RESILIENCE
Managing the Risk of Natural Disaster

David Vaughn, Jeff Plumblee, Jonathan Vaughn, and Bob Prieto
Acknowledgements

Resilience: Managing the Risk of Natural Disaster considers risk management strategies, risk identification methods, and pre- and post-event activities to minimize risk. Post-event recovery is a more widely understood field, as practitioners have a plethora of lessons learned from completed projects. Pre-event planning as a means of minimizing damage and downtime is a lesser developed field, and this book organizes both literature supported data and the authors’ anecdotal experiences into a framework for disaster management, spanning pre- and post-event.

The authors’ each have their own areas of expertise, and this book would not have been possible without coordination between, and dedication of, each author. The book serves as a companion to Resilience: An Engineering & Construction Perspective, in which co-author Bob Prieto describes his perspectives on the challenges of resilience in large scale engineering and construction programs. Together, these books offer the reader fresh perspectives on the challenges and opportunities that exist before and after disaster strikes and how to act to improve outcomes.

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David is the Founder and Owner of Integrated Resilience, LLC, a full spectrum service offering for pre- and post-event risk management solutions. These services include site-specific multi-hazard modeling and assessments, multidimensional vulnerability assessments, preventative action plans, recovery plans, tabletop exercises, public/private integration, insurance coordination, and comprehensive recovery services. Beyond the business-focused offering, strategies and tools have been developed to build Community Resilience. These tools and plans leverage a development strategy based upon a resilient engineering framework that focuses on process- and outcome-driven accountability.

David is a former Fluor Fellow and the Director of Resilience Solutions, and he has also served as the Secretariat of the WEF DRP in Greenville, South Carolina. There, he developed resilience strategies that offered risk reduction and capability/capacity building in developed and developing regions of the world.

David’s experience in rapid deployment, planning, disaster management, and reconstruction is a culmination of his work in support of the U.S. Army Sustainment Command, FEMA, and various private sector companies. David’s passion for his profession is demonstrated by his personal commitment to a number of humanitarian projects, including:

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- In honor of his support for engineering students who are changing the world, David was awarded the 2014 Distinguished Service Award and 2012 Martin Luther King Jr. Excellence in Service Award from Clemson University.

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As Program Manager, Jonathan supports clients in reducing natural disaster related risks through enterprise planning. By analyzing enterprise level risks, asset criticality is determined allowing prioritization of risk mitigation spending. For critical assets, threat identification and vulnerability assessments are performed and mitigation strategies identified. Jonathan also develops rapid mobilization and recovery capabilities in support of post event recovery efforts, ensuring clients are ready to recovery from any disaster event that may impact their business operations.
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Bob is a member of the ASCE Industry Leaders Council, National Academy of Construction and a Fellow of the Construction Management Association of America. Bob served until 2006 as one of three U.S. presidential appointees to the Asia Pacific Economic Cooperation (APEC) Business Advisory Council (ABAC), working with U.S. and Asia-Pacific business leaders to shape the framework for trade and economic growth and had previously served as both as Chairman of the Engineering and Construction Governors of the World Economic Forum and co-chair of the infrastructure task force formed after September 11th by the New York City Chamber of Commerce. Previously, he served as Chairman at Parsons Brinckerhoff (PB), one of the world’s leading engineering companies. Bob Prieto can be contacted at Bob.Prieto@fluor.com.
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Preface

“Resilience” has recently become a cure-all buzzword. Its varied concepts have been applied across developed and developing nations, with fields ranging from ecology, psychology, and sociology to community planning, engineering, economics, supply chain management, infrastructure, and corporate management. It seems to be a panacea, but when searching for the definition of resilience, the results are inconsistent. This book will not offer an all-encompassing definition of resilience, but instead will give practical insight into community, corporate, and governmental resilience.

Admiral Thad Allen defined resilience as “the immune system of our nation.”\(^{(1)}\) This definition met his intent, but it is not granular enough to fulfill the needs of the masses, nor was it intended to do so.

During a recent trip to the Philippines, I had the opportunity to meet with a fellow engineer who had just visited Japan. While in Japan, he experienced a magnitude-6.2 earthquake. Being from the Philippines, he began to panic and asked, “Where should we evacuate to, and what are the procedures?” To his surprise, hotel management calmly explained that the facility’s seismic design criteria exceeded a magnitude 9.0 and that he could simply remain in his room. This is a great example of one portion of resilience – resilient design, but it still does not offer a common definition of resilience.

The Community and Regional Resilience Institute (CARRI) dissected resilience into attributes and applications, ultimately defining the term in their 2013 paper “Definitions of Resilience: An Analysis.”\(^{(2)}\) The report
states that a definition of resilience should embody the following core concepts:

- Resilience is an inherent and dynamic attribute of the community.
- Adaptability is at the core of this attribute.
- Any adaptation must improve the community; it must result in a positive outcome for the community relative to its state after experiencing adversity.
- Resilience should be defined in a manner that enables useful predictions to be made about a community’s ability to recover from adversity.

Based on these principles, CARRI derived the following definition, which will be used as a foundation for this book:

“Community resilience is the capability to anticipate risk, limit impact, and bounce back rapidly through survival, adaptability, evolution, and growth in the face of turbulent change.”

The intent of this work is not to offer the perfect solution to resilience. Instead, the hope is that the book will push forward the international conversation on resilience. The book does not offer exhaustive definitions and reviews. Instead, the goal is to give an overview of salient topics and reveal the connections between them.

Introduction

Over the last several decades, the world has experienced an increase in frequency and magnitude of natural and man-made hazards, and this trend is anticipated to continue for the foreseeable future. The population is shifting to more vulnerable locations, leaving all stakeholders more at risk than ever. Despite budgetary constraints, federal, state and local governments have made promising headway to develop emergency plans to respond to crises efficiently. Unfortunately, these government programs have primarily focused efforts on assistance for individual households and infrastructure, and these techniques have largely fallen short of helping private industry build resilience. This book discusses strategies to help private and public sectors reduce risk, minimize downtime, and increase overall resilience.

Risk management has been studied for more than half a century, and most management professionals are concerned that their business may be at risk from natural or man-made hazards. Chapter 1 serves as a primer for natural
disaster risk management. The chapter attempts to create a common operating picture by giving a brief history of risk management, outlining threats and potential risks, identifying relevant stakeholders, and explaining the benefits of corporate natural disaster risk management.

Chapter 2 serves as a primer for the book and is intended set the stage and establish context for the discussion. Chapter 3 builds a process for identifying and managing hazard risk throughout an enterprise and presents suggestions for rapid post-event recovery. Chapter 4 describes the concept and process of enterprise network engineering. Chapter 5 discusses how geography can affect risk. Chapter 6 briefly discusses resilient design and pre-event activities that should be undertaken, and Chapter 7 details challenges of the post-event recovery process and gives guidance of best practices.

Bibliography


History of the Field

Disasters have impacted human civilization throughout time, and as population and development continues to increase, the effects of disasters are expected to increase. The United States Federal Government has provided disaster relief dating back to 1803. From that time to 1950, when the Defense Production Act was established as the first comprehensive legislation on federal disaster relief, the Federal Government intervened in approximately 100 disaster events.

In the United States, the centerpiece legislation for providing federal aid in emergency and disaster relief is the Robert T. Stafford Disaster Relief and Emergency Assistance Act. This act, signed into law in November 1988, gives the Federal Emergency Management Agency (FEMA) responsibility for coordinating federal response with the intent to supplement the resources of state, local, and private sector resources.

PPD-8 also mandates a new piece of the national preparedness system: planning frameworks for each of the preparedness objectives, from prevention to recovery. It was envisioned that each planning framework would include a basic plan to address all hazards.

In 2008, the DHS developed the Voluntary Private Sector Preparedness Accreditation and Certification Program, known as PS-Prep\(^3\). As a voluntary program, organizations can become certified through an independent assessment of an entity’s preparedness to survive, respond to, and recover more effectively from adverse conditions. DHS has adopted three standards to form the basis of PS-Prep:

- **British Standards Institution 25999-1 (2007 Edition), Business Continuity Management.**
- **National Fire Protection Association 1600-Standard on Disaster/Emergency Management and Business Continuity Programs, 2010 Edition.**

Building on previous presidential declarations, Presidential Policy Directive (PPD)-21 Critical Infrastructure Security and Resilience further acknowledged the importance of critical infrastructure, pushing forward the following action items:

- Develop a situational awareness capability that addresses both physical and cyber aspects of how infrastructure is functioning in near-real time
- Understand the cascading consequences of infrastructure failures
- Evaluate and mature the public-private partnership
- Update the National Infrastructure Protection Plan
- Develop comprehensive research and development plan\(^4\)

**Risks and Current Trends**

Companies and communities are exposed to many types of risks. Risks can be both naturally occurring and human-caused. Naturally occurring events can be classified as meteorological, geological, or biological. Similarly, man-made events can be grouped as accidental, intentional, or technological. The scope of this book primarily focuses on natural events.
Some events can be forecasted, allowing preparations to be made in advance of the impact. These events are referred to as notice events. Examples of notice events include tropical cyclones and winter storms. Other events, such as earthquakes, occur without warning and are referred to as zero-notice events.

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<tr>
<th>Natural Hazards – Geological</th>
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<tr>
<td>- Earthquake</td>
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<td>- Tsunami</td>
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<td>- Landslide, mudslide, subsidence</td>
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<td>- Glacier, iceberg</td>
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<th>Natural Hazards – Meteorological</th>
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<td>- Drought</td>
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<td>- Windstorm, tropical cyclone,                 hurricane, tornado, water spout, dust/sand storm</td>
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<td>- Extreme temperatures (head, cold)</td>
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<td>- Lightning strikes</td>
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<td>- Snow, ice, hail, sleet, avalanche</td>
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<th>Natural Hazards – Biological</th>
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<td>- Diseases (pandemic)</td>
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<td>- Animal or insect infestation or damage</td>
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**Known-Known, Known-Unknown, Unknown-Known, and Unknown-Unknown Risks**

Risks are comprised of two core pieces of information: the what and when of an event and the impact of the event. When both pieces of information are known (referred to as a known-known event), one can plan for the event and its impacts.

Difficulties begin to arise when dealing with known-unknown or unknown-known events. Known-unknown events are those events where the event can be described, but the impacts of the event are unknown. Unknown-known events are those events where the event is vague, yet the potential effects of the event are known.

Black swans are described as events that come as a surprise, have a major impact, and are often inappropriately rationalized after the fact with the benefit of
hindsight\(^5\). These are also referred to as unknown-unknown events. The four quadrants seen below represent the four types of risk, with the darkest quadrants representing risk with the highest level of certainty.

In the past 50 years, technology has transformed hurricanes from Black Swan events into virtually known-known events. Historically, hurricanes would strike the coastline with no notice. Those in its path were sitting ducks, unaware that the hurricane was coming and unaware of how it would affect their home, life, and community. Satellite imagery and forecasting models have transitioned this unknown-unknown event into a known-unknown event. The National Weather Service, National Oceanic and Atmospheric Administration (NOAA) and other organizations began disseminating information ahead of the hurricane, warning residents, and issuing evacuation orders. Additionally, by aggregating historical data, catastrophe modeling experts have been able to create probabilistic models, giving insight into not only what events are possible, but also of the likelihood of the event occurring.

Still, up until recently, few people understood how the hurricane would impact the region and individual buildings. Catastrophe modeling; structural engineering research; wind tunnel testing; sea, lake, and overland surges from hurricanes (SLOSH) modeling; and other research has revealed valuable information regarding the interaction between natural hazards and the built and natural environment. Scientists and engineers can now begin to predict the effects of a specific hurricane, from a regional approach down to individual building damages. This technology has allowed that second piece of information, the impact, to be predicted and therefore known.

As risks are explored, it is important to realize that we live in an ever-changing world. New risks will appear, and current risks will evolve. Globalization and the increasing reliance on technology have proven to be significant factors for business, both as opportunities and as risks. Large companies have also noted that they are concerned over the impacts of climate change. As we continue to gain a better understanding of the science behind risk, it is imperative to remain progressive. Unknown-unknown risks are unlikely to disappear, but as we prepare for the known risks, we are often also preparing for the unknown-unknown risks.

**Increasing Magnitude, Frequency, and Cost of Disaster**

Over the past few decades, data indicates that there are more natural hazard events and that there are higher economic impacts from these events. Research suggests that the increase in frequency and magnitude of weather-related events is tied to climate change (whether it be a natural cycle or human caused). In *Building Safer Cities*, Torben Juul Andersen
notes that in the past 30 years, the frequency of disaster events has quadrupled, economic losses have increased by a factor of 2,000 to 3,000, and insurance losses have increased by a factor of 1,000\(^{(6)}\). The economic losses have far outweighed economic growth figures for the same period, suggesting that factors beyond the increase in number of events have impacted loss figures. These loss trends can be seen in Figure 2-2.

Additionally, in *Catastrophe Modeling: A New Approach to Managing Risk*, Grossi notes that losses from individual disasters during the past 15 years (as of 2005) are an order of magnitude above what they were over the previous 35 years. Figure 2-2 shows an increase in the annual number of high-loss catastrophes in the United States (defined as $1 billion in economic loss and/or 50 fatalities\(^{(7)}\)). Further emphasized throughout this book, Grossi states, “Residential and commercial development along coastlines and areas with high seismic hazard indicate that the potential for large insured losses in the future is substantial. The increasing trend for catastrophe losses over the last two decades provides compelling evidence for the need to manage risks both on a national, as well as on a global scale.\(^{(8)}\)”

**Figure 2-2: Economic Losses in the United States**
(Source: *Catastrophe Modeling: A New Approach to Managing Risk*)

**Who is at Risk?**

As noted in the previous section, factors beyond climate change are increasing the economic effects of natural hazards. Human migration patterns over the past century have also exacerbated the effects of natural hazards. Figure 2-3 compare population by county in 1900 and 2010. As
seen in the maps, U.S. population has increased in most areas, but the largest increases are in coastal areas, indicating a population shift towards the coast over the last century. In 2010, 39% of the U.S. population lived in coastal shoreline counties, which represent less than 10% of the U.S. land area\(^{(9)}\). The shift towards the coastline is expected to continue, with the population density in coastal areas expected to increase at more than three times the national average between 2010 and 2020\(^{(10)}\).

![US Census Population 1900](image1)

![US Census Population 2010](image2)

*Figure 2-3: Population Densities of U.S. Counties, 1900 and 2010 (Source: United States Census Bureau)*

As population increases, urbanization creates other concerns. Infrastructure, which has largely been neglected in the United States, has deteriorated, and population growth has overloaded the systems, often leaving them functionally obsolete. Poor urban planning has increased the risk for flooding and landslides. As noted in the State of the Environment and Policy Retrospective, seismic activity has remained constant over recent years, but the effects of earthquakes on the urban population appears to be increasing\(^{(11)}\).

Because individuals provide the necessary labor for industry, the private sector (industry) has similar migration patterns to the population as a whole. To gain a broad understanding of industry risk, tropical cyclone and seismic probability data was overlaid with industry density data, as seen in Figure 2-4. The areas in red indicate areas with a large number of potentially vulnerable companies, while areas in yellow or uncolored indicate regions with lower industry population and/or lower risk of tropical cyclone/earthquake. Note that the data is for visual purposes and does not include flood, volcanic, wildfire, windstorm, or other threats. Also, these maps do not account for any mitigation measures that may be required by
local laws or codes. To summarize the figure, population densities in vulnerable regions are increasing, creating more at-risk communities.

Figure 2-4: Heat Map of Industry Risk to Hurricanes and Earthquakes

To give the reader a perspective of cyclonic and earthquake activity, Figure 2-5 shows the total number of hurricane strikes for coastal counties, parishes, and boroughs in the United States\(^{(12)}\). Figure 2-6 shows a USGS seismic hazards map indicating peak horizontal acceleration with a 2% probability of exceedance in 50 years\(^{(13)}\).

Figure 2-5: Total Number of Hurricane Strikes by Counties, Parishes, and Boroughs, 1900-2010
(Source: National Hurricane Center)
Why Reduce Risk?

Direct Loss & Business Interruption

One cannot discuss the impact of hazard-related losses without considering the role of insurance. Most companies pay a third party to provide property and (sometimes) business interruption insurance, but some choose to maintain and finance their risk. In either case, there are clear benefits to mitigating against hazards, reducing the company’s overall risk profile.

Insurers, like most companies, are designed to be profitable. Most people assume that an insurer makes its money from premiums, but often, insurers spend more in claims than they earn in premiums. An insurance company’s income is largely generated by investing a portion of the premiums paid. The investment income ideally outweighs the losses in payouts.

A company pays an insurer to take on the risk to its facilities (and potentially the impacts of business interruption). This money (the portion that is not paid out in claims) is invested to gain a positive return. If the company were to self-insure, they would be required to maintain enough working capital in case a damaging event were to occur. The company has the opportunity to invest the money in the meanwhile and gain their own
returns. Insurers are used when a company does not want to or does not have the ability to maintain enough capital to recover from an event.

In both cases, the risk must be weighed when determining the appropriate premiums for an insurer to charge or the appropriate available capital necessary for self-insurance. Higher risk demands higher premiums, and likewise, higher risk requires more available capital for self-insurance. If a company were to provide evidence of reduced risk to their insurer, through mitigation and planning, they ideally would have their premiums reduced. Unfortunately, reducing premiums based on reduced risk is not common practice. In order to better incentivize risk mitigation, those involved with setting insurance rates (government programs, state insurance commissioners, insurers, etc.) should work to create a system that better aligns premiums with actual risk. Instead of risk transference, companies should aim to mitigate risks; risk mitigation builds a stronger company and often increases the value of assets.

In the case of self-insurance, if the company reduces the probability of major damage due to an event or if it reduces the chance of an event occurring, it has reduced its risk. In reducing risk, the company will be able to reduce the capital it requires itself to maintain for self-insurance and maintain the same overall risk profile. By performing mitigation as a risk management technique, they become more proactive and do not just accept the risk in its entirety.

**Enterprise Benefits**

Natural hazards are inevitable, and the manner in which a company handles disaster response plays as much of a role in the perceived value of the company as the disaster itself. Facility damage and business interruption are straightforward in their calculation, but other less tangible effects need to be considered in the resilience discussion.

Stock prices are closely tied to a company’s risk. As a company builds more resilience into its enterprise, it lowers the risk to shareholders, and positive responses to potentially devastating events build shareholder confidence in the company. Insurance may cover property and business interruption losses, but understanding and having a plan as to how to manage public relations in the aftermath of an event is undervalued. If a company has done its due diligence and is capable of an efficient recovery, the company can and should be transparent to its shareholders with regards to the impacts to the company.
Similar to shareholder confidence, losing customer confidence and satisfaction is also a potentially crippling result of a disaster. Customers depend on their suppliers. If Supplier A cannot supply its products or services for an extended period, customers will seek to have their needs fulfilled elsewhere. As customers build relationships with other suppliers, they are less likely to return to Supplier A once it has recovered. As a result, Supplier A has permanently lost market share. Additionally, it leads customers to wonder when the next event will bring Supplier A offline again. By providing evidence of resilience planning and pre-event action, suppliers can instill confidence in their customers that they are not a risk with which the customer should be concerned.

Shareholder and customer confidence are primarily enterprise-level issues. At a micro-level, if Company A goes offline for 6 months and employees are relocated for temporary housing, what happens to the employees? Skilled employees are often forced to seek work elsewhere. As they transition their careers to other companies and industries, Company A loses experienced personnel. For skilled employees, the typical cost of turnover is 21% of the employee’s annual salary\(^{(14)}\). Not only does Company A have to foot the cost of training employees, but the employees are less productive and more prone to errors during the first 1-2 years of employment\(^{(15)}\). In addition, as Company A sheds its employees, competitors may have access to Company A’s top performers, building the competition’s competitive advantage.

**Community Context**

The companies mentioned previously are part of an ecosystem – their community. For purposes of discussion in this book, the community is divided into the following four sectors: public sector, private sector, citizens, and the insurance industry (Figure 2-7). The insurance industry fits within the private sector, but since it also serves as a risk management opportunity, this book will address it separately. The following text details the interconnectedness of the sectors by analyzing how they acquire funds required to operate.
Public sector. Operating funds are generated through various forms of taxation of the private sector, citizens, the insurance industry, and public employees.

Private sector. Operating funds are generated by selling services and goods to the public sector, citizens, private sector, and insurance industry.

Citizens. Operating funds are generated by performing services for the public sector, private sector, insurance industry, and other citizens.

Insurance. Operating funds are generated by investing available capital and charging fees for taking on risk from the private sector, citizens, the public sector, and in some cases, other insurers.

Each of these sectors is reliant on the others, which creates challenges. Infrastructure, for instance, impacts both government and private industry, which makes financing mitigation difficult. Additionally, government recovery programs primarily focus on individual and public assistance but largely overlook the private sector (with the exception of some small business loans). When any of the four sectors falter, all suffer as a consequence. Nearly 7,900 businesses were permanently shut down in southeast Louisiana after Hurricane Katrina\(^{16}\), and similar cases have emerged from Superstorm Sandy. These shutdown businesses reduce tax revenue to government, reduce available jobs to citizens, reduce the business-to-business customer base for other businesses, and reduce potential clients for insurers. With private industry serving as the primary source of income for the public sector (taxation), citizens (income), and insurance (premiums), it is imperative to develop approaches that will allow for rapid recovery of the private sector.

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National Centers for Environmental Prediction
National Hurricane Center
Miami, Florida 33165-2149 USA
Page last modified: Wednesday, 19-Mar-2014 20:21:12 UTC


SECTION II
RISK BASED LIFE CYCLE PLANNING
This chapter is intended to serve as an introduction to Risk Based Life Cycle Planning, and the following chapters will explore each of the stages as depicted in the diagram below. Every corporation faces a variety of risks on a daily basis. Management, in particular risk officers and other risk management personnel, must consider risks across their entire corporations. In addition, these individuals must be forward-thinking, anticipating future risks along the life-cycle of the corporation. To efficiently plan for risks throughout the life of a corporation, the following five-phase process is recommended as a framework.

The first phase, enterprise planning, looks at the value chains of a corporation in order to understand overall corporate risks. Site selection involves weighing the costs, benefits, and risks of potential corporate site locations. Resilient design incorporates engineering principles intended to reduce the risks associated with defined site locations, particularly for new construction.

Pre- and post-event actions work iteratively. After preparations are made and mitigation actions are in place, an event will eventually disrupt the corporation. The corporation must respond to the event and undertake recovery actions. Proactive corporations use these experiences as educational tools, creating after-action reviews and lessons-learned.
documents, which then feed back into the pre-event preparedness and planning processes. Figure 3-1 shows the iterative nature of pre-event and post-event actions.

Figure 3-1: Relationship between Pre-Event and Post-Event Actions
As the business environment continues to evolve into the 21st century, companies are forced to focus on enterprise risk management as part of their strategy to remain competitive and maintain or grow market share. Though developing countries often have higher socio-economic risks(1), developed countries, and their industries, have much higher absolute economic exposure to natural hazards. Maplecroft’s 2014 Natural Hazards Risk Atlas assessed 197 countries on exposure to the following natural hazards: flooding, storm surge, earthquakes, tsunamis, wildfires, and volcanoes. The study identified five countries at “extreme exposure” to these natural hazards, including Japan, the United States, Taiwan, China, and India. These five countries all have high manufacturing output and are industry dense(2).

Japan, one of the “extreme exposure” countries, had a magnitude 9.0 earthquake hit the main island on March 11, 2011. The earthquake, tsunami, and its aftermath killed an estimated 15,886, damaged or destroyed more than 1 million buildings, and disrupted global supply chains for months(3). Shortages of everything from raw materials to intermediate components and tools and equipment created challenges for manufacturers worldwide. These companies around the world, whether producing automobiles or microchips, may have had some materials warehoused for such an event, or they may have had alternate suppliers, but many were forced to shut down operations until their Japanese suppliers began shipping goods once again. As these companies worked to source materials from other suppliers, competitors were often doing the same. This created a competitive advantage for those
that foresaw potential issues and immediately began searching for alternate solutions versus those that did not realize the supplier disruptions until later. Scientists and engineers have compiled historical data and built robust hazard modeling platforms. These tools provide the necessary data to understand the threats for a given area. As a company reviews its enterprise-level risk, it is important to understand which facilities are in vulnerable locations, but equally important, an assessment of the global value chain is critical. The damage to a company’s physical facilities can be minor compared to lost revenue. This lost revenue due to natural hazards, often referred to as business interruption (BI), can impact more than just short-term profitability. Studies show that publicly traded companies that actively plan for disasters fare much better than those that did not have a plan. A 2005 Oxford Metrica report notes a 22% difference in stock prices between companies that did and did not effectively deal with the aftermath of a crisis. Planning for these crisis events is critical to ensuring an appropriate response, as evidenced by the stock price fluctuations of those who effectively managed the response versus those who did not, as seen in Figure 4-1(4).

![Figure 4-1: Value Reaction to Reputation Crises](Source: oxfordmetrica.com/public/CMS/Files/601/04RepComKen.pdf)

**Enterprise Risk Management**

Risk management is defined as “coordinated activities to direct and control an organization with regard to risk”(5). In this book, we focus on risk management as it applies to natural hazards. Risk management is a unique mix of business acumen and engineering, as one must understand when risks should be minimized through design criteria, transferred to insurers, or absorbed into the corporation.
Risks can be prioritized based upon the likelihood an event will occur and the severity of damage it would cause if such an event did occur. Often, a matrix similar to the one below is used to qualitatively determine risk based upon likelihood (probability) and severity (consequence). Severity, depending on the stakeholders’ interests, could be in terms of downtime, economic losses, environmental impact, societal impact, or lives lost. Low likelihood and low severity events have a lower risk, high likelihood and high severity events have an extremely high risk, and other combinations of likelihood and severity fall out somewhere in between.

![Figure 4-2: Qualitative Risk Index](image)

When possible, probabilities should be used for creating the different bands of likelihood (for example, 1 to 5% probability per year as a band). Also, severity should be concrete, such as the economic loss bands in the figure above. These objective measures, which should be defined by management, provide more consistency and transparency when prioritizing risks.

In order to address these risks, there are four primary risk management techniques, each of which is described below as it pertains to natural hazards.

1. **Avoidance**

   Avoidance of risk involves stopping any actions that involve a risk or somehow ending exposure to that risk. In most circumstances, this is not feasible, as the actions that involve risk are the ones that drive a company’s profits. In cases where a facility has not yet been built, one can avoid certain natural hazards by placing the facility in a location not susceptible to the particular natural hazards. For example, one could move a manufacturing
facility far inland to avoid hurricane risk. Even then, there are tradeoffs: a coastal location may provide better transportation capabilities than an inland location.

2. Reduction

Mitigation, or risk reduction, is the effort to reduce the consequences of an adverse event by lessening the impact of the event. Consequences can include loss of life, service interruption, environmental degradation, and damage to property\(^\text{6}\). Some examples of mitigation include pre-event planning for natural hazards, reinforcing a building for wind or seismic risks, or elevating critical equipment above expected flood levels.

Mitigation, as it relates to specific vulnerabilities, will be discussed in depth in Chapter 6.

3. Transference

Risk transference shifts the burden of loss for a risk to another party. Insurance is the most common type of risk transference, which shifts risk from a company to an insurer. Insurance, as related to hazard risk management, is offered to businesses for property and business interruption. Property insurance covers direct damages to the facilities and site. Business interruption insurance covers the loss of income that a business suffers from closure due to a hazard event. These policies may cover profits, fixed costs, temporary facilities, and other extra expenses as outlined in the insurance policy.

4. Acceptance

Sometimes, a company may decide to move forward knowing the risks. If the costs of risk reduction or transference are too high and if avoidance is not an option, the final risk management option is to accept the risk. Risk acceptance leaves a company vulnerable, and options should be carefully weighed before accepting risks. Risk acceptance should, in most cases, be considered a last resort.

**Enterprise Level Risk and Corporate Mitigation Strategies**

Corporations have been managing risk and building resilience as a matter of business for decades. The callout box highlights two specific industry categories and common enterprise resilience strategies within each. The following sections discuss enterprise and supply chain network mapping and resilience.
Benefits of Supply Chain Resilience Strategies

With an increase in terrorism, interconnectedness of infrastructure, globalization, and an increase in natural disaster magnitudes and frequencies, disruptions in supply chains have become more common. In response, companies have begun to take steps to increase the security of their supply chains. It is difficult to quantify avoided risk, so creating a business case to justify these investments is difficult. A 2006 study sought to demonstrate that investments in supply chain resilience can improve organizations’ business performance(7). Of the companies studied that invested in supply chain resilience:
• 63% reduced problem identification time
• 50% reduced response time to a problem
• 38% shortened problem resolution time
• 63% expected to see further reductions in problem identification time and in response time
• 50% expected to reduce problem resolution time

As of the conclusion of the survey, only one company had concretely tied its resilience benefits to actual cost savings, but 38% of the companies expected to realize cost savings related to resilience improvements in the future.

**Value Chain Process Mapping**

In order to assess and mitigate risk, companies should understand which processes are critical to their business operations and where vulnerabilities lie within these critical processes. Each value chain, the processes used to deliver a company’s goods or services, should be considered to determine which are vital for success of the company. Individual process maps should be developed for each essential value chain.

Value chain process mapping identifies critical nodes and interdependencies within the value chain and provides an understanding of the cascade effect that outages may have on the network. Critical nodes, depending on the level of granularity of analysis, could be equipment, process units, or even entire sites. The objective of the value chain process map is to provide a complete understanding of the processes through identification of critical nodes and interdependencies, and to allow prioritization of planning and mitigation efforts.

**Why Value Chain Process Mapping?**

The value chain of a company is its financial driver. Value chain process mapping identifies potential risks within a network. The company can use value chain process mapping to reveal potential internal vulnerabilities and vulnerabilities among suppliers. If a company must ship all work-in-progress products through a certain facility to create the final product, the company may seek to create redundancy for that facility’s processes at an alternate site. The facility may not necessarily be a bottleneck, but as a critical node, an outage could shut down the entire value chain.
Companies are trending towards requiring suppliers to provide proof of business continuity/disaster management plans to ensure that they are not a liability. For instance, if an airplane manufacturer receives all of its carbon fiber parts from a manufacturer in a vulnerable location, it may consider seeking out alternative suppliers in case the primary supplier were to face an extended disruption of services.

**Defining the Value Chain Network**

To begin analyzing the value chain network, network boundaries must first be defined. Value chain networks may include internal company assets across multiple sites, suppliers, utility providers, and public infrastructure. Internal assets consist of capital infrastructure such as facilities, equipment, and IT systems. Other critical network resources internal to a company include employees and intellectual property.

External resources include suppliers and offsite infrastructure networks. With the increasing complexity and globalization of networks, defining the supply chain is often a challenge. A Gartner survey found that less than one-third of companies surveyed looked beyond their first-tier suppliers, and the majority did not include their full supply chain in continuity planning\(^{(8)}\). Supply chain vulnerability assessments described in Chapter 4 will identify critical suppliers and determine the level of detail to which the supply chain should be assessed (e.g., assessing the supplier’s supplier and beyond). Offsite infrastructure networks include utilities and transportation networks. Infrastructure vulnerability assessments identify these critical elements within the value chain networks.

**Levels of Process Mapping**

A company’s operations rely on availability of a large number of resources. It is not always practical to include all relevant network resources on a single process map. Single value chains can be mapped independently, though often resources will overlap and appear in multiple value chains maps. To provide additional clarity, the network maps can be developed at multiple levels of the value chain. The two primary levels are enterprise and site, but additional granularity may be developed as needed.

Enterprise level process maps indicate material flow within the value chain between company sites at a global level. This level process map is used to determine the criticality of each site and the recovery time objective (RTO) for each site. The RTO is the maximum operational downtime acceptable to the company for a given event and is discussed further in Chapter 6. Site operations information (e.g., consumption and inventory levels of major
inputs, product demand and product inventory levels, equipment lead times for replacement, redundant offsite capacity or single points of failure) can be gathered from enterprise and site level stakeholders. The enterprise level process map helps management prioritize sites for pre-event planning and mitigation efforts based on criticality.

Critical nodes should take priority for further detailed planning efforts, such as site-level hazard assessments and vulnerability assessments discussed in Chapter 6. Data generated from the site assessments are added to the enterprise level process map to allow complete analysis of the networks, including resources internal and external to the company.

Figure 4-3 shows an enterprise level process map for a hypothetical aircraft manufacturing process. The manufacturer’s production facilities are shown as well as key suppliers that are considered critical to the production process. The aircraft is assembled in Charleston, South Carolina and flown to Mobile, Alabama for painting and completion of interior components. Interiors, including upholstery and furnishings, are manufactured in Atlanta, Georgia and Raleigh, North Carolina with the facilities having equivalent capability and capacity. The key suppliers are deemed critical because the electronics are only produced by a single manufacturer and the engines and composite components have long lead times.
Assessing Criticality

To understand enterprise risks, a company must first determine which value chains are critical. This determination may be based on current or projected revenue to the company, market reaction to supply disruptions, or other impacts considered by management. For example, management may decide that a product line is to be phased out within the next five years and is less critical than other product lines.

The critical value chains must then be assessed to determine critical nodes within the networks. A standard set of criteria should be defined and applied consistently for assessing criticality. Considerations that may increase criticality of nodes include single points of failure, extended recovery times, or extreme hazards to human life or the environment resulting from failure.

The critical path method can be applied to determine the processes which limit the production schedule and which processes have flexibility within the production schedule. Figure 4-4 illustrates a sample critical path analysis. The six-step process consists of three paths (ABDF, AEF, and ACDF). The path with the longest duration, ACDF totaling 9 days (1+4+2+2), is the critical path. The process cannot be completed in less than 9 days, and delaying any step within this path delays the overall schedule. Steps outside of the critical path have scheduling flexibility, also known as float (B has 1 day and E has 2 days). If the recovery time for an event exceeds the float for a step, the value chain will be disrupted.

Geographic Vulnerabilities

In addition to understanding criticality, another aim of process mapping is to identify those nodes that lie in areas highly susceptible to hazards. A macro-level risk assessment is performed by incorporating Geographic Information Systems (GIS) capabilities to determine geographic vulnerabilities for critical assets. The process is mapped geographically and compared against hazard maps to identify potential risks. Critical assets...
located in highly susceptible locations should take priority for detailed vulnerability assessments described in Chapter 6.

Using the aircraft manufacturing process example above, the critical sites are plotted geographically as shown in Figure 4-5. These locations are compared against hazard maps like that shown in Figure 4-6. This illustrates several potential risk exposures. Both the Main Assembly and Paint & Completions Facilities are single points of failure and located in hurricane prone areas with the Main Assembly Facility in Charleston also at risk of seismic events. Site-specific planning and mitigation efforts should take priority for these sites. Hazard models can be generated to provide more detailed information on threat exposure to the facilities.

Figure 4-5: Geographical Map of Aircraft Manufacturing Process
To continue the aircraft manufacturing example above, the following is a hypothetical action plan based upon the results.
The company decides that relocation or development of redundant capacity is not practical for Main Assembly operations. The risks associated with the Charleston site are reduced by identifying and mitigating vulnerabilities. Management funds retrofits, mitigation, and pre-disaster planning efforts to facilitate recovery of operations to meet the RTO for the maximum design threat.

A different strategy is taken to address risks associated with the Paint & Completion Facility. Paint operations are a bottleneck for the manufacturing process, and management decides to invest in additional paint capacity. To mitigate the risks of hurricane exposure to the Mobile site, a redundant facility will be constructed in a geographically dispersed location.

The Interiors facilities are located in lower threat areas with each facility capable of meeting production demand alone. As a result, site-level planning has a lower priority.

Of the critical suppliers, the electronics manufacturer in Manila likely poses the most severe risks. Manila is exposed to many natural hazards including flooding, earthquakes, tropical cyclones, tsunamis, landslides, and volcanoes. Considering the manufacturer is the sole producer of electronics for the aircraft and the elevated probability of a disruptive event, site specific planning and mitigation efforts are of high priority for this supplier. Mitigation strategies would include working with the supplier to identify vulnerabilities and develop mitigation strategies and/or redundancy, working with other manufacturers to develop alternate sourcing capabilities, or increasing inventory levels to protect against supplier outage.

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2. maplecroft.com/portfolio/new-analysis/2014/02/19/natural-hazards-risk-atlas-2014/


6. www.fema.gov/what-mitigation

According to Conway Data, a research firm that focuses on economic development, in 2012 there were approximately $342 billion in new industrial and office projects, covering 409 million square feet, and generating more than 480,000 jobs\(^1\). Assuming the average project size is $10 million, there were more than 34,000 location decisions made in 2012, and they were made in a variety of ways. Some decisions are purely emotional – the chief executive has a vacation home nearby and wants to spend more time there. Some are made by default – it is where the company is already located – and not considering other locations makes a location decision without even realizing it. Other decisions are made using the assistance of experts in site selection or by internal company resources with site selection experience. Almost half of all corporate location decisions are made using a site selection consultant\(^2\). In an ideal scenario, location decisions are made based on where the company can experience the highest returns with the most certainty. Accurately identifying, measuring and mitigating risks that can impact that return is a critical piece of making a sound location decision. The planning stage for new capacity is the most advantageous time to understand and mitigate risk.

There is no better time to understand and mitigate risks than when a company is in the planning stage for new capacity. And possibly no other decision has more impact on the risk exposure of a facility than the location of that operation. Hurricanes, tornadoes, earthquakes, and other natural
disasters are more common in certain regions, and even certain sites within those regions are at greater risk than others.

Site selection decisions are very complex in nature and include not only evaluation of a location’s risk but also its business environment and ability to maximize the return for the company. The following table lists common considerations for a company making a location decision.

<table>
<thead>
<tr>
<th>Business Environment</th>
<th>Cost</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workforce</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Quality and availability of workforce</td>
<td>• Cost of pay and benefits</td>
<td></td>
</tr>
<tr>
<td>• Labor posture (union versus non-union)</td>
<td>• Training costs</td>
<td></td>
</tr>
<tr>
<td>Site Characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Size and configuration of the site</td>
<td>• Purchase price</td>
<td></td>
</tr>
<tr>
<td>• Soil conditions</td>
<td>• Site preparation costs</td>
<td></td>
</tr>
<tr>
<td>Community Characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Strength of local government officials, including economic development office</td>
<td>• Tax implications</td>
<td></td>
</tr>
<tr>
<td>Logistics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Availability of raw materials</td>
<td>• Freight costs (inbound and outbound)</td>
<td></td>
</tr>
<tr>
<td>• Proximity to customers</td>
<td>• Transportation infrastructure costs</td>
<td></td>
</tr>
<tr>
<td>• Access to transportation infrastructure and services (rail, highway, marine, pipelines, air, etc.)</td>
<td>• Threat to transportation infrastructure from natural or manmade disasters</td>
<td></td>
</tr>
<tr>
<td>• Freight costs (inbound and outbound)</td>
<td>• Escalation of freight costs</td>
<td></td>
</tr>
<tr>
<td>Utilities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Quality and availability of utility infrastructure</td>
<td>• Utility rates (electric, natural gas, water, wastewater, etc.)</td>
<td></td>
</tr>
<tr>
<td>• Utility rates (electric, natural gas, water, wastewater, etc.)</td>
<td>• Vulnerability to outages caused by natural disasters</td>
<td></td>
</tr>
</tbody>
</table>
The ideal location for new capacity is the one that has the best business environment for the development of the project, the lowest investment and recurring costs, and the least risk. But typically, there are tradeoffs, which corporate executives must weigh to make the decision they believe will be the most beneficial in the long run.

An example where business environment and costs may trump avoidance of risk is in the petrochemical industry. The Gulf Coast, in particular the area between Houston and New Orleans, is one of the most developed petrochemical areas in the world. The recent discovery of new shale gas extraction techniques, combined with falling energy prices and the recovery of financial markets, has fueled petrochemical development. Yet, this area is also at high risk for major hurricanes (Category 4 and 5). Hurricanes of this magnitude can cause serious damage and medium- to long-term closures of plants. Even if the plant site is not affected, often the supporting utility infrastructure and service may take weeks to repair, and the plant’s workforce may not be able to get back into their homes to operate the plant.

Nevertheless, the potential benefits of the Gulf Coast for petrochemical projects are in many cases worth the risk. Low energy cost and the rich transportation infrastructure, combining rail, highway, marine, and pipelines to receive raw materials and deliver to their customers, create an atmosphere that provides unique opportunities. As mentioned in previous chapters, sometimes the benefits are worth the risks of locating a vulnerable area.

**Site Selection Process**

The site selection process can generally be divided into four phases:

I. Alignment and Search Region Definition
II. Alternative Identification
III. Alternative Evaluation
IV. Negotiations and Due Diligence

The process of selecting a site can be thought of like a funnel, where one begins with very wide range of alternatives and uses a process of elimination to narrow them down until one site is selected as the best location for the investment. Sound location decisions are made based on both the likely return on the investment in a given location and on the certainty of that return. This certainty is why the identification, measurement, and mitigation of risks during the site selection process is so critical. It also provides an opportunity to consider and choose a location that lowers the supply chain risk of the entire enterprise.

Following is an example of how the site selection process narrows down the location alternatives to the finalist sites.

![Figure 5-1: Site Selection Funneling Process]

During the site selection process, there are several opportunities to identify, avoid and mitigate risks. Primary site selection risks are those that pose a threat to cost (operating or investment), schedule, and predictability and flexibility of future operations. These are all threats to the potential return of an investment. If the investment cost is higher for a given profitability, the return decreases. If the project is delayed, it takes longer to realize that return. And, if the facility has to close or cannot operate at optimal production for any reason, the return is diminished. For this reason, companies avoid or minimize uncertainty and are risk averse in site selection. The following sections detail the four phases of site selection.
Phase I – Alignment and Search Region Definition

In Phase I – Alignment and Search Region Definition, the geographic areas that are projected to be the most attractive for the project are defined. The search region could include continents, countries, states or regions, or individual counties, parishes or cities. The determination of the search region is unique to every project. For industrial projects, the search region is typically determined by a few key factors:

- Proximity of suppliers
- Proximity to customers
- Operating costs
  - Freight costs
  - Energy costs
  - Labor costs
  - Taxes
- Business climate
  - Workforce
  - Infrastructure
  - Political stability
  - Currency stability
  - Government efficiency
  - Security
  - Intellectual property protection

This is the first filter to exclude areas with unacceptable risks from further study. Venezuela, rich in oil, may appear to be an attractive location for an oil processing facility due to its access to raw materials and low energy costs (some of the lowest in the world). However, for many companies, the risks associated with political and currency instability and government inefficiency do not outweigh the benefits. For projects that have sensitive technology, countries that do not offer meaningful intellectual property protection may be eliminated from consideration. For example, projects directly connected the United States of America Department of Defense can only locate in countries that are part of the NATO or Wassenaar agreements.

As noted above, operating costs carry weight when deciding what region of the world to focus siting efforts. The figure below depicts the range of costs that can be expected depending on the region and industry type. Fluctuating utility rates around the globe lead some investments to be more suited in one region rather than another.
Figure 5-2: Examples of Labor Intensive and Capital Intensive Manufacturing Site Costs

Once large regions are determined for further study, areas within those regions may be excluded or included for various reasons. Often these analyses are conducted using Geographic Information Systems. Some evaluations that may be used include:

- Proximity to highways
- Access to rail and/or marine facilities
- Proximity to airport
- Minimum population or workforce
- Average wage rates
- Air quality

This is the second opportunity to identify risk and classify certain risks as unacceptable. Additionally, areas within the search region may be excluded due to risk of natural disasters, as discussed in Chapter 4.

Phase II – Alternative Identification

Once the site region has been defined, all of the site alternatives that are feasible for the project are identified. In a typical site selection process for a large project, between 15 and 30 alternatives may be identified. This involves identifying sites and/or existing buildings that can accommodate all of the unique requirements of the project, which may include the following:

- Site characteristics
  - Size
  - Configuration
- Topography
- Soil conditions
- Access

- Building characteristics (if applicable)
  - Size
  - Bay spacing
  - Ceiling height
  - Loading docks

- Utilities infrastructure and service
  - Water
  - Wastewater
  - Electricity
  - Natural Gas

- Transportation infrastructure and service
  - Rail
  - Highway
  - Marine
  - Pipelines

- Favorable environmental conditions
  - Absence of environmental hazards from previous use
  - Minimal impact to cultural, archaeological or biological assets
  - Absence of wetlands

Any sites or buildings that do not meet the minimum project requirements are eliminated, and the rest further analyzed in Phase III. It is common for 10 to 20% of the identified sites to be eliminated during this phase.

**Phase III – Alternative Evaluation**

Phase III – Alternative Evaluation involves evaluating the remaining alternatives on cost, risk and scoring of qualitative factors. This includes looking at hundreds of data points for each site in order to better understand its fit for the project. In Phase II, a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis is developed as one of the first steps to identifying site-specific risks and threats. These risks are further developed as more information is gathered in subsequent phases. If any of the risks identified in the SWOT analysis or in subsequent investigations are deemed to be fatal flaws, then the alternative is eliminated from further consideration.
Phase III can be used as a platform to incorporate the costs to mitigate or avoid weaknesses and risks that were previously identified. For example, if the site is in an area of high seismicity, additional costs can be added to that site evaluation to account for resilient design and construction that minimizes seismic risk. If air quality in the region is poor, additional investment in pollution control equipment or the purchase of air emission credits may be required. Also, additional time in the schedule may be needed to allow for additional hurdles in environmental permitting.

Typically, what begins as 12 to 25 sites at the beginning of the phase is narrowed to 4 to 8 alternatives based on low costs, attractive qualitative characteristics and what are perceived to be manageable and/or acceptable risks. For this smaller number of alternatives, a full location-dependent risk assessment is developed. As noted previously, risks to cost, schedule and/or security and flexibility in future operations is assessed according to its probability and potential impact to determine a risk score.

Costs, the weighted comparative score for qualitative characteristics and the risk score are key factors in determining which location is the most suitable for the project. The results of these factors are compiled into a composite analysis as seen in Figure 5-3. The qualitative characteristics are scored on the x axis and the costs on the y axis. The risk scores are reflected in the size of the circle with smaller circles, indicating less risk.

![Figure 5-3: Example Composite Analysis of Various Sites](image)

From this evaluation, the two best alternatives are chosen for further assessment and negotiations in Phase IV.
**Phase IV – Negotiations and Due Diligence**

In Phase IV – Negotiations and Due Diligence, detailed analyses are performed on remaining alternatives. At this point, it is important to conduct due diligence to identify any previously unknown risks and adequately measure and mitigate those risks where possible.

Activities during the due diligence effort include detailed legal property surveys, geotechnical studies, environmental assessments, wetlands delineation and remediation plans, traffic studies, and other efforts that will accurately characterize the site.

Because it is possible that a fatal flaw or unacceptable risk may be uncovered during Phase IV, two sites – a primary and a backup – are included in the assessment. By moving forward with a preferred and alternative site in the due diligence process, even if most of the time and effort is spent on the preferred site, the company will not lose all the time that is spent during this phase should the preferred site be eliminated.

Phase IV is the last opportunity to mitigate risks in the site selection process. Sometimes, risk can be mitigated through incentive negotiations. Incentives are typically in the form of tax breaks or cash grants. These are sometimes seen as corporate charity, but the incentives typically pay for themselves through increased tax revenue and economic activity in the region. Incentives play an important role in site selection. While they cannot make a bad location good, they can make a good location better, helping a site have higher returns with greater incentives than competing sites.

Most often, incentives are focused on leveling the playing field when it comes to tax breaks and cash grants. If one site has higher costs for investment or operating than the other, incentives may be a way to offset those costs. For example, South Carolina has very high property taxes on industrial property relative to other states. Typical tax rates are around 1 to 1.5% of book value, but in South Carolina those rates can be between 3 to 4%. In response, South Carolina counties use a fee-in-lieu-of-taxes (FILOT) mechanism to reduce those tax rates so that they can remain competitive with surrounding states.

One location may also have higher costs because of the additional investment required to offset risks and/or weaknesses associated with a site. Poor soil conditions require greater investment in foundations. Being in a flood plain requires that the site be raised to a higher elevation. Electric reliability risks may require greater infrastructure development to build in
redundancy. Incentives can help offset these costs so that the site will not be penalized in the decision process.

Conclusion

Natural disaster risks are one of a number of risks that a company may face at any given location. Identifying and accurately weighing those risks is critical for selecting an optimal site.

Bibliography

1. Conway Data New Plant Report 2012. (This includes projects costing at least US$1 million, covering 20,000 sq. ft. or employing at least 50 people.)

2. 2013 Corporate Survey conducted by Area Development Magazine.
Resilient Design

Risk management for natural hazards should be considered in the front-end planning and design for new facilities. Resilient design should ideally be incorporated during the initial design of the facility as the costs are significantly lower than retrofitting the facility post-construction. Figure 6.1 depicts the project cost/influence curve and illustrates the tendency of decreasing influence and increasing costs of change as a project progresses toward completion. After construction, the cost of increasing resilience through retrofits to a facility increases further as a result of disruptions to operations.

In many cases, engineering efforts are counterproductive towards resilience as a result of value engineering. The goal of value engineering is to reduce project costs without reducing functionality. However, value engineering efforts often do not take resilience into consideration. The immediate benefit-to-cost ratio of increased resilience is not seen, and shortsightedness causes Figure 6-1: Cost-Influence Curve
resilient features to be eliminated or overlooked. One approach to ensure that resilience is not overlooked is to make sure the resilient design parameters are explicitly identified within the design basis of the facilities and systems.

Resilient design, like mitigation retrofits and pre-event planning, should be based upon a design threat and recovery time objective (RTO). For example, an emergency operations center (EOC) is critical before and after a disaster event. The EOC coordinates and directs information and resources at the strategic level, working to maintain organizational continuity and to protect life and property. An EOC should be designed to withstand the maximum probable threat at a minimal recovery time objective. In the Florida Keys, for instance, an EOC should be designed to withstand a strong Category 5 hurricane with an RTO no longer than that required to transition to auxiliary utilities. Most industrial facilities will have a longer RTO and will design to a lesser magnitude event than an EOC, as it is often more cost-effective to transfer excess risk over a certain threshold to a third party (insurance). Defining threat magnitudes and RTOs will be discussed in more detail in the risk management section within Pre-Event Planning.

Resilient design should follow a defined process, understanding threats and designing facilities to an allowable level of risk. Resilient design should acknowledge that modern facilities are a system of systems. Each system required for the facility to remain functional should be designed to meet the desired level of resilience. Beyond life safety considerations such as prevention of progressive collapse and ensuring evacuation routes, building designs should focus on maintaining structural integrity of the building envelope and protecting critical building equipment. Where it is possible, critical equipment should be redundant, separated and physically protected.

**Resilient Design – A Case of Community Action**

As previously discussed, resilient design accounts for recovery time objectives, the design threats based upon criticality of the facility and the location. Based upon lessons learned from Superstorm Sandy, many communities and jurisdictions have moved forward with building code and zoning regulation revisions to increase resilience within their communities.

To address the destruction from Sandy, the New York City Department of Buildings was tasked with developing plans for both the short-term response and the long-term recovery within their district. In the execution of these activities, the group also collected flood-related data that they have formed into compelling arguments supporting stronger zoning regulations.
The Department of Buildings found that the FEMA Flood Insurance Rate Maps (FIRMs) were outdated and that the storm surge from Sandy was nearly 30% higher than the previous record set by Hurricane Donna in 1960. Of the affected buildings, 50% of the residential units, 60% of all impacted buildings and 23% of all red-tagged buildings were outside of the 100-year flood zone. (‘Red-tagged’ buildings are those that are too damaged to inhabit.) The review indicated that the FIRMs were not as accurate as the state of the art allows, and because of the uncertainties around climate change, additional freeboard was necessary. This led to significant changes in the 2013 FIRMs.

Generally though, FIRM related regulations were effective: post-FIRM buildings only accounted for 14% of the buildings in the inundation zone and only 4% of the red-tagged structures. The table below suggests that flood mapping and building codes helped to avoid losses in the regions affected by Sandy(1).

<table>
<thead>
<tr>
<th>Year Built</th>
<th>Inundation area</th>
<th>Red tags</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before 1983</td>
<td>84%</td>
<td>95%</td>
</tr>
<tr>
<td>1983-2001</td>
<td>9%</td>
<td>3%</td>
</tr>
<tr>
<td>2002 or later</td>
<td>5%</td>
<td>1%</td>
</tr>
<tr>
<td>No data</td>
<td>2%</td>
<td>1%</td>
</tr>
</tbody>
</table>

The New York City Department of Planning took proactive measures to develop and gain approval on a zoning amendment to encourage flood-resilient building construction throughout designated flood zones. These flood-resilient zoning modifications mandate flood-resistant construction. The modification dictates that the lowest habitable floor must be located a minimum of 2 feet above base flood elevation (BFE) as determined by the revised 2013 FIRM and that all mechanical systems must be above the BFE. These efforts will reduce vulnerability to future floods, as well as help to avoid resulting higher flood insurance premiums(2).
Pre-Event Planning: Threat Identification, All Hazards Assessment, and RTO Determination

As discussed in Chapter 2, there are a number of hazards, both natural and human-caused, that can threaten a site. These hazards can range greatly in severity and can threaten a company’s ability to keep its people and facilities safe, protect the environment, and remain operational. Typically, human-caused hazards are less predictable and are often more difficult to plan for and mitigate against. As discussed in the primer, this book primarily addresses natural hazards, though the concepts can be adapted to human-caused hazards.

In the initial steps of resilience planning, it is critical to identify the potential hazards (threats) to a given site. The likelihood that an event will occur varies geographically. Some areas have virtually no risk of some events occurring (such as a hurricane in Kansas), but most areas are at risk of multiple hazards. An analysis of the site and region should be performed to determine the most likely and most severe threats. A number of government agencies worldwide have developed resources to help analyze threats. A partial list of publicly available tools to assist with performing the threat identification in the United States includes the following:

- Hazus-MH
- USGS hazard mapping images and data
- NOAA National Geophysical Data Center Natural Hazards Viewer
- NOAA’s National Weather Service Storm Prediction Center
- NOAA’s National Weather Service’s Sea, Lake, and Overland Surges from Hurricanes (SLOSH) Model
- Datasets from the National Hurricane Center
- Colorado State University’s Tropical Meteorology Project
- Wildland Fire Potential data from the Fire, Fuel, and Smoke Science Program (USDA Forest Service, Fire Modeling Institute)

Many states have their own datasets that are publicly available, such as the Colorado Wildfire Risk Assessment Portal. In addition to publicly available data, catastrophe modelers offer services that can provide more detailed simulations and analyses, primarily geared towards insurance markets.
Earthquakes occur most frequently along fault lines, and tropical cyclones (also referred to as hurricanes and typhoons) occur most frequently in coastal regions bordering relatively warm water. This likelihood can be expressed as an annual probability (5% chance per year), or as a return period (20-year return period). A 20-year return period is an average recurrence interval over a long period, and in this example, corresponds to a 5% chance of occurrence per year. This does not mean that one event will happen every 20 years. The probability of a 20-year event occurring at least once in 20 years is roughly 65%\(^*\).

Events are also classified by their magnitude. For example, tropical cyclones are often categorized by 1-minute sustained winds and earthquakes are often categorized by peak ground acceleration (PGA) as a percentage of gravity.

Risk management decision makers should estimate the maximum design threat (T\(_{\text{max}}\)) that they would like to improve resilience against. This decision should be driven by the risk appetite of a company. A risk-averse company may choose to mitigate to a theoretical maximum event such as a strong category 5 hurricane, whereas a company with a high risk appetite may choose to not mitigate their facilities at all. There are a number of different ways to set the T\(_{\text{max}}\), illustrated by the following:

- A risk manager of a tire manufacturer believes that his facility has an expected useful life of 50 years. He does not know exactly what threat he wants to mitigate to, but he knows that he wants to mitigate to a 50-year return period.
- An offshore oil platform is susceptible to hurricanes. The risk manager is highly concerned with any human health and environmental issues related to possible failure. She wants to mitigate the facility to withstand the strongest hurricane winds on record, or approximately 190 mph. This corresponds to an incredibly strong category 5 hurricane.
- Bill owns a new shoe company in the San Francisco Bay area. His site is prone to strong earthquakes, but Bill, just ramping up production, has a high-risk appetite and chooses not to invest in mitigation. Instead, he invests the money in higher output production equipment.

Once the threat has been identified, management should determine the maximum acceptable downtime if T\(_{\text{max}}\) occurs. This is referred to as the recovery time objective (RTO), or the time at which the business processes

\[ P_n = 1 - (1 - \frac{1}{T})^n \], where \( P_n \) is the probability of at least one event occurs in \( n \) years, \( n \) is the number of years, and \( T \) is the return period, so in this case, \( P_{20} = 1 - (1 - \frac{1}{20})^{20} \)
must be restored after the event. This can also be decided upon using a variety of methods.

Some facilities may have enterprise redundancy (such as alternate service sites that clients can be directed to), so management may decide to design to a lesser resilience and higher RTO. As discussed in the previous chapter, critical government assets, such as emergency operations centers (EOCs), may set an RTO of zero for a very large-scale hazard because they are expected to remain operational during any size event. Most facilities lie somewhere in between these two examples. Based upon daily profit or other financial factors, a company may set their RTO based on a maximum potential downtime loss for the design threat. Others often take a less analytical approach and come to an internal consensus based upon general risk tolerances.

The $T_{\text{max}}$ paired with its corresponding RTO create a target. To track progress towards this target, it is critical to start with a baseline. Though often difficult to predict downtime (business interruption) due to system complexities and external factors, resilience researchers and practitioners are developing techniques to do so more accurately. Using the critical path discussed in Chapter 3 as a guideline, risk managers can often estimate the potential business interruption time frame based on identified vulnerabilities. This baseline, referred to as the current recovery time (CRT), should be developed early in the resilience planning process.

**Vulnerability Assessments**

**Dimensions of Vulnerability**

Potential vulnerabilities may be hard assets, such as facilities and equipment, or the vulnerabilities may be organizational, such as employees and corporate governance. Management should work with subject matter experts in appropriate fields (engineers, inspectors, IT professionals, etc.) to perform a site-wide (and in some cases, enterprise-wide) vulnerability assessment. This book provides a framework for vulnerability assessment, dividing vulnerability into nine dimensions. These dimensions of vulnerability are detailed in the following section.
1. **Facility**
   “Facility” refers to the structural integrity of onsite buildings including manufacturing, warehousing, administrative, and other facilities necessary for business operations.

   Buildings serve the purpose of housing the resources necessary for business operations. In many cases, the building structure serves as the primary means of protection for critical assets during a disaster event.

2. **Equipment**
   “Equipment” refers to all necessary machinery and hardware required for business operations, such as automated manufacturing systems, vessels and pumps, material handling equipment, fixtures, job aids, maintenance tools, vehicles, and computers.

   Equipment failures can have serious consequences for a company. Downtime is unavoidable when critical equipment fails. Investing in spare equipment minimizes downtime but is not practical in many cases. Even worse, some equipment may have long lead times, meaning operations could be down for months or even more than a year in extreme cases.

3. **Onsite Utilities**
   “Onsite utilities” encompasses all onsite systems, such as electricity, compressed air, natural gas, propane, water, sanitary sewer, storm sewer, chilled water, steam, and other utility systems maintained by the company. For purposes of this discussion, these utilities can be broken down into two distinct categories: produced, distributed, and/or managed onsite; and connected to public utility. Utilities that are connected to public utilities offsite are classified as infrastructure. Onsite utilities only includes generation and distribution of utilities onsite, whereas offsite utility generation and distribution to the site is covered in the “infrastructure” dimension.

   Onsite utility disruptions can impact both operations and administration. As discussed previously, operations are critical to company success, but administration should not be overlooked. For example, an outage that impacts timely financial reporting or payment of employees can have significant consequences.

4. **IT Systems and Data Management**
   “IT Systems and Data Management” refers to onsite communication and data systems (hardware and software) as well as the management of company data. Data management includes access, storage, maintenance, and security of data critical to the company. Data, such as plans, design
documents, schematics, diagrams, manuals, procedures, regulatory requirements and other operational documents, may be in digital or paper form.

IT system failures and mismanagement of data can have serious consequences for a company. Manufacturing can stop without availability of design specifications, heavy fines may be imposed for noncompliance with regulatory requirements, a competitive advantage may be lost if intellectual property is lost to competitors, or a leak of sensitive information to the public may result in a negative impact on reputation.

5. Employee
“Employee” includes all necessities required to support basic needs (and to some extent, comfort) of employees, including food, water, shelter, and security. Many components of this dimension are dependent upon other offsite facilities and operations, such as temporary housing/shelters, grocery store operations, gas stations, and municipal services (fire department, police, medical services, and schools).

Employees are vital to business operations. Even the most automated processes are vulnerable to downtime due to absence of key personnel. If the community is unable to provide for the basic needs of employees, employees are forced to relocate, leading to business interruption.

6. Infrastructure
“Infrastructure” includes transportation requirements to the site (roads, bridges, tunnels, public transportation, airports, seaports, and rail) and generation and distribution of public utilities to the site. Utilities can include electricity, natural gas, water, sanitary sewer, cellular service, internet connectivity, landline telephone, and other IT requirements.

Offsite infrastructure outages are a common source of disruption to business operations. Relatively minor events, such as a lightning strike to the electric grid, frequently take utilities offline and have the potential to disrupt operations without appropriate mitigation actions.

7. Supply Chain
The “supply chain” assessment identifies critical suppliers and determines which of those have elevated risks (e.g., geographically vulnerable locations, sole source, and long lead time).

A breakdown in the supply chain leading to a single part being unavailable, no matter how small, has the potential to disrupt all downstream processes. An operation with the most robust physical assets is still vulnerable without
mitigation plans to ensure supply of essential materials and services. Unfortunately, studies show that as many as two-thirds of companies do not have visibility beyond their first tier of suppliers\(^3\).

8. **Security**

“Security” includes physical assets (guards, fences, barricades, surveillance systems, access control systems, etc.), personnel and security protocols.

A security breach can affect any company, whether the company is a high-profile target for terrorism or espionage, or simply the victim of a disgruntled employee. Although predicting and preventing damage from intentional human actions can be extremely difficult, sound security systems and protocols minimize the likelihood and impact of a potential threat.

9. **Administration**

“Administration” broadly includes all governance and finance mechanisms related to pre-event preparedness and post-event recovery. Governance includes management-level support and funding of the business continuity program. Business operations depend on critical financial functions. Companies are subject to financial reporting regulations. Cash flow must be maintained to support operations and employees must be paid. Critical financial functions include reporting, accounts payable/receivable, and payroll.

Without management support, business continuity planning can easily become an afterthought within the daily operations of the company. The message from management should consistently align with the stated goal of developing resilience.

**Risk Management**

Companies should perform a complete assessment of all risks and decide how each risk will be addressed. Dimensions of vulnerability identified in the previous section each have an associated risk, which is assessed by determining the likelihood of occurrence and severity of impact to the company. As discussed in Chapter 4, methods for addressing risks vary. An organization with a high risk tolerance may decide to accept the level of risk and take no action, whereas a risk averse company may decide to avoid risks by establishing or even relocating operations to areas not susceptible to hazard. A common method of risk management is transference of risks via insurance policies. The fourth method for risk management, mitigation of risks (or reduction), is discussed in detail in the following section.
Risk Mitigation

The potential to prevent, mitigate, and respond to all risks should be evaluated. With the exception of relocating operations outside the threat zone, avoiding risks associated with natural hazards is impossible. For those incidents that cannot be prevented or avoided, one of the most widely used standards, NFPA 1600, states that companies shall “develop and implement a mitigation strategy that includes measures to be taken to limit or control the consequences, extent, or severity of an incident that cannot be prevented.” Mitigation actions to reduce immediate impacts from an event are not practical in all cases. In most instances, operations are impacted to some extent despite mitigation efforts. Therefore, preparedness and planning for recovery are necessary to ensure operations are restored within the RTO.

This section focuses on mitigation actions taken to reduce the immediate impacts from the event. This typically involves physical strengthening of systems (robustness) and establishing backup systems (redundancy). The goal of mitigation efforts should be to address vulnerabilities so that operations are recovered within the RTO. A partial list of mitigation strategies for the nine dimensions of vulnerability are discussed below.

1. Facility

There are many variants to mitigation but the intent is to establish a configuration of facilities that will support the RTO based upon the $T_{\text{max}}$. Facility mitigation can be addressed by using several methodologies and could include:

- Structural strengthening of a building frame to address potential failures when exposed to maximum threat design conditions

- Addressing upgrades to the building envelope, such as roof improvements, flashing and impacted rated windows

- Where retrofitting of the structure is impractical, the operations may be relocated to a more robust building possessing the appropriate structural capacity

- Building new facilities that meet the desired design criteria

- Establishing redundant operation at another geographically dispersed location

2. Equipment

Equipment mitigation strategies address vulnerabilities to critical equipment. The strategy should prevent damage or establish a means for timely replacement of equipment. The strategy may be as simple as
maintaining duplicate equipment, but in many cases, this is cost prohibitive. Agreements can be maintained with equipment vendors/manufactures to provide replacement of equipment post-event, but again, this may be prohibited by lead times or costs for expensive equipment. In cases where costs or replacement times are prohibitive, the equipment must be physically protected to minimize the risk of damage during an event.

Examples of equipment mitigation strategies include:

- Elevating or diking to prevent flood damage
- Placing equipment on isolation pads to minimize seismic impacts
- Installing mounting brackets designed to withstand wind, seismic, and flood surge loads
- Mounting tanks to prevent uplift during flooding
- Installing expansion joints for connections

3. Onsite Utilities

Onsite utility systems mitigation addresses vulnerabilities to onsite utility equipment and distribution systems. Resilience of utility systems is dependent on the overall utility network, so consideration should be given to the reliability of the offsite infrastructure as well. If the offsite infrastructure supplying the site is highly susceptible to failure, investment in backup systems should be considered instead of strengthening of primary systems.

Procurement and installation time frames should be considered for backup systems. Mitigation of a utility outage affecting a highly critical operation with a small RTO (e.g., 1 hour) likely justifies installation of a backup system on standby. An operation with an RTO of 24 hours may require installation of utility tie-ins, with an agreement via retainer for the backup equipment to be supplied within that time frame. Backup systems installed onsite should be designed to withstand the maximum design threat.

Examples of mitigation strategies include:

- Installing backup equipment or installing transfer switches/tie-ins and establishing agreements with vendors for post-event sourcing (generators, compressors, chillers, boilers, etc.)
- Removing vegetation near power lines, reinforcing poles or burying lines
- Replacing standard conduit with flood rated conduit for below-grade conductors
• Installing expansion joints on piping to protect against shock
• Establishing service agreements for water supply, portable latrines, offsite treatment of industrial waste, and other necessary services

4. IT Systems and Data Management
IT systems and data management mitigation strategies address vulnerabilities within physical IT system infrastructure and weaknesses in data management practices. All critical data and software systems should have a minimum of one form of backup. Paper files should also be backed up electronically. In addition to data necessary for normal business operations, design drawings and specifications for critical assets such as equipment or building systems should be maintained to expedite repairs or reconstruction during post-event recovery.

Examples of mitigation strategies include:

• Protecting onsite IT infrastructure that supports critical operations
• Relocating IT systems to secure offsite facilities
• Maintaining current data management procedures with routine quality assurance audits to verify critical data is protected
• Maintaining offsite backup recordings of data with established retrieval procedures

5. Employee
Employee mitigation addresses vulnerabilities associated with availability of employees following an event. Should a major event impact the area surrounding a company’s facility, it is likely that employees necessary to support operations will be impacted. Depending on availability of temporary housing in the area, employees could be forced to relocate. Based on the maximum design threat, companies should estimate the number of potentially displaced employees along with the availability of temporary housing to determine the need for disaster housing plans. If a significant number of essential employees is at risk of being displaced and temporary housing is likely to be limited, the company may need to find ways to support their employees. This could include defining usable land (either owned or through a memorandum of understanding with a third party), providing housing, and ensuring basic life support (food, water, shelter, fuel, transportation, financial services, etc.) for employees and their families to support restoration of operations within the RTO. In extreme situations, this support could include repairing employees’ homes directly, as employees are much more productive if they can focus on work and are not preoccupied with how to get their home repaired/rebuilt.
6. **Infrastructure**

Infrastructure mitigation addresses vulnerabilities within offsite transportation and utility networks. These efforts are complicated, as companies do not have oversight of these networks. Companies should coordinate with local emergency management officials and utilities providers to identify vulnerabilities and develop potential mitigation strategies for external resources critical to business operations. These actions are best performed as part of a program to establish community resilience, as all sectors need to work together for a common cause.

7. **Supply Chain**

Supply chain mitigation strategies address vulnerabilities within the company’s external supply chain. Critical suppliers should be identified and may include sole-source vendors or suppliers of just-in-time and long lead items. It is also important to consider single sources beyond the first level of the supply chain. A failure of a common source for a company’s primary and alternate suppliers could result in downtime. Business continuity plans (BCPs) should be required of all critical suppliers, and BCPs should be approved by the company. Additional focus should be given to critical suppliers located in highly vulnerable locations.

Examples of mitigation strategies include:

- Establishing alternate suppliers
- Increasing inventory levels

8. **Security**

Security mitigation actions can include physical upgrades to facilities (berms, fence hardening, barriers, bollards, vehicle barriers, etc.), increased surveillance, establishing a hardened command post (typically the EOC with numerous layers of redundant communications and back-up electrical power), standing contracts for surge capacity of security personnel and pre-established post-event security procedures to address surge of contractors needed for recovery operations.

9. **Administration**

Mitigation actions for administration is typically more focused on continuity of operations, which will address management actions, human resources, time keeping, financial services, contingency contracting, procurement, temporary facilities, basic life support, planning, reporting, and communications. These plans should define the organization, the authorities and the overall mission to resume operations in the shortest time practical.
Preparedness & Planning

Companies can reduce an event’s disruptive impacts through mitigation actions, but the risk of downtime cannot be completely eliminated. Significant disruptions may occur due to an event with a magnitude exceeding the maximum design threat or unforeseen system failures. To further increase resilience, the company should establish detailed readiness plans to allow for rapid recovery from disruptive events. The following section discusses suggested readiness activities.

Alignment. All stakeholders should be identified with roles and responsibilities defined and agreed upon. In addition to management internal to the company, stakeholders may also include insurers, local officials, and key contractors. When possible, formal agreements should be established to ensure cooperation and delivery of services in a timely manner.

Rapid Deployment. The recovery mobilization and execution process should be well defined. For recovery, a phased deployment provides the most efficient means of execution by allowing deployment of resources based on the scale of the event. Companies should maintain rapid deployment teams (RDTs), whether internal or contracted, with the capability to rapidly assess damage, develop scopes of work, and mobilize additional resources as needed for the execution of the recovery project. The RDT should consist of multi-functional expertise including project management, project controls, IT, engineering, and procurement/contracting. Equipment and gear necessary to sustain the team during the initial deployment should also be maintained.

Contingency Contracting. Essential resources are limited during a post-event environment. Companies should perform a resource analysis to determine what resources are likely to be required during recovery from a significant event. Consideration also needs to be given to the strain companies will have on their internal resources. For example, a company’s procurement group may have adequate resources to support a large capital project during normal operations but it may be incapable of meeting the sourcing demand for an expedited recovery operation. Factors such as staffing availability, sourcing pool constraints due to impacted local vendors, or impacted procurement systems may overwhelm the department’s resources in a recovery scenario. Standing contracts should be established for those capabilities which will likely be required post-event. Potential post-event services include:

- Full-spectrum disaster recovery
- Power generation
• Fuel supply
• Demolition and debris removal
• Equipment and tools
• Facility restoration and cleaning
• Industrial hygiene
• Communications
• Temporary office space
• Food services
• Water supply
• Waste management
• Medical services
• Helicopter transport

Re-occupancy of Facilities. Safety evaluation of potentially damaged buildings must be performed post-event. The safety evaluations focus on structural integrity and determine if restrictions must be placed on the use of the building. Guidelines for performing safety evaluations have been published by Applied Technology Council (ATC) and serve as the industry standard (ATC-20 for seismic events and ATC-45 for wind and flooding events)\(^{(5,6)}\).

The demand for safety evaluations following a significant event far exceeds the capacity of most jurisdictions, leading to recovery delays. Some jurisdictions have established emergency inspection programs to allow companies to perform safety evaluations utilizing pre-approved private inspectors. Intel, for instance, realized that it did not want to have to wait for government provided inspectors post-event. Management established agreements with the community allowing Intel’s onsite inspectors to certify Intel’s buildings post-event and afterwards, assist the community in certifying other buildings\(^{(7)}\).

The limit of local inspection officials for code inspection during the reconstruction/repair of damaged facilities can also impede recovery. Companies should collaborate with local building officials to develop a comprehensive emergency inspection plan, covering both safety evaluations and reconstruction/repair code inspections. Following Hurricane Katrina, many commercial and government facilities had to delay reopening (for weeks or months) following the completion of repairs because inspectors and code officials were overwhelmed and could not approve facilities\(^{(8)}\).
**Exercises.** Readiness should include routine training and exercises to test and improve recovery plans. Exercises help clarify roles and responsibilities, improve stakeholder coordination, identify resource gaps, and drive continuous improvement. FEMA recognizes seven types of exercises ranging from seminars and other informal discussion-based exercises to full-scale exercises simulating high-stress events involving all stakeholders with actual deployment of resources\(^9\).

**Bibliography**


5. ATC 20. https://www.atcouncil.org/about-atc

6. ATC 45. https://www.atcouncil.org/about-atc


Throughout this book, resilience is defined as the “capability to anticipate risk, limit impact, and bounce back rapidly through survival, adaptability, evolution, and growth in the face of turbulent change(1).” Post-event recovery, as it relates to this definition, involves “bounc[ing] back rapidly through survival, adaptability, evolution, and growth in the face of turbulent change.”

In the post-event scenario, one has ideally anticipated the risk and limited impact through mitigation and preparedness/planning. Response, as defined by the National Response Framework, covers capabilities necessary to save lives, protect property and the environment, and meet basic human needs, and takes place immediately before, during, and in the first few days after a major or catastrophic disaster(2). Recovery efforts are then initiated to help the community get back on its feet. For most cases, response and recovery overlap; many of the damage assessments and restoration actions serve as both response and recovery purposes.

To facilitate expedited recovery, pre-scripted plans should be in place. These plans are designed to accelerate damage assessments, quickly acquire temporary housing and generators (and other equipment), address surge capabilities for professional staff as well as craft labor, and efficiently restore infrastructure. Resilience is built upon pre-event planning. If mitigation, risk reduction measures, and preparedness planning have been executed beforehand, response and recovery requirements are minimized.
However, each event presents new challenges and lessons learned, providing new opportunities to “build back better.” Figure 7-1, adapted from Lallemant\(^3\), shows the relationship between response and recovery and also shows the effects of “building back better,” ultimately creating a stronger entity than before the event. An accelerated recovery will create a steeper trajectory (shorter time frame), and a higher end-point represents a more resilient outcome.

![Figure 7-1: Recovery as a Process for Building Resilience](image)

Previous experience with recovery efforts have provided an extensive list of lessons learned, but the bulk of these can be grouped into the following categories:

- Employee vulnerability
- Resource constraints
- Failed utilities and infrastructure
- Public-private integration

**Employee Vulnerability**

Whether operating a manufacturing facility or a government office, employees are the lifeblood of the operations. If they do not return to work, the recovery is more difficult or even impossible. To make the situation even more challenging, recovery generally requires more labor than normal operations. Not only does the company need all existing employees, but they may also require additional resources to augment pre-event staffing levels to recover in the shortest timeframe possible.
Many companies’ planning efforts do not adequately consider employees. Some companies do not have defined employee assistance programs. Instead, the employers assume that employees will take care of themselves, the employee’s insurance company will handle it, or FEMA will offer assistance. Employees work to provide for their families, and their job is often just a means to do that. In an emergency, their family will, and should, take precedence over their job. If an employer can help their employees and their families, the employees will be much more likely to return to work quickly and fully engaged.

Resource Constraints

After an event occurs, one may find that resources, in the form of fuel, water, food, building material, equipment, labor, or other needs, may be in short supply.

In 2012, Superstorm Sandy made landfall, creating a major fuel shortage. The shortage was triggered by impaired infrastructure, lack of utility power, and distribution and refining facilities disruptions. According to the National Association for Convenience & Fuel Retailing (NACS), “Hurricane Sandy was unlike any storm in recent memory. Like many hurricanes, it hit some of the country’s refining capacity — about 7% of U.S. refining capacity was in the path of the storm.”

The gas supply for the northeast region, which was highly dependent upon the infrastructure, was broken down as follows:\(^4\):

- 42% from regional refineries
- 31% came from other areas of the country via pipeline
- 27% was imported, primarily to the New York Harbor

Customers who did not have standing contingency fuel contracts to supply fuel to their emergency power generators or their employee’s vehicles found themselves in need once the initial supply ran dry. If employers expect to maintain operations and need fuel for operations, they should invest in a contingency fuel contract, as those who had invested suffered minimal interruption as a result of fuel shortage.

Food, water, building material and equipment all have similar disruptive impacts when shortages occur. Food and water requirements should be handled ahead of time. Building materials, to some extent, can be stored, but it may not be cost effective and having established sources outside of the affected area may be a better approach. Heavy equipment is a commodity that is readily available across the country but will quickly become

7-3
constrained after an event. Having a contract with a national supplier is a wise investment, and beyond a simple contract, the company should consider sizing specific equipment needs prior to the event.

**Failed Utilities and Infrastructure**

Many facility owners consider loss of utilities as something outside of their control, but in reality, there are engineered measured that can be taken to ensure the facilities remain operational. For example, with electricity, uninterruptible power supplies (UPS), transfer switches and generators can all be sized by engineers prior to an event. The potential benefits and costs of installing each component should be weighed to determine their cost-effectiveness and potentially develop an execution strategy. At a minimum, simply sizing potential generator requirements and having a means to connect to the facility is crucial to saving time and money.

In previous events, many facility owners were caught unprepared when they lost utilities. The owners had insured their facilities against damage and business interruption. Sometimes though, their business interruption policy did not cover service disruption if the site was not damaged. In these cases, the companies were shut down and had no recourse to recoup lost revenue. Prior to an event, a company should investigate their current policy to ensure that its limitations of coverage are as expected.

As communications networks have bound companies to the grid, many of these companies have inadequate back-up plans for when the networks fail. Communication is becoming increasingly managed by IT, and management is often left under-informed on network risk. In cases where a facility has only one or two ground-based communications networks (for voice and data), other emergency options may need to be investigated. Communications networks are often taken for granted until they are offline. Companies should thoroughly understand how their communications networks impact daily operations. Similarly, companies often do not appreciate the impact that water, sewer, natural gas, cooling water, compressed air, and other utilities have on operations.

**Public-Private Integration is Vital**

There have been efforts by the public sector to get the private sector more engaged in post-event recovery efforts. This is illustrated through the authorization of PPD-8 to induce the private sector to engage in more in-depth planning and to develop recovery plans that will strengthen the resilience of the communities in which they operate(5).
Furthermore, the 9/11 Commission’s recommendations for implementation calls for the development of voluntary, private-sector emergency preparedness standards along with the creation of a voluntary preparedness accreditation and certification program for the private sector. For participation in this program to become commonplace, there will need to be acknowledgement that proper recovery planning is of financial benefit to the private sector and/or insurance industry. The reduced risk can be realized both by the company and the insurer, and the insurer has the opportunity to reduce premiums for their clients based upon proven risk reduction. Beyond the laws and standards, it is sometime wise to establish mutual aid agreements. For example, if the private sector needs to develop a disaster housing plan for its employees it may be able to establish a memorandum of understanding, or MOU, with the local municipality for land use. This could be mutually beneficial because it helps expedite recovery of the private sector, it reduces work load on the public sector, citizens have more immediate housing for their families, and it reestablishes tax revenue to the municipality more quickly.

The public sector has also failed to fully utilize the resources available within the private sector. For example, insufficient resources for building safety assessments (ATC 20 & ATC 45) and building code inspections for reoccupation has delayed recovery by weeks or months. Many municipalities and states do not have the financial capacity to maintain an adequate staff to meet these peaks in demand. The private sector has many individuals with the appropriate qualifications, and if organized nationally, a cost-effective solution could be developed to leverage the private sector in time of need.

One of the latest developments at the international level could help address the public-private integration gap via the World Economic Forum – Disaster Resource Partnership (WEF-DRP), which is an international alliance of engineering and construction (E&C) community companies. Its objective is to develop a cross-sector, professional, and accountable humanitarian response to disasters that has the ability to scale up to meet growing demands: “The vision of the E&C Disaster Resource Partnership is to form an ongoing collaboration with the humanitarian community at the global level and government and other key humanitarian actors at the national level in order to leverage the core strengths and existing capacities of the E&C community before, during and after natural rapid-onset disasters to reduce suffering and save lives.”
Post-Event Response and Recovery Challenges

Response and recovery to a disaster scenario present many unique challenges. Some common issues include:

- Emergency management officials and first responders often face an initial lack of resources.
- Facilities and operations critical to the response efforts such as emergency operations centers, hospitals, and shelters must be maintained.
- Power, fuel, water, food, shelter, and other resources must have alternatives, as primary providers of these services are likely offline.
- Transportation and communication networks are limited.
- Early damage reports are often incomplete and inaccurate, making it difficult to prioritize response efforts.
- Information management is also a common concern. An organized management system allows responders to make informed decisions related to effectively providing essential life services.

Currently, the private sector plays a limited role in the community response. Many facility owners have invested in emergency management personnel, equipment, training, and exercises to ensure readiness for an event that may affect their facilities. A company’s onsite personnel may be involved onsite with implementing shutdown procedures, clearing of buildings, and administering first aid, but in large-scale events, onsite personnel may not be adequately trained or equipped and may rely on the public sector for response. To build community resilience, it is becoming more common for emergency management agencies to integrate the private sector into response and recovery plans. In an ideal scenario, all available resources would cooperate to restore normalcy within the community in the most timely and efficient manner.

There is no distinct transition point from response to recovery. The recovery phase refers to the actions taken to restore operation to pre-event conditions, or a level accepted as the new normal. Recovery efforts should be started as soon as possible and will most likely be initiated while response efforts are ongoing in the surrounding areas. Mobilization of resources for the recovery effort should avoid interfering with ongoing response efforts, but recovery efforts will need to dovetail with these operations to minimize downtime.
Post-Event Recovery Planning

Pre-event planning is essential to accelerated recovery. In order to expedite facility recovery, it is critical to have a Facility Recovery Plan (FRP), which outlines the process for initiating recovery and lays the foundation for a successful project. The following section describes the elements of the FRP.

Developing a Facility Recovery Plan

In support of site a Business Continuity Plan, a Facility Recovery Plan (FRP) should be developed based on the $T_{\text{max}}$ specific disaster scenario and a Recovery Time Objective (RTO). The FRP should outline the plans to be executed in the event of a natural disaster that impacts operations of the site. The mission is to restore facilities to full operational capabilities in an expedited manner.

One of the elements of the FRP should address the methodology for the immediate deployment of support teams to the site that will begin the assessment of damage, draft work plans based on facility priorities, and expedite repairs thus, allowing operations to resume in the shortest timeframe possible. Readiness planning prior to the event is essential to this approach to allow for a rapid recovery. Detailed vulnerability assessments should be performed by discipline engineers thus, ensuring they are familiar prior to the event.

To accomplish the mission, augmentation teams will need to assimilate with the site organization, which will need to be predefined and approved. The structure of the organization will generally mirror the emergency operations team and will dictate both the structure and span of control. The RDT is a key part of the organization and is typically on the site or in a staging area within hours of the initial request for mobilization. As the mission matures, and as required, the organization can expand or contract as necessary to meet mission requirements.

As the mission progresses through the subsequent phases, planning and execution activities will become the focus. One of the most important elements to consider is control whether one thinks of scope, priorities, cost, schedule or quality. To accomplish effective project control, it is imperative to have a pre-scripted plan. The next section steps through a proposed process that starts with the pre-event planning efforts and demonstrates a methodology that can be implemented that will maintain control of recovery effort until the operations have been restored.
The next sections will identify elements that should be considered and included within the FRP.

**Facility Recovery Plan Overview**

First of all, it must be acknowledged that when dealing with a catastrophic event, current facility staff is not adequate to execute an expedited recovery project, and they may be lacking the needed skills. Therefore, you will need the capability to surge professional staff as required to meet the demand. The intent is to develop a plan that will rapidly mobilize a team of personnel in response to a significant event that has affected, or will affect, the operations of the facilities. This plan should be used in conjunction with the Facility Recovery Plan (FRP) that details the timeline, procedures, authorities, alignment measures, and the roles and responsibilities needed to return facilities to normal operations in an expedited manner. The purpose of this plan is to establish the steps needed to mobilize in a controlled fashion, in order to standardize execution and increase the opportunity for success of the recovery project.

This plan can be used in response to hurricanes, earthquakes, floods, tsunamis, and incidents of significance. Utilization of the strategies outlined in this plan will help define the following:

- Scope of work
- Project baseline-focused project management approach
- Roles and responsibilities of individuals within the organization
- Identification and prompt establishment of field functional requirements
- Organizational structure
  - Aligned with the management to improve communications
  - Fit-for-purpose and scaled to accomplish mission
  - Supervision maintains a manageable span of control
- Stakeholder alignment based upon expectations, procedures, and communications
- Establishment of partnership between private industry, federal, state, and local stakeholders
- Training requirements for each discipline upon mobilization
- Care, custody, and control of property
- Utilization of best practices from previous events
- Establishment of a contingency contracting plan
Use of health, safety and environmental (HSE) and quality plans

The FRP was developed to establish a sound and efficient framework to enable a rapid and efficient recovery operation within a contingency environment. Furthermore, the recovery team will need to quickly implement a sound, well-established HSE program, which effectively protects the workers, public, and environment during all phases of mobilization, project execution, and demobilization.

The referenced FRP provides the plan for development and implementation of programs and processes that enable teams to respond quickly and effectively in emergency situations, regardless of their location or significance. The FRP encompasses four distinct efforts and organizational structures, which include:

- Readiness
- Mobilization
- Project execution
- Demobilization

The FRP should also incorporate a monitoring and transition process, along with documented feedback and continuous improvements. This will require the FRP to be updated and enhanced after each deployment and whenever new guidance is issued.

**Readiness**

The intent of the readiness phase will ensure an effective response to any task that may be issued. This is accomplished through the following:

- Compiling procedures and training programs based upon established best practices
- Establishing a contingency contracting plan that includes local, regional, and national contractors with standing agreements for recovery services developed as necessary
- Identifying key personnel for the management of recovery efforts
- Maintaining databases for human resource, equipment, subcontractors and engineering documents that will be needed for recovery operations
- Developing work plans and estimates that will expedite project execution
Cost Control Procedures

Prior to an event, the cost control procedures should be created to ensure that budgets can be established quickly for each work plan. These procedures should encompass:

- A Work Breakdown Structure (WBS) – A subdivision of the project scope of work into manageable elements that form the structure to which the project work will be defined, planned, estimated, scheduled, managed, and controlled.
- Application of all direct and indirect costs.
- Incorporation of changes to the baseline.
- Establishment of objective performance measures to monitor project status and allow correction to negative trends as necessary.
- Explanation of significant cost and schedule variances, both on a cumulative basis and on a project-at-completion basis.

Expedited Task Order Estimating/Evaluation

To meet the objective of expediting task orders, several steps can be taken:

- Utilize a support office out of the affected area, who can focus on expediting estimates to support timeframe of the scope of work.
- Establish necessary resources at the site locations to understand the client requirements and develop the scope of work and execution strategy.
- Utilize proven estimating and subcontracting procedures.
- Develop a prequalified list of subcontractors as part of the contingency contracting strategy.

To expedite task order evaluation and estimating, a clear understanding of the Scope of Work must be established. Estimating and Subcontracts personnel from the support office lend support in preparation of the rough order or magnitude (ROM) estimate. This ROM estimate contains sufficient detail and backup that allows the authorizing party to review and evaluate the scope and costs.

Immediate Deployment of Surge Staffing

To increase the likelihood of success, a Rapid Deployment Team (RDT) can be established in support of the early mobilizations to identify scope of work.
and enable additional resources to be mobilized as required. To save time, it
could be wise to have pre-authorization contracts that can be initiated
immediately in response an event. Upon notice to proceed, the RDT would
mobilize to the designated area to assess and prepare an initial work plan
that would include a scope of work and ROM estimate along with an
execution plan. The RDT is typically comprised of five to six personnel who
are multi-disciplined; their mission is to perform the initial assessments and
to establish base camp as required. If needed, the RDT should have the
capability to call forward the next elements of the recovery team.

**Establishing Base Camp**

Based upon the geographical location, the RDT should locate facilities that
will meet the need of the operations. The facility could act as the initial
receiving and staging operation for resources, then transition to base
operations for the mission. The base camp should have adequate facilities
and utilities to meet the mobilization, housing and operations requirements.
Depending on the assigned task, base operations can act as the central depot
for staff, allowing an element of control as staffing needs may increase. The
base camp can also address any life support (food, water, shelter, fuel,
transportation, ablution, etc.) requirements of the staff, thereby removing
any demand on the surrounding hotels.

**Phases of the FRP**

The strategy of the FRP is to use a phased approach that defines activities
ranging from readiness to closeout. This approach allows for a rapid
response and recovery while providing control of scope, priorities, cost,
schedule and quality as discussed above. The phases, scope, and decision
points are briefly described below:

**Phase I – Readiness**

This phase involves operational readiness and alignment. During this phase,
an emphasis is placed on vulnerability assessments and establishing risk
mitigation plans. Agency and real estate memorandums of understanding
(MOUs) are coordinated, and further detailed planning is conducted based
on the vulnerability findings. An organizational structure is maintained that
will allow access to personnel needed for the RDT and the associated
equipment required. The RDT should monitor ongoing events and
circumstances to proactively and appropriately respond to emergency
situations.
**Phase II – Initial Mobilization**

This phase involves the initial response to a “Warning Order,” which is based on predefined mobilization plans for the RDT. The mobilization plan is developed to deploy field personnel in an effective manner, and the initial mobilization effort covers both compliance and infrastructure deployment.

For the purpose of this plan, there are two types of events:

- **Notice Events.** Preparations can be made prior to the actual event, such as a hurricane, tropical storm, wildfire, and certain types of flooding.
- **Zero Notice Events.** Event planning time is minimized, and immediate mobilization to the disaster location is the highest priority. These events can include earthquakes, fire, critical system failure, etc.

**Phase III – Alignment and Initial Work Plan (IWP)**

Upon arrival onsite, a joint windshield tour will be conducted by the RDT with site personnel for the initial quick assessment. Based upon a windshield assessment, additional assessment team personnel may be mobilized. Goals of this phase:

- Understand the scope of the work required
- Identify potential work elements that can be expedited
- Draft the IWP

Priority work elements will be identified, and a project team can be assigned to expedite the activities, as required.

**Phase IV – Expedited Priority Work Elements**

This phase involves expediting priority work elements such as perimeter fence, debris, road clearing, temporary repairs, critical facilities/utilities, high-priority production areas, etc.

The focus is to achieve limited operational status for the work elements identified. A project expediting team may be required to address these work elements.

**Phase V – Transition to Project Execution**

This phase can be considered as the ramp-up phase, as most of the efforts to this point have been to determine the scope and magnitude of the event.
During this phase, the following work elements will be addressed:

- Detailed assessments are performed by the project execution team.
- Design specifications are acquired.
- The subcontractor plans are developed.
- The WBS and schedule are finalized.
- Quality and HSE plans are submitted and approved.
- The scope of work and cost estimate are finalized.
- Work plans for construction and debris removal are created and submitted for approval.
- Subcontractors are prequalified, and work is sent out for bid.
- Final work plans are prepared and assembled for approval.

**Phase VI – Project Execution**

This phase involves execution of the work plans created above that are now supported by a fully mobilized project team and includes the following:

- An effective management team is established.
- Sound infrastructure (staff housing, office equipment/space, communication devices, electronic databases, etc.) is set up.
- Trained, qualified field and functional support personnel begin work.
- Contacts and interface arrangements with local, state, and federal officials are established.
- Methods for constantly assessing, evaluating, and improving performance during project execution are determined.
- Work packages are provided to subcontractors.
- Subcontractors execute work.
- Quality checks are completed, and turnover packages are created.
- Formal acceptance of full operational capacity is achieved.

**Phase VII – Demobilization and Closeout**

The plan for this phase promotes an efficient method to close out work, demobilize personnel and equipment, and document the completion and client acceptance of work performed. Utilization of defined procedures
ensures that required project completion documentation is compiled and submitted as required and that demobilization efforts are appropriately coordinated.

**Additional Elements of the FRP**

To supplement the FRP the following documents should be considered as appendices, as they are standalone documents but are needed for expedited recovery operations:

- **Scenario Information.** This document contains the detailed information for the location based on the requested disaster scenario, including maps with overlays and a summary of the analysis data.

- **Mobilization Plan.** This document includes mobilization procedures for assembling and staging resources after receiving the request to mobilize, readiness plans, support office, project execution plans, project controls methodology and project preparedness checklists.

- **Debris Management Plan.** The Debris Management Plan considers the proper handling and disposal methods for each debris type that could be generated during the disaster event. This plan includes types of debris anticipated, methods, means, staging locations and appropriate means of disposal.

- **Disaster Housing Strategy.** This document performs a detailed analysis to determine the need for a disaster housing plan and offers a recommendation as to whether one should be created.

- **Disaster Housing Plan.** The plan is created prior to an event and is intended to offer a plan that will expedite a temporary housing solution thus, enabling employees to return to work. This plan assumes that inadequate housing will be available in the affected area and should include location of suitable land, the identification of temporary housing units that will be available post-event, transportation capabilities, setup, occupancy inspections, maintenance, deactivation, restoration, reuse, and return to storage. This plan should also include housing assignment policies, the ability to track occupant data, property data, and any site assessments.

- **Quality Control Plan (QCP).** The QCP describes the policy, organization, and activities used to establish a quality program for a contingency project.
A Path Forward in Recovery

Over the past few decades, the Federal government has invested heavily to create better post event support systems, but they have primarily focused on individual assistance and public assistance. These were both greatly needed, but these efforts have not adequately addressed the private sector, which is typically only assisted through small-business loans. The private sector needs to be engaged and brought into the pre-event planning process to ensure quicker recovery from future events.

The private sector also needs to better understand the threats that they are facing, and in turn, take action. These actions include investing in robust facilities that have redundancies and developing pre-scripted plans that will expedite the recovery operations. The plans should address the fact that there will be limited resources, cost escalation, and a greater need for staff after an event. A contingency contracting strategy that addresses staff augmentation from a local, regional and national perspective is a helpful. Insurers are more frequently requiring pre-event planning and are auditing to ensure that these plans are in place.

When an event does occur, the alignment between the insured and insurer is critical for both parties. Often, misalignment regarding scope and change management processes can lead to legal battles over insurance payouts.

When possible, private sector businesses should engage the public sector to review their recovery plans and to establish memoranda of understanding (MOUs). These actions can streamline post event recovery operations and establish mutual aid agreements prior to an event, expediting recovery. As part of these agreements, creating joint disaster housing strategies and plans can save insurers, the public sector, and private industry time and money by combining efforts and finding ways to consolidate pre-event planning and post-event recovery. In addition, these pre-event relationships and agreements can help resolve post-event logistical challenges, minimizing impediments to the recovery operations.

Working together towards a common goal is beneficial for all parties and leads to a more resilient community.

Bibliography


As discussed throughout the book, we live in an interconnected society. We are only as strong as our weakest links. We must seek to build resilience as a community, working in lockstep with one another. The following suggestions are intended to help us more effectively do so.

**Align Cost and Risk.** We need to better align insurance premiums with risk. Government regulation and other factors often drive premiums, which may not accurately represent risk. Additionally, as a society, we should be cautious with providing programs that potentially incentivize risky behavior.

**Build a Resilience Code.** The implementation of building codes and the advancement of emergency management programs (including disaster preparedness and evacuation) have worked very well to reduce the loss of life from hazard events. As seen in Figure 8-1, the number of disasters reported and the number of people affected has increased drastically, but the loss of life has decreased significantly. Building codes were designed to save lives, and they have done that well. The next step is to create a “resilience code,” designed to minimize impacts to property and business interruption.
Develop Common Understanding. In order to communicate across the four sectors discussed in this book, we must all work from a common understanding. This understanding includes both terminology and evaluation of risk. We must develop a standard vernacular that bridges sectors. We must also create a common language for risk. The concept of a credit score was developed to standardize risk to lenders so individuals could be compared against one another. A “resilience score” should be developed so hazard risk profiles can be compared against individuals, companies, infrastructure, or communities.

Once we have a common language, a means of measuring risk and resilience, then we can financially reward those who have taken appropriate actions. There needs to be a return on investment for making the right decisions, whether that means placing facilities in less vulnerable locations, investing in resilient design or investing in robust pre-event planning. Resilience is not a destination but rather a journey that we must all embark upon as a team.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition &amp; References</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/11 Commission</td>
<td>The National Commission on Terrorist Attacks Upon the United States (also known as the 9-11 Commission), an independent, bipartisan commission created by congressional legislation and the signature of President George W. Bush in late 2002, is chartered to prepare a full and complete account of the circumstances surrounding the September 11, 2001 terrorist attacks, including preparedness for and the immediate response to the attacks. The Commission is also mandated to provide recommendations designed to guard against future attacks. (<a href="http://www.9-11commission.gov">http://www.9-11commission.gov</a>)</td>
</tr>
<tr>
<td>After Action Report (AAR)</td>
<td>A retrospective report that analyzes all aspects of preparations for, response to, and recovery from an event. The AAR identifies strengths and areas for improvement and provides recommendations for future response and recovery efforts. (<a href="http://www.fema.gov/media-library/assets/documents/33772">http://www.fema.gov/media-library/assets/documents/33772</a>)</td>
</tr>
<tr>
<td>Applied Technology Council (ATC-20 &amp; 45)</td>
<td>The Applied Technology Council (ATC) is a nonprofit, tax-exempt corporation with the mission to develop and promote state-of-the-art, user-friendly engineering resources and applications for use in mitigating the effects of natural and other hazards on the built environment. ATC-20 and ATC-45 establish procedures for</td>
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<td>Term</td>
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<tr>
<td>safety inspections of structures following earthquakes and windstorms/floods, respectively. (<a href="https://www.atcouncil.org/about-atc">https://www.atcouncil.org/about-atc</a>)</td>
<td></td>
</tr>
<tr>
<td>Base Camp</td>
<td>Operational base for post-event recovery efforts and may also provide life support for recovery personnel depending on available resources in the impacted area. (<a href="https://www.atcouncil.org/index.php/products/onlinestore">https://www.atcouncil.org/index.php/products/onlinestore</a>)</td>
</tr>
<tr>
<td>Base Flood Elevation (BFE)</td>
<td>The elevation shown on flood insurance rate maps (FIRMs) for indicating the water-surface elevation resulting from a flood that has a 1 percent chance of equaling or exceeding that level in any given year. (At War with the Weather)</td>
</tr>
<tr>
<td>Black Swan Event</td>
<td>Events that come as a surprise, have a major effect, and are often inappropriately rationalized after the fact with the benefit of hindsight. (<a href="http://mitpress.mit.edu/books/war-weather">http://mitpress.mit.edu/books/war-weather</a>)</td>
</tr>
<tr>
<td>Bottleneck</td>
<td>Department, facility, equipment, or resource operating at full capacity which cannot accommodate an increase in throughput, therefore limiting production. (businessdictionary.com)</td>
</tr>
<tr>
<td>Brand Erosion</td>
<td>Deterioration of the aspects of an organization that distinguish it from others within the market. (businessdictionary.com)</td>
</tr>
<tr>
<td>Business Continuity (BC)</td>
<td>An ongoing process to ensure that the necessary steps are taken to identify the impacts of potential losses and maintain viable recovery strategies, recovery plans, and continuity of services. (NFPA 1600)</td>
</tr>
<tr>
<td>Business Continuity Plan (Disaster Management Plan) (BCP)</td>
<td>Set of documents and procedures which establish an organization's response to a disruptive event with the intent of minimizing the impact to business operations. (NFPA 1600)</td>
</tr>
<tr>
<td>Business Interruption (BI)</td>
<td>Disruption to normal business operations. (businessdictionary.com)</td>
</tr>
<tr>
<td>Commodities</td>
<td>A reasonably homogeneous good or material bought and sold freely as an article of commerce. Examples include food staples, oil and gas, and metals. (businessdictionary.com)</td>
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<tr>
<td>Term</td>
<td>Definition &amp; References</td>
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<tr>
<td>Contingency Contracting Plan</td>
<td>Defines the methods used for sourcing of services following a disruptive event (typically large scale event). (businessdictionary.com)</td>
</tr>
<tr>
<td>Critical Path</td>
<td>Longest sequence of activities in a process which must be completed on time for there to be no production delays.</td>
</tr>
<tr>
<td>Critical Path Method (CPM)</td>
<td>Network analysis technique used in complex project plans with a large number of activities. CPM diagrams all activities, time required for their completion, and the interdependencies of each activity. (businessdictionary.com)</td>
</tr>
<tr>
<td>Criticality</td>
<td>A measure of the level of importance of an organization's network components. The loss of a highly critical component would have a severe consequence to the organization. (businessdictionary.com)</td>
</tr>
<tr>
<td>Current Recovery Time (CRT)</td>
<td>The expected operational downtime for a given event under the current conditions as related to preparedness.</td>
</tr>
<tr>
<td>Debris Management Plan</td>
<td>The plan considers the proper handling and disposal methods for each debris type that could be generated during the disaster event. The plan includes types of debris anticipated, methods, staging locations, and appropriate means of disposition. (Section 2.6)</td>
</tr>
<tr>
<td>Demobilization</td>
<td>The process of disbanding personnel, equipment, and other resources as a project effort draws down.</td>
</tr>
<tr>
<td>Department of Homeland Security (DHS)</td>
<td>Federal agency responsible for ensuring homeland safety, security, and resilience against terrorism and other hazards. (dhs.gov)</td>
</tr>
<tr>
<td>Direct Loss</td>
<td>Property loss caused by an unbroken chain of events covered under an insurance policy. (businessdictionary.com)</td>
</tr>
<tr>
<td>Disaster (Natural And Man-Made)</td>
<td>An event that results in the need for physical and economic assistance from outside sources. A U.S. natural disaster is deemed significant when the economic loss is at least $1 billion and/or over 50 deaths are attributed to the event. (businessdictionary.com)</td>
</tr>
<tr>
<td>Term</td>
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<tr>
<td>Disaster Housing Plan</td>
<td>Document outlining the procedures for establishing disaster housing. The plan should include pre-identifies sites, design documents for housing units and supporting systems, and other information necessary to rapidly establish disaster housing capability following an event. (<a href="http://www.springer.com/business+%26+management/finance/book/978-0-387-23082-5">http://www.springer.com/business+%26+management/finance/book/978-0-387-23082-5</a>)</td>
</tr>
<tr>
<td>Disaster Housing Strategy</td>
<td>Document assessing the need and various options for meeting disaster housing requirements.</td>
</tr>
<tr>
<td>Downtime</td>
<td>Period of time in which an organization is incapable of operating.</td>
</tr>
<tr>
<td>Emergency Operations Center (EOC)</td>
<td>Central command facility responsible for directing emergency management operations during an emergency situation.</td>
</tr>
<tr>
<td>Enterprise</td>
<td>A business or organization. (businessdictionary.com)</td>
</tr>
<tr>
<td>Event</td>
<td>In the context of this book, an occurrence resulting in negative consequences due to system vulnerabilities.</td>
</tr>
<tr>
<td>Facility Recovery Plan (FRP)</td>
<td>Document outlining the steps to be taken for the preparation, mobilization, and execution of recovery efforts.</td>
</tr>
<tr>
<td>Fee-In-Lieu-Of-Taxes (FILOT)</td>
<td>An agreement between an industry member and a government to reduce taxes (typically property taxes) as an incentive for large-scale investment in the area. (<a href="http://www.springer.com/business+%26+management/finance/book/978-0-387-23082-5">http://www.springer.com/business+%26+management/finance/book/978-0-387-23082-5</a>)</td>
</tr>
<tr>
<td>First-Tier Supplier</td>
<td>A company who supplies parts and materials directly to a manufacturer of goods. (<a href="http://dictionary.cambridge.org/us/dictionary/business-english/first-tier-supplier">http://dictionary.cambridge.org/us/dictionary/business-english/first-tier-supplier</a>)</td>
</tr>
<tr>
<td>Flexibility (Production Flexibility)</td>
<td>The ability of a system, such as a manufacturing process, to cost effectively vary its output within a certain range and given timeframe. (businessdictionary.com)</td>
</tr>
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<td>Term</td>
<td>Definition &amp; References</td>
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<tr>
<td>Flood Insurance Rate Map (FIRM)</td>
<td>Official map of a community that has delineated both the special hazard areas and the risk premium zones applicable to the community. (<a href="http://mitpress.mit.edu/books/war-weather">http://mitpress.mit.edu/books/war-weather</a>)</td>
</tr>
<tr>
<td>Global Information Systems (GIS)</td>
<td>An organized collection of computer hardware, software, and geographic data designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information. (<a href="http://mitpress.mit.edu/books/war-weather">http://mitpress.mit.edu/books/war-weather</a>)</td>
</tr>
<tr>
<td>Globalization</td>
<td>The worldwide movement toward economic, financial, trade, and communications integration. (businessdictionary.com)</td>
</tr>
<tr>
<td>Hazard</td>
<td>Source of potential harm. (ISO)</td>
</tr>
<tr>
<td>Hazard Assessment</td>
<td>Evaluation and ranking potential hazards by their estimated frequency and intensity. (businessdictionary.com)</td>
</tr>
<tr>
<td>Hazard Map</td>
<td>Geographical map of hazards depicting areas at various scales that are susceptible to hazards. (businessdictionary.com)</td>
</tr>
<tr>
<td>Hazus-MH</td>
<td>Hazards, U.S., the U.S.’s nationally applicable standardized methodology and software program for analyzing catastrophes. The model was first introduced in 1997, estimating loss from earthquakes. In 2004, the model was renamed HAZUS-MH (multi-hazard) and wind and flood loss estimation models were added. (Catastrophe Modeling)</td>
</tr>
<tr>
<td>Lead Time</td>
<td>The duration of time from the initiation to completion of an action or process. In reference to procurement, it is the amount of time from purchase order to receipt of the goods.</td>
</tr>
<tr>
<td>Maximum Design Threat (T_{\text{max}})</td>
<td>The magnitude of threat which an organization will plan and design systems against in order to enable operations to be restored within the Recovery Time Objective.</td>
</tr>
<tr>
<td>Memorandum of Understanding (MOU)</td>
<td>A document that expresses mutual accord on an issue between two or more parties. (businessdictionary.com)</td>
</tr>
<tr>
<td>Term</td>
<td>Definition &amp; References</td>
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</tr>
<tr>
<td><strong>Mitigation</strong></td>
<td>Activities taken to reduce the impact from hazards. (<a href="http://www.nfpa.org/codes-and-standards/document-information-pages?mode=code&amp;code=1600">http://www.nfpa.org/codes-and-standards/document-information-pages?mode=code&amp;code=1600</a>)</td>
</tr>
<tr>
<td><strong>Mitigation</strong></td>
<td>Loss reduction measure taken to reduce or eliminate damage or loss due to a natural or man-made hazard. (Catastrophe Modeling)</td>
</tr>
<tr>
<td><strong>Mobilization</strong></td>
<td>Activation of resources in support of a project to include field and supporting office operations. (<a href="http://www.springer.com/business+%26+management/finance/book/978-0-387-23082-5">http://www.springer.com/business+%26+management/finance/book/978-0-387-23082-5</a>)</td>
</tr>
<tr>
<td><strong>Mobilization Plan</strong></td>
<td>Document outlining the steps to be taken for mobilization of resources in support of a recovery operation.</td>
</tr>
<tr>
<td><strong>National Hurricane Center (NHC)</strong></td>
<td>The NHC mission is to save lives, mitigate property loss, and improve economic efficiency by issuing the best watches, warnings, forecasts, and analyses of hazardous tropical weather and by increasing understanding of these hazards. (<a href="http://www.nhc.noaa.gov/aboutintro.shtml">http://www.nhc.noaa.gov/aboutintro.shtml</a>)</td>
</tr>
<tr>
<td><strong>National Oceanic and Atmospheric Administration (NOAA)</strong></td>
<td>Established in 1970, this federally run organization monitors and predicts the state of the Earth, the oceans and their living resources, and the atmosphere. (<a href="http://www.springer.com/business+%26+management/finance/book/978-0-387-23082-5">http://www.springer.com/business+%26+management/finance/book/978-0-387-23082-5</a>)</td>
</tr>
<tr>
<td><strong>National Weather Service (NWS)</strong></td>
<td>The NWS mission is to provide weather, water, and climate data, forecasts, and warnings for the protection of life and property and enhancement of the national economy. (weather.gov)</td>
</tr>
<tr>
<td><strong>Node (Critical Node)</strong></td>
<td>An asset, or group of assets, within a network.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition &amp; References</td>
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<td>-------------------------------------------</td>
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</tr>
<tr>
<td>Notice Event</td>
<td>An event which can be forecasted to the extent which allows for preparations to be made prior to impact. For example, a hurricane is a notice event.</td>
</tr>
<tr>
<td>Operations</td>
<td>Operations transform resources or data inputs into desired goods, services, or results, and deliver value to the organization and customers. (businessdictionary.com)</td>
</tr>
<tr>
<td>Peak Ground Acceleration (PGA)</td>
<td>The maximum absolute magnitude of a ground acceleration time series, as measured during an earthquake event; PGA is often used as an indicator of damage in a catastrophe model. (<a href="http://www.springer.com/business+%26+management/finance/book/978-0-387-23082-5">http://www.springer.com/business+%26+management/finance/book/978-0-387-23082-5</a>) Catastrophe Modeling</td>
</tr>
<tr>
<td>Preparedness</td>
<td>Ongoing activities, tasks, and systems to develop, implement, and maintain an organization's capability to effectively respond and recovery from an event. (NFPA 1600)</td>
</tr>
<tr>
<td>Presidential Policy Directive 8 (PPD-8)</td>
<td>Presidential directive issued on March 30, 2011 aimed at strengthening the security and resilience of the United States through systematic preparation for the threats that pose the greatest risk to the security of the Nation, including acts of terrorism, cyber-attacks, pandemics, and catastrophic natural disasters. (<a href="http://www.dhs.gov/presidential-policy-directive-8-national-preparedness">http://www.dhs.gov/presidential-policy-directive-8-national-preparedness</a>)</td>
</tr>
<tr>
<td>Prevention</td>
<td>Activities to avoid or stop an incident from occurring. (NFPA 1600)</td>
</tr>
<tr>
<td>Probabilistic Model</td>
<td>In relation to hazard modeling, a statistical model that predicts the likelihood of an event occurring based on historical data.</td>
</tr>
<tr>
<td>Project Baseline</td>
<td>A document, or set of documents, which defines contractual requirement, scope of work, budget, schedule, and other elements necessary to successfully execute and manage a project.</td>
</tr>
<tr>
<td>Project Closeout</td>
<td>Project closeout is the sequence of activities required to complete all remaining project financial matters, satisfy all outstanding contractual requirements, and document project history.</td>
</tr>
<tr>
<td>Project Cost/Influence Curve</td>
<td>A graph depicting the increasing cost and decreasing influence planning efforts and engineering changes have as a project progresses toward completion.</td>
</tr>
<tr>
<td><strong>Term</strong></td>
<td><strong>Definition &amp; References</strong></td>
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<tr>
<td>Ps-Prep</td>
<td>The Voluntary Private Sector Preparedness Program: A voluntary accreditation and certification program designed to improve the preparedness of private sector organization through conformance to consensus-based preparedness standards and best practices (based on NFPA 1600).</td>
</tr>
<tr>
<td>Quality Plan</td>
<td>A document or set of documents that describe the standards, quality practices, resources and processes pertinent to a specific product, service, or project.</td>
</tr>
<tr>
<td>Rapid Deployment Team (RDT)</td>
<td>A multi-functional team that maintains constant readiness for mobilization with the objective of defining initial scope of work and establishing the foundation for mobilization of additional resources.</td>
</tr>
<tr>
<td>Readiness</td>
<td>Condition of being prepared and capable to act or respond as required. (dhs.gov)</td>
</tr>
<tr>
<td>Recovery</td>
<td>Activities and programs designed to return conditions to a level that is acceptable to the organization. (<a href="http://www.nfpa.org/codes-and-standards/document-information-pages?mode=code&amp;code=1600">http://www.nfpa.org/codes-and-standards/document-information-pages?mode=code&amp;code=1600</a>)</td>
</tr>
<tr>
<td>Recovery Time Objective (RTO)</td>
<td>The extent of operational downtime for a given event that is acceptable to the organization.</td>
</tr>
<tr>
<td>Redundancy</td>
<td>Repetition of systems, or parts of systems, to provide backup in case of primary system failure. (businessdictionary.com)</td>
</tr>
<tr>
<td>Re-Occupancy</td>
<td>The process of certification of repairs to a damaged facility to allow occupancy and operations.</td>
</tr>
<tr>
<td>Resilient Design</td>
<td>Design that exceeds the level of robustness and/or redundancy of the life safety code such that impact to facilities and associated systems from disruptive events is minimized.</td>
</tr>
<tr>
<td>Response</td>
<td>Immediate and ongoing activities, tasks, programs, and systems to manage the effects of an incident.</td>
</tr>
<tr>
<td>Term</td>
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<td>that threatens life, property, operations, or the environment.</td>
<td>(<a href="http://www.nfpa.org/codes-and-standards/document-information-pages?mode=code&amp;code=1600">http://www.nfpa.org/codes-and-standards/document-information-pages?mode=code&amp;code=1600</a>)</td>
</tr>
<tr>
<td>Return Period (Frequency, Annual Probability, Recurrence Interval)</td>
<td>The expected time between a certain magnitude of loss event, defined as the inverse of the annual exceedance probability. For example, a return period of 100 years corresponds to an annual exceedance probability of 1 percent. (<a href="http://www.springer.com/business+%26+management/finance/book/978-0-387-23082-5">http://www.springer.com/business+%26+management/finance/book/978-0-387-23082-5</a>)</td>
</tr>
<tr>
<td>Risk</td>
<td>The effect of uncertainty on objectives often expressed in terms of a combination of the consequences of an event and the associated likelihood. (<a href="http://www.iso.org/iso/catalogue_detail?csnumber=44651">http://www.iso.org/iso/catalogue_detail?csnumber=44651</a>)</td>
</tr>
<tr>
<td>Risk Appetite</td>
<td>The amount and type of risk that an organization is willing to pursue or retain. (<a href="http://www.iso.org/iso/catalogue_detail?csnumber=44651">http://www.iso.org/iso/catalogue_detail?csnumber=44651</a>)</td>
</tr>
<tr>
<td>Risk Management - Transference, Reduction, Avoidance, Accept</td>
<td>Coordinated activities to direct and control an organization with regard to risk. Methods of risk management include transference, reduction (mitigation), avoidance, and acceptance. (<a href="http://www.iso.org/iso/catalogue_detail?csnumber=44651">http://www.iso.org/iso/catalogue_detail?csnumber=44651</a>)</td>
</tr>
<tr>
<td>Robustness</td>
<td>The ability of a system to physically withstand damage from a disruptive event.</td>
</tr>
<tr>
<td>ROM Estimate</td>
<td>A rough order of magnitude estimate provides management with the information necessary to make a decision on whether it makes sense to move forward with the project based on the estimated level of effort, in terms of completion time and cost. (<a href="http://www.pmdocuments.com/2012/08/20/how-to-develop-a-rough-order-of-magnitude-estimate-romestimate/">http://www.pmdocuments.com/2012/08/20/how-to-develop-a-rough-order-of-magnitude-estimate-romestimate/</a>)</td>
</tr>
<tr>
<td>Scope of Work (SOW)</td>
<td>A project document that defines the work to be performed under the contract. The scope of work should provide a detailed description of physical components (buildings, equipment, and other systems) as well as services to be provided (engineering deliverables, maintenance, consulting, etc.).</td>
</tr>
<tr>
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<tr>
<td>Self-Insure</td>
<td>Risk management approach in which an entity sets aside a sum as a protection against a potential loss, instead of transferring the risk by purchasing an insurance policy. (<a href="http://www.businessdictionary.com">www.businessdictionary.com</a>)</td>
</tr>
<tr>
<td>Single Point Of Failure</td>
<td>Element or part of a system for which no backup exists and the failure of which will disable the entire system. (<a href="http://www.businessdictionary.com">www.businessdictionary.com</a>)</td>
</tr>
<tr>
<td>SLOSH Model</td>
<td>Sea, Lake and Overland Surges from Hurricanes (SLOSH) Model: A computerized numerical model developed by the National Weather Service to estimate storm surge heights resulting from historical, hypothetical, or predicted hurricanes by taking into account the atmospheric pressure, size, forward speed, and track data. These parameters are used to create a model of the wind field which drives the storm surge. (<a href="http://www.nhc.noaa.gov/surge/slosh.php">http://www.nhc.noaa.gov/surge/slosh.php</a>)</td>
</tr>
<tr>
<td>Sole Source Supplier</td>
<td>Those sources who provide highly specialized services and from which all required design and construction services must be procured. (<a href="http://www.colorado.edu/engineering/civil/db/DBS/glossary.cgi?word=Sole-source+Supplier">http://www.colorado.edu/engineering/civil/db/DBS/glossary.cgi?word=Sole-source+Supplier</a>)</td>
</tr>
<tr>
<td>Stakeholder</td>
<td>A person or organization that can affect, be affected by, or perceive themselves to be affected by a decision or activity. (<a href="http://www.iso.org/iso/catalogue_detail?csnumber=44651">http://www.iso.org/iso/catalogue_detail?csnumber=44651</a>)</td>
</tr>
<tr>
<td>SWOT Analysis</td>
<td>A structured planning method used to evaluate the strengths, weaknesses, opportunities, and threats involved in a project.</td>
</tr>
<tr>
<td>Task Order</td>
<td>Supplementary contractual and obligating document that usually includes task description. (businessdictionary.com)</td>
</tr>
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<tr>
<td>Threat</td>
<td>Negative event that can cause a risk to become a loss. A threat may be a natural event such as an earthquake, flood, storm, or a man-made incident such as fire, power failure, sabotage, etc. (businessdictionary.com)</td>
</tr>
<tr>
<td>Value Chain</td>
<td>The process used to deliver a company's goods or services.</td>
</tr>
<tr>
<td>Value Engineering</td>
<td>A systematic approach to reducing costs without reducing function.</td>
</tr>
<tr>
<td>Vulnerability</td>
<td>Intrinsic properties of a system resulting in susceptibility to a hazard that can lead to an event with a consequence. (<a href="http://www.iso.org/iso/catalogue_detail?csnumber=44651">http://www.iso.org/iso/catalogue_detail?csnumber=44651</a>)</td>
</tr>
<tr>
<td>Vulnerability Assessment</td>
<td>Process of assessing weaknesses across multiple dimensions of an organization's network as a result of exposure to maximum design threats.</td>
</tr>
<tr>
<td>Warning Order</td>
<td>Notification to contractor or subcontractor to be on standby for potential mobilization.</td>
</tr>
<tr>
<td>Wassenaar Countries</td>
<td>Countries participating in the Wassenaar Arrangement, a multilateral export control regime, currently consisting on 41 countries.</td>
</tr>
<tr>
<td>Windshield Assessment</td>
<td>An initial survey of damage to a site that provides enough detail to produce an order of magnitude estimate for level of effort required for the recovery project.</td>
</tr>
<tr>
<td>Work Breakdown Structure (WBS)</td>
<td>A subdivision of the project scope of work into manageable elements that form the structure, to which the project work will be defined, planned, estimated, scheduled, managed, and controlled.</td>
</tr>
<tr>
<td>Work Plan</td>
<td>Document that defines scope of work, ROM estimate, and execution strategy for a project.</td>
</tr>
<tr>
<td>Zero Notice Event</td>
<td>An event which cannot be forecasted such that preparations can be made prior to impact. For example, an earthquake is a zero notice event.</td>
</tr>
</tbody>
</table>