Chapter 4

COMMON THREATS: A BRIEF OVERVIEW

Computer systems are vulnerable to many threats that can inflict various types of damage resulting in significant losses. This damage can range from errors harming database integrity to fires destroying entire computer centers. Losses can stem, for example, from the actions of supposedly trusted employees defrauding a system, from outside hackers, or from careless data entry clerks. Precision in estimating computer security-related losses is not possible because many losses are never discovered, and others are "swept under the carpet" to avoid unfavorable publicity. The effects of various threats varies considerably: some affect the confidentiality or integrity of data while others affect the availability of a system.

This chapter presents a broad view of the risky environment in which systems operate today. The threats and associated losses presented in this chapter were selected based on their prevalence and significance in the current computing environment and their expected growth. This list is not exhaustive, and some threats may combine elements from more than one area.[19] This overview of many of today's common threats may prove useful to organizations studying their own threat environments; however, the perspective of this chapter is very broad. Thus, threats against particular systems could be quite different from those discussed here.[20]

To control the risks of operating an information system, managers and users need to know the vulnerabilities of the system and the threats that may exploit them. Knowledge of the threat[21] environment allows the system manager to implement the most cost-effective security measures. In some cases, managers may find it more cost-effective to simply tolerate the expected losses. Such decisions should be based on the results of a risk analysis. (See Chapter 7.)

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[19] As is true for this publication as a whole, this chapter does not address threats to national security systems, which fall outside of NIST's purview. The term "national security systems" is defined in National Security Directive 42 (7/5/90) as being "those telecommunications and information systems operated by the U.S. Government, its contractors, or agents, that contain classified information or, as set forth in 10 U.S.C. 2315, that involves intelligence activities, involves cryptologic activities related to national security, involves command and control of military forces, involves equipment that is an integral part of a weapon or weapon system, or involves equipment that is critical to the direct fulfillment of military or intelligence missions."

[20] A discussion of how threats, vulnerabilities, safeguard selection and risk mitigation are related is contained in Chapter 7, Risk Management.

[21] Note that one protects against threats that can exploit a vulnerability. If a vulnerability exists but no threat exists to take advantage of it, little or nothing is gained by protecting against the vulnerability. See Chapter 7, Risk Management.

4.1 Errors and Omissions

Errors and omissions are an important threat to data and system integrity. These errors are caused not only by data entry clerks processing hundreds of transactions per day, but also by all types of users who create and edit data. Many programs, especially those designed by users for personal computers, lack quality control measures. However, even the most sophisticated programs cannot detect all types of input errors or omissions. A sound awareness and training program can help an organization reduce the number and severity of errors and omissions.

Users, data entry clerks, system operators, and programmers frequently make errors that contribute directly or indirectly to security problems. In some cases, the error is the threat, such as a data entry error or a programming error that crashes a system. In other cases, the errors create vulnerabilities. Errors can occur during all phases of the systems life cycle. A long-term survey of computer-related economic losses conducted by Robert Courtney, a computer security consultant and former member of the Computer System Security and Privacy Advisory Board, found that 65 percent of losses to organizations were the result of errors and omissions.[22] This figure was relatively consistent between both private and public sector organizations.

Programming and development errors, often called "bugs," can range in severity from benign to catastrophic. In a 1989 study for the House Committee on Science, Space and Technology, entitled *Bugs in the Program,* the staff of the Subcommittee on Investigations and Oversight summarized the scope and severity of this problem in terms of government systems as follows:

> As expenditures grow, so do concerns about the reliability, cost and accuracy of ever-larger and more complex software systems. These concerns are heightened as computers perform more critical tasks, where mistakes can cause financial turmoil, accidents, or in extreme cases, death.[23]

Since the study's publication, the software industry has changed considerably, with measurable improvements in software quality. Yet software "horror stories" still abound, and the basic principles and problems analyzed in the report remain the same. While there have been great improvements in program quality, as reflected in decreasing errors per 1000 lines of code, the

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[22] Computer System Security and Privacy Advisory Board, *1991 Annual Report* (Gaithersburg, MD), March 1992, p. 18. The categories into which the problems were placed and the percentages of economic loss attributed to each were: 65%, errors and omissions; 13%, dishonest employees; 6%, disgruntled employees; 8%, loss of supporting infrastructure, including power, communications, water, sewer, transportation, fire, flood, civil unrest, and strikes; 5%, water, not related to fires and floods; less than 3%, outsiders, including viruses, espionage, dissidents, and malcontents of various kinds, and former employees who have been away for more than six weeks.

[23] House Committee on Science, Space and Technology, Subcommittee on Investigations and Oversight, *Bugs in the Program: Problems in Federal Government Computer Software Development and Regulation,* 101st Cong., 1st sess., 3 August 1989, p. 2.

concurrent growth in program size often seriously diminishes the beneficial effects of these program quality enhancements.

Installation and maintenance errors are another source of security problems. For example, an audit by the President's Council for Integrity and Efficiency (PCIE) in 1988 found that every one of the ten mainframe computer sites studied had installation and maintenance errors that introduced significant security vulnerabilities.[24]

4.2 Fraud and Theft

Computer systems can be exploited for both fraud and theft both by "automating" traditional methods of fraud and by using new methods. For example, individuals may use a computer to skim small amounts of money from a large number of financial accounts, assuming that small discrepancies may not be investigated. Financial systems are not the only ones at risk. Systems that control access to any resource are targets (e.g., time and attendance systems, inventory systems, school grading systems, and long-distance telephone systems).

Computer fraud and theft can be committed by insiders or outsiders. Insiders (i.e., authorized users of a system) are responsible for the majority of fraud. A 1993 *InformationWeek*/Ernst and Young study found that 90 percent of Chief Information Officers viewed employees "who do not need to know" information as threats.[25] The U.S. Department of Justice's Computer Crime Unit contends that "insiders constitute the greatest threat to computer systems."[26] Since insiders have both access to and familiarity with the victim computer system (including what resources it controls and its flaws), authorized system users are in a better position to commit crimes. Insiders can be both general users (such as clerks) or technical staff members. An organization's former employees, with their knowledge of an organization's operations, may also pose a threat, particularly if their access is not terminated promptly.

In addition to the use of technology to commit fraud and theft, computer hardware and software may be vulnerable to theft. For example, one study conducted by Safeware Insurance found that $882 million worth of personal computers was lost due to theft in 1992.[27]

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[24] President's Council on Integrity and Efficiency, *Review of General Controls in Federal Computer Systems*, October, 1988.

[25] Bob Violino and Joseph C. Panettieri, "Tempting Fate," *InformationWeek*, October 4, 1993: p. 42.

[26] Letter from Scott Charney, Chief, Computer Crime Unit, U.S. Department of Justice, to Barbara Guttman, NIST. July 29, 1993.

[27] "Theft, Power Surges Cause Most PC Losses," *Infosecurity News*, September/October, 1993, 13.

4.3 Employee Sabotage

Common examples of computer-related employee sabotage include:

- destroying hardware or facilities,
- planting logic bombs that destroy programs or data,
- entering data incorrectly,
- "crashing" systems,
- deleting data,
- holding data hostage, and
- changing data.

Employees are most familiar with their employer's computers and applications, including knowing what actions might cause the most damage, mischief, or sabotage. The downsizing of organizations in both the public and private sectors has created a group of individuals with organizational knowledge, who may retain potential system access (e.g., if system accounts are not deleted in a timely manner).[28] The number of incidents of employee sabotage is believed to be much smaller than the instances of theft, but the cost of such incidents can be quite high.

Martin Sprouse, author of *Sabotage in the American Workplace,* reported that the motivation for sabotage can range from altruism to revenge:

> As long as people feel cheated, bored, harassed, endangered, or betrayed at work, sabotage will be used as a direct method of achieving job satisfaction – the kind that never has to get the bosses' approval.[29]

4.4 Loss of Physical and Infrastructure Support

The loss of supporting infrastructure includes power failures (outages, spikes, and brownouts), loss of communications, water outages and leaks, sewer problems, lack of transportation services, fire, flood, civil unrest, and strikes. These losses include such dramatic events as the explosion at the World Trade Center and the Chicago tunnel flood, as well as more common events, such as broken water pipes. Many of these issues are covered in Chapter 15. A loss of infrastructure often results in system downtime, sometimes in unexpected ways. For example, employees may not be able to get to work during a winter storm, although the computer system may be functional.

4.5 Malicious Hackers

The term *malicious hackers*, sometimes called *crackers*, refers to those who break into computers without authorization. They can include both outsiders and insiders. Much of the rise

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[28] Charney.

[29] Martin Sprouse, ed., *Sabotage in the American Workplace: Anecdotes of Dissatisfaction, Mischief and Revenge* (San Francisco, CA: Pressure Drop Press, 1992), p. 7.

of hacker activity is often attributed to increases in connectivity in both government and industry. One 1992 study of a particular Internet site (i.e., one computer system) found that hackers attempted to break in at least once every other day.[30]

The hacker threat should be considered in terms of past and potential future damage. Although current losses due to hacker attacks are significantly smaller than losses due to insider theft and sabotage, the hacker problem is widespread and serious. One example of malicious hacker activity is that directed against the public telephone system.

Studies by the National Research Council and the National Security Telecommunications Advisory Committee show that hacker activity is not limited to toll fraud. It also includes the ability to break into telecommunications systems (such as switches), resulting in the degradation or disruption of system availability. While unable to reach a conclusion about the degree of threat or risk, these studies underscore the ability of hackers to cause serious damage.[31, 32]

The hacker threat often receives more attention than more common and dangerous threats. The U.S. Department of Justice's Computer Crime Unit suggests three reasons for this.

- First, the hacker threat is a more recently encountered threat. Organizations have always had to worry about the actions of their own employees and could use disciplinary measures to reduce that threat. However, these measures are ineffective against outsiders who are not subject to the rules and regulations of the employer.

- Second, organizations do not know the purposes of a hacker – some hackers browse, some steal, some damage. This inability to identify purposes can suggest that hacker attacks have no limitations.

- Third, hacker attacks make people feel vulnerable, particularly because their identity is unknown. For example, suppose a painter is hired to paint a house and, once inside, steals a piece of jewelry. Other homeowners in the neighborhood may not feel threatened by this crime and will protect themselves by not doing business with that painter. But if a burglar breaks into the same house and steals the same piece of jewelry, the entire neighborhood may feel victimized and

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[30] Steven M. Bellovin, "There Be Dragons," *Proceedings of the Third Usenix UNIX Security Symposium.*

[31] National Research Council, *Growing Vulnerability of the Public Switched Networks: Implication for National Security Emergency Preparedness* (Washington, DC: National Academy Press), 1989.

[32] Report of the National Security Task Force, November 1990.

vulnerable.[33]

4.6 Industrial Espionage

Industrial espionage is the act of gathering proprietary data from private companies or the government[34] for the purpose of aiding another company(ies). Industrial espionage can be perpetrated either by companies seeking to improve their competitive advantage or by governments seeking to aid their domestic industries. Foreign industrial espionage carried out by a government is often referred to as economic espionage. Since information is processed and stored on computer systems, computer security can help protect against such threats; it can do little, however, to reduce the threat of authorized employees selling that information.

Industrial espionage is on the rise. A 1992 study sponsored by the American Society for Industrial Security (ASIS) found that proprietary business information theft had increased 260 percent since 1985. The data indicated 30 percent of the reported losses in 1991 and 1992 had foreign involvement. The study also found that 58 percent of thefts were perpetrated by current or former employees.[35] The three most damaging types of stolen information were pricing information, manufacturing process information, and product development and specification information. Other types of information stolen included customer lists, basic research, sales data, personnel data, compensation data, cost data, proposals, and strategic plans.[36]

Within the area of economic espionage, the Central Intelligence Agency has stated that the main objective is obtaining information related to technology, but that information on U.S. Government policy deliberations concerning foreign affairs and information on commodities, interest rates, and other economic factors is also a target.[37] The Federal Bureau of Investigation concurs that technology-related information is the main target, but also lists corporate proprietary information, such as negotiating positions and other contracting data, as a target.[38]

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[33] Charney.

[34] The government is included here because it often is the custodian for proprietary data (e.g., patent applications).

[35] The figures of 30 and 58 percent are not mutually exclusive.

[36] Richard J. Heffernan and Dan T. Swartwood, "Trends in Competitive Intelligence," *Security Management* 37, no. 1 (January 1993), pp. 70-73.

[37] Robert M. Gates, testimony before the House Subcommittee on Economic and Commercial Law, Committee on the Judiciary, 29 April 1992.

[38] William S. Sessions, testimony before the House Subcommittee on Economic and Commercial Law, Committee on the Judiciary, 29 April 1992.

4.7 Malicious Code

Malicious code refers to viruses, worms, Trojan horses, logic bombs, and other "uninvited" software. Sometimes mistakenly associated only with personal computers, malicious code can attack other platforms.

A 1993 study of viruses found that while the number of known viruses is increasing exponentially, the number of virus incidents is not.[39] The study concluded that viruses are becoming more prevalent, but only "gradually."

> The rate of PC-DOS virus incidents in medium to large North American businesses appears to be approximately 1 per 1000 PCs per quarter; the number of infected machines is perhaps 3 or 4 times this figure if we assume that most such businesses are at least weakly protected against viruses.[40, 41]

Actual costs attributed to the presence of malicious code have resulted primarily from system outages and staff time involved in repairing the systems. Nonetheless, these costs can be significant.

Malicious Software: A Few Key Terms

Virus: A code segment that replicates by attaching copies of itself to existing executables. The new copy of the virus is executed when a user executes the new host program. The virus may include an additional "payload" that triggers when specific conditions are met. For example, some viruses display a text string on a particular date. There are many types of viruses, including variants, overwriting, resident, stealth, and polymorphic.

Trojan Horse: A program that performs a desired task, but that also includes unexpected (and undesirable) functions. Consider as an example an editing program for a multiuser system. This program could be modified to randomly delete one of the users' files each time they perform a useful function (editing), but the deletions are unexpected and definitely undesired!

Worm: A self-replicating program that is self-contained and does not require a host program. The program creates a copy of itself and causes it to execute; no user intervention is required. Worms commonly use network services to propagate to other host systems.
Source: NIST Special Publication 800-5.

4.8 Foreign Government Espionage

In some instances, threats posed by foreign government intelligence services may be present. In addition to possible economic espionage, foreign intelligence services may target unclassified systems to further their intelligence missions. Some unclassified information that may be of

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[39] Jeffrey O. Kephart and Steve R. White, "Measuring and Modeling Computer Virus Prevalence," *Proceedings, 1993 IEEE Computer Society Symposium on Research in Security and Privacy* (May 1993): 14.

[40] Ibid.

[41] Estimates of virus occurrences may not consider the strength of an organization's antivirus program.

interest includes travel plans of senior officials, civil defense and emergency preparedness, manufacturing technologies, satellite data, personnel and payroll data, and law enforcement, investigative, and security files. Guidance should be sought from the cognizant security office regarding such threats.

4.9 Threats to Personal Privacy

The accumulation of vast amounts of electronic information about individuals by governments, credit bureaus, and private companies, combined with the ability of computers to monitor, process, and aggregate large amounts of information about individuals have created a threat to individual privacy. The possibility that all of this information and technology may be able to be linked together has arisen as a specter of the modern information age. This is often referred to as "Big Brother." To guard against such intrusion, Congress has enacted legislation, over the years, such as the Privacy Act of 1974 and the Computer Matching and Privacy Protection Act of 1988, which defines the boundaries of the legitimate uses of personal information collected by the government.

The threat to personal privacy arises from many sources. In several cases federal and state employees have sold personal information to private investigators or other "information brokers." One such case was uncovered in 1992 when the Justice Department announced the arrest of over two dozen individuals engaged in buying and selling information from Social Security Administration (SSA) computer files.[42] During the investigation, auditors learned that SSA employees had unrestricted access to over 130 million employment records. Another investigation found that 5 percent of the employees in one region of the IRS had browsed through tax records of friends, relatives, and celebrities.[43] Some of the employees used the information to create fraudulent tax refunds, but many were acting simply out of curiosity.

As more of these cases come to light, many individuals are becoming increasingly concerned about threats to their personal privacy. A July 1993 special report in *MacWorld* cited polling data taken by Louis Harris and Associates showing that in 1970 only 33 percent of respondents were concerned about personal privacy. By 1990, that number had jumped to 79 percent.[44]

While the magnitude and cost to society of the personal privacy threat are difficult to gauge, it is

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[42] House Committee on Ways and Means, Subcommittee on Social Security, *Illegal Disclosure of Social Security Earnings Information by Employees of the Social Security Administration and the Department of Health and Human Services' Office of Inspector General: Hearing,* 102nd Cong., 2nd sess., 24 September 1992, Serial 102-131.

[43] Stephen Barr, "Probe Finds IRS Workers Were `Browsing' in Files," *The Washington Post,* 3 August 1993, p. A1.

[44] Charles Piller, "Special Report: Workplace and Consumer Privacy Under Siege," *MacWorld*, July 1993, pp. 1-14.

apparent that information technology is becoming powerful enough to warrant fears of both government and corporate "Big Brothers." Increased awareness of the problem is needed.

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II. MANAGEMENT CONTROLS

Chapter 5

COMPUTER SECURITY POLICY

In discussions of computer security, the term *policy* has more than one meaning.[45] *Policy* is senior management's directives to create a computer security program, establish its goals, and assign responsibilities. The term *policy* is also used to refer to the specific security rules for particular systems.[46] Additionally, *policy* may refer to entirely different matters, such as the specific managerial decisions setting an organization's e-mail privacy policy or fax security policy.

Policy means different things to different people. The term "policy" is used in this chapter in a broad manner to refer to important computer security-related decisions.

In this chapter the term *computer security policy* is defined as the "documentation of computer security decisions" – which covers all the types of policy described above.[47] In making these decisions, managers face hard choices involving resource allocation, competing objectives, and organizational strategy related to protecting both technical and information resources as well as guiding employee behavior. Managers at all levels make choices that can result in policy, with the scope of the policy's applicability varying according to the scope of the manager's authority. In this chapter we use the term *policy* in a broad manner to encompass all of the types of policy described above – regardless of the level of manager who sets the particular policy.

Managerial decisions on computer security issues vary greatly. To differentiate among various kinds of policy, this chapter categorizes them into three basic types:

- *Program policy* is used to create an organization's computer security program.
- *Issue-specific policies* address specific issues of concern to the organization.

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[45] There are variations in the use of the term *policy*, as noted in a 1994 Office of Technology Assessment report, *Information Security and Privacy in Network Environments*: "*Security Policy* refers here to the statements made by organizations, corporations, and agencies to establish overall policy on information access and safeguards. Another meaning comes from the Defense community and refers to the rules relating clearances of users to classification of information. In another usage, *security policies* are used to refine and implement the broader, organizational security policy...."

[46] These are the kind of policies that computer security experts refer to as being *enforced* by the system's technical controls as well as its management and operational controls.

[47] In general, policy is set by a manager. However, in some cases, it may be set by a group (e.g., an intraorganizational policy board).

- *System-specific policies* focus on decisions taken by management to protect a particular system.[48]

Procedures, standards, and guidelines are used to describe how these policies will be implemented within an organization. (See following box.)

Tools to Implement Policy:
Standards, Guidelines, and Procedures

Because policy is written at a broad level, organizations also develop standards, guidelines, and procedures that offer users, managers, and others a clearer approach to implementing policy and meeting organizational goals. Standards and guidelines specify technologies and methodologies to be used to secure systems. Procedures are yet more detailed steps to be followed to accomplish particular security-related tasks. Standards, guidelines, and procedures may be promulgated throughout an organization via handbooks, regulations, or manuals.

Organizational standards (not to be confused with American National Standards, FIPS, Federal Standards, or other national or international standards) specify uniform use of specific technologies, parameters, or procedures when such uniform use will benefit an organization. Standardization of organizationwide identification badges is a typical example, providing ease of employee mobility and automation of entry/exit systems. Standards are normally compulsory within an organization.

Guidelines assist users, systems personnel, and others in effectively securing their systems. The nature of guidelines, however, immediately recognizes that systems vary considerably, and imposition of standards is not always achievable, appropriate, or cost-effective. For example, an organizational guideline may be used to help develop system-specific standard procedures. Guidelines are often used to help ensure that specific security measures are not overlooked, although they can be implemented, and correctly so, in more than one way.

Procedures normally assist in complying with applicable security policies, standards, and guidelines. They are detailed steps to be followed by users, system operations personnel, or others to accomplish a particular task (e.g., preparing new user accounts and assigning the appropriate privileges).

Some organizations issue overall computer security manuals, regulations, handbooks, or similar documents. These may mix policy, guidelines, standards, and procedures, since they are closely linked. While manuals and regulations can serve as important tools, it is often useful if they clearly distinguish between policy and its implementation. This can help in promoting flexibility and cost-effectiveness by offering alternative implementation approaches to achieving policy goals.

Familiarity with various types and components of policy will aid managers in addressing computer security issues important to the organization. Effective policies ultimately result in the development and implementation of a better computer security program and better protection of

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[48] A *system* refers to the entire collection of processes, both those performed manually and those using a computer (e.g., manual data collection and subsequent computer manipulation), which performs a function. This includes both application systems and support systems, such as a network.

systems and information.

These types of policy are described to aid the reader's understanding.[49] It is not important that one categorizes specific organizational policies into these three categories; it is more important to focus on the functions of each.

5.1 Program Policy

A management official, normally the head of the organization or the senior administration official, issues program policy to establish (or restructure) the organization's computer security program and its basic structure. This high-level policy defines the purpose of the program and its scope within the organization; assigns responsibilities (to the computer security organization) for direct program implementation, as well as other responsibilities to related offices (such as the Information Resources Management [IRM] organization); and addresses compliance issues.

Program policy sets organizational strategic directions for security and assigns resources for its implementation.

5.1.1 Basic Components of Program Policy

Components of program policy should address:

Purpose. Program policy normally includes a statement describing why the program is being established. This may include defining the *goals* of the program. Security-related needs, such as integrity, availability, and confidentiality, can form the basis of organizational goals established in policy. For instance, in an organization responsible for maintaining large mission-critical databases, reduction in errors, data loss, data corruption, and recovery might be specifically stressed. In an organization responsible for maintaining confidential personal data, however, goals might emphasize stronger protection against unauthorized disclosure.

Scope. Program policy should be clear as to which resources -- including facilities, hardware, and software, information, and personnel -- the computer security program covers. In many cases, the program will encompass all systems and organizational personnel, but this is not always true. In some instances, it may be appropriate for an organization's computer security program to be more limited in scope.

Program policy establishes the security program and assigns program management and supporting responsibilities.

Responsibilities. Once the computer security program is established, its management is

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[49] No standard terms exist for various types of policies. These terms are used to aid the reader's understanding of this topic; no implication of their widespread usage is intended.

normally assigned to either a newly created or existing office.[50]

The responsibilities of officials and offices throughout the organization also need to be addressed, including line managers, applications owners, users, and the data processing or IRM organizations. This section of the policy statement, for example, would distinguish between the responsibilities of computer services providers and those of the managers of applications using the provided services. The policy could also establish operational security offices for major systems, particularly those at high risk or most critical to organizational operations. It also can serve as the basis for establishing employee accountability.

At the program level, responsibilities should be specifically assigned to those organizational elements and officials responsible for the implementation and continuity of the computer security policy.[51]

Compliance. Program policy typically will address two compliance issues:

1. General compliance to ensure meeting the requirements to establish a program and the responsibilities assigned therein to various organizational components. Often an oversight office (e.g., the Inspector General) is assigned responsibility for monitoring compliance, including how well the organization is implementing management's priorities for the program.

2. The use of specified penalties and disciplinary actions. Since the security policy is a high-level document, specific penalties for various infractions are normally not detailed here; instead, the policy may authorize the creation of compliance structures that include violations and specific disciplinary action(s).[52]

Those developing compliance policy should remember that violations of policy can be unintentional on the part of employees. For example, nonconformance can often be due to a lack of knowledge or training.

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[50] The program management structure should be organized to best address the goals of the program and respond to the particular operating and risk environment of the organization. Important issues for the structure of the computer security program include management and coordination of security-related resources, interaction with diverse communities, and the ability to relay issues of concern, trade-offs, and recommended actions to upper management. (See Chapter 6, Computer Security Program Management.)

[51] In assigning responsibilities, it is necessary to be specific; such assignments as "computer security is everyone's responsibility," in reality, mean no one has specific responsibility.

[52] The need to obtain guidance from appropriate legal counsel is critical when addressing issues involving penalties and disciplinary action for individuals. The policy does not need to restate penalties already provided for by law, although they can be listed if the policy will also be used as an awareness or training document.

5.2 Issue-Specific Policy

Whereas program policy is intended to address the broad organizationwide computer security program, issue-specific policies are developed to focus on areas of current relevance and concern (and sometimes controversy) to an organization. Management may find it appropriate, for example, to issue a policy on how the organization will approach contingency planning (centralized vs. decentralized) or the use of a particular methodology for managing risk to systems. A policy could also be issued, for example, on the appropriate use of a cutting-edge technology (whose security vulnerabilities are still largely unknown) within the organization. Issue-specific policies may also be appropriate when new issues arise, such as when implementing a recently passed law requiring additional protection of particular information. Program policy is usually broad enough that it does not require much modification over time, whereas issue-specific policies are likely to require more frequent revision as changes in technology and related factors take place.

In general, for issue-specific and system-specific policy, the issuer is a senior official; the more global, controversial, or resource-intensive, the more senior the issuer.

5.2.1 Example Topics for Issue-Specific Policy[53]

There are many areas for which issue-specific policy may be appropriate. Two examples are explained below.

Both new technologies and the appearance of new threats often require the creation of issue-specific policies.

Internet Access. Many organizations are looking at the Internet as a means for expanding their research opportunities and communications. Unquestionably, connecting to the Internet yields many benefits – and some disadvantages. Some issues an Internet access policy may address include who will have access, which types of systems may be connected to the network, what types of information may be transmitted via the network, requirements for user authentication for Internet-connected systems, and the use of firewalls and secure gateways.

Other potential candidates for issue-specific policies include: approach to risk management and contingency planning, protection of confidential/proprietary information, unauthorized software, acquisition of software, doing computer work at home, bringing in disks from outside the workplace, access to other employees' files, encryption of files and e-mail, rights of privacy, responsibility for correctness of data, suspected malicious code, and physical emergencies.

E-Mail Privacy. Users of computer e-mail systems have come to rely upon that service for informal communication with colleagues

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[53] Examples presented in this section are not all-inclusive nor meant to imply that policies in each of these areas are required by all organizations.

and others. However, since the system is typically owned by the employing organization, from time-to-time, management may wish to monitor the employee's e-mail for various reasons (e.g., to be sure that it is used for business purposes only or if they are suspected of distributing viruses, sending offensive e-mail, or disclosing organizational secrets.) On the other hand, users may have an expectation of privacy, similar to that accorded U.S. mail. Policy in this area addresses what level of privacy will be accorded e-mail and the circumstances under which it may or may not be read.

5.2.2 Basic Components of Issue-Specific Policy

As suggested for program policy, a useful structure for issue-specific policy is to break the policy into its basic components.

Issue Statement. To formulate a policy on an issue, managers first must define the issue with any relevant terms, distinctions, and conditions included. It is also often useful to specify the goal or justification for the policy – which can be helpful in gaining compliance with the policy. For example, an organization might want to develop an issue-specific policy on the use of "unofficial software," which might be defined to mean any software not approved, purchased, screened, managed, and owned by the organization. Additionally, the applicable distinctions and conditions might then need to be included, for instance, for software privately owned by employees but approved for use at work, and for software owned and used by other businesses under contract to the organization.

Statement of the Organization's Position. Once the issue is stated and related terms and conditions are discussed, this section is used to clearly state the organization's position (i.e., management's decision) on the issue. To continue the previous example, this would mean stating whether use of unofficial software as defined is prohibited in all or some cases, whether there are further guidelines for approval and use, or whether case-by-case exceptions will be granted, by whom, and on what basis.

Applicability. Issue-specific policies also need to include statements of applicability. This means clarifying where, how, when, to whom, and to what a particular policy applies. For example, it could be that the hypothetical policy on unofficial software is intended to apply only to the organization's own on-site resources and employees and not to contractors with offices at other locations. Additionally, the policy's applicability to employees travelling among different sites and/or working at home who need to transport and use disks at multiple sites might need to be clarified.

Roles and Responsibilities. The assignment of roles and responsibilities is also usually included in issue-specific policies. For example, if the policy permits unofficial software privately owned by employees to be used at work with the appropriate approvals, then the approval authority granting such permission would need to be stated. (Policy would stipulate, who, by position, has such authority.) Likewise, it would need to be clarified who would be responsible for ensuring that only approved software is used on organizational computer resources and, perhaps, for monitoring users in regard to unofficial software.

Compliance. For some types of policy, it may be appropriate to describe, in some detail, the infractions that are unacceptable, and the consequences of such behavior. Penalties may be explicitly stated and should be consistent with organizational personnel policies and practices. When used, they should be coordinated with appropriate officials and offices and, perhaps, employee bargaining units. It may also be desirable to task a specific office within the organization to monitor compliance.

Points of Contact and Supplementary Information. For any issue-specific policy, the appropriate individuals in the organization to contact for further information, guidance, and compliance should be indicated. Since positions tend to change less often than the people occupying them, specific positions may be preferable as the point of contact. For example, for some issues the point of contact might be a line manager; for other issues it might be a facility manager, technical support person, system administrator, or security program representative. Using the above example once more, employees would need to know whether the point of contact for questions and procedural information would be their immediate superior, a system administrator, or a computer security official.

Some Helpful Hints on Policy

To be effective, policy requires visibility. Visibility aids implementation of policy by helping to ensure policy is fully communicated throughout the organization. Management presentations, videos, panel discussions, guest speakers, question/answer forums, and newsletters increase visibility. The organization's computer security training and awareness program can effectively notify users of new policies. It also can be used to familiarize new employees with the organization's policies.

Computer security policies should be introduced in a manner that ensures that management's unqualified support is clear, especially in environments where employees feel inundated with policies, directives, guidelines, and procedures. The organization's policy is the vehicle for emphasizing management's commitment to computer security and making clear their expectations for employee performance, behavior, and accountability.

To be effective, policy should be consistent with other existing directives, laws, organizational culture, guidelines, procedures, and the organization's overall mission. It should also be integrated into and consistent with other organizational policies (e.g., personnel policies). One way to help ensure this is to coordinate policies during development with other organizational offices.

Guidelines and procedures often accompany policy. The issue-specific policy on unofficial software, for example, might include procedural guidelines for checking disks brought to work that had been used by employees at other locations.

5.3 System-Specific Policy

Program policy and issue-specific policy both address policy from a broad level, usually encompassing the entire organization. However, they do not provide sufficient information or direction, for example, to be used in establishing an access control list or in training users on what actions are permitted. System-specific policy fills this need. It is much more focused, since it addresses only one system.

Many security policy decisions may apply only at the system level and may vary from system to system within the same organization. While these decisions may appear to be too detailed to be policy, they can be extremely important, with significant impacts on system usage and security. These types of decisions can be made by a *management official*, not by a technical system administrator.[54] (The impacts of these decisions, however, are often analyzed by technical system administrators.)

System-specific security policy includes two components: security objectives and operational security rules. It is often accompanied by implementing procedures and guidelines.

To develop a cohesive and comprehensive set of security policies, officials may use a management process that derives security rules from security goals. It is helpful to consider a two-level model for system security policy: security objectives and operational security rules, which together comprise the system-specific policy. Closely linked and often difficult to distinguish, however, is the implementation of the policy in technology.

5.3.1 Security Objectives

Sample Security Objective

Only individuals in the accounting and personnel departments are authorized to provide or modify information used in payroll processing.

The first step in the management process is to define security objectives for the specific system. Although, this process may start with an analysis of the need for integrity, availability, and confidentiality, it should not stop there. A security *objective* needs to more specific; it should be concrete and well defined. It also should be stated so that it is clear that the objective is achievable. This process will also draw upon other applicable organization policies.

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[54] It is important to remember that policy is not created in a vacuum. For example, it is critical to understand the system mission and how the system is intended to be used. Also, users may play an important role in setting policy.

Security objectives consist of a series of statements that describe meaningful actions about explicit resources. These objectives should be based on system functional or mission requirements, but should state the security actions that support the requirements.

Development of system-specific policy will require management to make trade-offs, since it is unlikely that all desired security objectives will be able to be fully met. Management will face cost, operational, technical, and other constraints.

5.3.2 Operational Security Rules

After management determines the security objectives, the rules for operating a system can be laid out, for example, to define authorized and unauthorized modification. Who (by job category, organization placement, or name) can do what (e.g., modify, delete) to which specific classes and records of data, and under what conditions.

Sample Operational Security Rule

Personnel clerks may update fields for weekly attendance, charges to annual leave, employee addresses, and telephone numbers. Personnel specialists may update salary information. No employees may update their own records.

The degree of specificity needed for operational security rules varies greatly. The more detailed the rules are, *up to a point*, the easier it is to know when one has been violated. It is also, *up to a point*, easier to automate policy enforcement. However, overly detailed rules may make the job of instructing a computer to implement them difficult or computationally complex.

In addition to deciding the level of detail, management should decide the degree of formality in documenting the system-specific policy. Once again, the more formal the documentation, the easier it is to enforce and to follow policy. On the other hand, policy at the system level that is too detailed and formal can also be an administrative burden. In general, good practice suggests a reasonably detailed formal statement of the access privileges for a system. Documenting access controls policy will make it substantially easier to follow and to enforce. (See Chapters 10 and 17, Personnel/User Issues and Logical Access Control.) Another area that normally requires a detailed and formal statement is the assignment of security responsibilities. Other areas that should be addressed are the rules for system usage and the consequences of noncompliance.

Policy decisions in other areas of computer security, such as those described in this handbook, are often documented in the risk analysis, accreditation statements, or procedural manuals. However, any controversial, atypical, or uncommon policies will also need formal statements. Atypical policies would include any areas where the system policy is different from organizational policy or from normal practice within the organization, either more or less stringent. The documentation for a typical policy contains a statement explaining the reason for deviation from the organization's standard policy.

5.3.3 System-Specific Policy Implementation

Technology plays an important – but not sole – role in enforcing system-specific policies. When technology is used to enforce policy, it is important not to neglect nontechnology- based methods. For example, technical system-based controls could be used to limit the printing of confidential reports to a particular printer. However, corresponding physical security measures would also have to be in place to limit access to the printer output or the desired security objective would not be achieved.

Technical methods frequently used to implement system-security policy are likely to include the use of *logical access controls*. However, there are other automated means of enforcing or supporting security policy that typically supplement logical access controls. For example, technology can be used to block telephone users from calling certain numbers. Intrusion-detection software can alert system administrators to suspicious activity or can take action to stop the activity. Personal computers can be configured to prevent booting from a floppy disk.

Technology-based enforcement of system-security policy has both advantages and disadvantages. A computer system, properly designed, programmed, installed, configured, and maintained,[55] consistently enforces policy within the computer system, although no computer can force users to follow all procedures. Management controls also play an important role – and should not be neglected. In addition, deviations from the policy may sometimes be necessary and appropriate; such deviations may be difficult to implement easily with some technical controls. This situation occurs frequently if implementation of the security policy is too rigid (which can occur when the system analysts fail to anticipate contingencies and prepare for them).

5.4 Interdependencies

Policy is related to many of the topics covered in this handbook:

Program Management. Policy is used to establish an organization's computer security program, and is therefore closely tied to program management and administration. Both program and system-specific policy may be established in any of the areas covered in this handbook. For example, an organization may wish to have a consistent approach to incident handling for all its systems – and would issue appropriate program policy to do so. On the other hand, it may decide that its applications are sufficiently independent of each other that application managers

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[55] Doing all of these things properly is, unfortunately, the exception rather than the rule. Confidence in the system's ability to enforce system-specific policy is closely tied to assurance. (See Chapter 9, Assurance.)

should deal with incidents on an individual basis.

Access Controls. System-specific policy is often implemented through the use of access controls. For example, it may be a policy decision that only two individuals in an organization are authorized to run a check-printing program. Access controls are used by the system to implement (or enforce) this policy.

Links to Broader Organizational Policies. This chapter has focused on the types and components of computer security policy. However, it is important to realize that *computer* security policies are often *extensions* of an organization's *information* security policies for handling information in other forms (e.g., paper documents). For example, an organization's e-mail policy would probably be tied to its broader policy on privacy. Computer security policies may also be extensions of other policies, such as those about appropriate use of equipment and facilities.

5.5 Cost Considerations

A number of potential costs are associated with developing and implementing computer security policies. Overall, the major cost of policy is the cost of implementing the policy and its impacts upon the organization. For example, establishing a computer security program, accomplished through policy, does not come at negligible cost.

Other costs may be those incurred through the policy development process. Numerous administrative and management activities may be required for drafting, reviewing, coordinating, clearing, disseminating, and publicizing policies. In many organizations, successful policy implementation may require additional staffing and training – and can take time. In general, the costs to an organization for computer security policy development and implementation will depend upon how extensive the change needed to achieve a level of risk acceptable to management.

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Chapter 6

COMPUTER SECURITY PROGRAM MANAGEMENT

Computers and the information they process are critical to many organizations' ability to perform their mission and business functions.[56] It therefore makes sense that executives view computer security as a management issue and seek to protect their organization's computer resources as they would any other valuable asset. To do this effectively requires developing of a comprehensive management approach.

This chapter presents an organizationwide approach to computer security and discusses its important management function.[57] Because organizations differ vastly in size, complexity, management styles, and culture, it is not possible to describe one ideal computer security program. However, this chapter does describe some of the features and issues common to many federal organizations.

> OMB Circular A-130, "Management of Federal Information Resources," requires that federal agencies establish computer security programs.

6.1 Structure of a Computer Security Program

Many computer security programs that are distributed throughout the organization have different elements performing various functions. While this approach has benefits, the distribution of the computer security function in many organizations is haphazard, usually based upon history (i.e., who was available in the organization to do what when the need arose). Ideally, the distribution of computer security functions should result from a planned and integrated management philosophy.

Managing computer security at multiple levels brings many benefits. Each level contributes to the overall computer security program with different types of expertise, authority, and resources. In general, higher-level officials (such as those at the headquarters or unit levels in the agency described above) better understand the organization as a whole and have more authority. On the other hand, lower-level officials (at the computer facility and applications levels) are more familiar with the specific requirements, both technical and procedural, and problems of the

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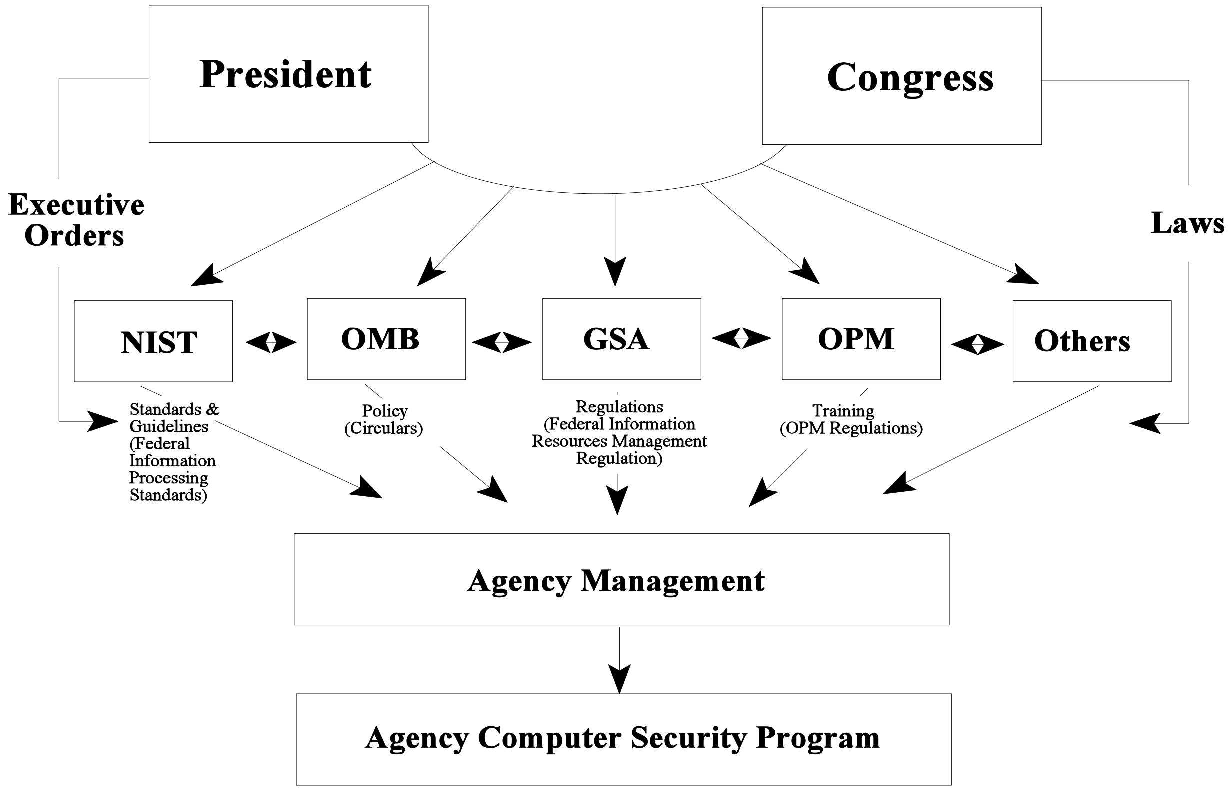
[56] This chapter is primarily directed at federal agencies, which are generally very large and complex organizations. This chapter discusses programs which are suited to managing security in such environments. They may be wholly inappropriate for smaller organizations or private sector firms.

[57] This chapter addresses the management of security programs, not the various activities such as risk analysis or contingency planning that make up an effective security program.

Sources of (Some) Requirements for Federal Unclassified Computer Security Programs



A federal agency computer security program is created and operates in an environment rich in guidance and direction from other organizations. Figure 6.1 illustrates some of the external sources of requirements and guidance directed toward agency management with regard to computer security. While a full discussion of each is outside the scope of this chapter, it is important to realize that a program does not operate in a vacuum; federal organizations are constrained -- by both statute and regulation -- in a number of ways.

Figure 6.1

systems and the users. The levels of computer security program management should be complementary; each can help the other be more effective.

Since many organizations have at least two levels of computer security management, this chapter divides computer security program management into two levels: the *central* level and the *system* level. (Each organization, though, may have its own unique structure.) The central computer

Sample Federal Agency Management Structure

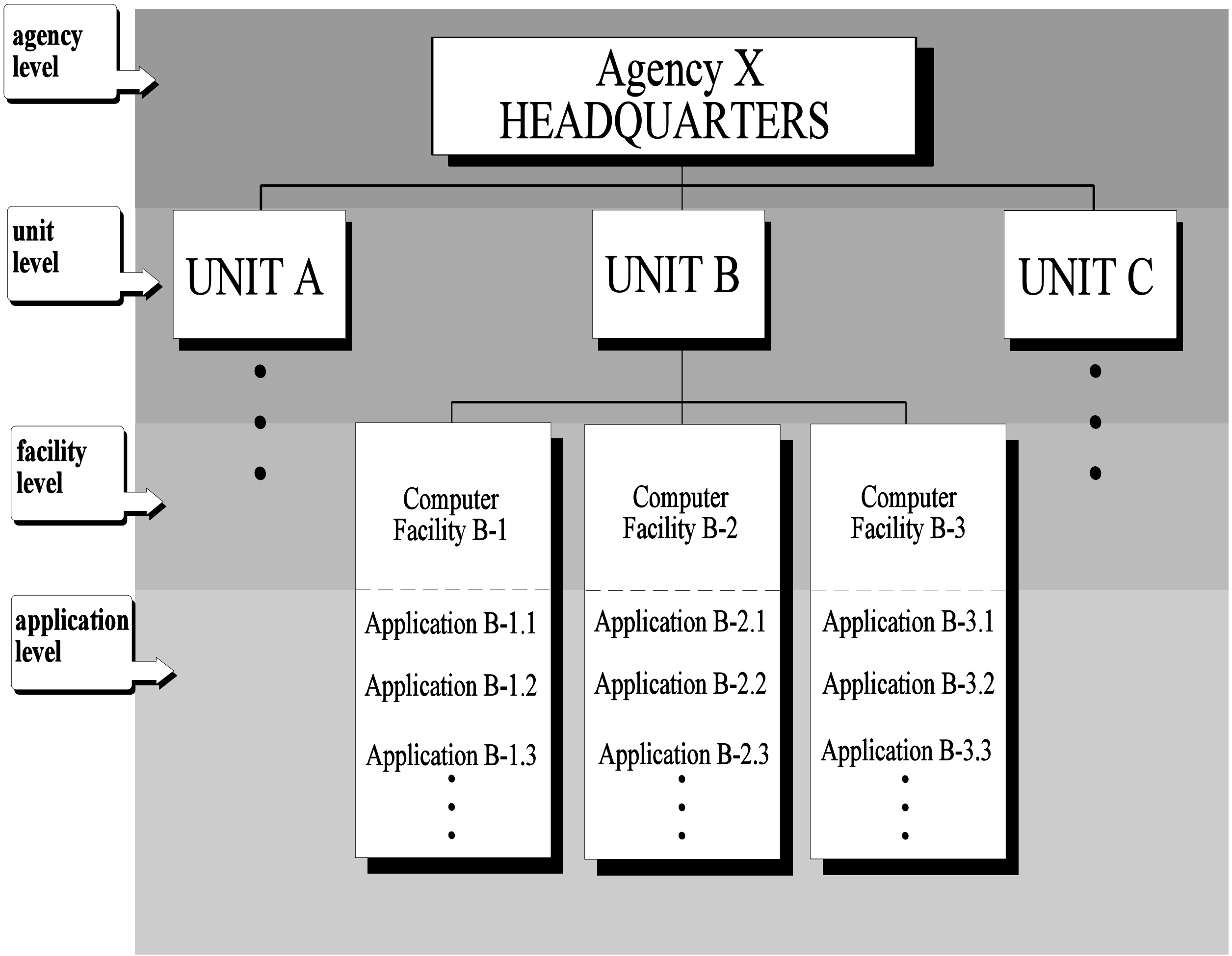


Figure 6.2 shows a management structure based on that of an actual federal agency. The agency consists of three major units, each with several large computer facilities running multiple applications. This type of organization needs to manage computer security at the *agency* level, the *unit* level, the *computer facility* level, and the *application* level.

Figure 6.2

security program can be used to address the overall management of computer security within an organization or a major component of an organization. The system-level computer security program addresses the management of computer security for a particular system.

6.2 Central Computer Security Programs

The purpose of a central computer security program is to address the overall management of computer security within an organization. In the federal government, the organization could consist of a department, agency, or other major operating unit.

As with the management of all resources, central computer security management can be performed in many practical and cost-effective ways. The importance of sound management cannot be overemphasized. There is also a downside to centrally managed computer security programs. Specifically, they present greater risk that errors in judgement will be more widely propagated throughout the organization. As they strive to meet their objectives, managers need to consider the full impact of available options when establishing their computer security programs.

6.2.1 Benefits of Central Computer Security Programs

A central security program should provide two quite distinct types of benefits:

- Increased efficiency and economy of security throughout the organization, and
- the ability to provide centralized enforcement and oversight.

Both of these benefits are in keeping with the purpose of the Paperwork Reduction Act, as implemented in OMB Circular A-130.

> The Paperwork Reduction Act establishes a broad mandate for agencies to perform their information management activities in an efficient, effective, and economical manner... . Agencies shall assure an adequate level of security for all agency automated information systems, whether maintained in-house or commercially.[58]

6.2.2 Efficient, Economic Coordination of Information

A central computer security program helps to coordinate and manage effective use of security-related resources throughout the organization. The most important of these resources are normally *information* and *financial resources*.

Sound and timely information is necessary for managers to accomplish their tasks effectively. However, most organizations have trouble collecting information from myriad sources and effectively processing and distributing it within the organization. This section discusses some of

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[58] OMB Circular A-130, Section 5; Appendix III, Section 3.

the sources and efficient uses of *computer security* information.

Within the federal government, many organizations such as the Office of Management and Budget, the General Services Administration, the National Institute of Standards and Technology, and the National Telecommunications and Information Administration, provide information on computer, telecommunications, or information resources. This information includes security-related policy, regulations, standards, and guidance. A portion of the information is channelled through the senior designated official for each agency (see Federal Information Resources Management Regulation [FIRMR] Part 201-2). Agencies are expected to have mechanisms in place to distribute the information the senior designated official receives.

Computer security-related information is also available from private and federal professional societies and groups. These groups will often provide the information as a public service, although some private groups charge a fee for it. However, even for information that is free or inexpensive, the costs associated with personnel gathering the information can be high.

Internal security-related information, such as which procedures were effective, virus infections, security problems, and solutions, need to be shared within an organization. Often this information is specific to the operating environment and culture of the organization.

A computer security program administered at the organization level can provide a way to collect the internal security-related information and distribute it as needed throughout the organization. Sometimes an organization can also share this information with external groups. See Figure 6.3.

Another use of an effective conduit of information is to increase the central computer security program's ability to influence external and internal policy decisions. If the central computer security program office can represent the entire organization, then its advice is more likely to be heeded by upper management and external organizations. However, to be effective, there should be excellent communication between the system-level computer security programs and the organization level. For example, if an organization were considering consolidating its mainframes into one site (or considering distributing the processing currently done at one site), personnel at the central program could provide initial opinions about the security implications. However, to speak authoritatively, central program personnel would have to actually know the security impacts of the proposed change – information that would have to be obtained from the system-level computer security program.

Besides being able to help an organization use information more cost effectively, a computer security program can also help an organization better spend its scarce security dollars. Organizations can develop expertise and then share it, reducing the need to contract out repeatedly for similar services. The central computer security program can help facilitate information sharing.

> An organization's components may develop specialized expertise, which can be shared among components. For example, one operating unit may primarily use UNIX and have developed skills in UNIX security. A second operating unit (with only one UNIX machine), may concentrate on MVS security and rely on the first unit's knowledge and skills for its UNIX machine.

Some Principal Security Program Interactions

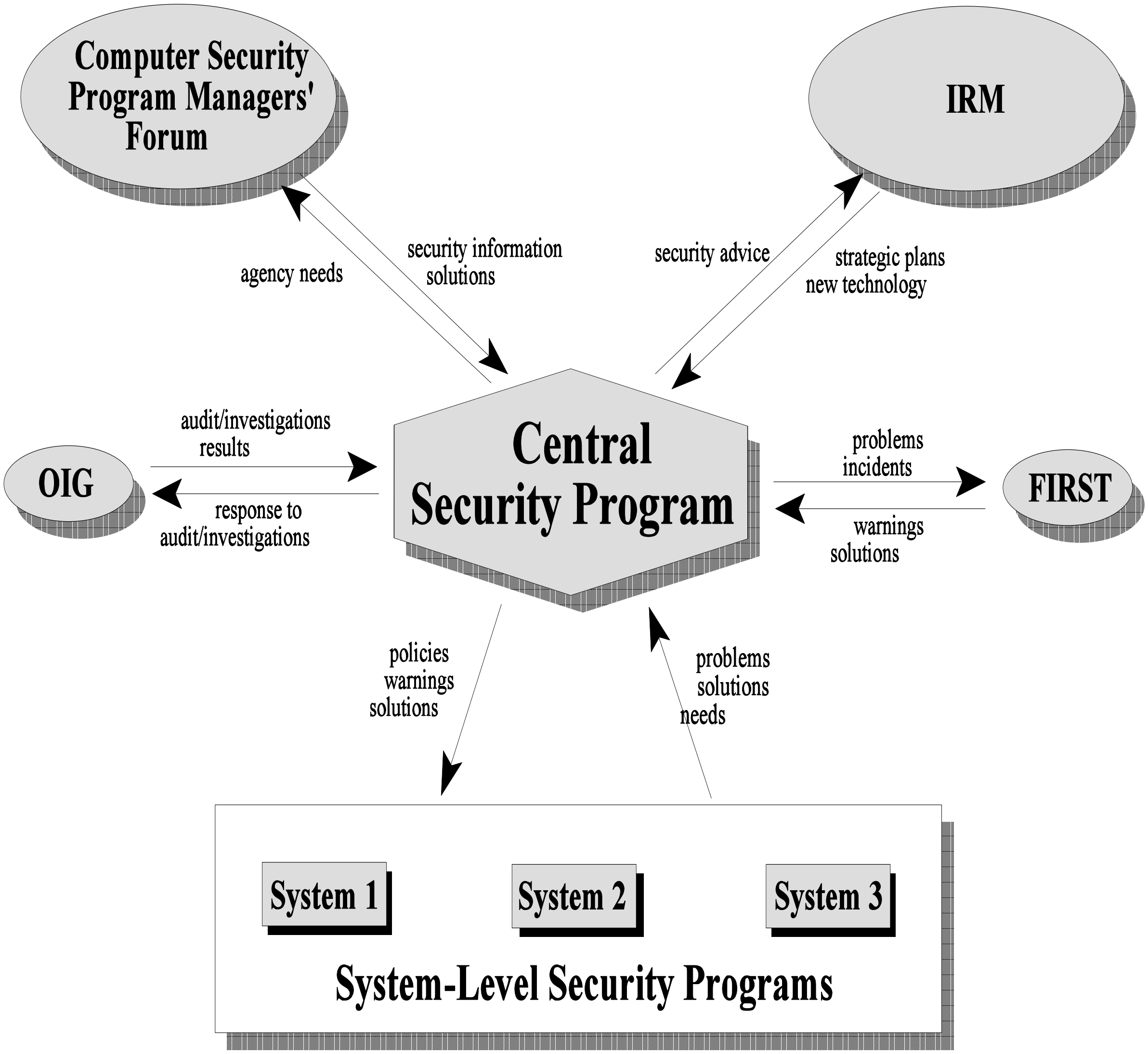

Figure 6.3 shows a *simplified* version of the flow of computer security-related information among various parts of an organization and across different organizations.

Figure 6.3

Personnel at the central computer security program level can also develop their own areas of expertise. For example, they could sharpen their skills could in contingency planning and risk analysis to help the entire organization perform these vital security functions.

Besides allowing an organization to share expertise and, therefore, save money, a central computer security program can use its position to consolidate requirements so the organization can negotiate discounts based on volume purchasing of security hardware and software. It also facilitates such activities as strategic planning and organizationwide incident handling and security trend analysis.

6.2.3 Central Enforcement and Oversight

Besides helping an organization improve the economy and efficiency of its computer security program, a centralized program can include an independent evaluation or enforcement function to ensure that organizational subunits are cost-effectively securing resources and following applicable policy. While the Office of the Inspector General (OIG) and external organizations, such as the General Accounting Office (GAO), also perform a valuable evaluation role, they operate outside the regular management channels. Chapters 8 and 9 further discuss the role of independent audit.

There are several reasons for having an oversight function within the regular management channel. First, computer security is an important component in the management of organizational resources. This is a responsibility that cannot be transferred or abandoned. Second, maintaining an internal oversight function allows an organization to find and correct problems without the potential embarrassment of an IG or GAO audit or investigation. Third, the organization may find different problems from those that an outside organization may find. The organization understands its assets, threats, systems, and procedures better than an external organization; additionally, people may have a tendency to be more candid with insiders.

6.3 Elements of an Effective Central Computer Security Program

For a central computer security program to be effective, it should be an established part of organization management. If system managers and applications owners do not need to consistently interact with the security program, then it can become an empty token of upper management's "commitment to security."

Stable Program Management Function. A well-established program will have a program manager recognized within the organization as the central computer security program manager. In addition, the program will be staffed with able personnel, and links will be established between the program management function and computer security personnel in other parts of the organization. A computer security program is a complex function that needs a stable base from which to direct the management of such security resources as information and money. The benefits of an oversight function cannot be achieved if the computer security program is not recognized within an organization as having expertise and authority.

Stable Resource Base. A well-established program will have a stable resource base in terms of personnel, funds, and other support. Without a stable resource base, it is impossible to plan and execute programs and projects effectively.

Existence of Policy. Policy provides the foundation for the central computer security program and is the means for documenting and promulgating important decisions about computer security. A central computer security program should also publish standards, regulations, and guidelines that implement and expand on policy. (See Chapter 5.)

Published Mission and Functions Statement. A published mission statement grounds the central computer security program into the unique operating environment of the organization. The statement clearly establishes the function of the computer security program and defines responsibilities for both the computer security program and other related programs and entities. Without such a statement, it is impossible to develop criteria for evaluating the effectiveness of the program.

Long-Term Computer Security Strategy. A well-established program explores and develops long-term strategies to incorporate computer security into the next generation of information technology. Since the computer and telecommunications field moves rapidly, it is essential to plan for future operating environments.

Compliance Program. A central computer security program needs to address compliance with national policies and requirements, as well as organization-specific requirements. National requirements include those prescribed under the Computer Security Act of 1987, OMB Circular A-130, the FIRMR, and Federal Information Processing Standards.

Intraorganizational Liaison. Many offices within an organization can affect computer security. The Information Resources Management organization and physical security office are two obvious examples. However, computer security often overlaps with other offices, such as safety, reliability and quality assurance, internal control, or the Office of the Inspector General. An effective program should have established relationships with these groups in order to integrate computer security into the organization's management. The relationships should encompass more than just the sharing of information; the offices should influence each other.

Example

Agency IRM offices engage in strategic and tactical planning for both information and information technology, in accordance with the Paperwork Reduction Act and OMB Circular A-130. Security should be an important component of these plans. The security needs of the agency should be reflected in the information technology choices and the information needs of the agency should be reflected in the security program.

Liaison with External Groups. There are many sources of computer security information, such as NIST's Computer Security Program Managers' Forum, computer security clearinghouse, and the Forum of Incident Response and Security Teams (FIRST). An established program will be knowledgeable of and will take advantage of external sources of information. It will also be a provider of information.

6.4 System-Level Computer Security Programs

While the central program addresses the entire spectrum of computer security for an organization, system-level programs ensure appropriate and cost-effective security for each system.[59] This includes influencing decisions about what controls to implement, purchasing and installing technical controls, day-to-day computer security administration, evaluating system vulnerabilities, and responding to security problems. It encompasses all the areas discussed in the handbook.

System-level computer security program personnel are the local advocates for computer security. The system security manager/officer raises the issue of security with the cognizant system manager and helps develop solutions for security problems. For example, has the application owner made clear the system's security requirements? Will bringing a new function online affect security, and if so, how? Is the system vulnerable to hackers and viruses? Has the contingency plan been tested? Raising these kinds of questions will force system managers and application owners to identify and address their security requirements.

6.5 Elements of Effective System-Level Programs

Like the central computer security program, many factors influence how successful a system-level computer security program is. Many of these are similar to the central program. This section addresses some additional considerations.

Security Plans. The Computer Security Act mandates that agencies develop computer security and privacy plans for sensitive systems. These plans ensure that each federal and federal interest system has appropriate and cost-effective security. System-level security personnel should be in a position to develop and implement security plans. Chapter 8 discusses the plans in more detail.

System-Specific Security Policy. Many computer security policy issues need to be addressed on a system-specific basis. The issues can vary for each system, although access control and the designation of personnel with security responsibility are likely to be needed for all systems. A cohesive and comprehensive set of security policies can be developed by using a process that derives security rules from security goals, as discussed in Chapter 5.

Life Cycle Management. As discussed in Chapter 8, security must be managed throughout a system's life cycle. This specifically includes ensuring that changes to the system are made with attention to security and that accreditation is accomplished.

Integration With System Operations. The system-level computer security program should consist of people who understand the system, its mission, its technology, and its operating environment. Effective security management usually needs to be integrated into the management of the system. Effective integration will ensure that system managers and application owners consider security in the planning and operation of the system. The system security manager/officer should be able to participate in the selection and implementation of

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[59] As is implied by the name, an organization will typically have several system-level computer security programs. In setting up these programs, the organization should carefully examine the scope of each system-level program. System-level computer security programs may address, for example, the computing resources within an operational element, a major application, or a group of similar systems (either technologically or functionally).

appropriate technical controls and security procedures and should understand system vulnerabilities. Also, the system-level computer security program should be capable of responding to security problems in a timely manner.

For large systems, such as a mainframe data center, the security program will often include a manager and several staff positions in such areas as access control, user administration, and contingency and disaster planning. For small systems, such as an officewide local-area-network (LAN), the LAN administrator may have adjunct security responsibilities.

Separation From Operations. A natural tension often exists between computer security and operational elements. In many instances, operational components -- which tend to be far larger and therefore more influential -- seek to resolve this tension by embedding the computer security program in computer operations. The typical result of this organizational strategy is a computer security program that lacks independence, has minimal authority, receives little management attention, and has few resources. As early as 1978, GAO identified this organizational mode as one of the principal basic weaknesses in federal agency computer security programs.[60] System-level programs face this problem most often.

This conflict between the need to be a part of system management and the need for independence has several solutions. The basis of many of the solutions is a link between the computer security program and upper management, often through the central computer security program. A key requirement of this setup is the existence of a reporting structure that does not include system management. Another possibility is for the computer security program to be completely independent of system management and to report directly to higher management. There are many hybrids and permutations, such as co-location of computer security and systems management staff but separate reporting (and supervisory) structures. Figure 6.4 presents *one example* of placement of the computer security program within a typical Federal agency.[61]

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[60] General Accounting Office, "Automated System Security -- Federal Agencies Should Strengthen Safeguards Over Personal and Other Sensitive Data," GAO Report LCD 78-123, Washington, DC, 1978.

[61] No implication that this structure is ideal is intended.

Example of Organizational Placement of Computer Security Functions

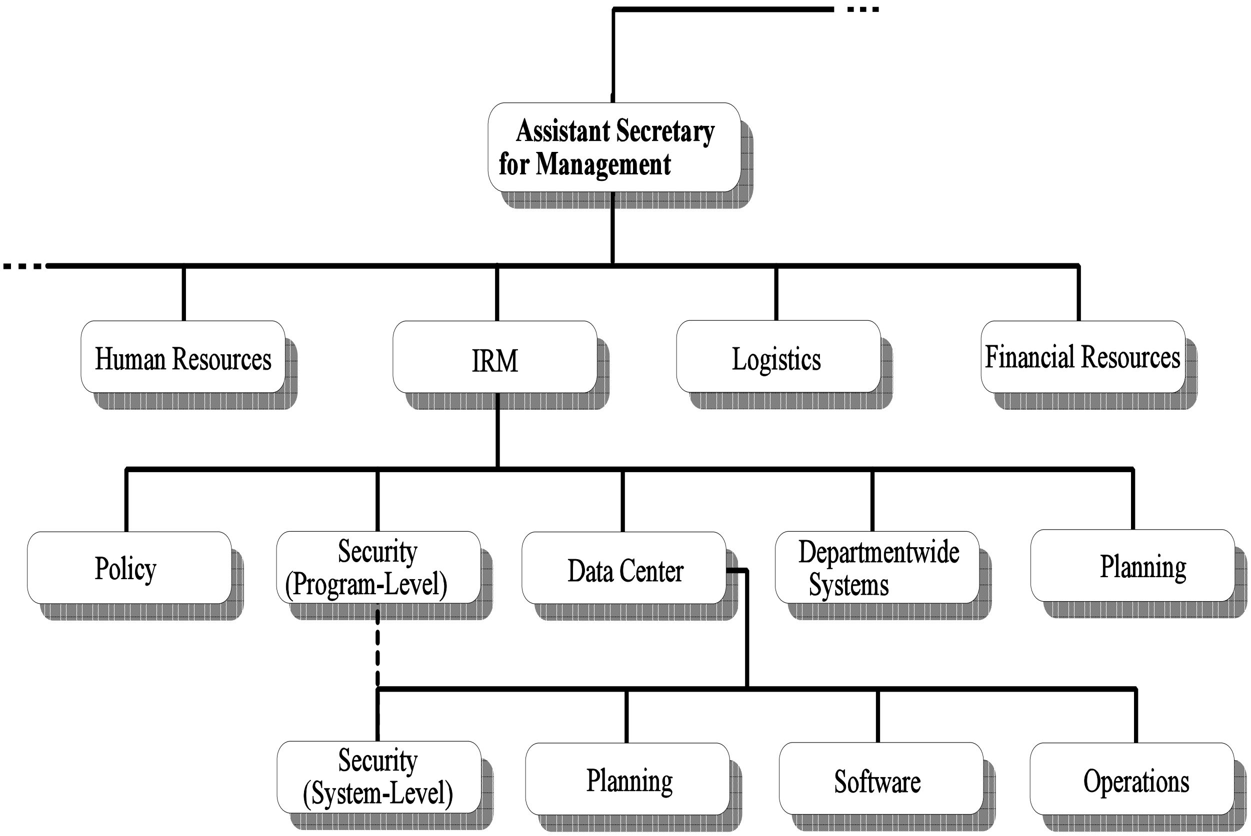

Figure 6.4 illustrates one example of the placement of the computer security program-level and system-level functions. The program-level function is located within the IRM organization and sets policy for the organization as a whole. The system-level function, located within the Data Center, provides for day-to-day security at that site. Note that, although not pictured, other system-level programs may exist for other facilities (e.g., under another Assistant Secretary).

Figure 6.4

6.6 Central and System-Level Program Interactions

A system-level program that is not integrated into the organizational program may have difficulty influencing significant areas affecting security. The system-level computer security program implements the policies, guidance, and regulations of the central computer security program. The system-level office also learns from the information disseminated by the central program and uses the experience and expertise of the entire organization. The system-level computer security program further distributes information to systems management as appropriate.

Communications, however, should not be just one way. System-level computer security programs inform the central office about their needs, problems, incidents, and solutions. Analyzing this information allows the central computer security program to represent the various systems to the organization's management and to external agencies and advocate programs and policies beneficial to the security of all the systems.

6.7 Interdependencies

The general purpose of the computer security program, to improve security, causes it to overlap with other organizational operations as well as the other security controls discussed in the handbook. The central or system computer security program will address most controls at the policy, procedural, or operational level.

Policy. Policy is issued to establish the computer security program. The central computer security program(s) normally produces policy (and supporting procedures and guidelines) concerning general and organizational security issues and often issue-specific policy. However, the system-level computer security program normally produces policy for that system. Chapter 5 provides additional guidance.

Life Cycle Management. The process of securing a system over its life cycle is the role of the system-level computer security program. Chapter 8 addresses these issues.

Independent Audit. The independent audit function described in Chapters 8 and 9 should complement a central computer security program's compliance functions.

6.8 Cost Considerations

This chapter discussed how an organizationwide computer security program can manage security resources, including financial resources, more effectively. The cost considerations for a system-level computer security program are more closely aligned with the overall cost savings in having security.

The most significant direct cost of a computer security program is personnel. In addition, many programs make frequent and effective use of consultants and contractors. A program also needs funds for training and for travel, oversight, information collection and dissemination, and meetings with personnel at other levels of computer security management.

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Chapter 7

COMPUTER SECURITY RISK MANAGEMENT

Risk is the possibility of something adverse happening. Risk management is the process of assessing risk, taking steps to reduce risk to an acceptable level and maintaining that level of risk. Though perhaps not always aware of it, individuals manage risks every day. Actions as routine as buckling a car safety belt, carrying an umbrella when rain is forecast, or writing down a list of things to do rather than trusting to memory fall into the purview of risk management. People recognize various threats to their best interests and take precautions to guard against them or to minimize their effects.

Both government and industry routinely manage a myriad of risks. For example, to maximize the return on their investments, businesses must often decide between aggressive (but high-risk) and slow-growth (but more secure) investment plans. These decisions require analysis of risk, relative to potential benefits, consideration of alternatives, and, finally, implementation of what management determines to be the best course of action.

Management is concerned with many types of risk. Computer security risk management addresses risks which arise from an organization's use of information technology.

While there are many models and methods for risk management, there are several basic activities and processes that should be performed. In discussing risk management, it is important to recognize its basic, most fundamental assumption: computers cannot ever be fully secured. There is always risk, whether it is from a trusted employee who defrauds the system or a fire that destroys critical resources. Risk management is made up of two primary and one underlying activities; risk assessment and risk mitigation are the primary activities and uncertainty analysis is the underlying one.

Risk assessment often produces an important side benefit -- indepth knowledge about a system and an organization as risk analysts try to figure out how systems and functions are interrelated.

7.1 Risk Assessment

Risk assessment, the process of analyzing and interpreting risk, is comprised of three basic activities: (1) determining the assessment's scope and methodology; (2) collecting and analyzing data; and 3) interpreting the risk analysis results.[62]

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[62] Many different terms are used to describe risk management and its elements. The definitions used in this paper are based on the NIST Risk Management Framework.

7.1.1 Determining the Assessment's Scope and Methodology

The first step in assessing risk is to identify the system under consideration, the part of the system that will be analyzed, and the analytical method including its level of detail and formality.

A risk assessment can focus on many different areas such as: technical and operational controls to be designed into a new application, the use of telecommunications, a data center, or an entire organization.

The assessment may be focused on certain areas where either the degree of risk is unknown or is known to be high. Different parts of a system may be analyzed in greater or lesser detail. Defining the scope and boundary can help ensure a cost-effective assessment. Factors that influence scope include what phase of the life cycle a system is in: more detail might be appropriate for a new system being developed than for an existing system undergoing an upgrade. Another factor is the relative importance of the system under examination: the more essential the system, the more thorough the risk analysis should be. A third factor may be the magnitude and types of changes the system has undergone since the last risk analysis. The addition of new interfaces would warrant a different scope than would installing a new operating system.

Methodologies can be formal or informal, detailed or simplified, high or low level, quantitative (computationally based) or qualitative (based on descriptions or rankings), or a combination of these. No single method is best for all users and all environments.

How the boundary, scope, and methodology are defined will have major consequences in terms of (1) the total amount of effort spent on risk management and (2) the type and usefulness of the assessment's results. The boundary and scope should be selected in a way that will produce an outcome that is clear, specific, and useful to the system and environment under scrutiny.

7.1.2 Collecting and Analyzing Data

Good documentation of risk assessments will make later risk assessments less time consuming and, if a question arises, will help explain why particular security decisions were made.

Risk has many different components: assets, threats, vulnerabilities, safeguards, consequences, and likelihood. This examination normally includes gathering data about the threatened area *and* synthesizing and analyzing the information to make it useful.

Because it is possible to collect much more information than can be analyzed, steps need to be taken to limit information gathering and analysis. This process is called *screening*. A risk management effort should focus on those areas that result in the greatest consequence to the organization (i.e., can cause the most harm). This can be done by ranking threats and assets.

A risk management methodology does not necessarily need to analyze each of the components of risk separately. For example, assets/consequences or threats/likelihoods may be analyzed together.

Asset Valuation. These include the information, software, personnel, hardware, and physical assets (such as the computer facility). The value of an asset consists of its intrinsic value and the near-term impacts and long-term consequences of its compromise.

Consequence Assessment. The consequence assessment estimates the degree of harm or loss that could occur. *Consequences* refers to the overall, aggregate harm that occurs, not just to the near-term or immediate impacts. While such impacts often result in disclosure, modification, destruction, or denial of service, consequences are the more significant long-term effects, such as lost business, failure to perform the system's mission, loss of reputation, violation of privacy, injury, or loss of life. The more severe the consequences of a threat, the greater the risk to the system (and, therefore, the organization).

Threat Identification. A threat is an entity or event with the potential to harm the system. Typical threats are errors, fraud, disgruntled employees, fires, water damage, hackers, and viruses. Threats should be identified and analyzed to determine the likelihood of their occurrence and their potential to harm assets.

In addition to looking at "big-ticket" threats, the risk analysis should investigate areas that are poorly understood, new, or undocumented. If a facility has a well-tested physical access control system, less effort to identify threats may be warranted for it than for unclear, untested software backup procedures.

The risk analysis should concentrate on those threats most likely to occur and affect important assets. In some cases, determining which threats are realistic is not possible until after the threat analysis is begun. Chapter 4 provides additional discussion of today's most prevalent threats.

Safeguard Analysis. A safeguard is any action, device, procedure, technique, or other measure that reduces a system's vulnerability to a threat. Safeguard analysis should include an examination of the effectiveness of the existing security measures. It can also identify new safeguards that could be implemented in the system; however, this is normally performed later in the risk management process.

Vulnerability Analysis. A vulnerability is a condition or weakness in (or absence of) security procedures, technical controls, physical controls, or other controls that could be exploited by a threat. Vulnerabilities are often analyzed in terms of missing safeguards. Vulnerabilities contribute to risk because they may "allow" a threat to harm the system.

The interrelationship of vulnerabilities, threats, and assets is critical to the analysis of risk. Some of these interrelationships are pictured in Figure 7.1. However, there are other interrelationships such as the presence of a vulnerability inducing a threat. (For example, a normally honest employee might be tempted to alter data when the employee sees that a terminal has been left logged on.)

Likelihood Assessment. Likelihood is an estimation of the frequency or chance of a threat happening. A likelihood assessment considers the presence, tenacity, and strengths of threats as well as the effectiveness of safeguards (or presence of vulnerabilities). In general, historical information about many threats is weak, particularly with regard to human threats; thus, experience in this area is important. Some threat data -- especially on physical threats such as fires or floods -- is stronger. Care needs to be taken in using any statistical threat data; the source of the data or the analysis may be inaccurate or incomplete. In general, the greater the likelihood of a threat occurring, the greater the risk.

Threats, Vulnerabilities, Safeguards, and Assets

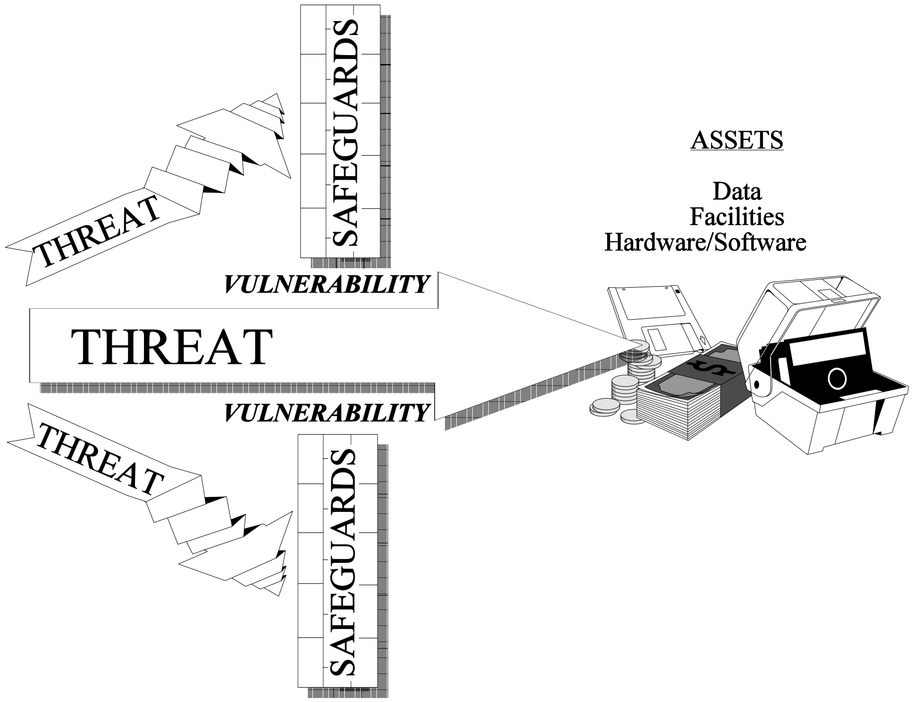

Figure 7.1 Safeguards prevent threats from harming assets. However, if an appropriate safeguard is not present, a vulnerability exists which can be exploited by a threat, thereby puttting assets at risk.

Figure 7.1

7.1.3 Interpreting Risk Analysis Results[63]

The risk assessment is used to support two related functions: the acceptance of risk and the selection of cost-effective controls. To accomplish these functions, the risk assessment must produce a meaningful output that reflects what is truly important to the organization. Limiting the risk interpretation activity to the most significant risks is another way that the risk management process can be focused to reduce the overall effort while still yielding useful results.

Risk Analysis Results

Risk analysis results are typically represented quantitatively and/or qualitatively. Quantitative measures may be expressed in terms of reduced expected monetary losses, such as annualized loss expectancies or single occurrences of loss. Qualitative measures are descriptive, expressed in terms such as high, medium, or low, or rankings on a scale of 1 to 10.

If risks are interpreted consistently across an organization, the results can be used to prioritize systems to be secured.

7.2 Risk Mitigation

Risk mitigation involves the selection and implementation of security controls to reduce risk to a level acceptable to management, within applicable constraints. Although there is flexibility in how risk assessment is conducted, the sequence of identifying boundaries, analyzing input, and producing an output is quite natural. The process of risk mitigation has greater flexibility, and the sequence will differ more, depending on organizational culture and the purpose of the risk management activity. Although these activities are discussed

Risk management can *help* a manager select the most appropriate controls; however, it is not a magic wand that instantly eliminates all difficult issues. The quality of the output depends on the quality of the input and the type of analytical methodology used. In some cases, the amount of work required to achieve high-quality input will be too costly. In other cases, achieving high-quality input may be impossible, especially for such variables as the prevalence of a particular threat or the anticipated effectiveness of a proposed safeguard. For all practical purposes, complete information is never available; uncertainty is always present. Despite these drawbacks, risk management provides a very powerful tool for analyzing the risk associated with computer systems.

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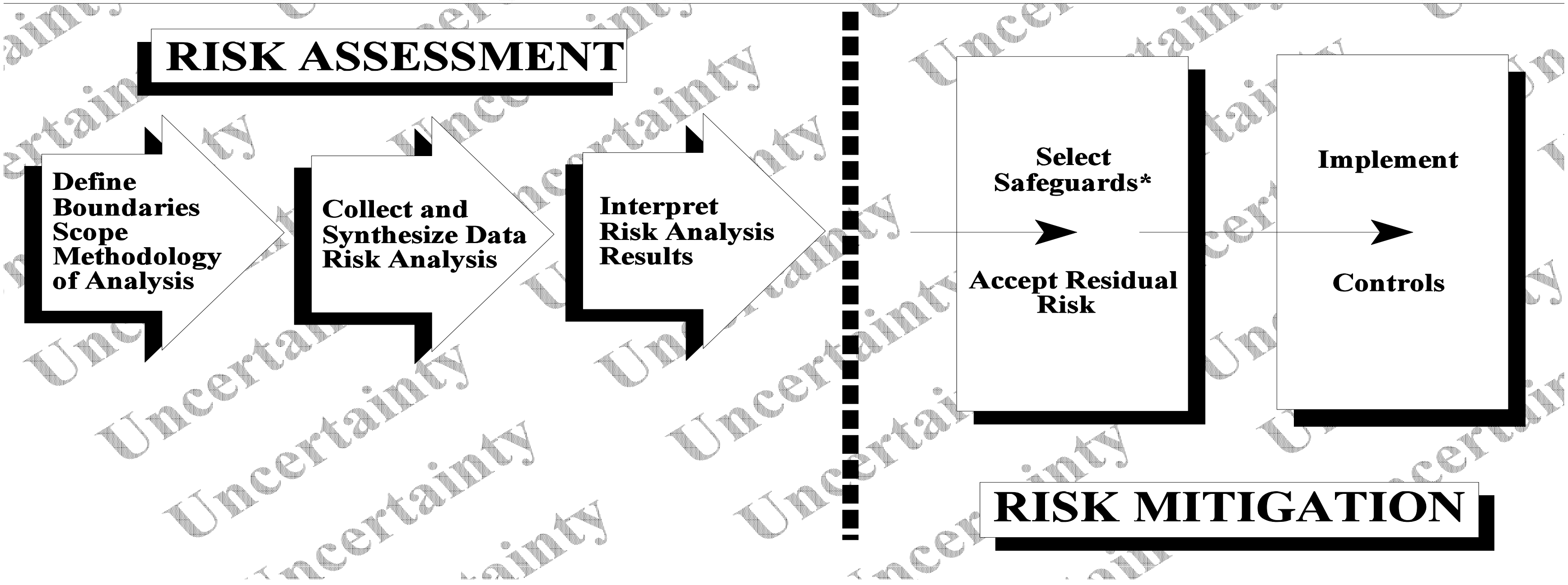
[63] The NIST Risk Management Framework refers to risk interpretation as risk measurement. The term "interpretation" was chosen to emphasize the wide variety of possible outputs from a risk assessment.

How Risk Management Works



* There are many possible approaches to safeguard selection. Some involve looping back and reexamining risk analysis data.

Figure 7.2 shows the flow of risk management activities and processes. A major division in risk management (shown by the verticle line) is between risk assessment and risk mitigation. Both are critical parts of the risk management process. Uncertainty is always present.

Figure 7.2

in a specific sequence, they need not be performed in that sequence. In particular, the selection of safeguards and risk acceptance testing are likely to be performed simultaneously.[64]

7.2.1 Selecting Safeguards

A primary function of computer security risk management is the identification of appropriate controls. In designing (or reviewing) the security of a system, it may be obvious that some controls should be added (e.g., because they are required by law or because they are clearly cost-effective). It may also be just as obvious that other controls may be too expensive (considering both monetary and nonmonetary factors). For example, it may be immediately apparent to a manager that closing and locking the door to a particular room that contains local area network equipment is a needed control, while posting a guard at the door would be too expensive and not user-friendly.

In every assessment of risk, there will be many areas for which it will not be obvious what kind of controls are appropriate. Even considering only monetary issues, such as whether a control would cost more than the loss it is supposed to prevent, the selection of controls is not simple. However, in selecting appropriate controls, managers need to consider many factors, including:

- organizational policy, legislation, and regulation;
- safety, reliability, and quality requirements;
- system performance requirements;

What Is a *What If* Analysis?

A *what if* analysis looks at the costs and benefits of various combinations of controls to determine the optimal combination for a particular circumstance. In this simple example (which addresses only one control), suppose that hacker break-ins alert agency computer security personnel to the security risks of using passwords. They may wish to consider replacing the password system with stronger identification and authentication mechanisms, or just strengthening their password procedures. First, the **status quo** is examined. The system in place puts minimal demands upon users and system administrators, but the agency has had three hacker break-ins in the last six months.

What if passwords are strengthened? Personnel may be required to change passwords more frequently or may be required to use a numeral or other nonalphabetic character in their password. There are no direct monetary expenditures, but staff and administrative overhead (e.g., training and replacing forgotten passwords) is increased. Estimates, however, are that this will reduce the number of successful hacker break-ins to three or four per year.

What if stronger identification and authentication technology is used? The agency may wish to implement stronger safeguards in the form of one-time cryptographic-based passwords so that, even if a password were obtained, it would be useless. Direct costs may be estimated at $45,000, and yearly recurring costs at $8,000. An initial training program would be required, at a cost of $17,500. The agency estimates, however, that this would prevent virtually all break-ins.

Computer security personnel use the results of this analysis to make a recommendation to their management officer, who then weighs the costs and benefits, takes into account other constraints (e.g., budget), and selects a solution.

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[64] This is often viewed as a circular, iterative process.

- timeliness, accuracy, and completeness requirements;
- the life cycle costs of security measures;
- technical requirements; and
- cultural constraints.

One method of selecting safeguards uses a "what if" analysis. With this method, the effect of adding various safeguards (and, therefore, reducing vulnerabilities) is tested to see what difference each makes with regard to cost, effectiveness, and other relevant factors, such as those listed above. Trade-offs among the factors can be seen. The analysis of trade-offs also supports the acceptance of residual risk, discussed below. This method typically involves multiple iterations of the risk analysis to see how the proposed changes affect the risk analysis result.

Another method is to categorize types of safeguards and recommend implementing them for various levels of risk. For example, stronger controls would be implemented on high-risk systems than on low-risk systems. This method normally does not require multiple iterations of the risk analysis.

As with other aspects of risk management, screening can be used to concentrate on the highest-risk areas. For example once could focus on risks with very severe consequences, such as a very high dollar loss or loss of life or on the threats that are most likely to occur.

7.2.2 Accept Residual Risk

At some point, management needs to decide if the operation of the computer system is acceptable, given the kind and severity of remaining risks. Many managers do not fully understand computer-based risk for several reasons: (1) the type of risk may be different from risks previously associated with the organization or function; (2) the risk may be technical and difficult for a lay person to understand, or (3) the proliferation and decentralization of computing power can make it difficult to identify key assets that may be at risk.

Risk acceptance, like the selection of safeguards, should take into account various factors besides those addressed in the risk assessment. In addition, risk acceptance should take into account the limitations of the risk assessment. (See the section below on uncertainty.) Risk acceptance is linked to the selection of safeguards since, in some cases, risk may have to be accepted because safeguards are too expensive (in either monetary or nonmonetary factors).

Within the federal government, the acceptance of risk is closely linked with the authorization to use a computer system, often called *accreditation*, discussed in Chapters 8 and 9. Accreditation is the acceptance of risk by management resulting in a formal approval for the system to become operational or remain so. As discussed earlier in this chapter, one of the two primary functions of risk management is the interpretation of risk for the purpose of risk acceptance.

7.2.3 Implementing Controls and Monitoring Effectiveness

Merely selecting appropriate safeguards does not reduce risk; those safeguards need to be effectively implemented. Moreover, to continue to be effective, risk management needs to be an ongoing process. This requires a periodic assessment and improvement of safeguards and re-analysis of risks. Chapter 8 discusses how periodic risk assessment is an integral part of the overall management of a system. (See especially the diagram on page 83.)

The risk management process normally produces security requirements that are used to design, purchase, build, or otherwise obtain safeguards or implement system changes. The integration of risk management into the life cycle process is discussed in Chapter 8.

7.3 Uncertainty Analysis

Risk management often must rely on speculation, best guesses, incomplete data, and many unproven assumptions. The uncertainty analysis attempts to document this so that the risk management results can be used knowledgeably. There are two primary sources of uncertainty in the risk management process: (1) a lack of confidence or precision in the risk management model or methodology and (2) a lack of sufficient information to determine the exact value of the elements of the risk model, such as threat frequency, safeguard effectiveness, or consequences.

While uncertainty is always present it should not invalidate a risk assessment. Data and models, while imperfect, can be good enough for a given purpose.

The risk management framework presented in this chapter is a generic description of risk management elements and their basic relationships. For a methodology to be useful, it should further refine the relationships and offer some means of screening information. In this process, assumptions may be made that do not accurately reflect the user's environment. This is especially evident in the case of safeguard selection, where the number of relationships among assets, threats, and vulnerabilities can become unwieldy.

The data are another source of uncertainty. Data for the risk analysis normally come from two sources: statistical data and expert analysis. Statistics and expert analysis can sound more authoritative than they really are. There are many potential problems with statistics. For example, the sample may be too small, other parameters affecting the data may not be properly accounted for, or the results may be stated in a misleading manner. In many cases, there may be insufficient data. When expert analysis is used to make projections about future events, it should be recognized that the projection is subjective and is based on assumptions made (but not always explicitly articulated) by the expert.

7.4 Interdependencies

Risk management touches on every control and every chapter in this handbook. It is, however, most closely related to life cycle management and the security planning process. The requirement to perform risk management is often discussed in organizational policy and is an issue for organizational oversight. These issues are discussed in Chapters 5 and 6.

7.5 Cost Considerations

The building blocks of risk management presented in this chapter can be used creatively to develop methodologies that concentrate expensive analysis work where it is most needed. Risk management can become expensive very quickly if an expansive boundary and detailed scope are selected. It is very important to use screening techniques, as discussed in this chapter, to limit the overall effort. The goals of risk management should be kept in mind as a methodology is selected or developed. The methodology should concentrate on areas where identification of risk and the selection of cost-effective safeguards are needed.

The cost of different methodologies can be significant. A "back-of-the-envelope" analysis or high-medium-low ranking can often provide all the information needed. However, especially for the selection of expensive safeguards or the analysis of systems with unknown consequences, more in-depth analysis may be warranted.

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