

it is important that we take a broader view of the issue and think about the business processes that are implemented in our software systems.

**People** Many security experts consider humans to be the weakest link in the security chain. Whether or not you agree with this, it is important to consider the specific vulnerabilities that people present in a system. Though there are many ways to exploit the human in the loop, there are three that correspond to the bulk of the attacks, summarized briefly here:

- **Social engineering** This is the process of getting a person to violate a security procedure or policy, and usually involves human interaction or e-mail/text messages.
- **Social networks** The prevalence of social network use provides potential attackers with a wealth of information that can be leveraged directly (e.g., blackmail) or indirectly (e.g., crafting an e-mail with a link that is likely to be clicked) to exploit people.
- **Passwords** Weak passwords can be cracked in milliseconds using rainbow tables and are very susceptible to dictionary or brute-force attacks. Even strong passwords are vulnerable if they are reused across sites and systems.

## Threats

As you identify the vulnerabilities that are inherent to your organization and its systems, it is important to also identify the sources that could attack them. The International Organization for Standardization and the International Electrotechnical Commission in their joint ISO/IEC standard 27000 define a *threat* as a “potential cause of an unwanted incident, which can result in harm to a system or organization.” While this may sound somewhat vague, it is important to include the full breadth of possibilities. When a threat is one or more humans, we typically use the term *threat actor* or *threat agent*. Let’s start with the most obvious: malicious humans.

**Cybercriminals** Cybercriminals are the most common threat actors encountered by individuals and organizations. Most cybercriminals are motivated by greed, but some just enjoy breaking things. Their skills run the gamut, from so-called *script kiddies* with just a basic grasp of hacking (but access to someone else’s scripts or tools) to sophisticated cybercrime gangs who develop and sometimes sell or rent their services and tools to others. Cybercrime is the fastest-growing sector of criminal activity in many countries.

One of the factors that makes cybercrime so pervasive is that every connected device is a target. Some devices are immediately monetizable, such as your personal smartphone or home computer containing credentials, payment card information, and access to your financial institutions. Other targets provide bigger payouts, such as the finance systems in your place of work. Even devices that are not, by themselves, easily monetizable can be hijacked and joined into a botnet to spread malware, conduct distributed denial-of-service (DDoS) attacks, or serve as staging bases from which to attack other targets.

**Nation-State Actors** Whereas cybercriminals tend to cast a wide net in an effort to maximize their profits, nation-state actors (or simply *state actors*) are very selective in

who they target. They use advanced capabilities to compromise systems and establish a persistent presence to allow them to collect intelligence (e.g., sensitive data, intellectual property, etc.) for extended periods. After their presence is established, state actors may use prepositioned assets to trigger devastating effects in response to world events. Though their main motivations tend to be espionage and gaining persistent access to critical infrastructure, some state actors maintain good relations with cybercrime groups in their own country, mostly for the purposes of plausible deniability. By collaborating with these criminals, state actors can make it look as if an attack against another nation was a crime and not an act of war. At least one country is known to use its national offensive cyber capabilities for financial profit, stealing millions of dollars all over the world.

Many security professionals consider state actors a threat mostly to government organizations, critical infrastructure like power plants, and anyone with sophisticated research and development capabilities. In reality, however, these actors can and do target other organizations, typically to use them as a springboard into their ultimate targets. So, even if you work for a small company that seems uninteresting to a foreign nation, you could find your company in a state actor's crosshairs.

**Hacktivists** Hacktivists use cyberattacks to effect political or social change. The term covers a diverse ecosystem, encompassing individuals and groups of various skillsets and capabilities. Hacktivists' preferred objectives are highly visible to the public or yield information that, when made public, aims to embarrass government entities or undermine public trust in them.

**Internal Actors** Internal actors are people within the organization, such as employees, former employees, contractors, or business associates, who have inside information concerning the organization's security practices, data, and computer systems. Broadly speaking, there are two types of insider threats: negligent and malicious. A negligent insider is one who fails to exercise due care, which puts their organization at risk. Sometimes, these individuals knowingly violate policies or disregard procedures, but they are not doing so out of malicious intent. For example, an employee could disregard a policy requiring visitors to be escorted at all times because someone shows up wearing the uniform of a telecommunications company and claiming to be on site to fix an outage. This insider trusts the visitor, which puts the organization at risk, particularly if that person is an impostor.

The second type of insider threat is characterized by malicious intent. Malicious insiders use the knowledge they have about their organization either for their own advantage (e.g., to commit fraud) or to directly cause harm (e.g., by deleting sensitive files). While some malicious insiders plan their criminal activity while they are employees in good standing, others are triggered by impending termination actions. Knowing (or suspecting) that they're about to be fired, they may attempt to steal sensitive data (such as customer contacts or design documents) before their access is revoked. Other malicious insiders may be angry and plant malware or destroy assets in an act of revenge. This insider threat highlights the need for the "zero trust" secure design principle (discussed in Chapter 9). It is also a really good reason to practice the termination processes discussed in Chapter 1.

In the wake of the massive leak of classified data attributed to Edward Snowden in 2012, there's been increased emphasis on techniques and procedures for identifying and mitigating the insider threat source. While the deliberate insider dominates the news, it is important to note that the accidental insider can be just as dangerous, particularly if they fall into one of the vulnerability classes described in the preceding section.

**Nature** Finally, the nonhuman threat source can be just as important as the ones we've previously discussed. Hurricane Katrina in 2005 and the Tohoku earthquake and tsunami in 2011 serve as reminders that natural events can be more destructive than any human attack. They also force the information systems security professional to consider threats that fall way outside the norm. Though it is easier and, in many cases, cheaper to address likelier natural events such as a water main break or a fire in a facility, one should always look for opportunities to leverage countermeasures that protect against both mild and extreme events for small price differentials.

## Identifying Threats and Vulnerabilities

Earlier, it was stated that the definition of a risk is the probability of a threat exploiting a vulnerability to cause harm to an asset and the resulting business impact. Many types of threat actors can take advantage of several types of vulnerabilities, resulting in a variety of specific threats, as outlined in Table 2-1, which represents only a sampling of the risks many organizations should address in their risk management programs.

Other types of threats can arise in an environment that are much harder to identify than those listed in Table 2-1. These other threats have to do with application and user errors. If an application uses several complex equations to produce results, the threat can be difficult to discover and isolate if these equations are incorrect or if the application is using inputted data incorrectly. This can result in *illogical processing* and *cascading errors* as invalid results are passed on to another process. These types of problems can lie within application code and are very hard to identify.

Threat Actor	Can Exploit This Vulnerability	To Cause This Effect
Cybercriminal	Lack of antimalware software	Ransomed data
Nation-state actor	Password reuse in privileged accounts	Unauthorized access to confidential information
Negligent user	Misconfigured parameter in the operating system	Loss of availability due to a system malfunction
Fire	Lack of fire extinguishers	Facility and computer loss or damage, and possibly loss of life
Malicious insider	Poor termination procedures	Deletion of business-critical information
Hacktivist	Poorly written web application	Website defacement
Burglar	Lack of security guard	Breaking windows and stealing computers and devices

**Table 2-1** Relationship of Threats and Vulnerabilities

User errors, whether intentional or accidental, are easier to identify by monitoring and auditing users' activities. Audits and reviews must be conducted to discover if employees are inputting values incorrectly into programs, misusing technology, or modifying data in an inappropriate manner.

After the ISRM team has identified the vulnerabilities and associated threats, it must investigate the ramifications of any of those vulnerabilities being exploited. Risks have *loss potential*, meaning that the organization could lose assets or revenues if a threat agent actually exploited a vulnerability. The loss may be corrupted data, destruction of systems and/or the facility, unauthorized disclosure of confidential information, a reduction in employee productivity, and so on. When performing a risk assessment, the team also must look at *delayed loss* when assessing the damages that can occur. Delayed loss is secondary in nature and takes place well after a vulnerability is exploited. Delayed loss may include damage to the organization's reputation, loss of market share, accrued late penalties, civil suits, the delayed collection of funds from customers, resources required to reimage other compromised systems, and so forth.

For example, if a company's web servers are attacked and taken offline, the immediate damage (loss potential) could be data corruption, the man-hours necessary to place the servers back online, and the replacement of any code or components required. The company could lose revenue if it usually accepts orders and payments via its website. If getting the web servers fixed and back online takes a full day, the company could lose a lot more sales and profits. If getting the web servers fixed and back online takes a full week, the company could lose enough sales and profits to not be able to pay other bills and expenses. This would be a delayed loss. If the company's customers lose confidence in it because of this activity, the company could lose business for months or years. This is a more extreme case of delayed loss.

These types of issues make the process of properly quantifying losses that specific threats could cause more complex, but they must be taken into consideration to ensure reality is represented in this type of analysis.

## Assessing Risks

A *risk assessment*, which is really a tool for risk management, is a method of identifying vulnerabilities and threats and assessing the possible impacts to determine where to implement security controls. After parts of a risk assessment are carried out, the results are analyzed. *Risk analysis* is a detailed examination of the components of risk that is used to ensure that security is cost-effective, relevant, timely, and responsive to threats. It is easy to apply too much security, not enough security, or the wrong security controls and to spend too much money in the process without attaining the necessary objectives. Risk analysis helps organizations prioritize their risks and shows management the amount of resources that should be applied to protecting against those risks in a sensible manner.



**EXAM TIP** The terms risk assessment and risk analysis, depending on who you ask, can mean the same thing, or one must follow the other, or one is a subpart of the other. Here, we treat risk assessment as the broader effort, which is reinforced by specific risk analysis tasks as needed. This is how you should think of it for the CISSP exam.

Risk analysis has four main goals:

- Identify assets and their value to the organization.
- Determine the likelihood that a threat exploits a vulnerability.
- Determine the business impact of these potential threats.
- Provide an economic balance between the impact of the threat and the cost of the countermeasure.

Risk analysis provides a *cost/benefit comparison*, which compares the annualized cost of controls to the potential cost of loss. A control, in most cases, should not be implemented unless the annualized cost of loss exceeds the annualized cost of the control itself. This means that if a facility is worth \$100,000, it does not make sense to spend \$150,000 trying to protect it.

It is important to figure out what you are *supposed* to be doing before you dig right in and start working. Anyone who has worked on a project without a properly defined scope can attest to the truth of this statement. Before an assessment is started, the team must carry out *project sizing* to understand what assets and threats should be evaluated. Most assessments are focused on physical security, technology security, or personnel security. Trying to assess all of them at the same time can be quite an undertaking.

One of the risk assessment team's tasks is to create a report that details the asset valuations. Senior management should review and accept the list and use these values to determine the scope of the risk management project. If management determines at this early stage that some assets are not important, the risk assessment team should not spend additional time or resources evaluating those assets. During discussions with management, everyone involved must have a firm understanding of the value of the security CIA triad—confidentiality, integrity, and availability—and how it directly relates to business needs.

Management should outline the scope of the assessment, which most likely will be dictated by organizational compliance requirements as well as budgetary constraints. Many projects have run out of funds, and consequently stopped, because proper project sizing was not conducted at the onset of the project. Don't let this happen to you.

A risk assessment helps integrate the security program objectives with the organization's business objectives and requirements. The more the business and security objectives are in alignment, the more successful both will be. The assessment also helps the organization draft a proper budget for a security program and its constituent security components. Once an organization knows how much its assets are worth and the possible threats those assets are exposed to, it can make intelligent decisions about how much money to spend protecting those assets.

A risk assessment must be supported and directed by senior management if it is to be successful. Management must define the purpose and scope of the effort, appoint a team to carry out the assessment, and allocate the necessary time and funds to conduct it. It is essential for senior management to review the outcome of the risk assessment and to act on its findings. After all, what good is it to go through all the trouble of a risk assessment and *not* react to its findings? Unfortunately, this does happen all too often.

## Asset Valuation

To understand possible losses and how much we may want to invest in preventing them, we must understand the value of an asset that could be impacted by a threat. The value placed on information is relative to the parties involved, what work was required to develop it, how much it costs to maintain, what damage would result if it were lost or destroyed, how much money enemies would pay for it, and what liability penalties could be endured. If an organization does not know the value of the information and the other assets it is trying to protect, it does not know how much money and time it should spend on protecting them. If the calculated value of your company's secret formula is  $x$ , then the total cost of protecting it should be some value less than  $x$ . Knowing the value of our information allows us to make quantitative cost/benefit comparisons as we manage our risks.

The preceding logic applies not only to assessing the value of *information* and protecting it but also to assessing the value of the organization's other assets, such as facilities, systems, and even intangibles like the value of the brand, and protecting them. The value of the organization's facilities must be assessed, along with all printers, workstations, servers, peripheral devices, supplies, and employees. You do not know how much is in danger of being lost if you don't know what you have and what it is worth in the first place.

The actual value of an asset is determined by the importance it has to the organization as a whole. The value of an asset should reflect all identifiable costs that would arise if the asset were actually impaired. If a server cost \$4,000 to purchase, this value should not be input as the value of the asset in a risk assessment. Rather, the cost of replacing or repairing it, the loss of productivity, and the value of any data that may be corrupted or lost must be accounted for to properly capture the amount the organization would lose if the server were to fail for one reason or another.

The following issues should be considered when assigning values to assets:

- Cost to acquire or develop the asset
- Cost to maintain and protect the asset
- Value of the asset to owners and users
- Value of the asset to adversaries
- Price others are willing to pay for the asset
- Cost to replace the asset if lost
- Operational and production activities affected if the asset is unavailable
- Liability issues if the asset is compromised
- Usefulness and role of the asset in the organization
- Impact of the asset's loss on the organization's brand or reputation

Understanding the value of an asset is the first step to understanding what security mechanisms should be put in place and what funds should go toward protecting it. A very important question is how much it could cost the organization to *not* protect the asset.

Determining the value of assets may be useful to an organization for a variety of reasons, including the following:

- To perform effective cost/benefit analyses
- To select specific countermeasures and safeguards
- To determine the level of insurance coverage to purchase
- To understand what exactly is at risk
- To comply with legal and regulatory requirements

Assets may be tangible (computers, facilities, supplies) or intangible (reputation, data, intellectual property). It is usually harder to quantify the values of intangible assets, which may change over time. How do you put a monetary value on a company's reputation? This is not always an easy question to answer, but it is important to be able to do so.

## Risk Assessment Teams

Each organization has different departments, and each department has its own functionality, resources, tasks, and quirks. For the most effective risk assessment, an organization must build a risk assessment team that includes individuals from many or all departments to ensure that all of the threats are identified and addressed. The team members may be part of management, application programmers, IT staff, systems integrators, and operational managers—indeed, any key personnel from key areas of the organization. This mix is necessary because if the team comprises only individuals from the IT department, it may not understand, for example, the types of threats the accounting department faces with data integrity issues, or how the organization as a whole would be affected if the accounting department's data files were wiped out by an accidental or intentional act.

### Asking the Right Questions

When looking at risk, it's good to keep several questions in mind. Raising these questions helps ensure that the risk assessment team and senior management know what is important. Team members must ask the following:

- What event could occur (threat event)?
- What could be the potential impact (risk)?
- How often could it happen (frequency)?
- What level of confidence do we have in the answers to the first three questions (certainty)?

A lot of this information is gathered through internal surveys, interviews, or workshops. Viewing threats with these questions in mind helps the team focus on the tasks at hand and assists in making the decisions more accurate and relevant.



Or, as another example, the IT staff may not understand all the risks the employees in the warehouse would face if a natural disaster were to hit, or what it would mean to their productivity and how it would affect the organization overall. If the risk assessment team is unable to include members from various departments, it should, at the very least, make sure to interview people in each department so it fully understands and can quantify all threats.

The risk assessment team must also include people who understand the processes that are part of their individual departments, meaning individuals who are at the right levels of each department. This is a difficult task, since managers sometimes delegate any sort of risk assessment task to lower levels within the department. However, the people who work at these lower levels may not have adequate knowledge and understanding of the processes that the risk assessment team may need to deal with.

## Methodologies for Risk Assessment

The industry has different standardized methodologies for carrying out risk assessments. Each of the individual methodologies has the same basic core components (identify vulnerabilities, associate threats, calculate risk values), but each has a specific focus. Keep in mind that the methodologies have a lot of overlapping similarities because each one has the specific goal of identifying things that could hurt the organization (vulnerabilities and threats) so that those things can be addressed (risk reduced). What make these methodologies different from each other are their unique approaches and focuses.

If you need to deploy an organization-wide risk management program and integrate it into your security program, you should follow the OCTAVE method. If you need to focus just on IT security risks during your assessment, you can follow NIST SP 800-30. If you have a limited budget and need to carry out a focused assessment on an individual system or process, you can follow the Facilitated Risk Analysis Process. If you really want to dig into the details of how a security flaw within a specific system could cause negative ramifications, you could use Failure Modes and Effect Analysis or fault tree analysis.

### NIST SP 800-30

NIST SP 800-30, Revision 1, *Guide for Conducting Risk Assessments*, is specific to information systems threats and how they relate to information security risks. It lays out the following steps:

1. Prepare for the assessment.
2. Conduct the assessment:
  - a. Identify threat sources and events.
  - b. Identify vulnerabilities and predisposing conditions.
  - c. Determine likelihood of occurrence.
  - d. Determine magnitude of impact.
  - e. Determine risk.
3. Communicate results.
4. Maintain assessment.



The NIST risk management methodology is mainly focused on computer systems and IT security issues. It does not explicitly cover larger organizational threat types, as in succession planning, environmental issues, or how security risks associate to business risks. It is a methodology that focuses on the operational components of an enterprise, not necessarily the higher strategic level.

## FRAP

*Facilitated Risk Analysis Process (FRAP)* is a second type of risk assessment methodology. The crux of this qualitative methodology is to focus only on the systems that really need assessing, to reduce costs and time obligations. FRAP stresses prescreening activities so that the risk assessment steps are only carried out on the item(s) that needs it the most. FRAP is intended to be used to analyze one system, application, or business process at a time. Data is gathered and threats to business operations are prioritized based upon their criticality. The risk assessment team documents the controls that need to be put into place to reduce the identified risks along with action plans for control implementation efforts.

This methodology does not support the idea of calculating exploitation probability numbers or annualized loss expectancy values. The criticalities of the risks are determined by the team members' experience. The author of this methodology (Thomas Peltier) believes that trying to use mathematical formulas for the calculation of risk is too confusing and time consuming. The goal is to keep the scope of the assessment small and the assessment processes simple to allow for efficiency and cost-effectiveness.

## OCTAVE

The *Operationally Critical Threat, Asset, and Vulnerability Evaluation (OCTAVE)* methodology was created by Carnegie Mellon University's Software Engineering Institute (SIE). OCTAVE is intended to be used in situations where people manage and direct the risk evaluation for information security within their organization. This places the people who work inside the organization in the power positions of being able to make the decisions regarding what is the best approach for evaluating the security of their organization. OCTAVE relies on the idea that the people working in these environments best understand what is needed and what kind of risks they are facing. The individuals who make up the risk assessment team go through rounds of facilitated workshops. The facilitator helps the team members understand the risk methodology and how to apply it to the vulnerabilities and threats identified within their specific business units. OCTAVE stresses a self-directed team approach.

The scope of an OCTAVE assessment is usually very wide compared to the more focused approach of FRAP. Where FRAP would be used to assess a system or application, OCTAVE would be used to assess all systems, applications, and business processes within the organization.

The OCTAVE methodology consists of the seven processes (or steps) listed here:

1. Identify enterprise knowledge.
2. Identify operational area knowledge.
3. Identify staff knowledge.

4. Establish security requirements.
5. Map high-priority information assets to information infrastructure.
6. Perform infrastructure vulnerability evaluation.
7. Conduct multidimensional risk analysis.
8. Develop protection strategy.

## FMEA

*Failure Modes and Effect Analysis (FMEA)* is a method for determining functions, identifying functional failures, and assessing the causes of failure and their failure effects through a structured process. FMEA is commonly used in product development and operational environments. The goal is to identify where something is most likely going to break and either fix the flaws that could cause this issue or implement controls to reduce the impact of the break. For example, you might choose to carry out an FMEA on your organization's network to identify single points of failure. These single points of failure represent vulnerabilities that could directly affect the productivity of the network as a whole. You would use this structured approach to identify these issues (vulnerabilities), assess their criticality (risk), and identify the necessary controls that should be put into place (reduce risk).

The FMEA methodology uses failure modes (how something can break or fail) and effects analysis (impact of that break or failure). The application of this process to a chronic failure enables the determination of where exactly the failure is most likely to occur. Think of it as being able to look into the future and locate areas that have the potential for failure and then applying corrective measures to them before they do become actual liabilities.

By following a specific order of steps, the best results can be maximized for an FMEA:

1. Start with a block diagram of a system or control.
2. Consider what happens if each block of the diagram fails.
3. Draw up a table in which failures are paired with their effects and an evaluation of the effects.
4. Correct the design of the system, and adjust the table until the system is not known to have unacceptable problems.
5. Have several engineers review the Failure Modes and Effect Analysis.

Table 2-2 is an example of how an FMEA can be carried out and documented. Although most organizations will not have the resources to do this level of detailed work for every system and control, an organization can carry it out on critical functions and systems that can drastically affect the organization.

FMEA was first developed for systems engineering. Its purpose is to examine the potential failures in products and the processes involved with them. This approach proved to be successful and has been more recently adapted for use in evaluating risk management priorities and mitigating known threat vulnerabilities.

<b>Prepared by:</b>							
<b>Approved by:</b>							
<b>Date:</b>							
<b>Revision:</b>							
Item Identification	Function	Failure Mode	Failure Cause	Failure Effect on . . .			Failure Detection Method
				Component or Functional Assembly	Next Higher Assembly	System	
IPS application content filter	Inline perimeter protection	Fails to close	Traffic overload	Single point of failure Denial of service	IPS blocks ingress traffic stream	IPS is brought down	Health check status sent to console and e-mail to security administrator
Central antivirus signature update engine	Push updated signatures to all servers and workstations	Fails to provide adequate, timely protection against malware	Central server goes down	Individual node's antivirus software is not updated	Network is infected with malware	Central server can be infected and/or infect other systems	Heartbeat status check sent to central console, and e-mail to network administrator
Fire suppression water pipes	Suppress fire in building 1 in 5 zones	Fails to close	Water in pipes freezes	None	Building 1 has no suppression agent available	Fire suppression system pipes break	Suppression sensors tied directly into fire system central console
Etc.							

**Table 2-2** How an FMEA Can Be Carried Out and Documented

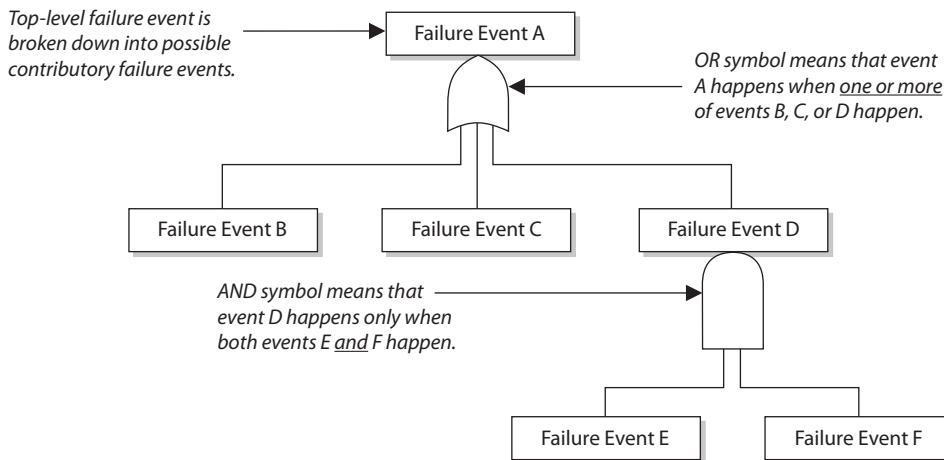
FMEA is used in assurance risk management because of the level of detail, variables, and complexity that continues to rise as corporations understand risk at more granular levels. This methodical way of identifying potential pitfalls is coming into play more as the need for risk awareness—down to the tactical and operational levels—continues to expand.

## Fault Tree Analysis

While FMEA is most useful as a survey method to identify major failure modes in a given system, the method is not as useful in discovering complex failure modes that may be involved in multiple systems or subsystems. A *fault tree analysis* usually proves to be a more useful approach to identifying failures that can take place within more complex environments and systems. First, an undesired effect is taken as the root or top event of a tree of logic. Then, each situation that has the potential to cause that effect is added to the tree as a series of logic expressions. Fault trees are then labeled with actual numbers pertaining to failure probabilities. This is typically done by using computer programs that can calculate the failure probabilities from a fault tree.

Figure 2-3 shows a simplistic fault tree and the different logic symbols used to represent what must take place for a specific fault event to occur.

When setting up the tree, you must accurately list all the threats or faults that can occur within a system. The branches of the tree can be divided into general categories, such as physical threats, network threats, software threats, Internet threats, and component failure threats. Then, once all possible general categories are in place, you can trim them and effectively prune from the tree the branches that won't apply to the system in question. In general, if a system is not connected to the Internet by any means, remove that general branch from the tree.



**Figure 2-3** Fault tree and logic components

Some of the most common software failure events that can be explored through a fault tree analysis are the following:

- False alarms
- Insufficient error handling
- Sequencing or order
- Incorrect timing outputs
- Valid but unexpected outputs

Of course, because of the complexity of software and heterogeneous environments, this is a very small sample list.



**EXAM TIP** A risk assessment is used to gather data. A risk analysis examines the gathered data to produce results that can be acted upon.

## Risk Analysis Approaches

So up to this point, we have accomplished the following items:

- Developed a risk management policy
- Developed a risk management team
- Identified organizational assets to be assessed
- Calculated the value of each asset
- Identified the vulnerabilities and threats that can affect the identified assets
- Chosen a risk assessment methodology that best fits our needs

The next thing we need to figure out is if our risk analysis approach should be quantitative or qualitative in nature. A *quantitative risk analysis* is used to assign monetary and numeric values to all elements of the risk analysis process. Each element within the analysis (asset value, threat frequency, severity of vulnerability, impact damage, safeguard costs, safeguard effectiveness, uncertainty, and probability items) is quantified and entered into equations to determine total and residual risks. It is more of a scientific or mathematical approach (objective) to risk analysis compared to qualitative. A *qualitative risk analysis* uses a “softer” approach to the data elements of a risk analysis. It does not quantify that data, which means that it does not assign numeric values to the data so that it can be used in equations. As an example, the results of a quantitative risk analysis could be that the organization is at risk of losing \$100,000 if a buffer overflow were exploited on a web server, \$25,000 if a database were compromised, and \$10,000 if a file server were compromised. A qualitative risk analysis would not present these findings in monetary values, but would assign ratings to the risks, as in Red, Yellow, and Green.

A quantitative analysis uses risk calculations that attempt to predict the level of monetary losses and the probability for each type of threat. Qualitative analysis does not

use calculations. Instead, it is more opinion and scenario based (subjective) and uses a rating system to relay the risk criticality levels.

Quantitative and qualitative approaches have their own pros and cons, and each applies more appropriately to some situations than others. An organization's management and risk analysis team, and the tools they decide to use, will determine which approach is best.

In the following sections we will dig into the depths of quantitative analysis and then revisit the qualitative approach. We will then compare and contrast their attributes.

## Automated Risk Analysis Methods

Collecting all the necessary data that needs to be plugged into risk analysis equations and properly interpreting the results can be overwhelming if done manually. Several automated risk analysis tools on the market can make this task much less painful and, hopefully, more accurate. The gathered data can be reused, greatly reducing the time required to perform subsequent analyses. The risk analysis team can also print reports and comprehensive graphs to present to management.



**EXAM TIP** Remember that vulnerability assessments are different from risk assessments. A vulnerability assessment just finds the vulnerabilities (the holes). A risk assessment calculates the probability of the vulnerabilities being exploited and the associated business impact.

The objective of these tools is to reduce the manual effort of these tasks, perform calculations quickly, estimate future expected losses, and determine the effectiveness and benefits of the security countermeasures chosen. Most automatic risk analysis products port information into a database and run several types of scenarios with different parameters to give a panoramic view of what the outcome will be if different threats come to bear. For example, after such a tool has all the necessary information inputted, it can be rerun several times with different parameters to compute the potential outcome if a large fire were to take place; the potential losses if a virus were to damage 40 percent of the data on the main file server; how much the organization would lose if an attacker were to steal all the customer credit card information held in three databases; and so on. Running through the different risk possibilities gives an organization a more detailed understanding of which risks are more critical than others, and thus which ones to address first.

## Steps of a Quantitative Risk Analysis

If we choose to carry out a quantitative risk analysis, then we are going to use mathematical equations for our data interpretation process. The most common equations used for this purpose are the *single loss expectancy (SLE)* and the *annualized loss expectancy (ALE)*. The SLE is a monetary value that is assigned to a single event that represents the organization's potential loss amount if a specific threat were to take place. The equation is laid out as follows:

$$\text{Asset Value} \times \text{Exposure Factor (EF)} = \text{SLE}$$

The *exposure factor (EF)* represents the percentage of loss a realized threat could have on a certain asset. For example, if a data warehouse has the asset value of \$150,000, it can be estimated that if a fire were to occur, 25 percent of the warehouse would be damaged, in which case the SLE would be \$37,500:

$$\text{Asset Value } (\$150,000) \times \text{Exposure Factor } (25\%) = \$37,500$$

This tells us that the organization could potentially lose \$37,500 if a fire were to take place. But we need to know what our annual potential loss is, since we develop and use our security budgets on an annual basis. This is where the ALE equation comes into play. The ALE equation is as follows:

$$\text{SLE} \times \text{Annualized Rate of Occurrence (ARO)} = \text{ALE}$$

The *annualized rate of occurrence (ARO)* is the value that represents the estimated frequency of a specific threat taking place within a 12-month timeframe. The range can be from 0.0 (never) to 1.0 (once a year) to greater than 1 (several times a year), and anywhere in between. For example, if the probability of a fire taking place and damaging our data warehouse is once every 10 years, the ARO value is 0.1.

So, if a fire within an organization's data warehouse facility can cause \$37,500 in damages, and the frequency (or ARO) of a fire taking place has an ARO value of 0.1 (indicating once in 10 years), then the ALE value is \$3,750 ( $\$37,500 \times 0.1 = \$3,750$ ).

The ALE value tells the organization that if it wants to put in controls to protect the asset (warehouse) from this threat (fire), it can sensibly spend \$3,750 or less per year to provide the necessary level of protection. Knowing the real possibility of a threat and how much damage, in monetary terms, the threat can cause is important in determining how much should be spent to try and protect against that threat in the first place. It would not make good business sense for the organization to spend more than \$3,750 per year to protect itself from this threat.

Clearly, this example is overly simplistic in focusing strictly on the structural losses. In the real world, we should include other related impacts such as loss of revenue due to the disruption, potential fines if the fire was caused by a violation of local fire codes, and injuries to employees that would require medical care. The number of factors to consider can be pretty large and, to some of us, not obvious. This is why you want to have a diverse risk assessment team that can think of all the myriad impacts that a simple event might have.

### Uncertainty

In risk analysis, uncertainty refers to the degree to which you lack confidence in an estimate. This is expressed as a percentage, from 0 to 100 percent. If you have a 30 percent confidence level in something, then it could be said you have a 70 percent uncertainty level. Capturing the degree of uncertainty when carrying out a risk analysis is important, because it indicates the level of confidence the team and management should have in the resulting figures.



Asset	Threat	Single Loss Expectancy (SLE)	Annualized Rate of Occurrence (ARO)	Annualized Loss Expectancy (ALE)
Facility	Fire	\$230,000	0.1	\$23,000
Trade secret	Stolen	\$40,000	0.01	\$400
File server	Failed	\$11,500	0.1	\$1,150
Business data	Ransomware	\$283,000	0.1	\$28,300
Customer credit card info	Stolen	\$300,000	3.0	\$900,000

**Table 2-3** Breaking Down How SLE and ALE Values Are Used

Now that we have all these numbers, what do we do with them? Let’s look at the example in Table 2-3, which shows the outcome of a quantitative risk analysis. With this data, the organization can make intelligent decisions on what threats must be addressed first because of the severity of the threat, the likelihood of it happening, and how much could be lost if the threat were realized. The organization now also knows how much money it should spend to protect against each threat. This will result in good business decisions, instead of just buying protection here and there without a clear understanding of the big picture. Because the organization’s risk from a ransomware incident is \$28,300, it would be justified in spending up to this amount providing ransomware preventive measures such as offline file backups, phishing awareness training, malware detection and prevention, or insurance.

When carrying out a quantitative analysis, some people mistakenly think that the process is purely objective and scientific because data is being presented in numeric values. But a purely quantitative analysis is hard to achieve because there is still some subjectivity when it comes to the data. How do we know that a fire will only take place once every 10 years? How do we know that the damage from a fire will be 25 percent of the value of the asset? We don’t know these values exactly, but instead of just pulling them out of thin air, they should be based upon historical data and industry experience. In quantitative risk analysis, we can do our best to provide all the correct information, and by doing so we will come close to the risk values, but we cannot predict the future and how much future incidents will cost us or the organization.

**Results of a Quantitative Risk Analysis**

The risk analysis team should have clearly defined goals. The following is a short list of what generally is expected from the results of a risk analysis:

- Monetary values assigned to assets
- Comprehensive list of all significant threats
- Probability of the occurrence rate of each threat
- Loss potential the organization can endure per threat in a 12-month time span
- Recommended controls

Although this list looks short, there is usually an incredible amount of detail under each bullet item. This report will be presented to senior management, which will be concerned with possible monetary losses and the necessary costs to mitigate these risks. Although the report should be as detailed as possible, it should also include an executive summary so that senior management can quickly understand the overall findings of the analysis.

## Qualitative Risk Analysis

Another method of risk analysis is *qualitative*, which does not assign numbers and monetary values to components and losses. Instead, qualitative methods walk through different scenarios of risk possibilities and rank the seriousness of the threats and the validity of the different possible countermeasures based on opinions. (A wide-sweeping analysis can include hundreds of scenarios.) Qualitative analysis techniques include judgment, best practices, intuition, and experience. Examples of qualitative techniques to gather data are Delphi, brainstorming, storyboarding, focus groups, surveys, questionnaires, checklists, one-on-one meetings, and interviews. The risk analysis team will determine the best technique for the threats that need to be assessed, as well as the culture of the organization and individuals involved with the analysis.

The team that is performing the risk analysis gathers personnel who have knowledge of the threats being evaluated. When this group is presented with a scenario that describes threats and loss potential, each member responds with their gut feeling and experience on the likelihood of the threat and the extent of damage that may result. This group explores a scenario of each identified vulnerability and how it would be exploited. The “expert” in the group, who is most familiar with this type of threat, should review the scenario to ensure it reflects how an actual threat would be carried out. Safeguards that would diminish the damage of this threat are then evaluated, and the scenario is played out for each safeguard. The exposure possibility and loss possibility can be ranked as high, medium, or low on a scale of 1 to 5 or 1 to 10.

A common qualitative risk matrix is shown in Figure 2-4. Once the selected personnel rank the likelihood of a threat happening, the loss potential, and the advantages of each

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Severe
Almost certain	M	H	H	E	E
Likely	M	M	H	H	E
Possible	L	M	M	H	E
Unlikely	L	M	M	M	H
Rare	L	L	M	M	H

**Figure 2-4** Qualitative risk matrix: likelihood vs. consequences (impact)

The Delphi Technique

The Delphi technique is a group decision method used to ensure that each member gives an honest opinion of what he or she thinks the result of a particular threat will be. This avoids a group of individuals feeling pressured to go along with others' thought processes and enables them to participate in an independent and anonymous way. Each member of the group provides his or her opinion of a certain threat and turns it in to the team that is performing the analysis. The results are compiled and distributed to the group members, who then write down their comments anonymously and return them to the analysis group. The comments are compiled and redistributed for more comments until a consensus is formed. This method is used to obtain an agreement on cost, loss values, and probabilities of occurrence without individuals having to agree verbally.

safeguard, this information is compiled into a report and presented to management to help it make better decisions on how best to implement safeguards into the environment. The benefits of this type of analysis are that communication must happen among team members to rank the risks, evaluate the safeguard strengths, and identify weaknesses, and the people who know these subjects the best provide their opinions to management.

Let's look at a *simple* example of a qualitative risk analysis.

The risk analysis team presents a scenario explaining the threat of a hacker accessing confidential information held on the five file servers within the organization. The risk analysis team then distributes the scenario in a written format to a team of five people (the IT manager, database administrator, application programmer, system operator, and operational manager), who are also given a sheet to rank the threat's severity, loss potential, and each safeguard's effectiveness, with a rating of 1 to 5, 1 being the least severe, effective, or probable. Table 2-4 shows the results.

Threat = Hacker Accessing Confidential Information	Severity of Threat	Probability of Threat Taking Place	Potential Loss to the Organization	Effectiveness of Firewall	Effectiveness of Intrusion Detection System	Effectiveness of Honeypot
IT manager	4	2	4	4	3	2
Database administrator	4	4	4	3	4	1
Application programmer	2	3	3	4	2	1
System operator	3	4	3	4	2	1
Operational manager	5	4	4	4	4	2
Results	3.6	3.4	3.6	3.8	3	1.4

Table 2-4 Example of a Qualitative Analysis

This data is compiled and inserted into a report and presented to management. When management is presented with this information, it will see that its staff (or a chosen set) feels that purchasing a firewall will protect the organization from this threat more than purchasing an intrusion detection system (IDS) or setting up a honeypot system.

This is the result of looking at only one threat, and management will view the severity, probability, and loss potential of each threat so it knows which threats cause the greatest risk and should be addressed first.

## Quantitative vs. Qualitative

Each method has its advantages and disadvantages, some of which are outlined in Table 2-5 for purposes of comparison.

The risk analysis team, management, risk analysis tools, and culture of the organization will dictate which approach—quantitative or qualitative—should be used. The goal of either method is to estimate an organization's real risk and to rank the severity of the threats so the correct countermeasures can be put into place within a practical budget.

Table 2-5 refers to some of the positive aspects of the quantitative and qualitative approaches. However, not everything is always easy. In deciding to use either a quantitative or qualitative approach, the following points might need to be considered.

### Quantitative Cons:

- Calculations can be complex. Can management understand how these values were derived?
- Without automated tools, this process is extremely laborious.
- More preliminary work is needed to gather detailed information about the environment.
- Standards are not available. Each vendor has its own way of interpreting the processes and their results.

Attribute	Quantitative	Qualitative
Requires no calculations		X
Requires more complex calculations	X	
Involves high degree of guesswork		X
Provides general areas and indications of risk		X
Is easier to automate and evaluate	X	
Used in risk management performance tracking	X	
Allows for cost/benefit analysis	X	
Uses independently verifiable and objective metrics	X	
Provides the opinions of the individuals who know the processes best		X
Shows clear-cut losses that can be accrued within one year's time	X	

**Table 2-5** Quantitative vs. Qualitative Characteristics

### Qualitative Cons:

- The assessments and results are subjective and opinion based.
- Eliminates the opportunity to create a dollar value for cost/benefit discussions.
- Developing a security budget from the results is difficult because monetary values are not used.
- Standards are not available. Each vendor has its own way of interpreting the processes and their results.



**NOTE** Since a purely quantitative assessment is close to impossible and a purely qualitative process does not provide enough statistical data for financial decisions, these two risk analysis approaches can be used in a hybrid approach. Quantitative evaluation can be used for tangible assets (monetary values), and a qualitative assessment can be used for intangible assets (priority values).

## Responding to Risks

Once an organization knows the amount of total and residual risk it is faced with, it must decide how to handle it. Risk can be dealt with in four basic ways: transfer it, avoid it, reduce it, or accept it.

Many types of insurance are available to organizations to protect their assets. If an organization decides the total risk is too high to gamble with, it can purchase insurance, which would *transfer the risk* to the insurance company.

If an organization decides to terminate the activity that is introducing the risk, this is known as *risk avoidance*. For example, if a company allows employees to use instant messaging (IM), there are many risks surrounding this technology. The company could decide not to allow any IM activity by employees because there is not a strong enough business need for its continued use. Discontinuing this service is an example of risk avoidance.

Another approach is *risk mitigation*, where the risk is reduced to a level considered acceptable enough to continue conducting business. The implementation of firewalls, training, and intrusion/detection protection systems or other control types represent types of risk mitigation efforts.

The last approach is to *accept the risk*, which means the organization understands the level of risk it is faced with, as well as the potential cost of damage, and decides to just live with it and not implement the countermeasure. Many organizations will accept risk when the cost/benefit ratio indicates that the cost of the countermeasure outweighs the potential loss value.

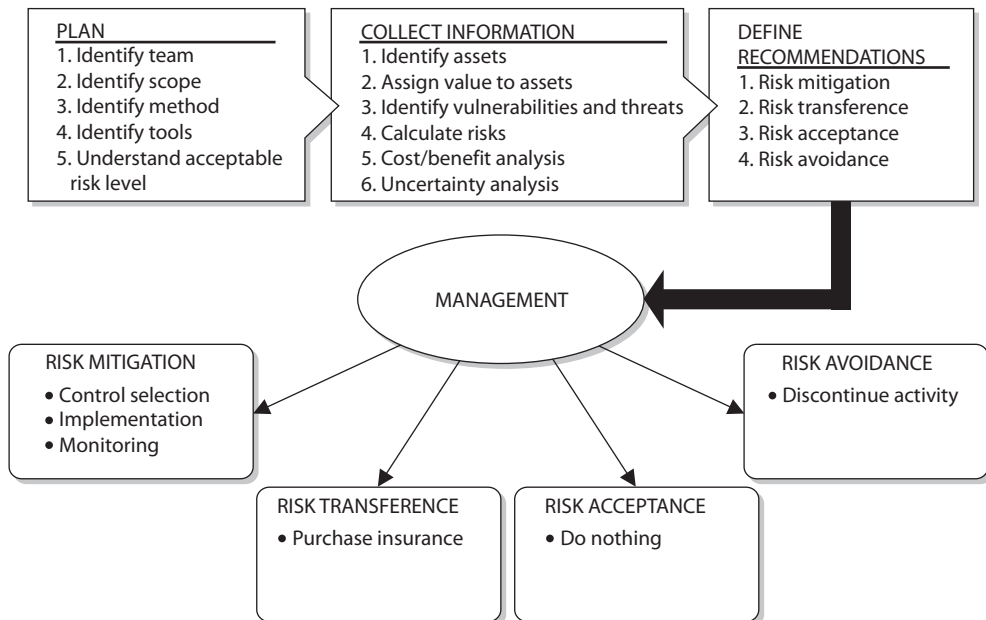
A crucial issue with risk acceptance is understanding why this is the best approach for a specific situation. Unfortunately, today many people in organizations are accepting risk and not understanding fully what they are accepting. This usually has to do with the relative newness of risk management in the security field and the lack of education and experience in those personnel who make risk decisions. When business managers are charged with the responsibility of dealing with risk in their department, most of the time

they will accept whatever risk is put in front of them because their real goals pertain to getting a project finished and out the door. They don't want to be bogged down by this silly and irritating security stuff.

Risk acceptance should be based on several factors. For example, is the potential loss lower than the countermeasure? Can the organization deal with the “pain” that will come with accepting this risk? This second consideration is not purely a cost decision, but may entail noncost issues surrounding the decision. For example, if we accept this risk, we must add three more steps in our production process. Does that make sense for us? Or if we accept this risk, more security incidents may arise from it, and are we prepared to handle those?

The individual or group accepting risk must also understand the potential visibility of this decision. Let's say a company has determined that it is not legally required to protect customers' first names, but that it does have to protect other items like Social Security numbers, account numbers, and so on. So, the company ensures that its current activities are in compliance with the regulations and laws, but what if its customers find out that it is not protecting their full names and they associate this with identity fraud because of their lack of education on the matter? The company may not be able to handle this potential reputation hit, even if it is doing all it is supposed to be doing. Perceptions of a company's customer base are not always rooted in fact, but the possibility that customers will move their business to another company is a potential fact your company must comprehend.

Figure 2-5 shows how a risk management program can be set up, which ties together many of the concepts covered thus far in this chapter.



**Figure 2-5** How a risk management program can be set up

## Total Risk vs. Residual Risk

The reason an organization implements countermeasures is to reduce its overall risk to an acceptable level. As stated earlier, no system or environment is 100 percent secure, which means there is always some risk left over to deal with. This is called *residual risk*.

Residual risk is different from *total risk*, which is the risk an organization faces if it chooses not to implement any type of safeguard. An organization may choose to take on total risk if the cost/benefit analysis results indicate this is the best course of action. For example, if there is a small likelihood that an organization's web servers can be compromised and the necessary safeguards to provide a higher level of protection cost more than the potential loss in the first place, the organization will choose not to implement the safeguard, choosing to deal with the total risk.

There is an important difference between total risk and residual risk and which type of risk an organization is willing to accept. The following are conceptual formulas:

$$\text{threats} \times \text{vulnerability} \times \text{asset value} = \text{total risk}$$
$$(\text{threats} \times \text{vulnerability} \times \text{asset value}) \times \text{controls gap} = \text{residual risk}$$

You may also see these concepts illustrated as the following:

$$\text{total risk} - \text{countermeasures} = \text{residual risk}$$


**NOTE** The previous formulas are not constructs you can actually plug numbers into. They are instead used to illustrate the relation of the different items that make up risk in a conceptual manner. This means no multiplication or mathematical functions actually take place. It is a means of understanding what items are involved when defining either total or residual risk.

During a risk assessment, the threats and vulnerabilities are identified. The possibility of a vulnerability being exploited is multiplied by the value of the assets being assessed, which results in the total risk. Once the controls gap (protection the control cannot provide) is factored in, the result is the residual risk. Implementing countermeasures is a way of mitigating risks. Because no organization can remove all threats, there will always be some residual risk. The question is what level of risk the organization is willing to accept.

## Countermeasure Selection and Implementation

Countermeasures are the means by which we reduce specific risks to acceptable levels. This section addresses identifying and choosing the right countermeasures for computer systems. It gives the best attributes to look for and the different cost scenarios to investigate when comparing different types of countermeasures. The end product of the analysis of choices should demonstrate why the selected control is the most advantageous to the organization.





**NOTE** The terms control, countermeasure, safeguard, security mechanism, and protection mechanism are synonymous in the context of information systems security. We use them interchangeably.

## Control Selection

A security control must make good business sense, meaning it is cost-effective (its benefit outweighs its cost). This requires another type of analysis: a *cost/benefit analysis*. A commonly used cost/benefit calculation for a given safeguard (control) is

$$(\text{ALE before implementing safeguard}) - (\text{ALE after implementing safeguard}) - (\text{annual cost of safeguard}) = \text{value of safeguard to the organization}$$

For example, if the ALE of the threat of a hacker bringing down a web server is \$12,000 prior to implementing the suggested safeguard, and the ALE is \$3,000 after implementing the safeguard, while the annual cost of maintenance and operation of the safeguard is \$650, then the value of this safeguard to the organization is \$8,350 each year.

Recall that the ALE has two factors, the single loss expectancy and the annual rate of occurrence, so safeguards can decrease either or both. The countermeasure referenced in the previous example could aim to reduce the costs associated with restoring the web server, or make it less likely that it is brought down, or both. All too often, we focus our attention on making the threat less likely, while, in some cases, it might be less expensive to make it easier to recover.

The cost of a countermeasure is more than just the amount filled out on the purchase order. The following items should be considered and evaluated when deriving the full cost of a countermeasure:

- Product costs
- Design/planning costs
- Implementation costs
- Environment modifications (both physical and logical)
- Compatibility with other countermeasures
- Maintenance requirements
- Testing requirements
- Repair, replacement, or update costs
- Operating and support costs
- Effects on productivity
- Subscription costs
- Extra staff-hours for monitoring and responding to alerts

Many organizations have gone through the pain of purchasing new security products without understanding that they will need the staff to maintain those products. Although tools automate tasks, many organizations were not even carrying out these tasks before, so they do not save on staff-hours, but many times require more hours. For example, Company A decides that to protect many of its resources, purchasing an intrusion detection system is warranted. So, the company pays \$5,500 for an IDS. Is that the total cost? Nope. This software should be tested in an environment that is segmented from the production environment to uncover any unexpected activity. After this testing is complete and the security group feels it is safe to insert the IDS into its production environment, the security group must install the monitoring management software, install the sensors, and properly direct the communication paths from the sensors to the management console. The security group may also need to reconfigure the routers to redirect traffic flow, and it definitely needs to ensure that users cannot access the IDS management console. Finally, the security group should configure a database to hold all attack signatures and then run simulations.

Costs associated with an IDS alert response should most definitely be considered. Now that Company A has an IDS in place, security administrators may need additional alerting equipment such as smartphones. And then there are the time costs associated with a response to an IDS event.

Anyone who has worked in an IT group knows that some adverse reaction almost always takes place in this type of scenario. Network performance can take an unacceptable hit after installing a product if it is an inline or proactive product. Users may no longer be able to access a server for some mysterious reason. The IDS vendor may not have explained that two more service patches are necessary for the whole thing to work correctly. Staff time will need to be allocated for training and to respond to all of the alerts (true or false) the new IDS sends out.

So, for example, the cost of this countermeasure could be \$23,500 for the product and licenses; \$2,500 for training; \$3,400 for testing; \$2,600 for the loss in user productivity once the product is introduced into production; and \$4,000 in labor for router reconfiguration, product installation, troubleshooting, and installation of the two service patches. The real cost of this countermeasure is \$36,000. If our total potential loss was calculated at \$9,000, we went over budget by 300 percent when applying this countermeasure for the identified risk. Some of these costs may be hard or impossible to identify before they are incurred, but an experienced risk analyst would account for many of these possibilities.

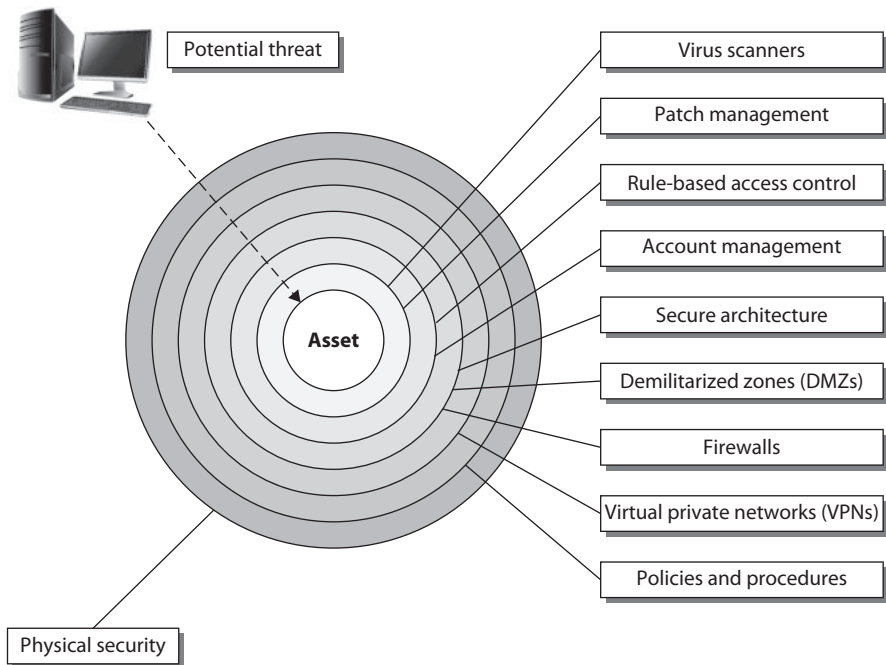
## Types of Controls

In our examples so far, we've focused on countermeasures like firewalls and IDSs, but there are many more options. Controls come in three main categories: administrative, technical, and physical. *Administrative controls* are commonly referred to as "soft controls" because they are more management oriented. Examples of administrative controls are security documentation, risk management, personnel security, and training. *Technical controls* (also called logical controls) are software or hardware components, as in firewalls, IDS, encryption, and identification and authentication mechanisms. And *physical controls*

are items put into place to protect facilities, personnel, and resources. Examples of physical controls are security guards, locks, fencing, and lighting.

These control categories need to be put into place to provide *defense-in-depth*, which is the coordinated use of multiple security controls in a layered approach, as shown in Figure 2-6. A multilayered defense system minimizes the probability of successful penetration and compromise because an attacker would have to get through several different types of protection mechanisms before she gained access to the critical assets. For example, Company A can have the following physical controls in place that work in a layered model:

- Fence
- Locked external doors
- Closed-circuit TV (CCTV)
- Security guard
- Locked internal doors
- Locked server room
- Physically secured computers (cable locks)



**Figure 2-6** Defense-in-depth

Technical controls that are commonly put into place to provide this type of layered approach are

- Firewalls
- Intrusion detection system
- Intrusion prevention system
- Antimalware
- Access control
- Encryption

The types of controls that are actually implemented must map to the threats the organization faces, and the number of layers that are put into place must map to the sensitivity of the asset. The rule of thumb is the more sensitive the asset, the more layers of protection that must be put into place.

So the different *categories* of controls that can be used are administrative, technical, and physical. But what do these controls actually *do* for us? We need to understand what the different control types can provide us in our quest to secure our environments.

The different types of security controls are *preventive*, *detective*, *corrective*, *deterrent*, *recovery*, and *compensating*. By having a better understanding of the different control types, you will be able to make more informed decisions about what controls will be best used in specific situations. The six different control types are as follows:

- **Preventive** Intended to avoid an incident from occurring
- **Detective** Helps identify an incident's activities and potentially an intruder
- **Corrective** Fixes components or systems after an incident has occurred
- **Deterrent** Intended to discourage a potential attacker
- **Recovery** Intended to bring the environment back to regular operations
- **Compensating** Provides an alternative measure of control

Once you understand fully what the different controls do, you can use them in the right locations for specific risks.

When looking at a security structure of an environment, it is most productive to use a preventive model and then use detective, corrective, and recovery mechanisms to help support this model. Basically, you want to stop any trouble before it starts, but you must be able to quickly react and combat trouble if it does find you. It is not feasible to prevent everything; therefore, what you cannot prevent, you should be able to quickly detect. That's why preventive and detective controls should always be implemented together and should complement each other. To take this concept further: what you can't prevent, you should be able to detect, and if you detect something, it means you weren't able to prevent it, and therefore you should take corrective action to make sure it is indeed prevented the next time around. Therefore, all three types work together: preventive, detective, and corrective.

The control types described next (administrative, physical, and technical) are preventive in nature. These are important to understand when developing an enterprise-wide security program. Obviously, these are only provided as illustrative examples. Keep in mind as you go over them that a specific control may fall within multiple classifications. For example, most security cameras could be considered preventive (since they may dissuade criminals from breaking in if they are highly visible), detective (if there is a person monitoring them live), and corrective (if they are used to track a criminal that breached your physical perimeter).

**Preventive: Administrative**

- Policies and procedures
- Effective hiring practices
- Pre-employment background checks
- Controlled termination processes
- Data classification and labeling
- Security awareness

**Preventive: Physical**

- Badges, swipe cards
- Guards, dogs
- Fences, locks, mantraps

**Preventive: Technical**

- Passwords, biometrics, smart cards
- Encryption, secure protocols, call-back systems, database views, constrained user interfaces
- Antimalware software, access control lists, firewalls, IPS

Table 2-6 shows how these types of control mechanisms perform different security functions. Many students get themselves wrapped around the axle when trying to get their mind around which control provides which functionality. This is how this train of thought usually takes place: “A security camera system is a detective control, but if an attacker sees its cameras, it could be a deterrent.” Let’s stop right here. Do not make this any harder than it has to be. When trying to map the functionality requirement to a control, think of the *main* reason that control would be put into place. A firewall tries to prevent something bad from taking place, so it is a preventive control. Auditing logs is done after an event took place, so it is detective. A data backup system is developed so that data can be recovered; thus, this is a recovery control. Computer images are created so that if software gets corrupted, they can be reloaded; thus, this is a corrective control.

Note that some controls can serve different functions. Security guards can deter would-be attackers, but if they don’t deter all of them, they can also stop (prevent)

Control Type:	Preventive	Detective	Corrective	Deterrent	Recovery	Compensating
<b>Controls by Category:</b>						
<b>Physical</b>						
Fences				X		
Locks	X					
Badge system	X					
Security guard	X	X	X	X		
Mantrap doors	X					
Lighting				X		
Motion detectors		X				
Closed-circuit TVs		X				
Offsite facility					X	X
<b>Administrative</b>						
Security policy	X					X
Monitoring and supervising		X				X
Separation of duties	X					
Job rotation		X		X		
Information classification	X					
Investigations		X				
Security awareness training	X					
<b>Technical</b>						
ACLs	X					
Encryption	X					
Audit logs		X				
IDS		X				
Antimalware software	X	X				
Workstation images			X			
Smart cards	X					
Data backup					X	

**Table 2-6** Control Categories and Types

the ones that try to get into a facility. Perhaps the attacker was particularly sneaky and he managed to get into an office building, in which case the security guards can be detective controls as they make the rounds and even corrective controls when they find the intruder, call law enforcement, and escort the attacker out of the building and into the backseat of a police car. When taking the CISSP exam, look for clues in the question to determine which functionality is most relevant.

One control functionality that some people struggle with is a compensating control. Let's look at some examples of compensating controls to best explain their function. If your organization needed to implement strong physical security, you might suggest to management that they employ security guards. But after calculating all the costs of security guards, your organization might decide to use a compensating (alternative) control that provides similar protection but is more affordable—as in a fence. In another example, let's say you are a security administrator and you are in charge of maintaining the organization's firewalls. Management tells you that a certain protocol that you know is vulnerable to exploitation has to be allowed through the firewall for business reasons. The network needs to be protected by a compensating (alternative) control pertaining to this protocol, which may be setting up a proxy server for that specific traffic type to ensure that it is properly inspected and controlled. So a compensating control is just an alternative control that provides similar protection as the original control but has to be used because it is more affordable or allows specifically required business functionality.

Several types of security controls exist, and they all need to work together. The complexity of the controls and of the environment they are in can cause the controls to contradict each other or leave gaps in security. This can introduce unforeseen holes in the organization's protection that are not fully understood by the implementers. An organization may have very strict technical access controls in place and all the necessary administrative controls up to snuff, but if any person is allowed to physically access any system in the facility, then clear security dangers are present within the environment. Together, these controls should work in harmony to provide a healthy, safe, and productive environment.

The risk assessment team must evaluate the security controls' functionality and effectiveness. When selecting a security control, some attributes are more favorable than others. Table 2-7 lists and describes attributes that should be considered before purchasing and committing to a security control.

Security controls can provide deterrence attributes if they are highly visible. This tells potential evildoers that adequate protection is in place and that they should move on to an easier target. Although the control may be highly visible, attackers should not be able to discover the way it works, thus enabling them to attempt to modify it, or know how to get around the protection mechanism. If users know how to disable the antimalware program that is taking up CPU cycles or know how to bypass a proxy server to get to the Internet without restrictions, they will do so.

## Control Assessments

Once you select the administrative, technical, and physical controls that you think will reduce your risks to acceptable levels, you have to ensure that this is actually the case.



Characteristic	Description
Modular	The control can be installed or removed from an environment without adversely affecting other mechanisms.
Provides uniform protection	A security level is applied in a standardized method to all mechanisms the control is designed to protect.
Provides override functionality	An administrator can override the restriction if necessary.
Defaults to least privilege	When installed, the control defaults to a lack of permissions and rights instead of installing with everyone having full control.
Independence of control and the asset it is protecting	The given control can protect multiple assets, and a given asset can be protected by multiple controls.
Flexibility and security	The more security the control provides, the better. This functionality should come with flexibility, which enables you to choose different functions instead of all or none.
Usability	The control does not needlessly interfere with users' work.
Asset protection	The asset is still protected even if the countermeasure needs to be reset.
Easily upgraded	Software continues to evolve, and updates should be able to happen painlessly.
Auditing functionality	The control includes a mechanism that provides auditing at various levels of verbosity.
Minimizes dependence on other components	The control should be flexible and not have strict requirements about the environment into which it will be installed.
Must produce output in usable and understandable format	The control should present important information in a format easy for humans to understand and use for trend analysis.
Testable	The control should be able to be tested in different environments under different situations.
Does not introduce other compromises	The control should not provide any covert channels or back doors.
System and user performance	System and user performance should not be greatly affected by the control.
Proper alerting	The control should have the capability for thresholds to be set as to when to alert personnel of a security breach, and this type of alert should be acceptable.
Does not affect assets	The assets in the environment should not be adversely affected by the control.

**Table 2-7** Characteristics to Consider When Assessing Security Controls

A *control assessment* is an evaluation of one or more controls to determine the extent to which they are implemented correctly, operating as intended, and producing the desired outcome. Let's look at each of those test elements in turn using anonymized examples from the real world.

You may have chosen the right control for a given risk, but you also need *verification* that the manner in which it is implemented is correct too. Let's suppose you decide to upgrade a firewall to mitigate a number of risks you've identified. You invest a ton of money in the latest and greatest firewall and apply a bunch of rules to filter out the good from the bad. And yet, you forget to change the administrator's default password, and an attacker is able to log into your firewall, lock out the security team by changing the password, and then change the rules to allow malicious traffic through. The technical control was good, it just wasn't implemented correctly. You avoid this by developing a thorough set of tests that look at every aspect of the implementation and ensure no steps were skipped or done wrong.

Another aspect of verification is to ensure that the controls are operating as intended. You may have implemented the control correctly, but there are many reasons why it may not work as you expected it would. For example, suppose you implement a policy that all personnel in a facility must wear identification badges. Employees, contractors, and visitors each get their own unique badge design to differentiate them. The policy is implemented, and all staff are trained on it, but after a few weeks people get complacent and stop noticing whether they (or others) are wearing badges. The administrative control was properly implemented but is not working as intended. The control assessment should include operational checks, such as having different people (perhaps some who are well known in the organization and some who are not part of it) walk through the facility with no badges and see whether they are challenged or reported.

Finally, we want *validation* that the controls are producing the desired outcomes. Controls are selected for the purpose of reducing risk...so are they? Suppose you install temperature sensors in your data center that generate alarms whenever they get too hot. You are trying to reduce the risk of hardware failures due to high temperatures. These physical controls are properly installed and work as intended. In fact, they generate alarms every day during peak usage hours. Are they reducing the risk? Unless you upgrade the underpowered air conditioning unit, all these alarms will do nothing to help you avoid outages. Any assessment of your controls must explicitly test whether the risk for which they were selected is actually being reduced.



**EXAM TIP** An easy way to differentiate verification and validation is that verification answers the question "did we implement the control right?" while validation answers the question "did we implement the right control?"

## Security and Privacy

*Security effectiveness* deals with metrics such as meeting service level agreement (SLA) requirements, achieving returns on investment (ROIs), meeting set baselines, and providing management with a dashboard or balanced scorecard system. These are ways to determine how useful the current security solutions and architecture as a whole are performing.

Another side to assessing security controls is ensuring that they do not violate our privacy policies and regulations. It does us no good to implement the best security controls if they require gross violations of people's right to keep certain information

about themselves from being known or used in inappropriate ways. For example, an organization could have a policy that allows employees to use the organization's assets for personal purposes while they are on breaks. The same organization has implemented Transport Layer Security (TLS) proxies that decrypt all network traffic in order to conduct deep packet analysis and mitigate the risk that a threat actor is using encryption to hide her malicious deeds. Normally, the process is fully automated and no other staff members look at the decrypted communications. Periodically, however, security staff manually check the system to ensure everything is working properly. Now, suppose an employee reveals some very private health information to a friend over her personal webmail and that traffic is monitored and observed by a security staffer. That breach of privacy could cause a multitude of ethical, regulatory, and even legal problems for the organization.

When implementing security controls, it is critical to consider their privacy implications. If your organization has a chief privacy officer (or other privacy professional), that person should be part of the process of selecting and implementing security controls to ensure they don't unduly (or even illegally) violate employee privacy.

## Monitoring Risks

We really can't just build a risk management program (or any program, for that matter), call it good, and go home. We need a way to assess the effectiveness of our work, identify deficiencies, and prioritize the things that still need work. We need a way to facilitate decision making, performance improvement, and accountability through collection, analysis, and reporting of the necessary information. More importantly, we need to be able to identify changes in the environment and be able to understand their impacts on our risk posture. All this needs to be based on facts and metrics. As the saying goes, "You can't manage something you can't measure."

*Risk monitoring* is the ongoing process of adding new risks, reevaluating existing ones, removing moot ones, and continuously assessing the effectiveness of our controls at mitigating all risks to tolerable levels. Risk monitoring activities should be focused on three key areas: effectiveness, change, and compliance. The risk management team should continually look for improvement opportunities, periodically analyze the data gathered from each key area, and report its findings to senior management. Let's take a closer look at how we might go about monitoring and measuring each area.

## Effectiveness Monitoring

There are many reasons why the effectiveness of our security controls decreases. Technical controls may not adapt quickly to changing threat actor behaviors. Employees may lose awareness of (or interest in) administrative controls. Physical controls may not keep up with changing behaviors as people move in and through our facilities. How do we measure this decline in the effectiveness of our controls and, more importantly, the rising risks to our organizations? This is the crux of effectiveness monitoring.

One approach is to keep track of the number of security incidents by severity. Let's say that we implemented controls to reduce the risk of ransomware attacks. We redesigned our security awareness training, deployed a new endpoint detection and

response (EDR) solution, and implemented an automated offline backup system. Subsequently, the number of ransomware-related incidents sharply declined across all severity categories. While we still see a handful of localized cases here and there, no data is lost, nobody is forced offline, and business is humming. However, recently we are noticing that the number of low-severity incidents has started to increase. These are cases where the ransomware makes it onto a workstation but is stopped as it attempts to encrypt files. If we're not paying attention to this trend, we may miss the fact that the malware is evolving and becoming more effective at evading our EDR solution. We'd be giving the adversary a huge advantage by letting them experiment and improve while we do nothing about it. This is why effectiveness monitoring is important, and why it has to be tied to specific metrics that can be quantified and analyzed over time.

In the previous example, the metric was the number of incidents related to ransomware in our environment. There are many other metrics you could use, depending on the control in question. You could use a red team and measure the number of times it is successful at compromising various assets. You could use the number of suspected phishing attacks reported by alert employees. Whatever your approach, you should determine the effectiveness metrics you'll use to monitor controls when you decide to use those controls. Then, you really need to track those metrics over time to identify trends. Failure to do so will result, almost inevitably, in the gradual (or perhaps sudden) increase in risk until, one sad day, it is realized.



**NOTE** The Center for Internet Security (CIS) publishes a helpful (and free) document titled "CIS Controls Measures and Metrics," currently in its seventh version. It provides specific measures for each control as well as goals for their values in your organization.

A good way to enable effectiveness monitoring is to establish a standing group that periodically checks known threats and the controls that are meant to mitigate them. An example of this is a threat working group (TWG), which consists of members of all major parts of the organization, meeting regularly (say, monthly) to review the list of risks (sometimes called a risk registry) and ensure that threats and controls remain valid. The TWG assigns owners to each risk and ensures those persons or groups are keeping up their responsibilities. The TWG can also be the focal point for scheduling security assessments, be they internal or external, to verify and validate the controls.

## Change Monitoring

Even if you keep track of known threats and the risks they pose, it is likely that changes in your organization's environment will introduce new risks. There are two major sources of change that impact your overall risk: information systems and business. The first is perhaps the most obvious to cybersecurity professionals. A new system is introduced, an old one retired, or an existing one updated or reconfigured. Any of these changes can produce new risks or change those you are already tracking. Another source of changes that introduce risks is the business itself. Over time, your organization will embark on new ventures, change internal processes, or perhaps merge with or acquire another organization.

All these changes need to be carefully analyzed to ensure an accurate understanding of their effects on the overall risk posture.

Monitoring changes to your environment and dealing with the risks they could introduce is part of a good change management process. Typically, organizations will have a change advisory board (CAB) or a similarly named standing group that reviews and approves any changes such as the development of new policies, systems, and business processes. The CAB measures changes through a variety of metrics that also are used to monitor risks, such as the following:

- Number of unauthorized changes
- Average time to implement a change
- Number of failed changes
- Number of security incidents attributable to changes



**NOTE** We will discuss change management in more detail in Chapter 19.

## Compliance Monitoring

Something else that could change in your organization and affect your risk are legal, regulatory, and policy requirements. Compliance monitoring is a bit easier than effectiveness monitoring and change monitoring, because compliance tends to change fairly infrequently. Laws and external regulations usually take years to change, while internal regulations and policies should be part of the change management process we discussed previously. Though the frequency of compliance changes is fairly low, these changes can have significant impacts in the organization. A great example of this is the General Data Protection Regulation (GDPR) that came into effect in May 2018. It was years in the making, but it has had huge effects on any organization that stores or processes data belonging to a person from the European Union (EU).

Another aspect of compliance monitoring is responding to audit findings. Whether it is an external or internal audit, any findings dealing with compliance need to be addressed. If the audit reveals risks that are improperly mitigated, the risk team needs to respond to them. Failure to do so could result in significant fines or even criminal charges.

So, what can we measure to monitor our compliance? It varies among organizations, but here are some common metrics to consider:

- Number of audit findings
- Ratio of internal (i.e., self-discovered) to external (i.e., audit) inquiries
- Average time to close an inquiry
- Number of internal disciplinary actions related to compliance

No organization is perfectly compliant all the time, so there is always an element of compliance risk. These risks, however, increase dramatically if there is no formal process for searching for and dealing with issues that violate policies, regulations, or laws.

## Risk Reporting

Risk reporting is an essential component of risk management in general and risk monitoring in particular. (Recall that risk management encompasses framing, assessing, responding to, and monitoring the risks.) Reporting enables organizational decision-making, security governance, and day-to-day operations. It is also important for compliance purposes.

So, how *should* we report risks? There is no set formula for reporting, but there are a couple of guiding principles. The first one is to understand the audience. There are at least three groups at which you may target risk reports: executives (and board members), managers, and risk owners. Each requires a different approach.

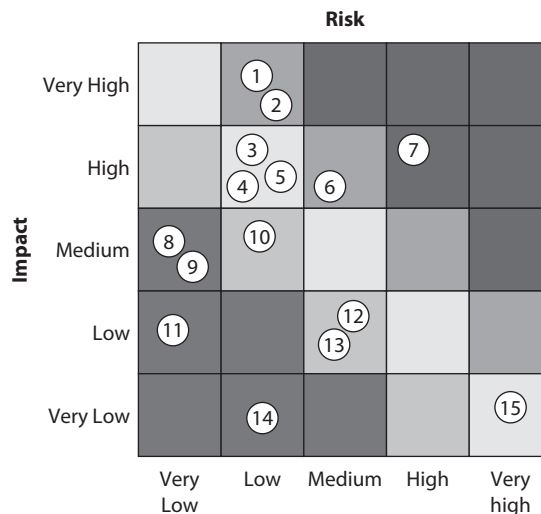
### Executives and Board Members

Senior leaders in an organization are generally not interested in the details, nor should they be. Their role is to set and monitor the strategic direction, not to run day-to-day operations. These leaders want to know whether risks can be properly mitigated or require change to the organizational strategy. They will be interested in the biggest risks to the organization and will want to know what is being done to address them. Executives and board members should also be briefed on risks that have been “accepted” and what their potential impacts could be.

When dealing with senior decision makers, risk heat maps, such as illustrated in Figure 2-7, are typically used rather than verbose descriptions. This is to ensure that these leaders can get the information they need at a glance in order to decide whether strategic adjustments may be needed. In Figure 2-7, board members likely would be interested in

**Figure 2-7**

Sample risk heat map



discussing risk item #7 first since it is particularly significant. That is the point of a heat map: it allows senior-level audiences to home in on the important topics for discussion.

## Managers

Managers across the organization will need much more detailed reports because they are responsible for, well, managing the risks. They will want to know current risks and how they've been trending over time. Are risks decreasing or increasing? Either way, why? Where does progress seem to be stuck? These are some of the questions managers will want the report to answer. They will also want to be able to drill into specific items of interest to get into the details, such as who owns the risk, how we are responding to the risk, and why the current approach may not be working.

Many organizations rely on risk management dashboards for this level of reporting. These dashboards may be part of a risk management tool, in which case they'd be interactive and allow drilling into specific items in the report. Organizations without these automated tools typically use spreadsheets to generate graphs (showing trends over time) or even manually developed slides. Whatever the approach, the idea is to present actionable information allowing business unit managers to track their progress over time with respect to risks.

## Risk Owners

This is the internal audience that needs the most detailed reporting, because the risk owners are the staff members responsible for managing individual risks. They take direction from management as they respond to specific risks. For example, if the organization decides to transfer a given risk, the risk owner will be responsible for ensuring the insurance policy is developed and acquired effectively. This will include performance indicators, such as cost, coverage, and responsiveness. Cybersecurity insurance companies often require that certain controls be in place in order to provide coverage, so the risk owner must also ensure that these conditions are met so that the premiums are not being paid in vain.

## Continuous Improvement

Only by reassessing the risks on a periodic basis can the risk management team's statements on security control performance be trusted. If the risk has not changed and the safeguards implemented are functioning in good order, then it can be said that the risk is being properly mitigated. Regular risk management monitoring will support the information security risk ratings.

Vulnerability analysis and continued asset identification and valuation are also important tasks of risk management monitoring and performance. The cycle of continued risk analysis is a very important part of determining whether the safeguard controls that have been put in place are appropriate and necessary to safeguard the assets and environment.

*Continuous improvement* is the practice of identifying opportunities, mitigating threats, improving quality, and reducing waste as an ongoing effort. It is the hallmark of mature and effective organizations.



Level	Maturity	Characteristics
1	Initial	Risk activities are ad hoc, reactive, and poorly controlled.
2	Repeatable	Procedures are documented and (mostly) followed.
3	Defined	Standard procedures, tools, and methods are applied consistently.
4	Managed	Quantitative methods are applied both to risk management and to the program.
5	Optimizing	Data-driven innovation occurs across the entire organization.

**Table 2-8** Typical Maturity Model

## Risk Maturity Modeling

Maturity models are tools that allow us to determine the ability of our organizations for continuous improvement. We generally assess the maturity of an organization's risk management on a scale of 1 to 5, as shown in Table 2-8. There is actually a level 0, which is where the organization is not managing risk at all.

While it may be tempting to think that we should all strive to achieve the highest level of maturity with regard to risk management, the reality is that we should reach the right level of maturity given our resources, strategies, and business environment. It would make little sense for a very small retail company to strive for level 5, because doing so would require a level of resource investment that is not realistic. Conversely, it would be a very bad idea for a large enterprise in the defense industry to be satisfied with a maturity level 1, because the risks it faces are substantial. Ultimately, the level of maturity that makes sense is a business decision, not a cybersecurity one.

## Supply Chain Risk Management

Many organizations fail to consider their supply chain when managing risk, despite the fact that it often presents a convenient and easier back door to an attacker. So what is a supply chain anyway? A supply chain is a sequence of suppliers involved in delivering some product. If your company manufactures laptops, your supply chain will include the vendor that supplies your video cards. It will also include whoever makes the integrated circuits that go on those cards, as well as the supplier of the raw chemicals that are involved in that process. The supply chain also includes suppliers of services, such as the company that maintains the heating, ventilation, and air conditioning (HVAC) systems needed to keep your assembly lines running.

The various organizations that make up your supply chain will have a different outlook on security than you do. For one thing, their threat modeling will include different threats than yours. Why would a criminal looking to steal credit card information target an HVAC service provider? This is exactly what happened in 2013 when Target had over 40 million credit cards compromised. Target had done a reasonable job at securing its perimeter, but not its internal networks. The attacker, unable (or maybe just unwilling) to penetrate Target's outer shell head-on, decided to exploit the vulnerable network of one of Target's HVAC service providers and steal its credentials. Armed with these, the

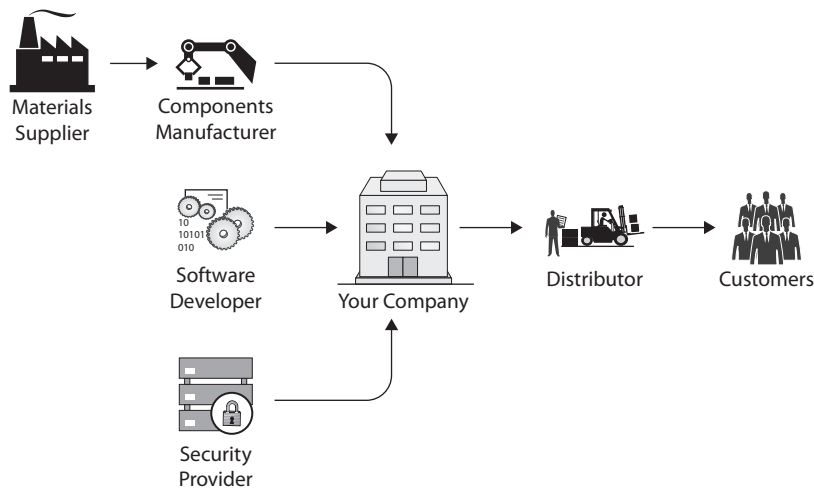
thieves were able to gain access to the point of sale terminals and, from there, the credit card information.

The basic processes you'll need to implement to manage risk in your supply chain are the same ones you use in the rest of your risk management program. The differences are mainly in what you look at (that is, the scope of your assessments) and what you can do about it (legally and contractually). A good resource to help integrate supply chain risk into your risk management program is NIST SP 800-161, *Supply Chain Risk Management Practices for Federal Information Systems and Organizations*.

One of the first things you'll need to do is to create a supply chain map for your organization. This is essentially a network diagram of who supplies what to whom, down to your ultimate customers. Figure 2-8 depicts a simplified systems integrator company ("Your Company"). It has a hardware components manufacturer that supplies it hardware and is, in turn, supplied by a materials producer. Your Company receives software from a developer and receives managed security from an external service provider. The hardware and software components are integrated and configured into Your Company's product, which is then shipped to its distributor and on to its customers. In this example, the company has four suppliers on which to base its supply chain risk assessment. It is also considered a supplier to its distributor.

Now, suppose the software developer in Figure 2-8 is attacked and the threat actors insert malicious code into the developer's software product. Anyone who receives that application from Your Company, or perhaps through an otherwise legitimate software update, also gets a very stealthy piece of malware that "phones home" to these actors, telling them where the malware is and what its host network looks like. These are sophisticated, nation-state spies intent on remaining undetected while they penetrate some very specific targets. If an infected organization is of interest to them, they'll deliver the next stage of malware with which to quietly explore and steal files. Otherwise, they'll

**Figure 2-8**  
Simplified supply chain



tell the malware to go dormant, making their actions extremely difficult to detect. This is a high-level description of a cyber campaign discovered in late 2020 that exploited the Orion software developed by U.S.-based firm SolarWinds. The magnitude of this series of attacks underscores the importance of managing risk introduced by your suppliers.

## Upstream and Downstream Suppliers

Suppliers are “upstream” from your company if they supply materials, goods, or services to your company and your company uses those in turn to provide whatever it is that it supplies to others. The core vulnerability that exists in these supply arrangements is that you could allow untrusted hardware, software, or services into your organization or products, where they could cause security problems. The Greeks used this to their advantage against the Trojans.

Conversely, your company may be upstream from others in the same supply chain. These would be your company’s downstream suppliers. While it may be tempting to think that you should be concerned only about supply chain security upstream, those who follow your company in the supply chain may have their own set of upstream requirements for your firm. Furthermore, your customers may not care that a security issue was caused by your downstream distributor; your brand name could be damaged all the same.

## Risks Associated with Hardware, Software, and Services

While we explore risks inherent in *any* hardware, software, and services later in this book, for now let’s consider those risks that are specifically tied to supply chains. That is to say, what risks do you face when you acquire something (or someone’s service) and insert it into your information systems?

### Hardware

One of the major supply chain risks is the addition of hardware Trojans to electronic components. A hardware Trojan is an electronic circuit that is added to an existing device in order to compromise its security or provide unauthorized functionality. Depending on the attacker’s access, these mechanisms can be inserted at any stage of the hardware development process (specification, design, fabrication, testing, assembly, or packaging). It is also possible to add them after the hardware is packaged by intercepting shipments in the supply chain. In this case, the Trojan may be noticeable if the device is opened and visually inspected. The earlier in the supply chain that hardware Trojans are inserted, the more difficult they are to detect.

Another supply chain risk to hardware is the substitution of counterfeit components. The problems with these clones are many, but from a security perspective one of the most important is that they don’t go through the same quality controls that the real ones do. This leads to lower reliability and abnormal behavior. It could also lead to undetected hardware Trojans (perhaps inserted by the illicit manufacturers themselves). Obviously, using counterfeits could have legal implications and will definitely be a problem when you need customer support from the manufacturer.

## Software

Like hardware, third-party software can be Trojaned by an adversary in your supply chain, particularly if it is custom-made for your organization. This could happen if your supplier reuses components (like libraries) developed elsewhere and to which the attacker has access. It can also be done by a malicious insider working for the supplier or by a remote attacker who has gained access to the supplier's software repositories. Failing all that, the software could be intercepted in transit to you, modified, and then sent on its way. This last approach could be made more difficult for the adversary by using code signing or hashes, but it is still possible.

## Services

More organizations are outsourcing services to allow them to focus on their core business functions. Organizations use hosting companies to maintain websites and e-mail servers, service providers for various telecommunication connections, disaster recovery companies for co-location capabilities, cloud computing providers for infrastructure or application services, developers for software creation, and security companies to carry out vulnerability management. It is important to realize that while you can outsource functionality, you cannot outsource risk. When your organization is using these third-party service providers, it can still be ultimately responsible if something like a data breach takes place. The following are some things an organization should do to reduce its risk when outsourcing:

- Review the service provider's security program
- Conduct onsite inspection and interviews
- Review contracts to ensure security and protection levels are agreed upon
- Ensure service level agreements are in place
- Review internal and external audit reports and third-party reviews
- Review references and communicate with former and existing customers
- Review Better Business Bureau reports
- Ensure the service provider has a business continuity plan (BCP) in place
- Implement a nondisclosure agreement (NDA)
- Understand the provider's legal and regulatory requirements

Service outsourcing is prevalent within organizations today but is commonly forgotten about when it comes to security and compliance requirements. It may be economical to outsource certain functionalities, but if this allows security breaches to take place, it can turn out to be a very costly decision.

## Other Third-Party Risks

An organization's supply chain is not its only source of third-party risks. There are many other ways in which organizations may be dependent on each other that don't really fit the

supplier–consumer model. For example, many companies have a network of channel partners that help them directly or indirectly sell products. Others engage in general or limited partnerships for specific projects, and these relationships require sharing some resources and risks. Most organizations nowadays have a complex web of (sometimes not so obvious) third parties on whom they rely to some extent and who, therefore, introduce risks.

## Minimum Security Requirements

The key to effectively mitigating risks to an organization introduced by its suppliers is to clearly state each party's requirements in the contract or agreement that governs their relationship. In terms of cybersecurity, this includes whatever measures are needed to protect sensitive data at rest, in transit, and in use. It also includes the actions the supplier shall perform should the data become compromised, as well as the means through which the purchasing organization may proactively verify compliance. In summary, the critical classes of requirements that should be included in a contractual agreement are as follows.

- **Data protection** Proactive cybersecurity measures
- **Incident response** Reactive cybersecurity measures
- **Verification means** Ways in which the customer may verify the preceding requirements

If any requirements are missing, ambiguously stated, or otherwise vitiated, the supplier agreement can become void, voidable, or unenforceable. So, how do you verify that your supplier is complying with all contractual requirements dealing with risk? Third-party assessments are considered best practice and may be required for compliance (e.g., with PCI DSS). The following are some examples of external evaluations that would indicate a supplier's ability to comply with its contractual obligations:

- ISO 27001 certification
- U.S. Department of Defense Cybersecurity Maturity Model Certification (CMMC)
- Payment Card Industry Digital Security Standard (PCI DSS) certification
- Service Organization Control 1 (SOC1) or 2 (SOC2) report
- U.S. Federal Risk and Authorization Management Program (FedRAMP) authorization



**NOTE** We will discuss these third-party evaluations in subsequent chapters.

Other third-party evaluations, such as vulnerability assessments and penetration tests, are helpful in establishing a baseline of security in the organization. However, by themselves, these limited-scope tests are insufficient to verify that the supplier is able to fulfill its contractual obligations.

## Service Level Agreements

A *service level agreement (SLA)* is a contractual agreement that states that a service provider guarantees a certain level of service. If the service is not delivered at the agreed-upon level (or better), then there are consequences (typically financial) for the service provider. SLAs provide a mechanism to mitigate some of the risk from service providers in the supply chain. For example, an Internet service provider (ISP) may sign an SLA of 99.999 percent (commonly called “five nines”) uptime to the Internet backbone. That means that the ISP guarantees less than 26 seconds of downtime per month.

## Business Continuity

Though we strive to drive down the risks of negative effects in our organizations, we can be sure that sooner or later an event will slip through and cause negative impacts. Ideally, the losses are contained and won't affect the major business efforts. However, as security professionals we need to have plans in place for when the unthinkable happens. Under those extreme (and sometimes unpredictable) conditions, we need to ensure that our organizations continue to operate at some minimum acceptable threshold capacity and quickly bounce back to full productivity.

*Business continuity (BC)* is an organization's ability to maintain business functions or quickly resume them in the event that risks are realized and result in disruptions. The events can be pretty mundane, such as a temporary power outage, loss of network connectivity, or a critical employee (such as a systems administrator) suddenly becoming ill. These events could also be major disasters, such as an earthquake, explosion, or energy grid failure. *Disaster recovery (DR)*, by contrast to BC, is the process of minimizing the effects of a disaster or major disruption. It means taking the necessary steps to ensure that the resources, personnel, and business processes are safe and able to resume operation in a timely manner. So, DR is part of BC and the *disaster recovery plan (DRP)* covers a subset of events compared to the broader *business continuity plan (BCP)*.



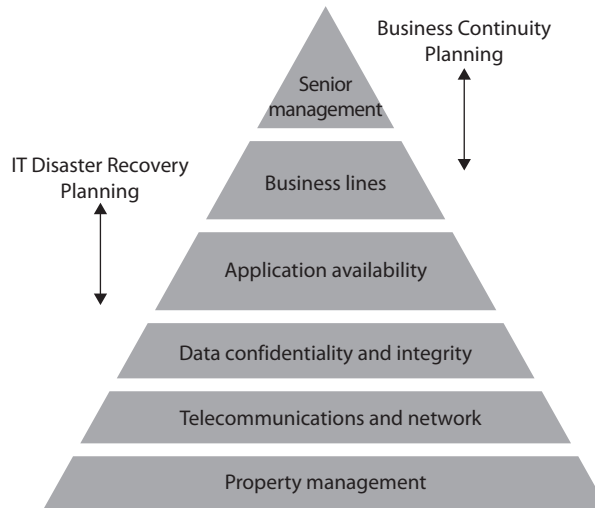
**EXAM TIP** A business continuity plan (BCP) and a disaster recovery plan (DRP) are related but different. The DRP is a subset of the BCP and is focused on the immediate aftermath of a disaster. The BCP is much broader and covers any disruption including (but not limited to) disasters.



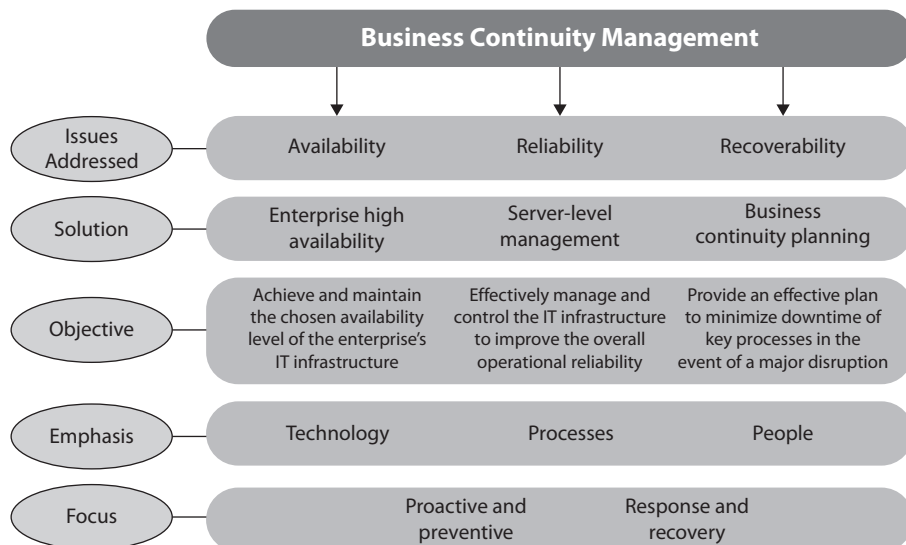
**NOTE** We discuss disaster recovery plans in detail in Chapter 23.

A BCP can include getting critical systems to another environment while repair of the original facilities is underway, getting the right people to the right places during this time, and performing business in a different mode until regular conditions are back in place. A BCP also involves dealing with customers, partners, and shareholders through different channels until everything returns to normal. So, disaster recovery deals with,

“Oh my goodness, the sky is falling,” and continuity planning deals with, “Okay, the sky fell. Now, how do we stay in business until someone can put the sky back where it belongs?”



While disaster recovery and business continuity planning are directed at the development of plans, *business continuity management (BCM)* is the holistic management process that should cover both of them. BCM provides a framework for integrating resilience with the capability for effective responses in a manner that protects the interests of an organization’s key stakeholders. The main objective of BCM is to allow the organization to continue to perform business operations under various conditions.



Certain characteristics run through many of the chapters in this book: availability, integrity, and confidentiality. Here, we point out that integrity and confidentiality must be considered not only in everyday procedures but also in those procedures undertaken immediately after a disaster or disruption. For instance, it may not be appropriate to leave a server that holds confidential information in one building while everyone else moves to another building. Equipment that provides secure VPN connections may be destroyed and the team might respond by focusing on enabling remote access functionality while forgetting about the needs of encryption. In most situations the organization is purely focused on getting back up and running, thus focusing on functionality. If security is not integrated and implemented properly, the effects of the physical disaster can be amplified as threat actors come in and steal sensitive information. Many times an organization is much more vulnerable *after* a disaster hits, because the security services used to protect it may be unavailable or operating at a reduced capacity. Therefore, it is important that if the organization has secret stuff, it stays secret.

Availability is one of the main themes behind business continuity planning, in that it ensures that the resources required to keep the business going will continue to be available to the people and systems that rely upon them. This may mean backups need to be done religiously and that redundancy needs to be factored into the architecture of the systems, networks, and operations. If communication lines are disabled or if a service is rendered unusable for any significant period of time, there must be a quick and tested way of establishing alternative communications and services. We will be diving into the many ways organizations can implement availability solutions for continuity and recovery purposes throughout this section.

When looking at business continuity planning, some organizations focus mainly on backing up data and providing redundant hardware. Although these items are extremely important, they are just small pieces of the organization's overall operations pie. Hardware and computers need people to configure and operate them, and data is usually not useful unless it is accessible by other systems and possibly outside entities. Thus, a larger picture

### **Business Continuity Planning**

Preplanned procedures allow an organization to

- Provide an immediate and appropriate response to emergency situations
- Protect lives and ensure safety
- Reduce business impact
- Resume critical business functions
- Work with outside vendors and partners during the recovery period
- Reduce confusion during a crisis
- Ensure survivability of the organization
- Get “up and running” quickly after a disaster



of how the various processes within an organization work together needs to be understood. Planning must include getting the right people to the right places, documenting the necessary configurations, establishing alternative communications channels (voice and data), providing power, and making sure all dependencies are properly understood and taken into account.

It is also important to understand how automated tasks can be carried out manually, if necessary, and how business processes can be safely altered to keep the operation of the organization going. This may be critical in ensuring the organization survives the event with the least impact to its operations. Without this type of vision and planning, when a disaster hits, an organization could have its backup data and redundant servers physically available at the alternative facility, but the people responsible for activating them may be standing around in a daze, not knowing where to start or how to perform in such a different environment.

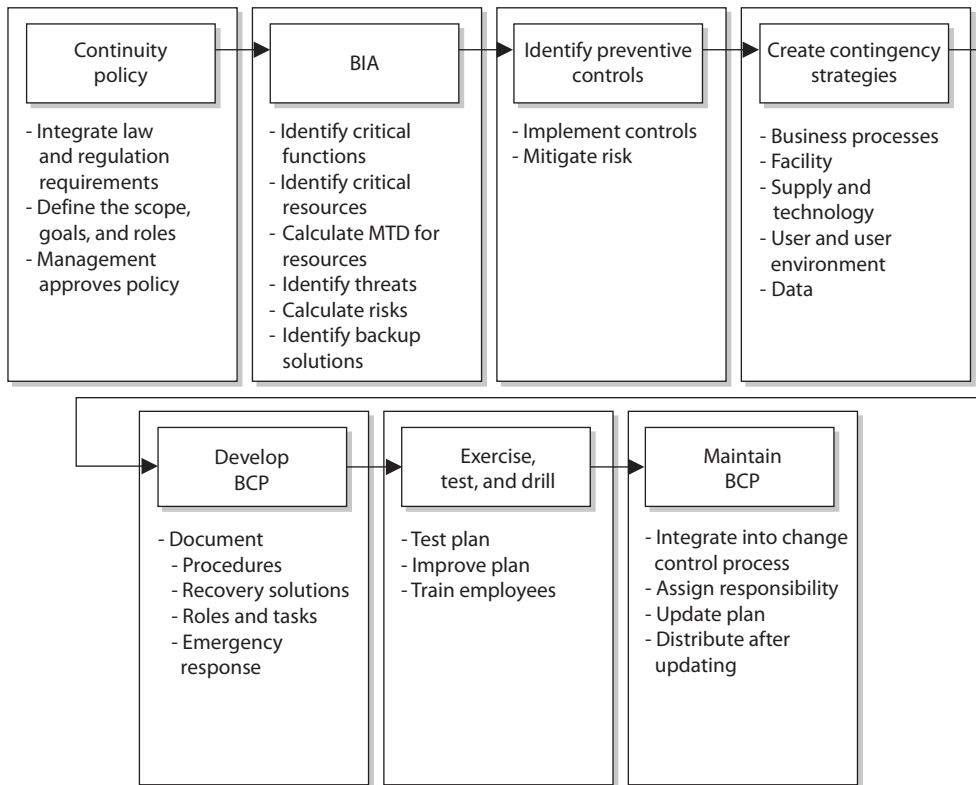
## Standards and Best Practices

Although no specific scientific equation must be followed to create continuity plans, certain best practices have proven themselves over time. The National Institute of Standards and Technology is responsible for developing best practices and standards as they pertain to U.S. government and military environments. It is common for NIST to document the requirements for these types of environments, and then everyone else in the industry uses NIST's documents as guidelines. So these are "musts" for U.S. government organizations and "good to have" for other, nongovernment entities.

NIST outlines the following steps in SP 800-34, Rev. 1, *Contingency Planning Guide for Federal Information Systems*:

1. *Develop the continuity planning policy statement.* Write a policy that provides the guidance necessary to develop a BCP and that assigns authority to the necessary roles to carry out these tasks.
2. *Conduct the business impact analysis (BIA).* Identify critical functions and systems and allow the organization to prioritize them based on necessity. Identify vulnerabilities and threats, and calculate risks.
3. *Identify preventive controls.* Once threats are recognized, identify and implement controls and countermeasures to reduce the organization's risk level in an economical manner.
4. *Create contingency strategies.* Formulate methods to ensure systems and critical functions can be brought online quickly.
5. *Develop an information system contingency plan.* Write procedures and guidelines for how the organization can still stay functional in a crippled state.
6. *Ensure plan testing, training, and exercises.* Test the plan to identify deficiencies in the BCP, and conduct training to properly prepare individuals on their expected tasks.
7. *Ensure plan maintenance.* Put in place steps to ensure the BCP is a living document that is updated regularly.

Although NIST SP 800-34 deals specifically with IT contingency plans, these steps are similar when creating enterprise-wide BCPs and BCM programs.



Since BCM is so critical, it is actually addressed by other standards-based organizations, listed here:

**ISO/IEC 27031:2011** Guidelines for information and communications technology readiness for business continuity. This ISO/IEC standard is a component of the overall ISO/IEC 27000 series.

**ISO 22301:2019** International standard for business continuity management systems. The specification document against which organizations will seek certification.

**Business Continuity Institute's Good Practice Guidelines (GPG)** Represents the consensus view of an international group of BC practitioners. As of this writing, the latest edition was published in 2018. It is organized around six Professional Practices (PP):

- **Policy and Program Management (PP1)** Focuses on governance
- **Embedding Business Continuity (PP2)** Provides guidance on embedding BCM in the organization's culture, which includes awareness and training

- **Analysis (PP3)** Addresses organizational review, risk assessment, and business impact analysis, among other topics
- **Design (PP4)** Focuses on identifying and selecting the right BC solutions
- **Implementation (PP5)** Addresses what should go into the BC plan
- **Validation (PP6)** Covers exercising, maintaining, and reviewing the program

**DRI International Institute's Professional Practices for Business Continuity Management** Best practices and framework to allow for BCM processes, which are broken down into the following sections:

- Program Initiation and Management
- Risk Assessment
- Business Impact Analysis
- Business Continuity Strategies
- Incident Response
- Plan Development and Implementation
- Awareness and Training Programs
- Business Continuity Plan Exercise, Assessment, and Maintenance
- Crisis Communications
- Coordination with External Agencies

Why are there so many sets of best practices and which is the best for your organization? If your organization is part of the U.S. government or a government contracting organization, then you need to comply with the NIST standards. If your organization is in Europe or your organization does business with other organizations in Europe, then you might need to follow the European Union Agency for Cybersecurity (ENISA) requirements. While we are not listing all of them here, there are other country-based BCM standards that your organization might need to comply with if it is residing in or does business in one of those specific countries. If your organization needs to get ISO certified, then ISO/IEC 27031 and ISO 22301 could be the standards to follow. While the first of these is focused on IT, the second is broader in scope and addresses the needs of the entire organization.

## Making BCM Part of the Enterprise Security Program

As we already explained, every organization should have security policies, procedures, standards, and guidelines. People who are new to information security commonly think that this is one pile of documentation that addresses all issues pertaining to security, but it is more complicated than that—of course.

Business continuity planning ought to be fully integrated into the organization as a regular management process, just like auditing or strategic planning or other “normal”

### Understanding the Organization First

An organization has no real hope of rebuilding itself and its processes after a disaster if it does not have a good understanding of how its organization works in the first place. This notion might seem absurd at first. You might think, “Well, of course an organization knows how it works.” But you would be surprised at how difficult it is to fully understand an organization down to the level of detail required to rebuild it. Each individual may know and understand his or her little world within the organization, but hardly anyone at any organization can fully explain how each and every business process takes place.

processes. Instead of being considered an outsider, BCP should be “part of the team.” Further, final responsibility for BCP should belong not to the BCP team or its leader, but to a high-level executive manager, preferably a member of the executive board. This will reinforce the image and reality of continuity planning as a function seen as vital to the organizational chiefs.

By analyzing and planning for potential disruptions to the organization, the BCP team can assist other business disciplines in their own efforts to effectively plan for and respond effectively and with resilience to emergencies. Given that the ability to respond depends on operations and management personnel throughout the organization, such capability should be developed organization-wide. It should extend throughout every location of the organization and up the employee ranks to top-tier management.

As such, the BCP program needs to be a living entity. As an organization goes through changes, so should the program, thereby ensuring it stays current, usable, and effective. When properly integrated with change management processes, the program stands a much better chance of being continually updated and improved upon. Business continuity is a foundational piece of an effective security program and is critical to ensuring relevance in time of need.

A very important question to ask when first developing a BCP is *why* it is being developed. This may seem silly and the answer may at first appear obvious, but that is not always the case. You might think that the reason to have these plans is to deal with an unexpected disaster and to get people back to their tasks as quickly and as safely as possible, but the full story is often a bit different. Why are most companies in business? To make money and be profitable. If these are usually the main goals of businesses, then any BCP needs to be developed to help achieve and, more importantly, maintain these goals. The main reason to develop these plans in the first place is to reduce the risk of financial loss by improving the company’s ability to recover and restore operations. This encompasses the goals of mitigating the effects of the disaster.

Not all organizations are businesses that exist to make profits. Government agencies, military units, nonprofit organizations, and the like exist to provide some type of protection or service to a nation or society. Whereas a company must create its BCP to ensure that revenue continues to come in so that the company can stay in business,

other types of organizations must create their BCPs to make sure they can still carry out their critical tasks. Although the focus and business drivers of the organizations and companies may differ, their BCPs often have similar constructs—which is to get their critical processes up and running.

Protecting what is most important to a company is rather difficult if what is most important is not first identified. Senior management is usually involved with this step because it has a point of view that extends beyond each functional manager's focus area of responsibility. Senior management has the visibility needed to establish the scope of the plan. The company's BCP should be focused on the company's critical mission and business functions. And, conversely, the BCP must support the organization's overall strategy. The functions must have priorities set upon them to indicate which is most crucial to a company's survival. The scope of the BCP is defined by which of these functions are considered important enough to warrant the investment of resources required for BC.

As stated previously, for many companies, financial operations are most critical. As an example, an automotive company would be affected far more seriously if its credit and loan services were unavailable for a day than if, say, an assembly line went down for a day, since credit and loan services are where it generates the biggest revenues. For other organizations, customer service might be the most critical area to ensure that order processing is not negatively affected. For example, if a company makes heart pacemakers and its physician services department is unavailable at a time when an operating room surgeon needs to contact it because of a complication, the results could be disastrous for the patient. The surgeon and the company would likely be sued, and the company would likely never again be able to sell another pacemaker to that surgeon, her colleagues, or perhaps even the patient's health maintenance organization (HMO). It would be very difficult to rebuild reputation and sales after something like that happened.

Advanced planning for emergencies covers issues that were thought of and foreseen. Many other problems may arise that are not covered in the BCP; thus, flexibility in the plan is crucial. The plan is a systematic way of providing a checklist of actions that should take place right after a disaster. These actions have been thought through to help the people involved be more efficient and effective in dealing with traumatic situations.

The most critical part of establishing and maintaining a current BCP is management support. Management must be convinced of the necessity of such a plan. Therefore, a business case must be made to obtain this support. The business case may include current vulnerabilities, regulatory and legal obligations, the current status of recovery plans, and recommendations. Management is mostly concerned with cost/benefit issues, so preliminary numbers need to be gathered and potential losses estimated. A cost/benefit analysis should include shareholder, stakeholder, regulatory, and legislative impacts, as well as impacts on products, services, and personnel. The decision of how a company should recover is commonly a business decision and should always be treated as such.

## **Business Impact Analysis**

Business continuity planning deals with uncertainty and chance. What is important to note here is that even though you cannot predict whether or when a disaster will happen,

that doesn't mean you can't plan for it. Just because we are not planning for an earthquake to hit us tomorrow morning at 10 A.M. doesn't mean we can't plan the activities required to successfully survive when an earthquake (or a similar disaster) does hit. The point of making these plans is to try to think of all the possible disasters that could take place, estimate the potential damage and loss, categorize and prioritize the potential disasters, and develop viable alternatives in case those events do actually happen.

A *business impact analysis (BIA)* is considered a *functional analysis*, in which a team collects data through interviews and documentary sources; documents business functions, activities, and transactions; develops a hierarchy of business functions; and finally applies a classification scheme to indicate each individual function's criticality level. But how do we determine a classification scheme based on criticality levels?

The BCP committee must identify the threats to the organization and map them to the following characteristics:

- Maximum tolerable downtime and disruption for activities
- Operational disruption and productivity
- Financial considerations
- Regulatory responsibilities
- Reputation

The committee will not truly understand all business processes, the steps that must take place, or the resources and supplies these processes require. So the committee must gather this information from the people who do know—department managers and specific employees throughout the organization. The committee starts by identifying the people who will be part of the BIA data-gathering sessions. The committee needs to identify how it will collect the data from the selected employees, be it through surveys, interviews, or workshops. Next, the team needs to collect the information by actually conducting surveys, interviews, and workshops. Data points obtained as part of the information gathering will be used later during analysis. It is important that the team members ask about how different tasks—whether processes, transactions, or services, along with any relevant dependencies—get accomplished within the organization. The team should build process flow diagrams, which will be used throughout the BIA and plan development stages.

Upon completion of the data collection phase, the BCP committee needs to conduct a BIA to establish which processes, devices, or operational activities are critical. If a system stands on its own, doesn't affect other systems, and is of low criticality, then it can be classified as a tier-two or tier-three recovery step. This means these resources will not be dealt with during the recovery stages until the most critical (tier one) resources are up and running. This analysis can be completed using a standard risk assessment as illustrated in Figure 2-9.

## Risk Assessment

To achieve success, the organization should systematically plan and execute a formal BCP-related risk assessment. The assessment fully takes into account the organization's