Earthquake Hazards Reduction Program (NEHRP) that limits the adaptation of basic research knowledge into practice. Available through ATC. (Published 2003, 102 pages)

ATC-58: The ATC-58/ATC-58-1/ATC-58-2 series of projects, "Development of Next-Generation Performance-Based Seismic Design Guidelines for New and Existing Buildings," was a multi-year, multi-phase effort funded by FEMA that resulted in the publication of the following:

ATC-58-1, *Proceedings of a FEMA-Sponsored Workshop on Communicating Earthquake Risk*. Available through ATC. (Published 2002, 87 pages).

ATC-58-2, *Preliminary Evaluation of Methods for Defining Performance*. Available through ATC. (Published 2003, 99 pages).

ATC-58-3, *Proceedings of a FEMA-Sponsored Workshop on Performance-Based Design*. Available through ATC. (Published 2003, 146 pages).

ATC-58-4, *Proceedings of a FEMA-Sponsored Workshop on Communicating Seismic Performance Metrics in Design Decision-Making*. Available through ATC. (Published 2014, 73 pages).

ATC-52-5, *Proceedings of FEMA-Sponsored Workshop on Design Guidelines and Tools to Implement Next-Generation Performance-Based Seismic Design*. Available through ATC. (Published 2014, 85 pages)

FEMA 445, *Next-Generation Performance-Based Seismic Design Guidelines, Program Plan for New and Existing Buildings*. Available through ATC and FEMA. (Published 2006, 131 pages).

FEMA 461, *Interim Testing Protocols for Determining the Seismic Performance Characteristics of Structural and Nonstructural Components*. Available through ATC and FEMA. (Published 2007, 113 pages).

FEMA P-58-1, *Seismic Performance Assessment of Buildings, Volume 1 – Methodology*. Available through ATC and FEMA. (Published 2012, 319 pages).

FEMA P-58-2, *Seismic Performance Assessment of Buildings, Volume 2 – Implementation Guide*. Available through ATC and FEMA. (Published 2012, 365 pages).

FEMA P-58-3, *Seismic Performance Assessment of Buildings, Volume 3 – Supporting Electronic Materials and Background Documentation*. Available through ATC and FEMA. (Published 2012, on CD).

FEMA P-58-4, *Seismic Performance Assessment of Buildings, Volume 4 – Methodology for Assessing Environmental Impacts*. Available through ATC and FEMA. (Published 2012, 120 pages)

ATC-60: The 2-volume report, *SEAW Commentary on Wind Code Provisions, Volume 1* and *Volume 2 - Example Problems,* was developed by the Structural Engineers Association of Washington (SEAW) in cooperation with ATC. Available through ATC. (Published 2004; *Volume 1*, 238 pages; *Volume 2*, 245 pages)

ATC-61: The 2-volume report, *Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities, Volume 1 – Findings, Conclusions, and Recommendations*, and *Volume 2 – Study Documentation,* was prepared for the Multihazard Mitigation Council (MMC) of the National Institute of Building Sciences, with funding provided by FEMA. Available through ATC and the MMC. (Published 2005; *Volume 1*, 11 pages; *Volume 2*, 366 pages)

ATC-62: The report, FEMA P-440A, *Effects of Strength and Stiffness Degradation on Seismic Response*, was developed under a contract with FEMA. Developed as a supplement to the FEMA 440 report, it provides additional guidance on modeling of nonlinear degrading response. Available through ATC and FEMA. (Published 2009, 310 pages)

ATC-63: The report, FEMA P-695, *Quantification of Building Seismic Performance Factors*, was developed under a contract with FEMA. It describes a methodology for establishing seismic performance factors (R , Ω_0, and C_d) that involves the development of detailed system design information and probabilistic assessment of collapse risk. Available through ATC and FEMA. (Published 2009, 420 pages)

ATC-63-1: The report, FEMA P-795, *Quantification of Building Seismic Performance Factors: Component Equivalency Methodology*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2011, 264 pages)

ATC-64: The reports, *Guidelines for Design of Structures for Vertical Evacuation from Tsunamis* (FEMA P-646), and *Vertical Evacuation from Tsunamis: A Guide for Community Officials* (FEMA P-646A), were developed under a contract with FEMA. Available through ATC and FEMA. (*Design Guidelines*, Published 2008, 174 pages; *Guide for Community Officials*, Published 2009, 62 pages)

ATC-65: The FEMA P-455 report, *Handbook for Rapid Visual Screening of Buildings to Evaluate Terrorism Risks*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2009, 174 pages)

ATC-66: The FEMA P-774 report, *Unreinforced Masonry Buildings and Earthquakes, Developing Successful Risk Reduction Programs*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2009, 194 pages)

ATC-66-Series: The project, "National Earthquake Technical Assistance Program (NETAP)," was funded by the Federal Emergency Management Agency and provides support for course development, logistical coordination, training delivery, technical assistance, performance tracking, and development of tools necessary to support the effective implementation of the National Earthquake Hazards Reduction Program.

ATC-67: The *Rapid Observation of Vulnerability and Estimation of Risk* (ROVER) smartphone application was developed in collaboration with specialists form SPA Risk LLC, and Instrumental Software Technologies Inc. under a contract with FEMA. It is intended for use by building professionals (engineers, architects, firefighters, building officials, and others) to do pre-earthquake screening and post-earthquake safety evaluation of buildings in an electronic format. Available through ATC and FEMA. (Published 2014, online and on CD)

ATC-68: The FEMA P-420 report, *Engineering Guideline for Incremental Seismic Rehabilitation*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2009, 94 pages)

ATC-68-3: The FEMA P-50-1 report, *Seismic Retrofit Guidelines for Detached, Single-Family, Wood-Frame Dwellings*, was developed under a contract with FEMA. The original version of the report was developed under the ATC-50 Project. Available through ATC and FEMA. (Published 2012, 168 pages)

ATC-69: The report, *Reducing the Risks of Nonstructural Earthquake Damage, State-of-the-Art and Practice Report*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2008, 144 pages)

ATC-69-1: The electronic document, FEMA E-74, *Reducing the Risks of Nonstructural Earthquake Damage, A Practical Guide*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2011, 750 pages)

ATC-70: The report, NIST Technical Note 1476, *Performance of Physical Structures in Hurricane Katrina and Hurricane Rita: A Reconnaissance Report*, was developed under a contract with NIST. Available through NIST. (Published 2006, 222 pages)

ATC-71: The reports, *Workshop on Meeting the Challenges of Existing Buildings, Part 1 Workshop Proceedings; Part 2: Status Report on Seismic Evaluation and Rehabilitation of Existing Buildings;* and *Part 3: Action Plan for the FEMA Existing Buildings Program*, were developed under a contract with FEMA. Available through ATC and FEMA. (*Part 1*, Published 2008, 142 pages; *Part 2*, Published 2009, 140 pages; *Part 3*, Published 2009, 118 pages)

ATC-71-1: The FEMA P-807 report, *Seismic Evaluation and Retrofit of Multi-Unit Wood-Frame Buildings with Weak First Stories*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2012, 230 pages, including the *Weak Story Tool* on CD)

ATC-71-2: The report, *Proceedings: Workshop on a Rating System for the Earthquake Performance of Buildings*, was developed under a contract with FEMA. Available through ATC. (Published 2011, 102 pages)

ATC-71-3: The FEMA P-50 report, *Simplified Seismic Assessment of Detached, Single-Family, Wood-Frame Dwellings*, was developed under a contract with FEMA. The original version of the report was developed under the ATC-50 Project. Available through ATC and FEMA. (Published 2012, 190 pages)

ATC-71-4/ATC-71-5/ATC-71-6: The FEMA P-154 report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook, Third Edition*, and the FEMA P-155 Report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation, Third Edition*, were developed under a series of contracts with FEMA. Available through ATC and FEMA. (Published, 2014; *Handbook*, 388 pages; *Supporting Documentation*, 206 pages)

ATC-72: The report, *Proceedings of Workshop on Tall Building Seismic Design and Analysis Issues* (ATC-72) was prepared for the Building Seismic Safety Council of the National Institute of Building Sciences, with funding provided by FEMA. The report, *Modeling and Acceptance Criteria for Seismic Design and Analysis of Tall Buildings* (PEER/ATC-72-1) was prepared for the Pacific Earthquake Engineering Research Center. Available through ATC and PEER. (*Proceedings*, Published 2007, 84 pages; *Modeling and Acceptance Criteria*, Published 2010, 242 pages)

ATC-73: The report, *NEHRP Workshop on Meeting the Challenges of Existing Buildings, Prioritized Research for Reducing the Seismic Hazards of Existing Buildings,* was developed under a grant from NSF. Available through ATC. (Published 2007, 22 pages)

ATC-74: The report, *Collaborative Recommended Requirements for Automatic Natural Gas Shutoff Valves in Italy,* was funded by the Department of Civil Protection, Italy. Available through ATC. (Published 2007, 76 pages)

ATC-75: The report, *Improvements to BIM Structural Software Interoperability*, was developed under a contract with the Charles Pankow Foundation. Available through ATC and CPF. (Published 2013, 155 pages)

ATC-76-1/ATC-76-4: The report, *Evaluation of the FEMA P-695 Methodology for the Quantification of Building Seismic Performance Factors,* was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 10-917-8. (Published 2010, 240 pages)

ATC-76-2: The report, *Program Plan for the Development of Seismic Design Guidelines for Port Container, Wharf, and Cargo Systems,* was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 12-917-19. (Published 2012, 134 pages)

ATC-76-3: The reports, *NEHRP Technical Brief No. 1, Seismic Design of Reinforced Concrete Special Moment Frames: A Guide for Practicing Engineers* and *NEHRP Technical Brief No. 2, Seismic Design of Steel Special Moment Frames:*

A Guide for Practicing Engineers, were developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST (*Technical Brief No. 1*, Report GCR 08-917-1. Published 2008, 32 pages; *Technical Brief No. 2*, Report GCR 09-917-3, Published 2009, 38 pages)

ATC-76-5: The report, *Program Plan for the Development of Collapse Assessment and Mitigation Strategies for Existing Reinforced Concrete Buildings,* was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 10-917-7. (Published 2010, 80 pages)

ATC-76-6: The report, *Applicability of Nonlinear Multiple-Degree-of-Freedom Modeling for Design,* was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 10-917-9. (Published 2010, 196 pages plus CD)

ATC-76-7: The report, *NEHRP Technical Brief No. 3, Seismic Design of Cast-in-Place Concrete Diaphragms, Chords, and Collectors: A Guide for Practicing Engineers,* was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 10-917-4. (Published 2010, 30 pages)

ATC-76-8: The report, *NEHRP Technical Brief No. 4, Nonlinear Structural Analysis for Seismic Design: A Guide for Practicing Engineers*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 10-917-5. (Published 2010, 32 pages)

ATC-76-9: The project, "Performance of Two Full Scale Reinforced Concrete Subassemblage Tests," was funded by NIST to perform tests in support of an internal research program to develop computer models for predicting the collapse potential of reinforced concrete structures. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-78: The report, *Identification and Mitigation of Seismically Hazardous Older Concrete Buildings: Interim Methodology Evaluation* (ATC-78), and its successor report, *Evaluation of the Methodology to Select and Prioritize Collapse Indicators in Older Concrete Buildings* (ATC-78-1), were developed under a contract with FEMA. ATC-78-1 is currently available through ATC. (Published 2012, 153 pages)

ATC-78-3: The report, *Seismic Evaluation of Older Concrete Frame Buildings for Collapse Potential*, was developed under a contract with FEMA and is available through ATC. (Published 2015, 201 pages)

ATC-78-4 (LADBS): The project, "Identification and Mitigation of Non-Ductile Concrete Buildings," was funded by the Federal Emergency Management Agency and the purpose is to begin developing an assessment guideline document for older or non-ductile concrete buildings to allow identification of those buildings that present an earthquake collapse hazard so that they may be evaluated and retrofitted, in order to mitigate the risks presented by this class of buildings,

ATC-78-5/78-6: The project, "Identification and Mitigation of Non-Ductile Concrete Buildings," was funded by the Federal Emergency Management Agency and the purpose is to develop an assessment guideline document for older, or non-ductile, concrete buildings to allow identification of those buildings that present an earthquake collapse hazard so that they may be evaluated and retrofitted.

ATC-79: The FEMA P-646 report, *Guidelines for Design of Structures for Vertical Evacuation from Tsunamis, Second Edition*, was developed under a contract with FEMA. The original version of the report was developed under the ATC-64 Project. Available through ATC and FEMA. (Published 2012, 194 pages)

ATC-82: The report, *Selecting and Scaling Earthquake Ground Motions for Performing Response-History Analyses*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 11-917-5. (Published 2011, 234 pages)

ATC-83: The report, *Soil-Structure Interaction for Building Structures*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 12-917-21. (Published 2012, 292 pages)

ATC-84: The report, *Tentative Framework for Development of Advanced Seismic Design Criteria for New Buildings*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 12-917-20. (Published 2012, 302 pages)

ATC-85: The project, "Assessment of ASCE 41 First Generation Performance-Based Seismic Design Methods for new Buildings in High-Seismic Regions: Phases I-III," was funded by NIST to obtain technical assistance on the initiation of an internal research project benchmarking ASCE 41 performance-based seismic design procedures as applied to new buildings designed in accordance with ASCE 7. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-86: The report, FEMA P-58-4, *Seismic Performance Assessment of Buildings, Volume 4 – Methodology for Assessing Environmental Impacts*, was developed under a contract with FEMA in support of the ATC-58 Project. Available through ATC and FEMA. (Published 2012, 120 pages)

ATC-87: The report, *NEHRP Technical Brief No. 5, Seismic Design of Composite Steel Deck and Concrete-filled Diaphragms: A Guide for Practicing Engineers*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 11-917-4. (Published 2011, 34 pages)

ATC-88: The report, *NEHRP Technical Brief No. 6, Seismic Design of Cast-in-Place Concrete Special Structural Walls and Coupling Beams: A Guide for Practicing Engineers*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 11-917-11. (Published 2011, 38 pages)

ATC-89: The report, *Cost Analyses and Benefit Studies for Earthquake-Resistant Construction in Memphis, Tennessee*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 14-917-26. (Published 2014, 227 pages)

ATC-90: The report, *Research Plan for the Study of Seismic Behavior and Design of Deep, Slender Wide Flange Structural Steel Beam-Column Members*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 11-917-13. (Published 2011, 148 pages)

ATC-91: The project, "Assessment of Nonlinear Seismic Analysis of Structures Based on Modal Superposition," was funded by NIST to obtain technical support for an internal research program investigating the use of a new approach to nonlinear analysis. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-92: The report, *Comparison of U.S. and Chilean Building Code Requirements and Seismic Design Practice 1985–2010*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 12-917-18. (Published 2012, 110 pages)

ATC-93: The project, "Ground Motion and Building Performance Data From the 2010 Chile Earthquake," was funded by NIST to develop a prototypical web-based repository for post-event data in support of the NIST Disaster and Failure Events Database initiative. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-94: The report, *Recommendations for Seismic Design of Reinforced Concrete Wall Buildings Based on Studies of the 2010 Maule, Chile Earthquake*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 14-917-25. (Published 2014, 321 pages)

ATC-95: The report, *Review of Past Performance and Further Development of Modeling Techniques for Collapse Assessment of Existing Reinforced Concrete Buildings*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 14-917-28. (Published 2014, 201 pages)

ATC-96: The report, *Nonlinear Analysis Research and Development Program for Performance-Based Seismic Engineering*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 14-917-27. (Published 2014, 147 pages)

ATC-97: The report, *NEHRP Technical Brief No. 7, Seismic Design of Reinforced Concrete Mat Foundations: A Guide for Practicing Engineers*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 12-917-22. (Published 2012, 34 pages)

ATC-98: The report, *Use of High-Strength Reinforcement in Earthquake-Resistant Concrete Structures*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 14-917-30. (Published 2014, 231 pages)

ATC-99: The project, "Methodology to Assess and Verify the Seismic Capacity of Low-Rise Buildings," was funded by FEMA to study an alternative seismic design approach for low-rise construction in the United States.

ATC-100: The report, *Measurement Science R&D Roadmap for Windstorm and Coastal Inundation Impact Reduction*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 14-973-13. (Published 2014, 130 pages)

ATC-101: The report, A *Framework to Update the Plan to Coordinate NEHRP Post-Earthquake Investigations*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 14-917-29. (Published 2014, 103 pages)

ATC-102: The report, *Earthquake-Resilient Lifelines: NEHRP Research, Development and Implementation Roadmap*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 14-917-33. (Published 2014, 163 pages)

ATC-103: The report, *NEHRP Technical Brief No. 8, Seismic Design of Steel Special Concentrically Braced Frame Systems: A Guide for Practicing Engineers*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 13-917-24. (Published 2013, 36 pages)

ATC-104: The project, "Assessment of the Performance of Slender Reinforced Concrete Walls under Significant Lateral Loads," was funded by NIST to obtain technical support for an internal research project investigating the behavior of reinforced concrete shear walls. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-105: The project, "Development of Annual Report for National Earthquake Hazards Reduction Program Covering Fiscal Year 2012," was funded by NIST to obtain assistance in the development of the NEHRP Annual Report in 2013. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-106: The project, "Seismic Behavior and Design of Deep, Slender Wide-Flange Structural Steel Beam-Column Members**:** Phase 2 Experimental Evaluation," was funded by NIST to perform testing in support of an internal research program investigating the behavior of steel beam-column members. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-107: The project, "Wind Speed Mapping," was funded by NIST to obtain technical assistance in the development of revised wind speed maps incorporating NIST non-tropical wind analysis at different return periods. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-108: The project, "Assessment of ASCE 41 First Generation Performance-Based Seismic Design Methods for new Buildings in High-Seismic Regions" was funded by NIST to obtain technical assistance on the completion of an internal research project benchmarking ASCE 41 performance-based seismic design procedures as applied to new buildings designed in accordance with ASCE 7. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-110: The report, *Plan for Development of a Prestandard for Evaluation and Retrofit of Wood Light-Frame Dwellings*, was developed under a contract with the California Earthquake Authority (CEA) in collaboration with FEMA. Available through ATC and CEA. (Published 2014, 85 pages)

ATC-110 (CEA 2): The project, "Development of a Prestandard for the Evaluation and Retrofit of One and Two Family Light Frame Residential Buildings," was jointly funded by the California Earthquake Authority (CEA) and FEMA, this work is intended to develop an eventual prestandard for the evaluation and retrofit of one- and two-family wood light frame residential buildings, building on available technical resource documents, but extending beyond their current reach to develop a single, stand-alone engineering resource document addressing structural and nonstructural evaluation and retrofit issues specific to this class of construction.

ATC-110 (CEA 3/CEA 4): The project "Delivery of FEMA P-50/P-50-1 Training for the California Earthquake Authority" was funded by CEA and to conduct on-demand training for FEMA P-50, Simplified Seismic Assessment of Detached, Single-Family, Wood-Frame Dwellings, and FEMA P-50-1, Seismic Retrofit Guidelines for Detached, Single-Family, Wood-Frame Dwellings at locations selected by CEA.

ATC-111: The report, *NEHRP Technical Brief No. 9, Seismic Design of Special Reinforced Masonry Shear Walls: A Guide for Practicing Engineers*, was developed under a contract with NIST, and prepared in collaboration with CUREE. Available through ATC and NIST as GCR 14-917-31. (Published 2014, 42 pages)

ATC-112: The report, *NEHRP Technical Brief No. 10, Seismic Design of Wood Light-Frame Structural Diaphragm Systems: A Guide for Practicing Engineers*, was developed under a contract with NIST, and prepared in collaboration with CUREE. Available through ATC and NIST as GCR 14-917-32. (Published 2014, 47 pages)

ATC-113: The project, "Development of Annual Report for National Earthquake Hazards Reduction Program Covering Fiscal Year 2013," was funded by NIST to obtain assistance in the development of the NEHRP Annual Report in 2014.

ATC-114: The project, "Analysis, Modeling, and Simulation for Performance-Based Seismic Engineering" was funded by NIST to close the gap between state-of-the-art academic research and state-of-practice engineering applications for nonlinear structural analysis, analytical structural modeling, and computer simulation for performance-based seismic engineering.

ATC-115: The ATC-115 report, *Roadmap for the Use of High-Strength Reinforcement in Reinforced Concrete Design*, was developed under a contract with the Charles Pankow Foundation (CPF). Available through ATC and CPF. (Published 2014, 197 pages)

ATC-116-2/116-3: The project, "Solutions to the Issue of Short-Period Building Performance," was funded by FEMA to advance the roadmap developed on the ATC-116 Project to: (1) identify key missing elements of current modeling practice related to short period buildings; (2) develop a methodology to improve analytical modeling of short period buildings; (3) calibrate the methodology with observed performance of short period buildings in recent earthquakes; and (4) simplify the methodology into practical solutions that can be implemented in codes and standards.

ATC-118: The FEMA P-1019 report, *Emergency Power Systems for Critical Facilities: A Best Practices Approach to Improving Reliability*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2014, 170 pages)

ATC-119: The project, "Seismic Safety and Engineering Consulting Services for the Earthquake Safety Implementation Program (ESIP), City and County of San Francisco," was funded by CCSF to provide technical expertise in completing selected tasks from the Earthquake Safety Implementation Program (ESIP) work plan that was developed under the CAPSS project. The project produced the report, *Recommendations for Mitigation of Chimney Hazards*. (Published 2015, 63 pages)

ATC-120: The project, "Scoping Study: Seismic Analysis and Design of Nonstructural Components and Systems," was funded by NIST to provide support for seismic analysis and design of nonstructural components and systems by bringing together relevant sources of information and formulating specific tasks to be addressed in subsequent studies.

ATC-121: The report, *NEHRP Seismic Design Technical Brief No. 11, Seismic Design of Steel Buckling-Restrained Braced Frames*, was produced under a contract with NIST. Available through ATC and NIST. (Published 2015, 34 pages)

ATC-122-1: The project, "Reducing the Risk to our Schools from Natural Hazards and Improving the Safety of Our Children" was funded by FEMA to develop a School Safety Guide addressing multiple natural hazards, including earthquakes, tornadoes, tsunamis, and flooding.

ATC-123-1/123-2: The project, "Improving Seismic Design of Buildings with Configuration Irregularities," was funded by FEMA to conduct comprehensive quantitative studies of horizontal and vertical irregularity limits in current building seismic codes using the FEMA P-695 methodology.

ATC-124-1/124-2: The project, "Update of Seismic Retrofitting Guidance," was funded by FEMA to develop a new FEMA support document that would provide design examples for seismic retrofit of specific buildings using the new ASCE/SEI 41-13 consensus standard. This new document would replace FEMA 276 Example Applications document.

ATC-125: The FEMA Recovery Advisory DR-4193-RA1, *Repair of Earthquake-Damaged Masonry Fireplace Chimneys*, was developed under a contract with FEMA following the 2014 South Napa earthquake. Available through ATC and FEMA. (Published 2015, 11 pages)

ATC-126: The report, *Critical Assessment of Lifeline System Performance: Understanding Societal Needs in Disaster Recovery*, was developed under a contract with NIST. Available through ATC and NIST. (Published 2016, 392 pages)

ATC-127: The report, *Proceedings: ATC/USGS Seismic Hazard User-Needs Workshop*, was developed by ATC with funding from the USGS. (Published 2015, 89 pages)

ATC-128: The report, *Proceedings of Forum on Performance-Based Structural-Fire Engineering: Examples of Current Practice and Discussion on Future Directions*, was developed by ATC with funding from the ATC Degenkolb Endowment Fund. (Published 2015, 101 pages)

ATC-128-1: The project, "AISC-ATC Workshop on Performance-Based Structural-Fire Engineering," was intended to build on ATC's London Forum on performance-based structure-fire engineering to answer questions related to benefits and incentives for performance-based structural fire-engineering, cost savings, barriers to implementation in the United States, and strategies for implementation.

ATC-129: The project, "Development of Updated Standards of Seismic Safety for Existing Federally Owned and Leased Buildings," was funded by NIST to update ICSSC RP 8 (which was published in 2011) to harmonize with the latest reference standards and to address review comments from ICSSC Federal agencies during the development and approval phases of work.

ATC-130: The project, "Updates of NEHRP Seismic Design Technical Briefs 1-3," was developed under a contract with NIST and produced three reports, available through ATC and NIST:

NEHRP Seismic Design Technical Brief No. 1 (2nd Edition), Seismic Design of Reinforced Concrete Special Moment Frames: A Guide for Practicing Engineers (Published 2016, 46 pages)

NEHRP Seismic Design Technical Brief No. 2 (2nd Edition), Seismic Design of Steel Special Moment Frames: A Guide for Practicing Engineers (Published 2016, 40 pages)

NEHRP Seismic Design Technical Brief No. 3 (2nd Edition), Seismic Design of Cast-in-Place Concrete Diaphragms, Chords, and Collectors: A Guide for Practicing Engineers (Published 2016, 43 pages)

ATC-131: The report, NEHRP Seismic Design Technical Brief No. 12, *Seismic Design of Cold-Formed Steel Lateral Force-Resisting Systems: A Guide for Practicing Engineers*, was developed under a contract with NIST. (Published 2016, 56 pages)

ATC-132: The project, "Practical Guidelines and Training for Ensuring Seismic Safety of Schools in the Republic of Armenia," was funded by the World Bank with the support of Global Facility for Disaster Reduction and Recovery's (GFDRR) Global Program for Safer Schools (GPSS) to develop guidelines that focus on the seismic retrofit of existing schools and design of new schools in Armenia, as well as develop and conduct training on the guidelines.

ATC-133: The project, "Development of Technical Brief on Structural Design Issues: Seismic Design of Precast Concrete Diaphragms," was funded by NIST to produce a new technical brief on seismic design of precast concrete diaphragms integral to the lateral load resisting systems used to resist lateral loads in buildings in areas of moderate to high seismic activity.

ATC-134: The project, "Performance-Based Seismic Engineering: Benchmarking of Existing Building Evaluation Methodologies," was funded by NITS to conduct an objective comparison of the evaluation and assessment procedures contained in ASCE/SEI 41 in regards to other design and evaluation standards and to data recorded for reinforced concrete buildings. The project will consider both the current standard, ASCE/SEI 41-13, and the more recent version currently under development, ASCE/SEI 41-17.

ATC-135: The project, "Studies for Improving Seismic Design Procedures and Requirements for New Buildings," was funded by FEMA to develop design procedures and requirements including, but not limited to: (1) an alternate design procedure for one-story, flexible diaphragm buildings with stiff vertical elements; (2) design procedure with requirements for rocking seismic force-resisting systems; (3) the inclusion of soil structure interaction effects on the design of inelastic seismic force-resisting systems; and (4) consolidation and simplification of design requirements based upon the Seismic Design Category (SDC) assigned to a building.

ATC-136: The project, "Technical Monitoring of New and Existing Seismic Building Codes and Related Training," was funded by FEMA to continue FEMA's support of the model codes and consensus standards development processes, submit proposed changes to the model codes based on the most recent edition of the NEHRP Recommended Seismic Provisions and other FEMA publications, assist state and local code adoption efforts upon request, and to support other code-related activities such as outreach and education to ensure that seismic risk is adequately addressed at the State and local levels.

ATC-137: The project, "National Earthquake Technical Assistance Program (NETAP) Seismic Technical Guidance Development and Support Contract," was funfed by FEMA to provide a mechanism for delivering direct assistance to the public to: (1) increase local earthquake knowledge and awareness; and (2) support the effective implementation of risk reduction activities from earthquakes or related hazards.

ATC-139: The purpose of this project was to support the FEMA-funded Project 17 effort that is examining the basis for the national seismic design value maps and the design procedures that reference them, in preparation for the 2020 Provisions update cycle. This work investigated the effects of duration on building response and collapse behavior, which is a topic that is not currently funded within the Project 17 scope of work.

ATC-R-1: The report, *Cyclic Testing of Narrow Plywood Shear Walls*, was developed with funding from the ATC Endowment Fund. Available through ATC (Published 1995, 64 pages)

ATC Design Guide 1: The report, *Minimizing Floor Vibration*, was developed with funding from the ATC Endowment Fund. Available through ATC. (Published, 1999, 64 pages)

ATC Design Guide 2: The report, *Basic Wind Engineering for Low-Rise Buildings*, was developed with funding from the ATC Endowment Fund. Available through ATC. (Published, 2009, 114 pages)

ATC TechBrief 1: The ATC TechBrief 1, *Liquefaction Maps*, was developed under a contract with the United States Geological Survey. Available through ATC. (Published 1996, 12 pages)

ATC TechBrief 2: The ATC TechBrief 2, *Earthquake Aftershocks − Entering Damaged Buildings*, was developed under a contract with the United States Geological Survey. Available through ATC. (Published 1996, 12 pages)

FEMA Support for Earthquake Subject Matter Experts (SMEs): Seismic Technical Guidance Development and Support is funded by FEMA to provide overarching management of the task orders authorized under the existing FEMA Task Order Contract for Seismic Technical Guidance Development and Support, and to provide support for Earthquake Subject Matter Experts (SMEs) who report independently to FEMA.

Northeastern RSB: Northeastern University Multi-Hazard Resilient and Sustainable Buildings aimed to provide technical advice and assistance to Northeastern University on their NSF- funded project to develop a decision framework that accounts for both resilience and sustainability across multiple hazards with different levels of severity, while optimizing lifecycle costs throughout the design process.

STARR II JV: Strategic Alliance for Risk Reduction (STARR) II Joint Venture, Production and Technical Services (PTS) for Architect and Engineering Services Nationwide Contract aimed to provide technical assistance and support services to FEMA on Hazard Mitigation Technical Assistance Projects (HMTAP) and Technical Assistance and Research Contract (TARC) projects on an as-needed, on-demand basis.

Website for Geographic Based Design Load Parameters: This project aimed to maintain and enhance the ATC windspeed website, and to add additional functionality related to other design loads, including ground snow loads and possible future earthquake ground accelerations.

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