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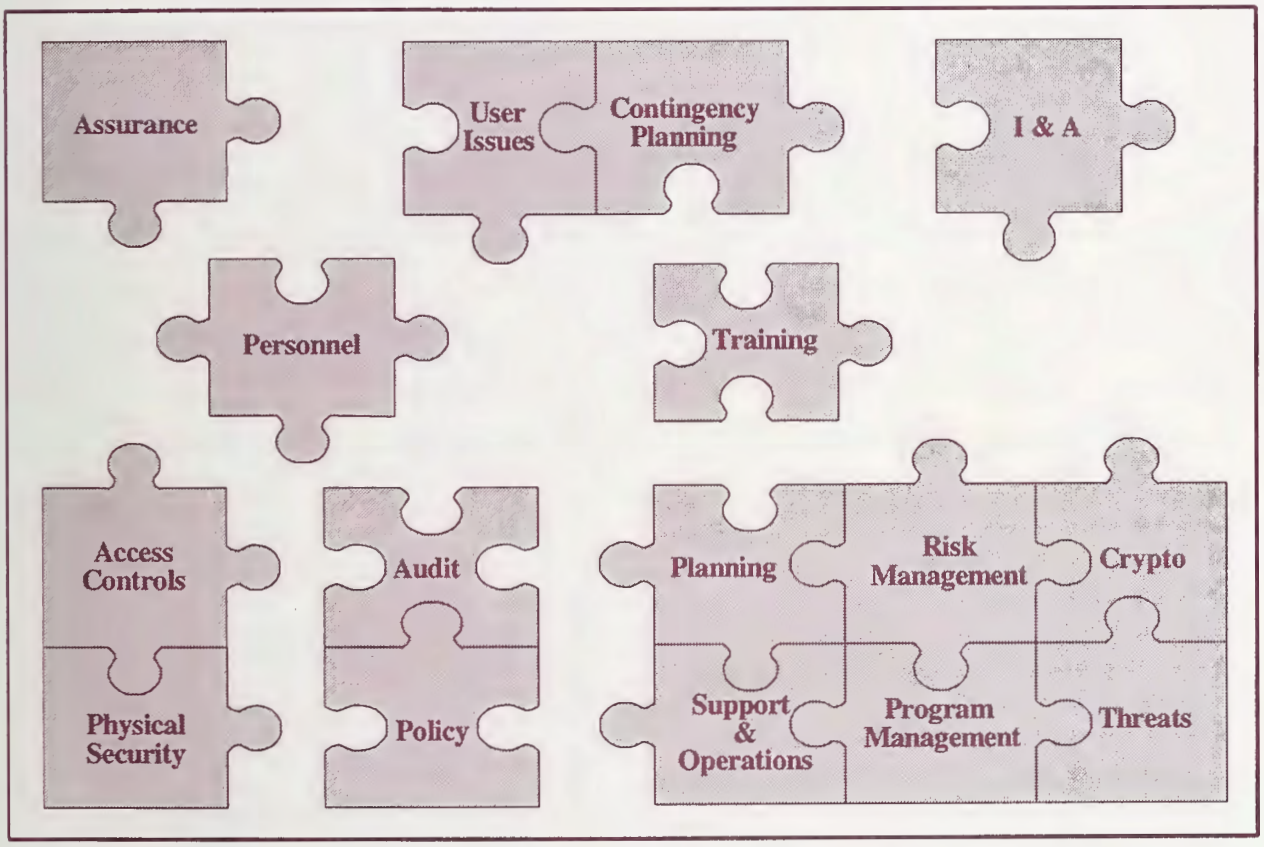
NIST Special Publication 800-12

An Introduction to Computer Security: The NIST Handbook

U.S. DEPARTMENT OF COMMERCE
Technology Administration
National Institute of Standards and Technology

Barbara Guttman and Edward A. Roback

C O M P U T E R S E C U R I T Y



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NIST Special Publication 800-12

An Introduction to Computer Security: The NIST Handbook

Barbara Guttman and Edward Roback

C O M P U T E R S E C U R I T Y

Computer Systems Laboratory

National Institute of Standards
and Technology
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I. INTRODUCTION AND OVERVIEW

Chapter 1

INTRODUCTION

1.1 Purpose

This handbook provides assistance in securing computer-based resources (including hardware, software, and information) by explaining important concepts, cost considerations, and interrelationships of security controls. It illustrates the benefits of security controls, the major techniques or approaches for each control, and important related considerations.[1]

The handbook provides a broad overview of computer security to help readers understand their computer security needs and develop a sound approach to the selection of appropriate security controls. It does not describe detailed steps necessary to implement a computer security program, provide detailed implementation procedures for security controls, or give guidance for auditing the security of specific systems. General references are provided at the end of this chapter, and references of "how-to" books and articles are provided at the end of each chapter in Parts II, III and IV.

The purpose of this handbook is not to specify requirements but, rather, to discuss the benefits of various computer security controls and situations in which their application may be appropriate. Some requirements for federal systems[2] are noted in the text. This document provides advice and guidance; no penalties are stipulated.

1.2 Intended Audience

The handbook was written primarily for those who have computer security responsibilities and need assistance understanding basic concepts and techniques. Within the federal government,[3] this includes those who have computer security responsibilities for *sensitive* systems.

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[1] It is recognized that the computer security field continues to evolve. To address changes and new issues, NIST's Computer Systems Laboratory publishes the *CSL Bulletin* series. Those bulletins which deal with security issues can be thought of as supplements to this publication.

[2] Note that these requirements do not arise from this handbook, but from other sources, such as the Computer Security Act of 1987.

[3] In the Computer Security Act of 1987, Congress assigned responsibility to NIST for the preparation of standards and guidelines for the security of sensitive *federal* systems, excluding classified and "Warner Amendment" systems (unclassified intelligence-related), as specified in 10 USC 2315 and 44 USC 3502(2).

For the most part, the concepts presented in the handbook are also applicable to the private sector.[4] While there are differences between federal and private-sector computing, especially in terms of priorities and legal constraints, the underlying principles of computer security and the available safeguards – managerial, operational, and technical – are the same. The handbook is therefore useful to anyone who needs to learn the basics of computer security or wants a broad overview of the subject. However, it is probably too detailed to be employed as a user awareness guide, and is not intended to be used as an audit guide.

Definition of Sensitive Information

Many people think that sensitive information only requires protection from unauthorized disclosure. However, the Computer Security Act provides a much broader definition of the term "sensitive" information:

any information, the loss, misuse, or unauthorized access to or modification of which could adversely affect the national interest or the conduct of federal programs, or the privacy to which individuals are entitled under section 552a of title 5, United States Code (the Privacy Act), but which has not been specifically authorized under criteria established by an Executive Order or an Act of Congress to be kept secret in the interest of national defense or foreign policy.

The above definition can be contrasted with the long-standing confidentiality-based information classification system for national security information (i.e., CONFIDENTIAL, SECRET, and TOP SECRET). This system is based only upon the need to protect classified information from unauthorized disclosure; the U.S. Government does not have a similar system for unclassified information. No governmentwide schemes (for either classified or unclassified information) exist which are based on the need to protect the integrity or availability of information.

1.3 Organization

The first section of the handbook contains background and overview material, briefly discusses of threats, and explains the roles and responsibilities of individuals and organizations involved in computer security. It explains the executive principles of computer security that are used throughout the handbook. For example, one important principle that is repeatedly stressed is that only security measures that are cost-effective should be implemented. A familiarity with the principles is fundamental to understanding the handbook's philosophical approach to the issue of security.

The next three major sections deal with security controls: Management Controls[5] (II), Operational Controls (III), and Technical Controls (IV). Most controls cross the boundaries between management, operational, and technical. Each chapter in the three sections provides a basic explanation of the control; approaches to implementing the control, some cost considerations in selecting, implementing, and using the control; and selected interdependencies that may exist with

[4] As necessary, issues that are specific to the federal environment are noted as such.

[5] The term *management controls* is used in a broad sense and encompasses areas that do not fit neatly into operational or technical controls.

other controls. Each chapter in this portion of the handbook also provides references that may be useful in actual implementation.

- The *Management Controls* section addresses security topics that can be characterized as managerial. They are techniques and concerns that are normally addressed by management in the organization's computer security program. In general, they focus on the management of the computer security program and the management of risk within the organization.

- The *Operational Controls* section addresses security controls that focus on controls that are, broadly speaking, implemented and executed by people (as opposed to systems). These controls are put in place to improve the security of a particular system (or group of systems). They often require technical or specialized expertise – and often rely upon management activities as well as technical controls.

- The *Technical Controls* section focuses on security controls that the computer system executes. These controls are dependent upon the proper functioning of the system for their effectiveness. The implementation of technical controls, however, always requires significant operational considerations – and should be consistent with the management of security within the organization.

Finally, an example is presented to aid the reader in correlating some of the major topics discussed in the handbook. It describes a hypothetical system and discusses some of the controls that have been implemented to protect it. This section helps the reader better understand the decisions that must be made in securing a system, and illustrates the interrelationships among controls.

1.4 Important Terminology

To understand the rest of the handbook, the reader must be familiar with the following key terms and definitions as used in this handbook. In the handbook, the terms *computers* and *computer systems* are used to refer to the entire spectrum of information technology, including application and support systems. Other key terms include:

Computer Security: The protection afforded to an automated information system in order to attain the applicable objectives of preserving the integrity, availability and confidentiality of information system resources (includes hardware, software, firmware, information/data, and telecommunications).

Integrity: In lay usage, information has integrity when it is timely, accurate, complete, and consistent. However, computers are unable to provide or protect all of these qualities. Therefore, in the computer security field, integrity is often discussed more narrowly as having two

Location of Selected Security Topics

Because this handbook is structured to focus on computer security controls, there may be several security topics that the reader may have trouble locating. For example, no separate section is devoted to mainframe or personal computer security, since the controls discussed in the handbook can be applied (albeit in different ways) to various processing platforms and systems. The following may help the reader locate areas of interest not readily found in the table of contents:

Topic	Chapter
Accreditation	8. Life Cycle 9. Assurance
Firewalls	17. Logical Access Controls
Security Plans	8. Life Cycle
Trusted Systems	9. Assurance Security features, including those incorporated into trusted systems, are discussed throughout.
Viruses & Other Malicious Code	9. Assurance (Operational Assurance section) 12. Incident Handling
Network Security	Network security uses the same basic set of controls as mainframe security or PC security. In many of the handbook chapters, considerations for using the control is a networked environment are addressed, as appropriate. For example, secure gateways are discussed as a part of Access Control; transmitting authentication data over insecure networks is discussed in the Identification and Authentication chapter; and the Contingency Planning chapter talks about data communications contracts. For the same reason, there is not a separate chapter for PC, LAN, minicomputer, or mainframe security.

facets: *data integrity* and *system integrity*. "Data integrity is a requirement that information and programs are changed only in a specified and authorized manner."[6] System integrity is a requirement that a system "performs its intended function in an unimpaired manner, free from deliberate or inadvertent unauthorized manipulation of the system."[7] The definition of *integrity*

[6] National Research Council, *Computers at Risk*, (Washington, DC: National Academy Press, 1991), p. 54.

[7] National Computer Security Center, Pub. NCSC-TG-004-88.

has been, and continues to be, the subject of much debate among computer security experts.

Availability: A "requirement intended to assure that systems work promptly and service is not denied to authorized users."[8]

Confidentiality: A requirement that private or confidential information not be disclosed to unauthorized individuals.

1.5 Legal Foundation for Federal Computer Security Programs

The executive principles discussed in the next chapter explain the need for computer security. In addition, within the federal government, a number of laws and regulations mandate that agencies protect their computers, the information they process, and related technology resources (e.g., telecommunications).[9] The most important are listed below.

- The *Computer Security Act of 1987* requires agencies to identify sensitive systems, conduct computer security training, and develop computer security plans.

- The *Federal Information Resources Management Regulation* (FIRMR) is the primary regulation for the use, management, and acquisition of computer resources in the federal government.

- *OMB Circular A-130* (specifically Appendix III) requires that federal agencies establish security programs containing specified elements.

Note that many more specific requirements, many of which are agency specific, also exist.

Federal managers are responsible for familiarity and compliance with applicable legal requirements. However, laws and regulations do not normally provide detailed instructions for protecting computer-related assets. Instead, they specify requirements – such as restricting the availability of personal data to authorized users. This handbook aids the reader in developing an effective, overall security approach and in selecting cost-effective controls to meet such requirements.

---

[8] *Computers at Risk*, p. 54.

[9] Although not listed, readers should be aware that laws also exist that may affect nongovernment organizations.

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Chapter 2

ELEMENTS OF COMPUTER SECURITY

This handbook's general approach to computer security is based on eight major elements:

1. Computer security should support the mission of the organization.
2. Computer security is an integral element of sound management.
3. Computer security should be cost-effective.
4. Computer security responsibilities and accountability should be made explicit.
5. System owners have computer security responsibilities outside their own organizations.
6. Computer security requires a comprehensive and integrated approach.
7. Computer security should be periodically reassessed.
8. Computer security is constrained by societal factors.

Familiarity with these elements will aid the reader in better understanding how the security controls (discussed in later sections) support the overall computer security program goals.

2.1 Computer Security Supports the Mission of the Organization.

The purpose of computer security is to protect an organization's valuable resources, such as information, hardware, and software. Through the selection and application of appropriate safeguards, security helps the organization's mission by protecting its physical and financial resources, reputation, legal position, employees, and other tangible and intangible assets. Unfortunately, security is sometimes viewed as thwarting the mission of the organization by imposing poorly selected, bothersome rules and procedures on users, managers, and systems. On the contrary, well-chosen security rules and procedures do not exist for their own sake – they are put in place to protect important assets and thereby support the overall organizational mission.

Security, therefore, is a means to an end and not an end in itself. For example, in a private- sector business, having good security is usually secondary to the need to make a profit. Security, then, *ought to* increase the firm's ability to make a profit. In a public-sector agency, security is usually secondary to the agency's service provided to citizens. Security, then, *ought to* help improve the service provided to the citizen.

To act on this, managers need to understand both their organizational mission and how each information system supports that mission. After a system's role has been defined, the security requirements implicit in that role can be defined. Security can then be explicitly stated in terms of the organization's mission.

The roles and functions of a system may not be constrained to a single organization. In an interorganizational system, each organization benefits from securing the system. For example, for electronic commerce to be successful, each of the participants requires security controls to protect their resources. However, good security on the buyer's system also benefits the seller; the buyer's system is less likely to be used for fraud or to be unavailable or otherwise negatively affect the seller. (The reverse is also true.)

This chapter draws upon the OECD's *Guidelines for the Security of Information Systems*, which was endorsed by the United States. It provides for:

Accountability - The responsibilities and accountability of owners, providers and users of information systems and other parties...should be explicit.

Awareness - Owners, providers, users and other parties should readily be able, consistent with maintaining security, to gain appropriate knowledge of and be informed about the existence and general extent of measures...for the security of information systems.

Ethics - The Information systems and the security of information systems should be provided and used in such a manner that the rights and legitimate interest of others are respected.

Multidisciplinary - Measures, practices and procedures for the security of information systems should take account of and address all relevant considerations and viewpoints....

Proportionality - Security levels, costs, measures, practices and procedures should be appropriate and proportionate to the value of and degree of reliance on the information systems and to the severity, probability and extent of potential harm....

Integration - Measures, practices and procedures for the security of information systems should be coordinated and integrated with each other and other measures, practices and procedures of the organization so as to create a coherent system of security.

Timeliness - Public and private parties, at both national and international levels, should act in a timely coordinated manner to prevent and to respond to breaches of security of information systems.

Reassessment - The security of information systems should be reassessed periodically, as information systems and the requirements for their security vary over time.

Democracy - The security of information systems should be compatible with the legitimate use and flow of data and information in a democratic society.

2.2 Computer Security is an Integral Element of Sound Management.

Information and computer systems are often critical assets that support the mission of an organization. Protecting them can be as critical as protecting other organizational resources, such as money, physical assets, or employees.

However, including security considerations in the management of information and computers does not completely eliminate the possibility that these assets will be harmed. Ultimately, organization managers have to decide what the level of risk they are willing to accept, taking into account the

cost of security controls.

As with many other resources, the management of information and computers may transcend organizational boundaries. When an organization's information and computer systems are linked with external systems, management's responsibilities also extend beyond the organization. This may require that management (1) know what general level or type of security is employed on the external system(s) or (2) seek assurance that the external system provides adequate security for the using organization's needs.

2.3 Computer Security Should Be Cost-Effective.

The costs and benefits of security should be carefully examined *in both monetary and non-monetary terms* to ensure that the cost of controls does not exceed expected benefits. Security should be appropriate and proportionate to the value of and degree of reliance on the computer systems and to the severity, probability and extent of potential harm. Requirements for security vary, depending upon the particular computer system.

In general, security is a smart business practice. By investing in security measures, an organization can reduce the frequency and severity of computer security-related losses. For example, an organization may estimate that it is experiencing significant losses per year in inventory through fraudulent manipulation of its computer system. Security measures, such as an improved access control system, may significantly reduce the loss.

Moreover, a sound security program can thwart hackers and can reduce the frequency of viruses. Elimination of these kinds of threats can reduce unfavorable publicity as well as increase morale and productivity.

Security benefits, however, do have both direct and indirect costs. Direct costs include purchasing, installing, and administering security measures, such as access control software or fire-suppression systems. Additionally, security measures can sometimes affect system performance, employee morale, or retraining requirements. All of these have to be considered in addition to the basic cost of the control itself. In many cases, these additional costs may well exceed the initial cost of the control (as is often seen, for example, in the costs of administering an access control package). Solutions to security problems should not be chosen if they cost more, directly or indirectly, than simply tolerating the problem.

2.4 Computer Security Responsibilities and Accountability Should Be Made Explicit.

The responsibilities and accountability[10] of owners, providers, and users of computer systems and other parties[11] concerned with the security of computer systems should be explicit.[12] The assignment of responsibilities may be internal to an organization or may extend across organizational boundaries.

Depending on the size of the organization, the program may be large or small, even a collateral duty of another management official. However, even small organizations can prepare a document that states organization policy and makes explicit computer security responsibilities. This element does *not* specify that individual accountability must be provided for on all systems. For example, many information dissemination systems do not require user identification and, therefore, cannot hold users accountable.

2.5 Systems Owners Have Security Responsibilities Outside Their Own Organizations.

If a system has external users, its owners have a responsibility to share appropriate knowledge about the existence and general extent of security measures so that other users can be *confident* that the system is adequately secure. (This does not imply that all systems must meet any minimum level of security, but does imply that system owners should inform their clients or users about the nature of the security.)

In addition to sharing information about security, organization managers "should act in a timely, coordinated manner to prevent and to respond to breaches of security" to help prevent damage to

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[10] The difference between responsibility and accountability is not always clear. In general, *responsibility* is a broader term, defining obligations and expected behavior. The term implies a proactive stance on the part of the responsible party and a causal relationship between the responsible party and a given outcome. The term *accountability* generally refers to the ability to hold people responsible for their actions. Therefore, people could be responsible for their actions but not held accountable. For example, an anonymous user on a system is responsible for not compromising security but cannot be held accountable if a compromise occurs since the action cannot be traced to an individual.

[11] The term *other parties* may include but is not limited to: executive management; programmers; maintenance providers; information system managers (software managers, operations managers, and network managers); software development managers; managers charged with security of information systems; and internal and external information system auditors.

[12] Implicit is the recognition that people or other entities (such as corporations or governments) *have* responsibilities and accountability related to computer systems. These are responsibilities and accountabilities are often shared among many entities. (Assignment of responsibilities is usually accomplished through the issuance of policy. See Chapter 5.)

others.[13] However, taking such action should *not* jeopardize the security of systems.

2.6 Computer Security Requires a Comprehensive and Integrated Approach.

Providing effective computer security requires a comprehensive approach that considers a variety of areas both within and outside of the computer security field. This comprehensive approach extends throughout the entire information life cycle.

2.6.1 Interdependencies of Security Controls

To work effectively, security controls often depend upon the proper functioning of other controls. In fact, many such interdependencies exist. If appropriately chosen, managerial, operational, and technical controls can work together synergistically. On the other hand, without a firm understanding of the interdependencies of security controls, they can actually undermine one another. For example, without proper training on how and when to use a virus-detection package, the user may apply the package incorrectly and, therefore, ineffectively. As a result, the user may mistakenly believe that their system will always be virus-free and may inadvertently spread a virus. In reality, these interdependencies are usually more complicated and difficult to ascertain.

2.6.2 Other Interdependencies

The effectiveness of security controls also depends on such factors as system management, legal issues, quality assurance, and internal and management controls. Computer security needs to work with traditional security disciplines including physical and personnel security. Many other important interdependencies exist that are often unique to the organization or system environment. Managers should recognize how computer security relates to other areas of systems and organizational management.

2.7 Computer Security Should Be Periodically Reassessed.

Computers and the environments they operate in are dynamic. System technology and users, data and information in the systems, risks associated with the system and, therefore, security requirements are ever-changing. Many types of changes affect system security: technological developments (whether adopted by the system owner or available for use by others); connecting to external networks; a change in the value or use of information; or the emergence of a new threat.

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[13] Organisation for Economic Co-operation and Development, *Guidelines for the Security of Information Systems*, Paris, 1992.

In addition, security is *never* perfect when a system is implemented. System users and operators discover new ways to intentionally or unintentionally bypass or subvert security. Changes in the system or the environment can create new vulnerabilities. Strict adherence to procedures is rare, and procedures become outdated over time. All of these issues make it necessary to reassess the security of computer systems.

2.8 Computer Security is Constrained by Societal Factors.

The ability of security to support the mission of the organization(s) may be limited by various factors, such as social issues. For example, security and workplace privacy can conflict. Commonly, security is implemented on a computer system by identifying users and tracking their actions. However, expectations of privacy vary and can be violated by some security measures. (In some cases, privacy may be mandated by law.)

Although privacy is an extremely important societal issue, it is not the only one. The flow of information, especially between a government and its citizens, is another situation where security may need to be modified to support a societal goal. In addition, some authentication measures, such as retinal scanning, may be considered invasive in some environments and cultures.

The underlying idea is that security measures should be selected and implemented with a recognition of the rights and legitimate interests of others. This many involve balancing the security needs of information owners and users with societal goals. However, rules and expectations change with regard to the appropriate use of security controls. These changes may either increase or decrease security.

The relationship between security and societal norms is not necessarily antagonistic. Security can enhance the access and flow of data and information by providing more accurate and reliable information and greater availability of systems. Security can also increase the privacy afforded to an individual or help achieve other goals set by society.

References

Organisation for Economic Co-operation and Development. *Guidelines for the Security of Information Systems.* Paris, 1992.

Chapter 3

ROLES AND RESPONSIBILITIES

One fundamental issue that arises in discussions of computer security is: "Whose responsibility is it?" Of course, on a basic level the answer is simple: computer security is the responsibility of everyone who can affect the security of a computer system. However, the specific duties and responsibilities of various individuals and organizational entities vary considerably.

This chapter presents a brief overview of roles and responsibilities of the various officials and organizational offices *typically* involved with computer security.[14] They include the following groups:[15]

- senior management
- program/functional managers/application owners,
- computer security management,
- technology providers,
- supporting organizations, and
- users.

This chapter is intended to give the reader a basic familiarity with the major organizational elements that play a role in computer security. *It does not describe all responsibilities of each in detail, nor will this chapter apply uniformly to all organizations.* Organizations, like individuals, have unique characteristics, and no single template can apply to all. Smaller organizations, in particular, are not likely to have separate individuals performing many of the functions described in this chapter. Even at some larger organizations, some of the duties described in this chapter may not be staffed with full-time personnel. What is important is that these *functions* be handled in a manner appropriate for the organization.

As with the rest of the handbook, *this chapter is not intended to be used as an audit guide.*

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[14] Note that this includes groups *within* the organization; outside organizations (e.g., NIST and OMB) are not included in this chapter.

[15] These categories are generalizations used to help aid the reader; if they are not applicable to the reader's particular environment, they can be safely ignored. While all these categories may not exist in a particular organization, the functionality implied by them will often still be present. Also, some organizations may fall into more than one category. For example, the personnel office both supports the computer security program (e.g., by keeping track of employee departures) and is also a user of computer services.

3.1 Senior Management

> Senior management has ultimate responsibility for the security of an organization's computer systems.

Ultimately, responsibility for the success of an organization lies with its senior managers. They establish the organization's computer security program and its overall program goals, objectives, and priorities in order to support the mission of the organization. Ultimately, the head of the organization is responsible for ensuring that adequate resources are applied to the program and that it is successful. Senior managers are also responsible for setting a good example for their employees by following all applicable security practices.

3.2 Computer Security Management

The *Computer Security Program Manager* (and support staff) directs the organization's day-to-day management of its computer security program. This individual is also responsible for coordinating all security-related interactions among organizational elements involved in the computer security program – as well as those external to the organization.

3.3 Program and Functional Managers/Application Owners

Program or Functional Managers/Application Owners are responsible for a program or function (e.g., procurement or payroll) including the supporting computer system.[16] Their responsibilities include providing for appropriate security, including management, operational, and technical controls. These officials are usually assisted by a technical staff that oversees the actual workings of the system. This kind of support is no different for other staff members who work on other program implementation issues.

Also, the program or functional manager/application owner is often aided by a *Security Officer* (frequently dedicated to that system, particularly if it is large or critical to the organization) in developing and implementing security requirements.

3.4 Technology Providers

System Management/System Administrators. These personnel are the managers and technicians who design and operate computer systems. They are responsible for implementing technical security on computer systems and for being familiar with security technology that relates to their system. They also need to ensure the continuity of their services to meet the needs of functional

[16] The functional manager/application owner may or may not be the *data owner*. Particularly within the government, the concept of the data owner may not be the most appropriate, since citizens ultimately own the data.

managers as well as analyzing technical vulnerabilities in their systems (and their security implications). They are often a part of a larger Information Resources Management (IRM) organization.

Communications/Telecommunications Staff. This office is normally responsible for providing communications services, including voice, data, video, and fax service. Their responsibilities for communication systems are similar to those that systems management officials have for their systems. The staff may not be separate from other technology service providers or the IRM office.

System Security Manager/Officers. Often assisting system management officials in this effort is a *system security manager/officer* responsible for day-to-day security implementation/administration duties. Although not normally part of the computer security program management office, this officer is responsible for coordinating the security efforts of a particular system(s). This person works closely with system management personnel, the computer security program manager, and the program or functional manager's security officer. In fact, depending upon the organization, this may be the same individual as the program or functional manager's security officer. This person may or may not be a part of the organization's overall security office.

Help Desk. Whether or not a Help Desk is tasked with incident handling, it needs to be able to recognize security incidents and refer the caller to the appropriate person or organization for a response.

What is a Program/Functional Manager?

The term *program/functional manager* or *application owner* may not be familiar or immediately apparent to all readers. The examples provided below should help the reader better understand this important concept. In reviewing these examples, note that computer systems often serve more than one group or function.

Example 1. A personnel system serves an entire organization. However, the Personnel Manager would normally be the application owner. This applies even if the application is distributed so that supervisors and clerks throughout the organization use and update the system.

Example #2. A federal benefits system provides monthly benefit checks to 500,000 citizens. The processing is done on a mainframe data center. The Benefits Program Manager is the application owner.

Example 3. A mainframe data processing organization supports several large applications. The mainframe director is *not* the Functional Manager for any of the applications.

Example 4. A 100-person division has a diverse collection of personal computers, work stations, and minicomputers used for general office support, Internet connectivity, and computer-oriented research. The division director would normally be the Functional Manager responsible for the system.

3.5 Supporting Functions[17]

The security responsibilities of managers, technology providers and security officers are supported by functions normally assigned to others. Some of the more important of these are described below.

Audit. Auditors are responsible for examining systems to see whether the system is meeting stated security requirements, including system and organization policies, and whether security controls are appropriate. Informal audits can be performed by those operating the system under review or, if impartiality is important, by outside auditors.[18]

Physical Security. The physical security office is usually responsible for developing and enforcing appropriate physical security controls, in consultation with computer security management, program and functional managers, and others, as appropriate. Physical security should address not only central computer installations, but also backup facilities and office environments. In the government, this office is often responsible for the processing of personnel background checks and security clearances.

Disaster Recovery/Contingency Planning Staff. Some organizations have a separate disaster recovery/contingency planning staff. In this case, they are normally responsible for contingency planning for the organization as a whole, and normally work with program and functional mangers/application owners, the computer security staff, and others to obtain additional

Who Should Be the Accrediting Official?

The Accrediting Officials are agency officials who have authority to accept an application's security safeguards and approve a system for operation. The Accrediting Officials must also be authorized to allocate resources to achieve acceptable security and to remedy security deficiencies. Without this authority, they cannot realistically take responsibility for the accreditation decision. In general, Accreditors are senior officials, who may be the Program or Function Manager/Application Owner. For some very sensitive applications, the Senior Executive Officer is appropriate as an Accrediting Official. In general, the more sensitive the application, the higher the Accrediting Officials are in the organization.

Where privacy is a concern, federal managers can be held personally liable for security inadequacies. The issuing of the accreditation statement fixes security responsibility, thus making explicit a responsibility that might otherwise be implicit. Accreditors should consult the agency general counsel to determine their personal security liabilities.

Note that accreditation is a formality unique to the government.

Source: NIST FIPS 102

[17] Categorization of functions and organizations in this section as supporting is in no way meant to imply any degree of lessened importance. Also, note that this list is not all-inclusive. Additional supporting functions that can be provided may include configuration management, independent verification and validation, and independent penetration testing teams.

[18] The term *outside auditors* includes both auditors external to the organization as a whole and the organization's internal audit staff. For purposes of this discussion, both are outside the management chain responsible for the operation of the system.

contingency planning support, as needed.

Quality Assurance. Many organizations have established a quality assurance program to improve the products and services they provide to their customers. The quality officer should have a working knowledge of computer security and how it can be used to improve the quality of the program, for example, by improving the integrity of computer-based information, the availability of services, and the confidentiality of customer information, as appropriate.

Procurement. The procurement office is responsible for ensuring that organizational procurements have been reviewed by appropriate officials. The procurement office cannot be responsible for ensuring that goods and services meet computer security expectations, because it lacks the technical expertise. Nevertheless, this office should be knowledgeable about computer security standards and should bring them to the attention of those requesting such technology.

Training Office. An organization has to decide whether the primary responsibility for training users, operators, and managers in computer security rests with the training office or the computer security program office. In either case, the two organizations should work together to develop an effective training program.

Personnel. The personnel office is normally the first point of contact in helping managers determine if a security background investigation is necessary for a particular position. The personnel and security offices normally work closely on issues involving background investigations. The personnel office may also be responsible for providing security-related exit procedures when employees leave an organization.

Risk Management/Planning Staff. Some organizations have a full-time staff devoted to studying all types of risks to which the organization may be exposed. This function should include computer security-related risks, although this office normally focuses on "macro" issues. Specific risk analyses for specific computer systems is normally not performed by this office.

Physical Plant. This office is responsible for ensuring the provision of such services as electrical power and environmental controls, necessary for the safe and secure operation of an organization's systems. Often they are augmented by separate medical, fire, hazardous waste, or life safety personnel.

3.6 Users

Users also have responsibilities for computer security. Two kinds of users, and their associated responsibilities, are described below.

Users of Information. Individuals who use information provided by the computer can be

considered the "consumers" of the applications. Sometimes they directly interact with the system (e.g., to generate a report on screen) – in which case they are also users of the system (as discussed below). Other times, they may only read computer-prepared reports or only be briefed on such material. Some users of information may be very far removed from the computer system. Users of information are responsible for letting the functional mangers/application owners (or their representatives) know what their needs are for the protection of information, especially for its integrity and availability.

Users of Systems. Individuals who directly use computer systems (typically via a keyboard) are responsible for following security procedures, for reporting security problems, and for attending required computer security and functional training.

References

Wood, Charles Cresson. "How to Achieve a Clear Definition of Responsibilities for Information Security." DATAPRO Information Security Service, IS115-200-101, 7 pp. April 1993.

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

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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.

improvements in program quality, as reflected in decreasing errors per 1000 lines of code, the 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

[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.

without authorization. They can include both outsiders and insiders. Much of the rise 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

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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.

piece of jewelry, the entire neighborhood may feel victimized and 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

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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.

systems to further their intelligence missions. Some unclassified information that may be of 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

[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.

development and implementation of a better computer security program and better protectio n of 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.

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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.

Responsibilities. Once the computer security program is established, its management is normally assigned to either a newly created or existing office.[50]

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

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]

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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.

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.

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]

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

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

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.

[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.

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

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.

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

[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.

that the objective is achievable. This process will also draw upon other applicable organization policies.

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

[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.)

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 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

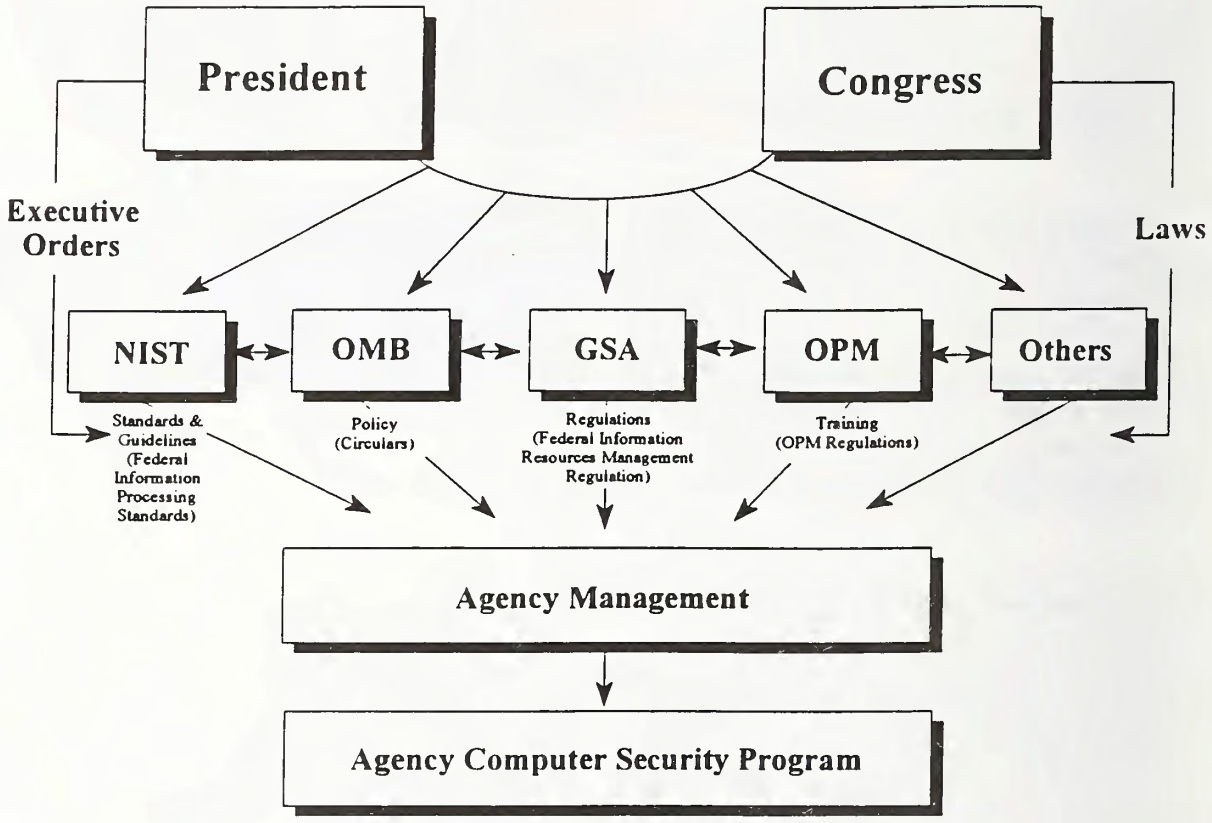
Many computer security programs that are distributed throughout the organization have different elements performing various functions. While this approach has benefits, the distribution of the computer security function in many organizations is haphazard, usually based upon history (i.e., who was available 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 systems and

[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

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

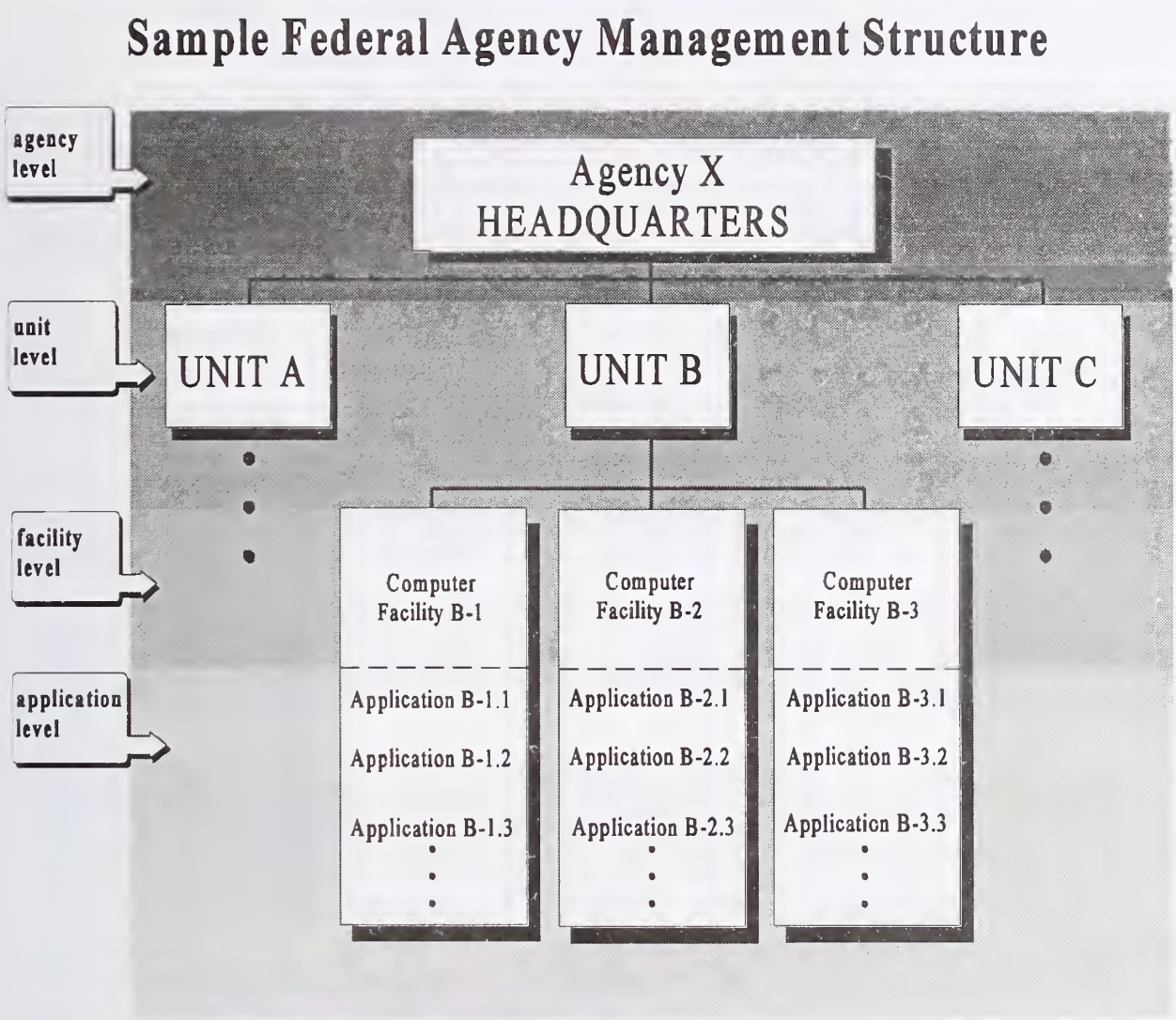


Figure 6.2 shows a management structure based on that of an actual federal agency. The agency consists of three major units, each with several large computer facilities running multiple applications. This type of organization needs to manage computer security at the *agency* level, the *unit* level,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

Within the federal government, many organizations such as the Office of Management and

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

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.

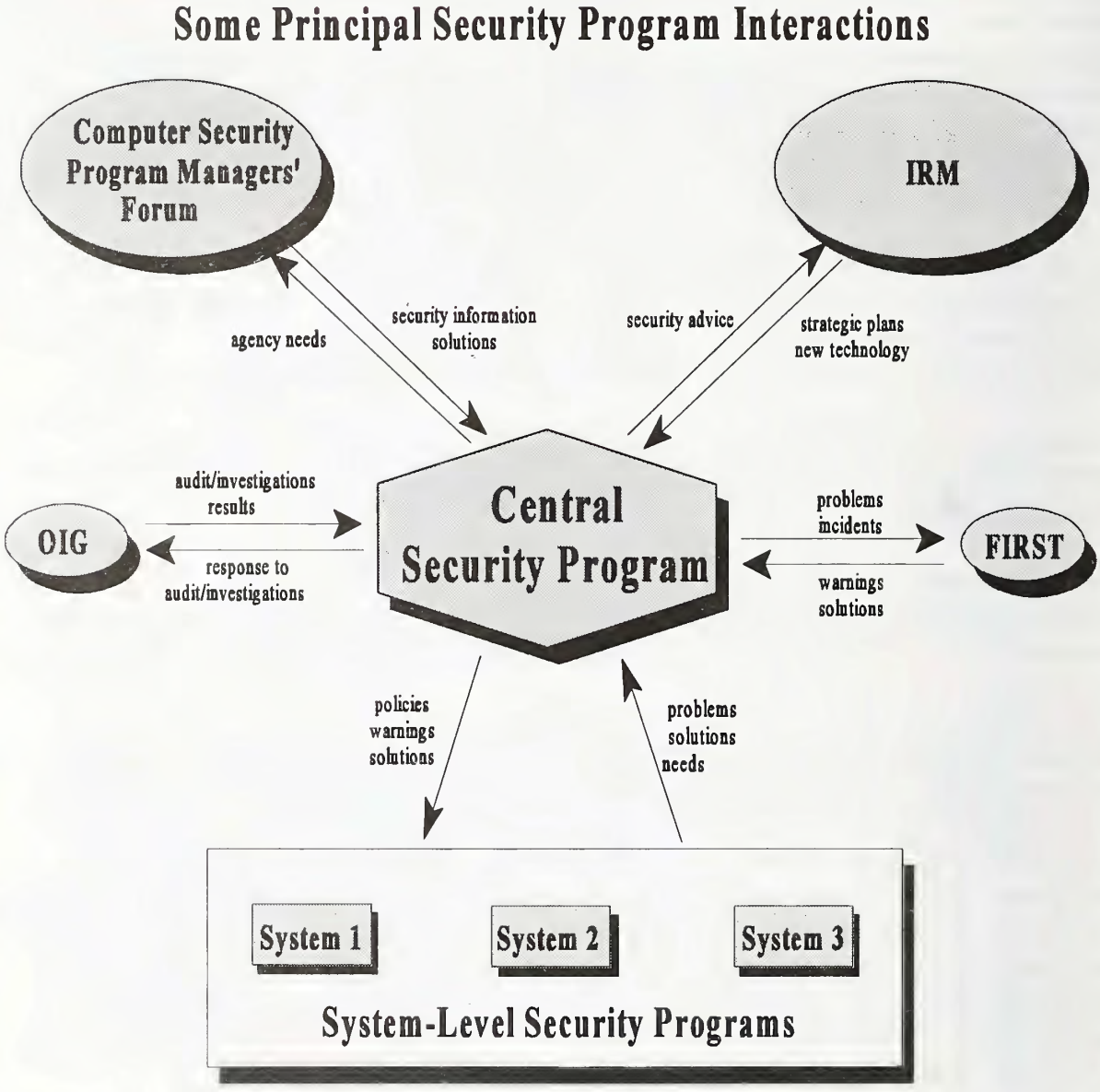

Figure 6.3 shows a *simplified* version of the flow of computer security-related information among various parts of an organization and across different organizations.

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

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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).

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 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

[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.

Example of Organizational Placement of Computer Security Functions

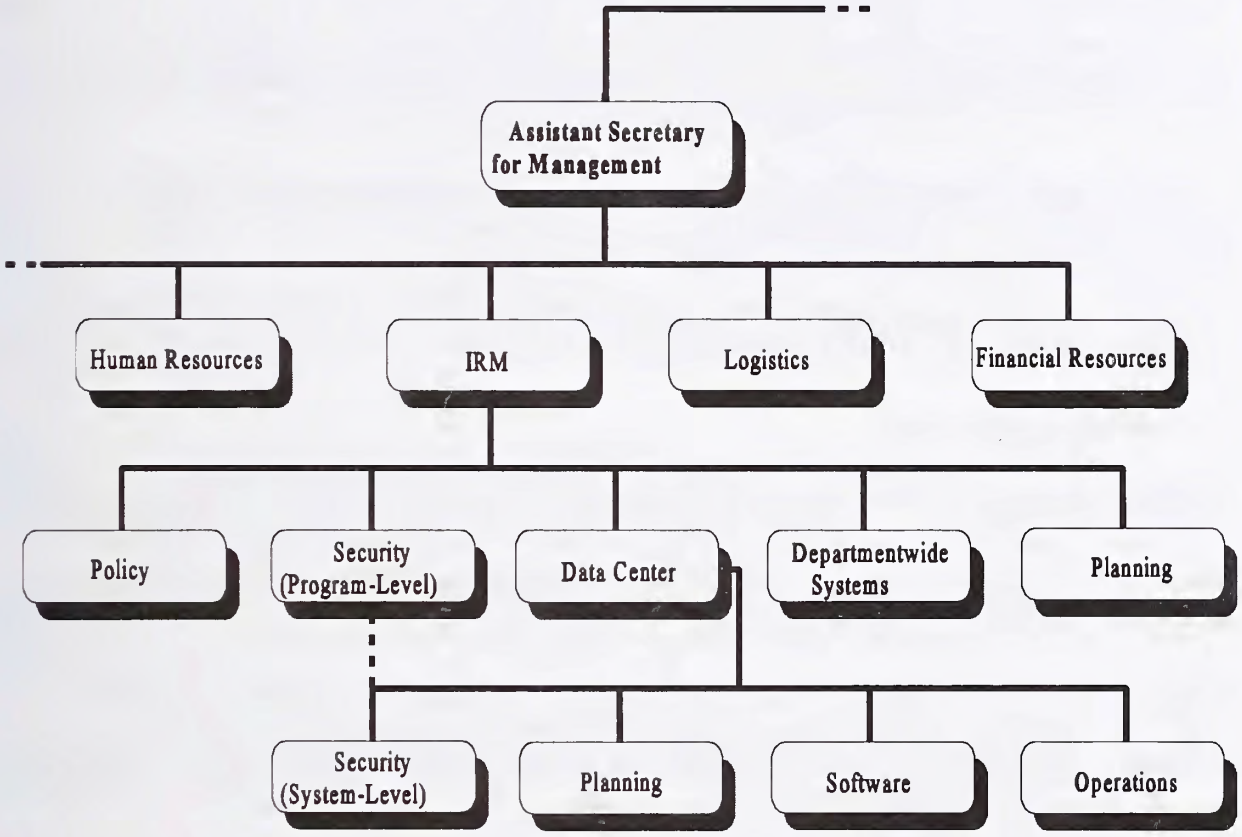

Figure 6.4 illustrates one example of the placement of the computer security program-level and system-level functions. The program-level function is located within the IRM organization and sets policy for the organization as a whole. The system-level function, located within the Data Center, provides 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

placement of the computer security program within a typical Federal agency.[61]

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

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.

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

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.

> 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.

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.

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]

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

[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.

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. Typi cal 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.)

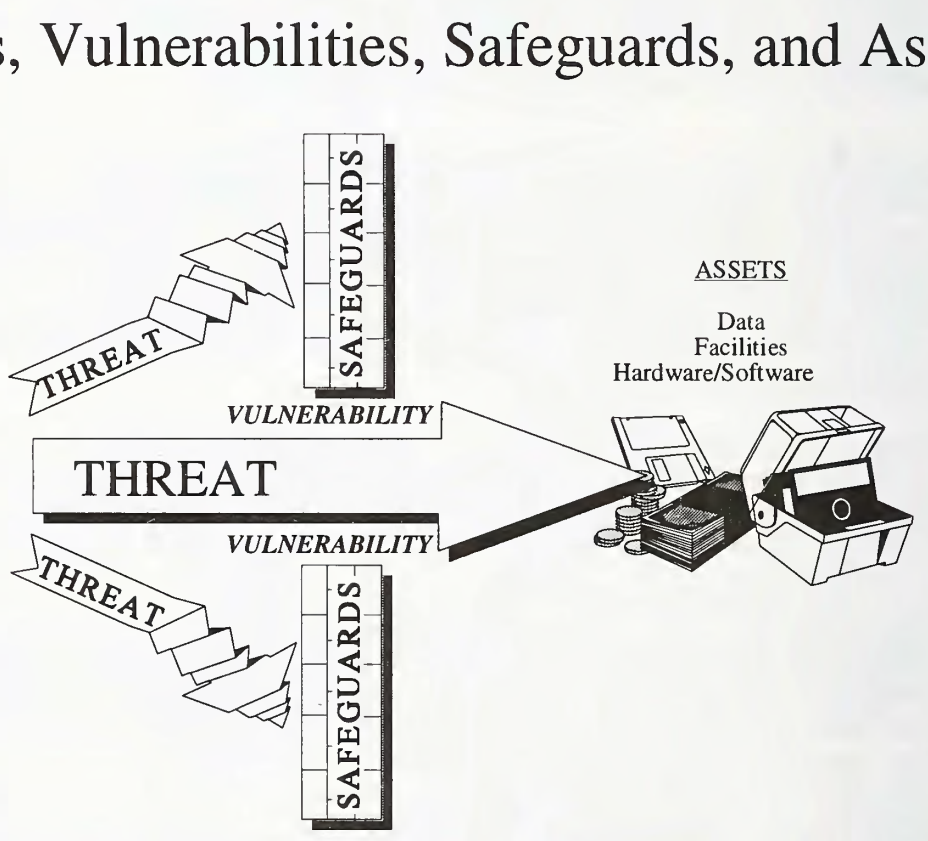


Figure 7.1 Safeguards prevent threats from harming assets. However, if an appropriate safeguard is not present, a vulnerability exists which can be exploited by a threat, thereby puttting assets at risk.

Figure 7.1

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.

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.

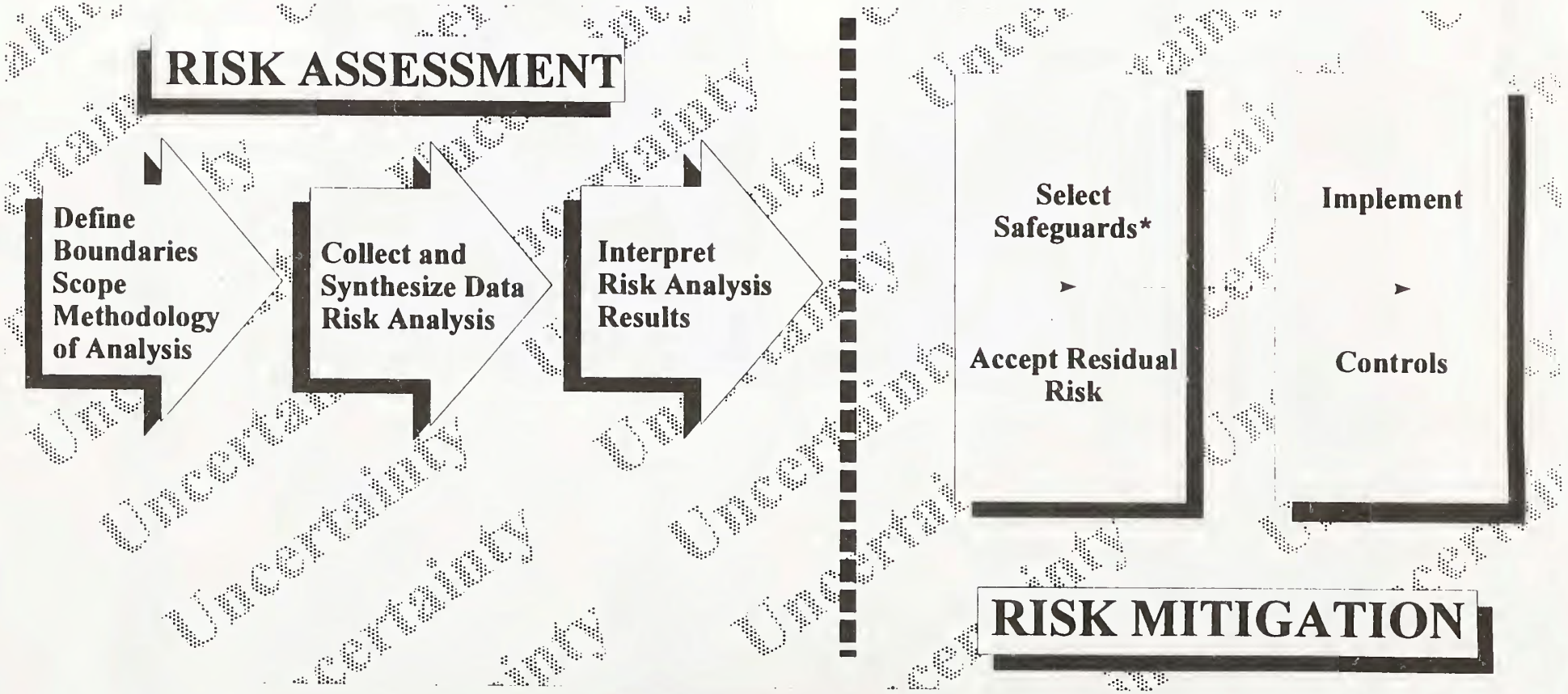
Risk management can *help* a manager select the most appropriate controls; however, it is not a magic wand that instantly eliminates all difficult issues. The quality of the output depends on the quality of the input and the type of analytical methodology used. In some cases, the amount of work required 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.

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

[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

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.

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

requirements;
- 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

> 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.

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.

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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Chapter 8

SECURITY AND PLANNING IN THE COMPUTER SYSTEM LIFE CYCLE

Like other aspects of information processing systems, security is most effective and efficient if planned and managed throughout a computer system's life cycle, from initial planning, through design, implementation, and operation, to disposal.[65] Many security-relevant events and analyses occur during a system's life. This chapter explains the relationship among them and how they fit together.[66] It also discusses the important role of security planning in helping to ensure that security issues are addressed comprehensively.

This chapter examines:

- system security plans,
- the components of the computer system life cycle,
- the benefits of integrating security into the computer system life cycle, and
- techniques for addressing security in the life cycle.

8.1 Computer Security Act Issues for Federal Systems

Planning is used to help ensure that security is addressed in a comprehensive manner throughout a system's life cycle. For federal systems, the Computer Security Act of 1987 sets forth a statutory requirement for the preparation of computer security plans for all sensitive systems.[67] The intent and spirit of the Act is to improve computer security in the federal government, not to create paperwork. In keeping with this intent, the Office of Management and Budget (OMB) and NIST have guided agencies toward a planning process that emphasizes good planning and management of computer security within an agency and for each computer system. As emphasized in this chapter, computer *security* management should be a part of computer *systems* management. The

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[65] A computer system refers to a collection of processes, hardware, and software that perform a function. This includes applications, networks, or support systems.

[66] Although this chapter addresses a life cycle process that starts with system initiation, the process can be initiated at any point in the life cycle.

[67] An organization will typically have many computer security plans. However, it is not necessary that a separate and distinct plan exist for every physical system (e.g., PCs). Plans may address, for example, the computing resources within an operational element, a major application, or a group of similar systems (either technologically or functionally).

benefit of having a distinct computer security plan is to ensure that computer security is not overlooked.

The Act required the submission of plans to NIST and the National Security Agency (NSA) for review and comment, a process which has been completed. Current guidance on implementing the Act requires agencies to obtain independent review of computer security plans. This review may be internal or external, as deemed appropriate by the agency.

> "The purpose of the system security plan is to provide a basic overview of the security and privacy requirements of the subject system and the agency's plan for meeting those requirements. The system security plan may also be viewed as documentation of the structured process of planning adequate, cost-effective security protection for a system."
>
> - OMB Bulletin 90-08

A "typical" plan briefly describes the important security considerations for the system and provides references to more detailed documents, such as system security plans, contingency plans, training programs, accreditation statements, incident handling plans, or audit results. This enables the plan to be used as a management tool without requiring repetition of existing documents. For smaller systems, the plan may include all security documentation. As with other security documents, if a plan addresses specific vulnerabilities or other information that could compromise the system, it should be kept private. It also has to be kept up-to-date.

8.2 Benefits of Integrating Security in the Computer System Life Cycle

> Different people can provide security input throughout the life cycle of a system, including the accrediting official, data users, systems users, and system technical staff.

Although a computer security plan can be developed for a system at any point in the life cycle, the recommended approach is to draw up the plan at the beginning of the computer system life cycle. Security, like other aspects of a computer system, is best managed if planned for throughout the computer system life cycle. It has long been a tenet of the computer community that it costs ten times more to add a feature in a system *after* it has been designed than to include the feature in the system at the initial design phase. The principal reason for implementing security during a system's development is that it is more difficult to implement it later (as is usually reflected in the higher costs of doing so). It also tends to disrupt ongoing operations.

Security also needs to be incorporated into the later phases of the computer system life cycle to help ensure that security keeps up with changes in the system's environment, technology, procedures, and personnel. It also ensures that security is considered in system upgrades, including the purchase of new components or the design of new modules. Adding new security controls to a system after a security breach, mishap, or audit can lead to haphazard security that

can be more expensive and less effective that security that is already integrated into the system. It can also significantly degrade system performance. Of course, it is virtually impossible to anticipate the whole array of problems that may arise during a system's lifetime. Therefore, it is generally useful to update the computer security plan at least at the end of each phase in the life cycle and after each re-accreditation. For many systems, it may be useful to update the plan more often.

Life cycle management also helps document security-relevant decisions, in addition to helping assure management that security is fully considered in all phases. This documentation benefits system management officials as well as oversight and independent audit groups. System management personnel use documentation as a self-check and reminder of why decisions were made so that the impact of changes in the environment can be more easily assessed. Oversight and independent audit groups use the documentation in their reviews to verify that system management has done an adequate job and to highlight areas where security may have been overlooked. This includes examining whether the documentation accurately reflects how the system is actually being operated.

Within the federal government, the Computer Security Act of 1987 and its implementing instructions provide specific requirements for computer security plans. These plans are a form of documentation that helps ensure that security is considered not only during system design and development but also throughout the rest of the life cycle. Plans can also be used to be sure that requirements of Appendix III to OMB Circular A-130, as well as other applicable requirements, have been addressed.

8.3 Overview of the Computer System Life Cycle

There are many models for the computer system life cycle but most contain five basic phases, as pictured in Figure 8.1.

- *Initiation*. During the initiation phase, the need for a system is expressed and the purpose of the system is documented.

- *Development/Acquisition*. During this phase the system is designed, purchased, programmed, developed, or otherwise constructed. This phase often consists of other defined cycles, such as the system development cycle or the acquisition cycle.

- *Implementation*. After initial system testing, the system is installed or fielded.

- *Operation/Maintenance*. During this phase the system performs its work. The system is almost always modified by the addition of hardware and software and by numerous other events.

- *Disposal.* The computer system is disposed of once the transition to a new computer system is completed.

Each phase can apply to an entire system, a new component or module, or a system upgrade. As with other aspects of systems management, the level of detail and analysis for each activity described here is determined by many factors including size, complexity, system cost, and sensitivity.

Many different "life cycles" are associated with computer systems, including the system development, acquisition, and information life cycles.

Many people find the concept of a computer system life cycle confusing because many cycles occur within the broad framework of the *entire* computer system life cycle. For example, an organization could develop a system, using a system *development* life cycle. During the system's life, the organization might purchase new components, using the *acquisition* life cycle.

Moreover, the computer system life cycle itself is merely one component of other life cycles. For example, consider the *information life cycle*. Normally information, such as personnel data, is used much longer than the life of one computer system. If an employee works for an organization for thirty years and collects retirement for another twenty, the employee's automated personnel record will probably pass through many different organizational computer systems owned by the company. In addition, parts of the information will also be used in other computer systems, such as those of the Internal Revenue Service and the Social Security Administration.

8.4 Security Activities in the Computer System Life Cycle[68]

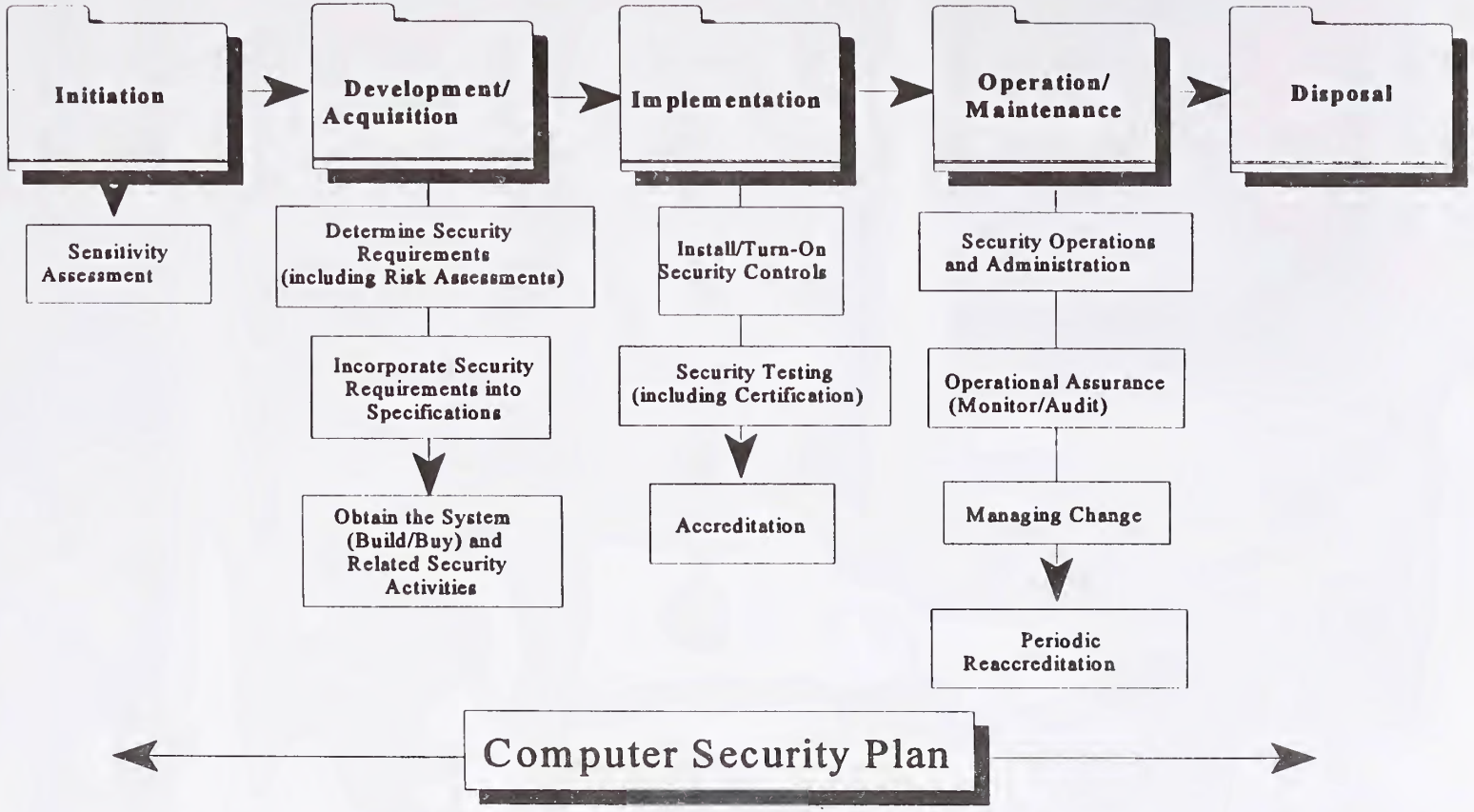
This section reviews the security activities that arise in each stage of the computer system life cycle. (See Figure 8.1.)

8.4.1 Initiation

The conceptual and early design process of a system involves the discovery of a need for a new system or enhancements to an existing system; early ideas as to system characteristics and proposed functionality; brainstorming sessions on architectural, performance, or functional system aspects; and environmental, financial, political, or other constraints. At the same time, the basic *security* aspects of a system should be developed along with the early system design. This can be done through a *sensitivity assessment.*

[68] For brevity and because of the uniqueness of each system, none of these discussions can include the details of all possible security activities at any particular life cycle phase.

Security in the System Life Cycle



The life cycle process described in this chapter consists of five separate phases. Security issues are present in each.

Figure 8.1

8.4.1.1 Conducting a Sensitivity Assessment

The definition of *sensitive* is often misconstrued. *Sensitive* is synonymous with *important* or *valuable*. Some data is sensitive because it must be kept confidential. Much more data, however, is sensitive because its integrity or availability must be assured. The Computer Security Act and OMB Circular A-130 clearly state that information is sensitive if its unauthorized disclosure, modification (i.e., loss of integrity), or unavailability would harm the agency. In general, the more important a system is to the mission of the agency, the more sensitive it is.

A *sensitivity assessment* looks at the sensitivity of both the information to be processed and the system itself. The assessment should consider legal implications, organization policy (including federal and agency policy if a federal system), and the functional needs of the system. Sensitivity is normally expressed in terms of integrity, availability, and confidentiality. Such factors as the importance of the system to the organization's mission and the consequences of unauthorized modification, unauthorized disclosure, or unavailability of the system or data need to be examined when assessing sensitivity. To address these types of issues, the people who use or own the system or information should participate in the assessment.

A sensitivity assessment should answer the following questions:

- What information is handled by the system?
- What kind of potential damage could occur through error, unauthorized disclosure or modification, or unavailability of data or the system?
- What laws or regulations affect security (e.g., the Privacy Act or the Fair Trade Practices Act)?
- To what threats is the system or information particularly vulnerable?
- Are there significant environmental considerations (e.g., hazardous location of system)?
- What are the security-relevant characteristics of the user community (e.g., level of technical sophistication and training or security clearances)?
- What internal security standards, regulations, or guidelines apply to this system?

The sensitivity assessment starts an analysis of security that continues throughout the life cycle. The assessment helps determine if the project needs special security oversight, if further analysis is

needed before committing to begin system development (to ensure feasibility at a reasonable cost), or in rare instances, whether the security requirements are so strenuous and costly that system development or acquisition will not be pursued. The sensitivity assessment can be included with the system initiation documentation either as a separate document or as a section of another planning document. The development of security features, procedures, and assurances, described in the next section, builds on the sensitivity assessment.

A sensitivity assessment can also be performed during the planning stages of system upgrades (for either upgrades being procured or developed in house). In this case, the assessment focuses on the affected areas. If the upgrade significantly affects the original assessment, steps can be taken to analyze the impact on the rest of the system. For example, are new controls needed? Will some controls become unnecessary?

8.4.2 Development/Acquisition

For most systems, the development/acquisition phase is more complicated than the initiation phase. Security activities can be divided into three parts:

- determining security features, assurances, and operational practices;
- incorporating these security requirements into design specifications; and
- actually acquiring them.

These divisions apply to systems that are designed and built in house, to systems that are purchased, and to systems developed using a hybrid approach.

During this phase, technical staff and system sponsors should actively work together to ensure that the technical designs reflect the system's security needs. As with development and incorporation of other system requirements, this process requires an open dialogue between technical staff and system sponsors. It is important to address security requirements effectively in synchronization with development of the overall system.

8.4.2.1 Determining Security Requirements

During the first part of the development/ acquisition phase, system planners define the requirements of the system. *Security requirements should be developed at the same time.* These requirements can be expressed as technical features (e.g., access controls), assurances (e.g., background checks for system developers), or operational practices (e.g., awareness and training). System security requirements, like other system requirements, are derived from a number of sources including law, policy, applicable standards and guidelines, functional needs of the system, and cost-benefit trade-offs.

Law. Besides specific laws that place security requirements on information, such as the Privacy Act of 1974, there are laws, court cases, legal opinions, and other similar legal material that may affect security directly or indirectly.

Policy. As discussed in Chapter 5, management officials issue several different types of policy. System security requirements are often derived from issue-specific policy.

Standards and Guidelines. International, national, and organizational standards and guidelines are another source for determining security features, assurances, and operational practices. Standards and guidelines are often written in an "if...then" manner (e.g., if the system is encrypting data, then a particular cryptographic algorithm should be used). Many organizations specify baseline controls for different types of systems, such as administrative, mission- or business-critical, or proprietary. As required, special care should be given to interoperability standards.

Functional Needs of the System. The purpose of security is to support the function of the system, not to undermine it. Therefore, many aspects of the function of the system will produce related security requirements.

Cost-Benefit Analysis. When considering security, cost-benefit analysis is done through risk assessment, which examines the assets, threats, and vulnerabilities of the system in order to determine the most appropriate, cost-effective safeguards (that comply with applicable laws, policy, standards, and the functional needs of the system). Appropriate safeguards are normally those whose anticipated benefits outweigh their costs. Benefits and costs include monetary and nonmonetary issues, such as prevented losses, maintaining an organization's reputation, decreased user friendliness, or increased system administration.

Risk assessment, like cost-benefit analysis, is used to support decision making. It helps managers select cost-effective safeguards. The extent of the risk assessment, like that of other cost-benefit analyses, should be commensurate with the complexity and cost (normally an indicator of complexity) of the system and the expected benefits *of the assessment*. Risk assessment is further discussed in Chapter 7.

Risk assessment can be performed during the requirements analysis phase of a procurement or the design phase of a system development cycle. Risk should also normally be assessed during the development/acquisition phase of a system upgrade. The risk assessment may be performed once or multiple times, depending upon the project's methodology.

Care should be taken in differentiating between *security* risk assessment and *project* risk analysis. Many system development and acquisition projects analyze the risk of failing to successfully complete the project – a different activity from *security* risk assessment.

8.4.2.2 Incorporating Security Requirements Into Specifications

Determining security features, assurances, and operational practices can yield significant security information and often voluminous requirements. This information needs to be validated, updated, and organized into the detailed security protection requirements and specifications used by systems designers or purchasers. Specifications can take on quite different forms, depending on the methodology used for to develop the system, or whether the system, or parts of the system, are being purchased off the shelf.

As specifications are developed, it may be necessary to update initial risk assessments. A safeguard recommended by the risk assessment could be incompatible with other requirements, or a control may be difficult to implement. For example, a security requirement that prohibits dial-in access could prevent employees from checking their e-mail while away from the office.[69]

> Developing testing specifications early can be critical to being able to cost-effectively test security features.

Besides the technical and operational controls of a system, assurance also should be addressed. The degree to which assurance (that the security features and practices can and do work correctly and effectively) is needed should be determined early. Once the desired level of assurance is determined, it is necessary to figure out how the system will be tested or reviewed to determine whether the specifications have been satisfied (to obtain the desired assurance). This applies to both system developments and acquisitions. For example, if rigorous assurance is needed, the ability to test the system or to provide another form of initial and ongoing assurance needs to be designed into the system or otherwise provided for. See Chapter 9 for more information.

8.4.2.3 Obtaining the System and Related Security Activities

During this phase, the system is actually built or bought. If the system is being built, security activities may include developing the system's security aspects, monitoring the development process itself for security problems, responding to changes, and monitoring threat. Threats or vulnerabilities that may arise during the development phase include Trojan horses, incorrect code, poorly functioning development tools, manipulation of code, and malicious insiders.

If the system is being acquired off the shelf, security activities may include monitoring to ensure security is a part of market surveys, contract solicitation documents, and evaluation of proposed systems. Many systems use a combination of development and acquisition. In this case, security activities include both sets.

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[69] This is an example of a risk-based decision.

As the system is built or bought, choices are made about the system, which can affect security. These choices include selection of specific off-the-shelf products, finalizing an architecture, or selecting a processing site or platform. Additional security analysis will probably be necessary.

> In federal government contracting, it is often useful if personnel with security expertise participate as members of the source selection board to help evaluate the security aspects of proposals.

In addition to obtaining the system, operational practices need to be developed. These refer to human activities that take place around the system such as contingency planning, awareness and training, and preparing documentation. The chapters in the Operational Controls section of this handbook discuss these areas. These need to be developed along with the system, although they are often developed by different individuals. These areas, like technical specifications, should be considered from the beginning of the development and acquisition phase.

8.4.3 Implementation

A separate implementation phase is not always specified in some life cycle planning efforts. (It is often incorporated into the end of development and acquisition or the beginning of operation and maintenance.) However, from a security point of view, a critical security activity, *accreditation*, occurs between development and the start of system operation. The other activities described in this section, turning on the controls and testing, are often incorporated at the end of the development/acquisition phase.

8.4.3.1 Install/Turn-On Controls

While obvious, this activity is often overlooked. When acquired, a system often comes with security features disabled. These need to be enabled and configured. For many systems this is a complex task requiring significant skills. Custom-developed systems may also require similar work.

8.4.3.2 Security Testing

System security testing includes both the testing of the particular parts of the system that have been developed or acquired and the testing of the entire system. Security management, physical facilities, personnel, procedures, the use of commercial or in-house services (such as networking services), and contingency planning are examples of areas that affect the security of the entire system, but may be specified outside of the development or acquisition cycle. Since only items within the development or acquisition cycle will have been tested during system acceptance testing, separate tests or reviews may need to be performed for these additional security elements.

Security certification is a formal testing of the security safeguards implemented in the computer system to determine whether they meet applicable requirements and specifications.[70] To provide more reliable technical information, certification is often performed by an independent reviewer, rather than by the people who designed the system.

8.4.3.3 Accreditation

System security accreditation is the *formal authorization* by the accrediting (management) official for system operation and an *explicit acceptance of risk*. It is usually supported by a review of the system, including its management, operational, and technical controls. This review may include a detailed technical evaluation (such as a Federal Information Processing Standard 102 certification, particularly for complex, critical, or high-risk systems), security evaluation, risk assessment, audit, or other such review. If the life cycle process is being used to manage a project (such as a system upgrade), it is important to recognize that the accreditation is for the entire system, not just for the new addition.

The best way to view computer security accreditation is as a form of quality control. It forces managers and technical staff to work together to find the best fit for security, given technical constraints, operational constraints, and mission requirements. The accreditation process obliges managers to make critical decisions regarding the adequacy of security safeguards. A decision based on reliable information about the effectiveness of technical and non-technical safeguards and the residual risk is more likely to be a sound decision.

Sample Accreditation Statement

In accordance with (Organization Directive), I hereby issue an accreditation for (name of system). This accreditation is my formal declaration that a satisfactory level of operational security is present and that the system can operate under reasonable risk. This accreditation is valid for three years. The system will be re-evaluated annually to determine if changes have occurred affecting its security.

After deciding on the acceptability of security safeguards and residual risks, the accrediting official should issue a formal accreditation statement. While most flaws in system security are not severe enough to remove an operational system from service or to prevent a new system from becoming operational, the flaws may require some restrictions on operation (e.g., limitations on dial-in access or electronic connections to other organizations). In some cases, an interim accreditation may be granted, allowing the system to operate requiring review at the end of the

[70] Some federal agencies use a broader definition of the term certification to refer to security reviews or evaluations, formal or information, that take place prior to and are used to support accreditation.

interim period, presumably after security upgrades have been made.

8.4.4 Operation and Maintenance

Many security activities take place during the operational phase of a system's life. In general, these fall into three areas: (1) security operations and administration; (2) operational assurance; and (3) periodic re-analysis of the security. Figure 8.2 diagrams the flow of security activities during the operational phase.

8.4.4.1 Security Operations and Administration

Operation of a system involves many security activities discussed throughout this handbook. Performing backups, holding training classes, managing cryptographic keys, keeping up with user administration and access privileges, and updating security software are some examples.

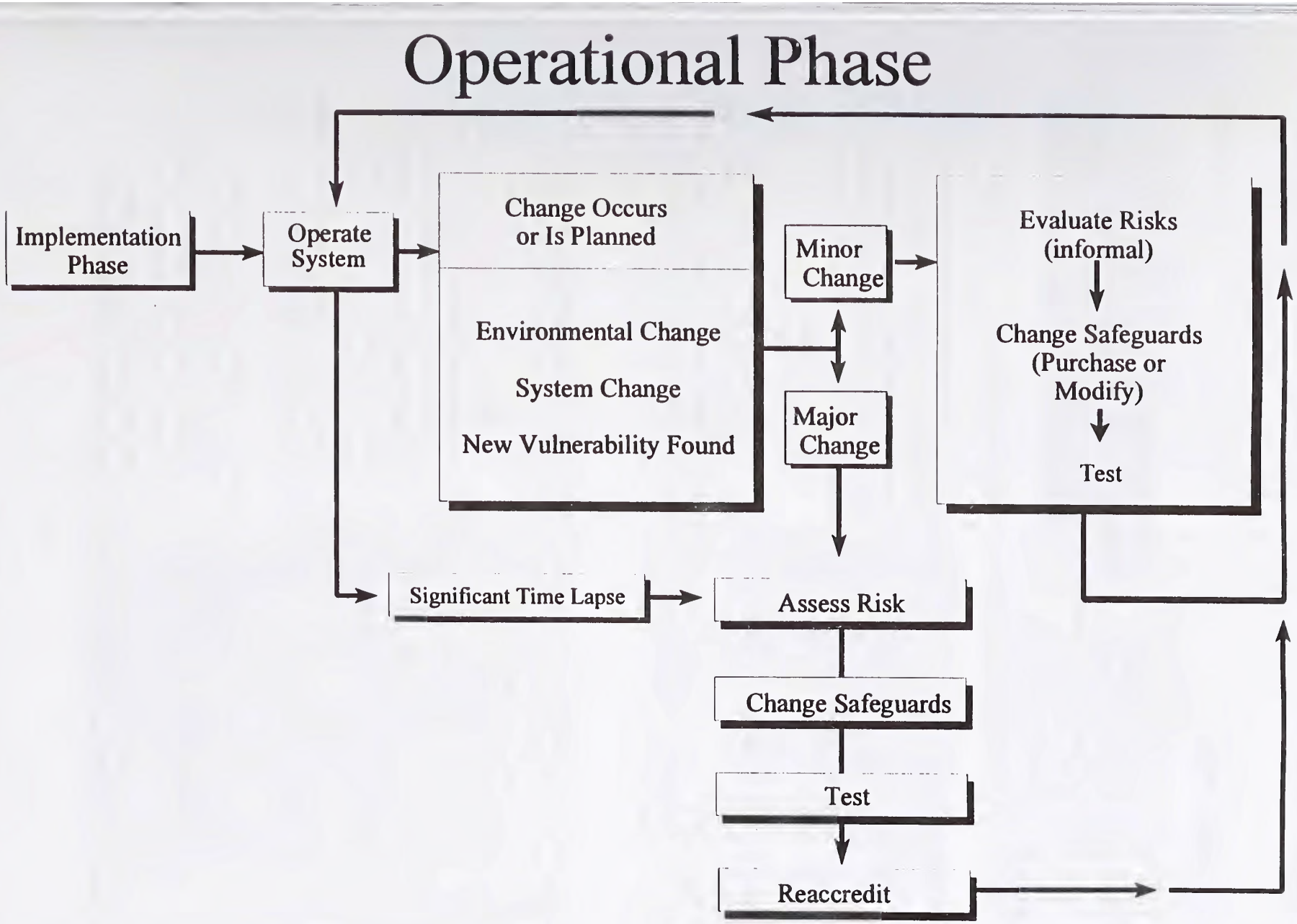
8.4.4.2 Operational Assurance

> Operational assurance examines whether a system is operated according to its current security requirements. This includes both the actions of people who operate or use the system and the functioning of technical controls.

Security is *never* perfect when a system is implemented. In addition, system users and operators discover new ways to intentionally or unintentionally bypass or subvert security. Changes in the system or the environment can create new vulnerabilities. Strict adherence to procedures is rare over time, and procedures become outdated. Thinking risk is minimal, users may tend to bypass security measures and procedures.

As shown in Figure 8.2, changes occur. Operational assurance is one way of becoming aware of these changes whether they are new vulnerabilities (or old vulnerabilities that have not been corrected), system changes, or environmental changes. Operational assurance is the process of reviewing an operational system to see that security controls, both automated and manual, are functioning correctly and effectively.

To maintain operational assurance, organizations use two basic methods: *system audits* and *monitoring*. These terms are used loosely within the computer security community and often overlap. A system audit is a one-time or periodic event to evaluate security. Monitoring refers to an ongoing activity that examines either the system or the users. In general, the more "real-time" an activity is, the more it falls into the category of monitoring. (See Chapter 9.)



During the operational phase of a system life cycle, major and minor changes will occur. This figure diagrams appropriate responses to change to help ensure the continued security of the system at a level acceptable to the accrediting official.

Figure 8.2

8.4.4.3 Managing Change

Security change management helps develop new security requirements.

Computer systems and the environments in which they operate change continually. In response to various events such as user complaints, availability of new features and services, or the discovery of new threats and vulnerabilities, system managers and users modify the system and incorporate new features, new procedures, and software updates.

The environment in which the system operates also changes. Networking and interconnections tend to increase. A new user group may be added, possibly external groups or anonymous groups. New threats may emerge, such as increases in network intrusions or the spread of personal computer viruses. If the system has a configuration control board or other structure to manage technical system changes, a security specialist can be assigned to the board to make determinations about whether (and if so, how) changes will affect security.

Security should also be considered during system upgrades (and other planned changes) and in determining the impact of unplanned changes. As shown in Figure 8.2, when a change occurs or is planned, a determination is made whether the change is major or minor. A major change, such as reengineering the structure of the system, significantly affects the system. Major changes often involve the purchase of new hardware, software, or services or the development of new software modules.

An organization does not need to have a specific cutoff for major-minor change decisions. A sliding scale between the two can be implemented by using a combination of the following methods:

- *Major change.* A major change requires analysis to determine security requirements. The process described above can be used, although the analysis may focus only on the area(s) in which the change has occurred or will occur. If the original analysis and system changes have been documented throughout the life cycle, the analysis will normally be much easier. Since these changes result in significant system acquisitions, development work, or changes in policy, the system should be reaccredited to ensure that the residual risk is still acceptable.

- *Minor change.* Many of the changes made to a system do not require the extensive analysis performed for major changes, but do require some analysis. Each change can involve a limited risk assessment that weighs the pros (benefits) and cons (costs) and that can even be performed on-the-fly at meetings. Even if the analysis is conducted informally, decisions should still be appropriately documented. This process recognizes that even "small" decisions should be

risk-based.

8.4.4.4 Periodic Reaccreditation

Periodically, it is useful to formally reexamine the security of a system from a wider perspective. The analysis, which leads to reaccreditation, should address such questions as: Is the security still sufficient? Are major changes needed?

The reaccreditation should address high-level security and management concerns as well as the implementation of the security. It is not always necessary to perform a new risk assessment or certification in conjunction with the re-accreditation, but the activities support each other (and both need be performed periodically). The more extensive system changes have been, the more extensive the analyses should be (e.g., a risk assessment or re-certification). A risk assessment is likely to uncover security concerns that result in system changes. After the system has been changed, it may need testing (including certification). Management then reaccredits the system for continued operation if the risk is acceptable.

It is important to consider legal requirements for records retention when disposing of computer systems. For federal systems, system management officials should consult with their agency office responsible for retaining and archiving federal records.

8.4.5 Disposal

The disposal phase of the computer system life cycle involves the disposition of information, hardware, and software. Information may be moved to another system, archived, discarded, or destroyed. When archiving information, consider the method for retrieving the information in the future. The technology used to create the records may not be readily available in the future.

Hardware and software can be sold, given away, or discarded. There is rarely a need to destroy hardware, except for some storage media containing confidential information that cannot be sanitized without destruction. The disposition of software needs to be in keeping with its license or other agreements with the developer, if applicable. Some licenses are site-specific or contain other agreements that

Media Sanitization

Since electronic information is easy to copy and transmit, information that is sensitive to disclosure often needs to be controlled throughout the computer system life cycle so that managers can ensure its proper disposition. The removal of information from a storage medium (such as a hard disk or tape) is called *sanitization*. Different kinds of sanitization provide different levels of protection. A distinction can be made between clearing information (rendering it unrecoverable by keyboard attack) and purging (rendering information unrecoverable against laboratory attack). There are three general methods of purging media: overwriting, degaussing (for magnetic media only), and destruction.

prevent the software from being transferred.

Measures may also have to be taken for the future use of data that has been encrypted, such as taking appropriate steps to ensure the secure long-term storage of cryptographic keys.

8.5 Interdependencies

Like many management controls, life cycle planning relies upon other controls. Three closely linked control areas are policy, assurance, and risk management.

Policy. The development of system-specific policy is an integral part of determining the security requirements.

Assurance. Good life cycle management provides assurance that security is appropriately considered in system design and operation.

Risk Management. The maintenance of security throughout the operational phase of a system is a process of risk management: analyzing risk, reducing risk, and monitoring safeguards. Risk assessment is a critical element in designing the security of systems and in reaccreditations.

8.6 Cost Considerations

Security is a factor throughout the life cycle of a system. Sometimes security choices are made by default, without anyone analyzing why choices are made; sometimes security choices are made carefully, based on analysis. The first case is likely to result in a system with poor security that is susceptible to many types of loss. In the second case, the cost of life cycle management should be *much smaller* than the losses avoided. The major cost considerations for life cycle management are personnel costs and some delays as the system progresses through the life cycle for completing analyses and reviews and obtaining management approvals.

It is possible to overmanage a system: to spend more time planning, designing, and analyzing risk than is necessary. Planning, by itself, does not further the mission or business of an organization. Therefore, while security life cycle management can yield significant benefits, the effort should be commensurate with the system's size, complexity, and sensitivity and the risks associated with the system. In general, the higher the value of the system, the newer the system's architecture, technologies, and practices, and the worse the impact if the system security fails, the more effort should be spent on life cycle management.

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Chapter 9

ASSURANCE

Computer security assurance is the degree of confidence one has that the security measures, both technical and operational, work as intended to protect the system and the information it processes. Assurance is not, however, an absolute guarantee that the measures work as intended. Like the closely related areas of reliability and quality, assurance can be difficult to analyze; however, it is something people expect and obtain (though often without realizing it). For example, people may routinely get product recommendations from colleagues but may not consider such recommendations as providing assurance.

Assurance is a degree of confidence, not a true measure of how secure the system actually is. This distinction is necessary because it is extremely difficult -- and in many cases virtually impossible -- to know exactly how secure a system is.

> Security assurance is the degree of confidence one has that the security controls operate correctly and protect the system as intended.

Assurance is a challenging subject because it is difficult to describe and even more difficult to quantify. Because of this, many people refer to assurance as a "warm fuzzy feeling" that controls work as intended. However, it is possible to apply a more rigorous approach by knowing two things: (1) who needs to be assured and (2) what types of assurance can be obtained. The person who needs to be assured is the management official who is ultimately responsible for the security of the system. Within the federal government, this person is the *authorizing or accrediting official.*[71]

There are many methods and tools for obtaining assurance. For discussion purposes, this chapter categorizes assurance in terms of a general system life cycle. The chapter first discusses planning for assurance and then presents the two categories of assurance methods and tools: (1) design and implementation assurance and (2) operational assurance. Operational assurance is further categorized into audits and monitoring.

The division between design and implementation assurance and operational assurance can be fuzzy. While such issues as configuration management or audits are discussed under operational assurance, they may also be vital during a system's development. The discussion tends to focus more on technical issues during design and implementation assurance and to be a mixture of

[71] Accreditation is a process used primarily within the federal government. It is the process of managerial authorization for processing. Different agencies may use other terms for this approval function. The terms used here are consistent with Federal Information Processing Standard 102, *Guideline for Computer Security Certification and Accreditation.* (See reference section of this chapter.)

management, operational, and technical issues under operational assurance. The reader should keep in mind that the division is somewhat artificial and that there is substantial overlap.

9.1 Accreditation and Assurance

Accreditation is a management official's formal acceptance of the adequacy of a system's security. The best way to view computer security accreditation is as a form of quality control. It forces managers and technical staff to work together to find workable, cost-effective solutions given security needs, technical constraints, operational constraints, and mission or business requirements. The accreditation process obliges managers to make the critical decision regarding the adequacy of security safeguards and, therefore, to recognize and perform their role in securing their systems. In order for the decisions to be sound, they need to be based on reliable information about the implementation of both technical and nontechnical safeguards. These include:

- Technical features (Do they operate as intended?).
- Operational practices (Is the system operated according to stated procedures?).
- Overall security (Are there threats which the technical features and operational practices do not address?).
- Remaining risks (Are they acceptable?).

A computer system should be accredited before the system becomes operational with periodic reaccreditation after major system changes or when significant time has elapsed.[72] Even if a system was not initially accredited, the accreditation process can be initiated at any time. Chapter 8 further discusses accreditation.

9.1.1 Accreditation and Assurance

Assurance is an extremely important -- but not the only -- element in accreditation. As shown in the diagram, assurance addresses whether the technical measures and procedures operate either (1) according to a set of security requirements and specifications or (2) according to general quality principles. Accreditation also addresses whether the system's security requirements are correct and well implemented and whether the level of quality is sufficiently high. These activities are discussed in Chapters 7 and 8.

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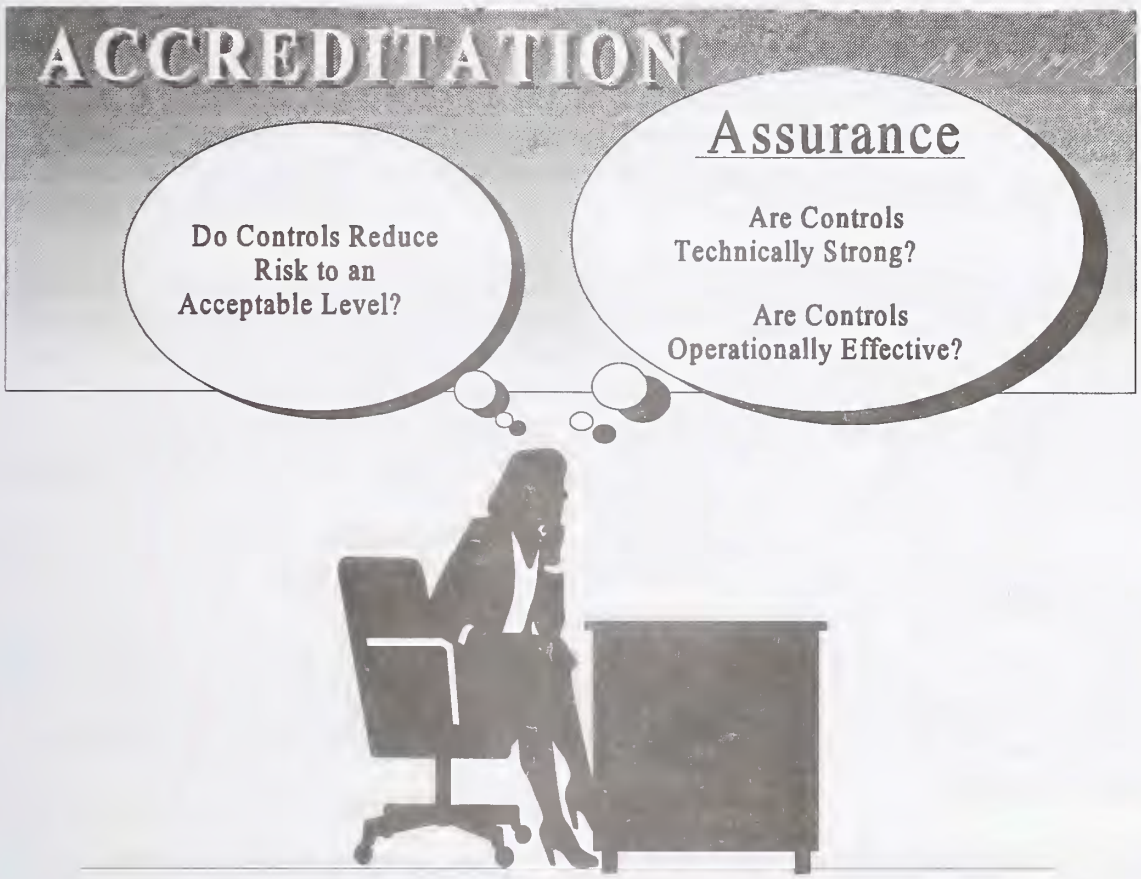
[72] OMB Circular A-130 requires management security authorization of operation for federal systems.



9.1.2 Selecting Assurance Methods

The accrediting official makes the final decision about how much and what types of assurance are needed for a system. For this decision to be informed, it is derived from a review of security, such as a risk assessment or other study (e.g., certification), as deemed appropriate by the accrediting official.[73] The accrediting official needs to be in a position to analyze the pros and cons of the cost of assurance, the cost of controls, and the risks to the organization. At the end of the accreditation process, the accrediting official will be the one to accept the remaining risk. Thus,

[73] In the past, accreditation has been defined to require a certification, which is an in-depth testing of technical controls. It is now recognized within the federal government that other analyses (e.g., a risk analysis or audit) can also provide sufficient assurance for accreditation.

the selection of assurance methods should be coordinated with the accrediting official.

In selecting assurance methods, the need for assurance should be weighed against its cost. Assurance can be quite expensive, especially if extensive testing is done. Each method has strengths and weaknesses in terms of cost and what kind of assurance is actually being delivered. A combination of methods can often provide greater assurance, since no method is foolproof, and can be less costly than extensive testing.

The accrediting official is not the only arbiter of assurance. Other officials who use the system should also be consulted. (For example, a Production Manager who relies on a Supply System should provide input to the Supply Manager.) In addition, there may be constraints outside the accrediting official's control that also affect the selection of methods. For instance, some of the methods may unduly restrict competition in acquisitions of federal information processing resources or may be contrary to the organization's privacy policies. Certain assurance methods may be required by organizational policy or directive.

9.2 Planning and Assurance

Assurance planning should begin during the planning phase of the system life cycle, either for new systems or a system upgrades. Planning for assurance when planning for other system requirements makes sense. If a system is going to need extensive testing, it should be built to facilitate such testing.

Planning for assurance helps a manager make decisions about what kind of assurance will be cost-effective. If a manager waits until a system is built or bought to consider assurance, the number of ways to obtain assurance may be much smaller than if the manager had planned for it earlier, and the remaining assurance options may be more expensive.

9.3 Design and Implementation Assurance

Design and implementation assurance should be examined from two points of view: the component and the system. Component assurance looks at the security of a specific product or system component, such as an operating system, application, security add-on, or telecommunications module. System assurance looks at the security of the entire system, including the interaction between products and modules.

Design and implementation assurance addresses whether the features of a system, application, or component meets security requirements and specifications and whether they are they are well designed and well built. Chapter 8 discusses the source for security requirements and specifications. Design and implementation assurance examines system design, development, and installation. Design and implementation assurance is usually associated

with the development/acquisition and implementation phase of the system life cycle; however, it should also be considered throughout the life cycle as the system is modified.

As stated earlier, assurance can address whether the product or system meets a set of security specifications, or it can provide other evidence of quality. This section outlines the major methods for obtaining design and implementation assurance.

9.3.1 Testing and Certification

Testing can address the quality of the system as built, as implemented, or as operated. Thus, it can be performed throughout the development cycle, after system installation, and throughout its operational phase. Some common testing techniques include functional testing (to see if a given function works according to its requirements) or penetration testing (to see if security can be bypassed). These techniques can range from trying several test cases to in-depth studies using metrics, automated tools, or multiple detailed test cases.

Certification is a formal process for testing components or systems against a specified set of security requirements. Certification is normally performed by an independent reviewer, rather than one involved in building the system. Certification is more often cost-effective for complex or high-risk systems. Less formal security testing can be used for lower-risk systems. Certification can be performed at many stages of the system design and implementation process and can take place in a laboratory, operating environment, or both.

9.3.2 NIST Conformance Testing and Validation Suites

NIST produces validation suites and conformance testing to determine if a product (software, hardware, firmware) meets specified standards. These test suites are developed for specific standards and use many methods. Conformance to standards can be important for many reasons, including interoperability or strength of security provided. NIST publishes a list of validated products quarterly.

9.3.3 Use of Advanced or Trusted Development

In the development of both commercial off-the-shelf products and more customized systems, the use of advanced or trusted system architectures, development methodologies, or software engineering techniques can provide assurance. Examples include security design and development reviews, formal modeling, mathematical proofs, ISO 9000 quality techniques, or use of security architecture concepts, such as a trusted computing base (TCB) or reference monitor.

9.3.4 Use of Reliable Architectures

Some system architectures are intrinsically more reliable, such as systems that use fault-tolerance,

redundance, shadowing, or redundant array of inexpensive disks (RAID) features. These examples are primarily associated with system availability.

9.3.5 Use of Reliable Security

One factor in reliable security is the concept of *ease of safe use*, which postulates that a system that is easier to secure will be more likely to be secure. Security features may be more likely to be used when the initial system defaults to the "most secure" option. In addition, a system's security may be deemed more reliable if it does not use very new technology that has not been tested in the "real" world (often called "bleeding-edge" technology). Conversely, a system that uses older, well-tested software may be less likely to contain bugs.

9.3.6 Evaluations

A product evaluation normally includes testing. Evaluations can be performed by many types of organizations, including government agencies, both domestic and foreign; independent organizations, such as trade and professional organizations; other vendors or commercial groups; or individual users or user consortia. Product reviews in trade literature are a form of evaluation, as are more formal reviews made against specific criteria. Important factors for using evaluations are the degree of independence of the evaluating group, whether the evaluation criteria reflect needed security features, the rigor of the testing, the testing environment, the age of the evaluation, the competence of the evaluating organization, and the limitations placed on the evaluations by the evaluating group (e.g., assumptions about the threat or operating environment).

9.3.7 Assurance Documentation

The ability to describe security requirements and how they were met can reflect the degree to which a system or product designer understands applicable security issues. Without a good understanding of the requirements, it is not likely that the designer will be able to meet them.

Assurance documentation can address the security either for a system or for specific components. System-level documentation should describe the system's security requirements and how they have been implemented, including *interrelationships* among applications, the operating system, or networks. System-level documentation addresses more than just the operating system, the security system, and applications; it describes the system as *integrated* and *implemented in a particular environment*. Component documentation will generally be an off-the-shelf product, whereas the system designer or implementer will generally develop system documentation.

9.3.8 Accreditation of Product to Operate in Similar Situation

The accreditation of a product or system to operate in a similar situation can be used to provide

some assurance. However, it is important to realize that an accreditation is environment- and system-specific. Since accreditation balances risk against advantages, the same product may be appropriately accredited for one environment but not for another, even by the same accrediting official.

9.3.9 Self-Certification

A vendor's, integrator's, or system developer's self-certification does not rely on an impartial or independent agent to perform a technical evaluation of a system to see how well it meets a stated security requirement. Even though it is not impartial, it can still provide assurance. The self-certifier's reputation is on the line, and a resulting certification report can be read to determine whether the security requirement was defined and whether a meaningful review was performed.

A hybrid certification is possible where the work is performed under the auspices or review of an independent organization by having that organization analyze the resulting report, perform spot checks, or perform other oversight. This method may be able to combine the lower cost and greater speed of a self-certification with the impartiality of an independent review. The review, however, may not be as thorough as independent evaluation or testing.

9.3.10 Warranties, Integrity Statements, and Liabilities

Warranties are another source of assurance. If a manufacturer, producer, system developer, or integrator is willing to correct errors within certain time frames or by the next release, this should give the system manager a sense of commitment to the product and of the product's quality. An integrity statement is a formal declaration or certification of the product. It can be backed up by a promise to (a) fix the item (warranty) or (b) pay for losses (liability) if the product does not conform to the integrity statement.

9.3.11 Manufacturer's Published Assertions

A manufacturer's or developer's published assertion or formal declaration provides a limited amount of assurance based exclusively on reputation.

9.3.12 Distribution Assurance

It is often important to know that software has arrived unmodified, especially if it is distributed electronically. In such cases, checkbits or digital signatures can provide high assurance that code has not been modified. Anti-virus software can be used to check software that comes from sources with unknown reliability (such as a bulletin board).

9.4 Operational Assurance

Design and implementation assurance addresses the quality of security features built into systems. Operational assurance addresses whether the system's technical features are being bypassed or have vulnerabilities and whether required procedures are being followed. It does not address changes in the system's security requirements, which could be caused by changes to the system and its operating or threat environment. (These changes are addressed in Chapter 8.)

Security tends to degrade during the operational phase of the system life cycle. System users and operators discover new ways to intentionally or unintentionally bypass or subvert security (especially if there is a perception that bypassing security improves functionality). Users and administrators often think that nothing will happen to them or their system, so they shortcut security. Strict adherence to procedures is rare, and they become outdated, and errors in the system's administration commonly occur.

Organizations use two basic methods to maintain operational assurance:

- A *system audit* -- a *one-time* or *periodic* event to evaluate security. An audit can vary widely in scope: it may examine an entire system for the purpose of reaccreditation or it may investigate a single anomalous event.

- *Monitoring* -- an *ongoing* activity that checks on the system, its users, or the environment.

In general, the more "real-time" an activity is, the more it falls into the category of monitoring. This distinction can create some unnecessary linguistic hairsplitting, especially concerning system-generated audit trails. Daily or weekly reviewing of the audit trail (for unauthorized access attempts) is generally monitoring, while an historical review of several months' worth of the trail (tracing the actions of a specific user) is probably an audit.

9.4.1 Audit Methods and Tools

An audit conducted to support operational assurance examines whether the system is meeting stated or implied security requirements including system and organization policies. Some audits also examine whether security requirements are appropriate, but this is outside the scope of operational assurance. (See Chapter 8.) Less formal audits are often called *security reviews*.

Audits can be self-administered or independent (either internal or external).[74] Both types can provide excellent information about technical, procedural, managerial, or other aspects of security. The essential difference between a self-audit and an independent audit is objectivity. Reviews done by system management staff, often called self-audits/ assessments, have an inherent conflict of interest. The system management staff may have little incentive to say that the computer system was poorly designed or is sloppily operated. On the other hand, they may be motivated by a strong desire to improve the security of the system. In addition, they are knowledgeable about the system and may be able to find hidden problems.

> A person who performs an independent audit should be free from personal and external constraints which may impair their independence and should be organizationally independent.

The independent auditor, by contrast, should have no professional stake in the system. Independent audit may be performed by a professional audit staff in accordance with generally accepted auditing standards.

There are many methods and tools, some of which are described here, that can be used to audit a system. Several of them overlap.

9.4.1.1 Automated Tools

Even for small multiuser computer systems, it is a big job to manually review security features. Automated tools make it feasible to review even large computer systems for a variety of security flaws.

There are two types of automated tools: (1) active tools, which find vulnerabilities by trying to exploit them, and (2) passive tests, which only examine the system and infer the existence of problems from the state of the system.

Automated tools can be used to help find a variety of threats and vulnerabilities, such as improper access controls or access control configurations, weak passwords, lack of integrity of the system software, or not using all relevant software updates and patches. These tools are often very successful at finding vulnerabilities and are sometimes used by hackers to break into systems. Not taking advantage of these tools puts system administrators at a disadvantage. Many of the tools are simple to use; however, some programs (such as access-control auditing tools for large

[74] An example of an internal auditor in the federal government is the Inspector General. The General Accounting Office can perform the role of external auditor in the federal government. In the private sector, the corporate audit staff serves the role of internal auditor, while a public accounting firm would be an external auditor.

mainframe systems) require specialized skill to use and interpret.

9.4.1.2 Internal Controls Audit

The General Accounting Office provides standards and guidance for internal controls audits of federal agencies.

An auditor can review controls in place and determine whether they are effective. The auditor will often analyze both computer and noncomputer-based controls. Techniques used include inquiry, observation, and testing (of both the controls themselves and the data). The audit can also detect illegal acts, errors, irregularities, or a lack of compliance with laws and regulations. Security checklists and penetration testing, discussed below, may be used.

9.4.1.3 Security Checklists

Warning: Security Checklists that are passed (e.g., with a B+ or better score) are often used mistakenly as proof (instead of an indication) that security is sufficient. Also, managers of systems which "fail" a checklist often focus too much attention on "getting the points," rather than whether the security measures makes sense in the particular environment and are correctly implemented.

Within the government, the computer security plan provides a checklist against which the system can be audited. This plan, discussed in Chapter 8, outlines the major security considerations for a system, including management, operational, and technical issues. One advantage of using a computer security plan is that it reflects the unique security environment of the system, rather than a generic list of controls. Other checklists can be developed, which include national or organizational security policies and practices (often referred to as *baselines*). Lists of "generally accepted security practices" (GSSPs) can also be used. Care needs to be taken so that deviations from the list are not automatically considered wrong, since they may be appropriate for the system's particular environment or technical constraints.

Checklists can also be used to verify that changes to the system have been reviewed from a security point of view. A common audit examines the system's configuration to see if major changes (such as connecting to the Internet) have occurred that have not yet been analyzed from a security point of view.

9.4.1.4 Penetration Testing

Penetration testing can use many methods to attempt a system break-in. In addition to using active automated tools as described above, penetration testing can be done "manually." The most useful type of penetration testing is to use methods that might really be used against the system. For hosts on the Internet, this would certainly include automated tools. For many systems, lax procedures or a lack of internal controls on applications are common vulnerabilities that penetration testing can target. Another method is "social engineering," which involves getting

users or administrators to divulge information about systems, including their passwords.[75]

9.4.2 Monitoring Methods and Tools

Security monitoring is an ongoing activity that looks for vulnerabilities and security problems. Many of the methods are similar to those used for audits, but are done more regularly or, for some automated tools, in real time.

9.4.2.1 Review of System Logs

As discussed in Chapter 8, a periodic review of system-generated logs can detect security problems, including attempts to exceed access authority or gain system access during unusual hours.

9.4.2.2 Automated Tools

Several types of automated tools monitor a system for security problems. Some examples follow:

- *Virus scanners* are a popular means of checking for virus infections. These programs test for the presence of viruses in executable program files.

- *Checksumming* presumes that program files should not change between updates. They work by generating a mathematical value based on the contents of a particular file. When the integrity of the file is to be verified, the checksum is generated on the current file and compared with the previously generated value. If the two values are equal, the integrity of the file is verified. Program checksumming can detect viruses, Trojan horses, accidental changes to files caused by hardware failures, and other changes to files. However, they may be subject to covert replacement by a system intruder. Digital signatures can also be used.

- *Password crackers* check passwords against a dictionary (either a "regular" dictionary or a specialized one with easy-to-guess passwords) and also check if passwords are common permutations of the user ID. Examples of special dictionary entries could be the names of regional sports teams and stars; common permutations could be the user ID spelled backwards.

- *Integrity verification programs* can be used by such applications to look for evidence of data tampering, errors, and omissions. Techniques include consistency and reasonableness checks

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[75] While penetration testing is a very powerful technique, it should preferably be conducted with the knowledge and consent of system management. Unknown penetration attempts can cause a lot of stress among operations personnel, and may create unnecessary disturbances.

and validation during data entry and processing. These techniques can check data elements, as input or as processed, against expected values or ranges of values; analyze transactions for proper flow, sequencing, and authorization; or examine data elements for expected relationships. These programs comprise a very important set of processes because they can be used to convince people that, if they do what they should not do, accidentally or intentionally, they will be caught. Many of these programs rely upon logging of individual user activities.

- *Intrusion detectors* analyze the system audit trail, especially log-ons, connections, operating system calls, and various command parameters, for activity that could represent unauthorized activity. Intrusion detection is covered in Chapters 12 and 18.

- *System performance monitoring* analyzes system performance logs in real time to look for availability problems, including active attacks (such as the 1988 Internet worm) and system and network slowdowns and crashes.

9.4.2.3 Configuration Management

From a security point of view, configuration management provides assurance that the system in operation is the correct version (configuration) of the system and that any changes to be made are reviewed for security implications. Configuration management can be used to help ensure that changes take place in an identifiable and controlled environment and that they do not unintentionally harm any of the system's properties, including its security. Some organizations, particularly those with very large systems (such as the federal government), use a configuration control board for configuration management. When such a board exists, it is helpful to have a computer security expert participate. In any case, it is useful to have computer security officers participate in system management decision making.

Changes to the system can have security implications because they may introduce or remove vulnerabilities and because significant changes may require updating the contingency plan, risk analysis, or accreditation.

9.4.2.4 Trade Literature/Publications/Electronic News

In addition to monitoring the system, it is useful to monitor external sources for information. Such sources as trade literature, both printed and electronic, have information about security vulnerabilities, patches, and other areas that impact security. The Forum of Incident Response Teams (FIRST) has an electronic mailing list that receives information on threats, vulnerabilities,

and patches.[76]

9.5 Interdependencies

Assurance is an issue for every control and safeguard discussed in this handbook. Are user ID and access privileges kept up to date? Has the contingency plan been tested? Can the audit trail be tampered with? One important point to be reemphasized here is that assurance is not only for technical controls, but for operational controls as well. Although the chapter focused on information systems assurance, it is also important to have assurance that management controls are working well. Is the security program effective? Are policies understood and followed? As noted in the introduction to this chapter, the need for assurance is more widespread than people often realize.

Life Cycle. Assurance is closely linked to the planning for security in the system life cycle. Systems can be designed to facilitate various kinds of testing against specified security requirements. By planning for such testing early in the process, costs can be reduced; in some cases, without proper planning, some kinds of assurance cannot be otherwise obtained.

9.6 Cost Considerations

There are many methods of obtaining assurance that security features work as anticipated. Since assurance methods tend to be qualitative rather than quantitative, they will need to be evaluated. Assurance can also be quite expensive, especially if extensive testing is done. It is useful to evaluate the amount of assurance received for the cost to make a best-value decision. In general, personnel costs drive up the cost of assurance. Automated tools are generally limited to addressing specific problems, but they tend to be less expensive.

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III. OPERATIONAL CONTROLS

Chapter 10

PERSONNEL/USER ISSUES

Many important issues in computer security involve human users, designers, implementors, and managers. A broad range of security issues relate to how these individuals interact with computers and the access and authorities they need to do their job. No computer system can be secured without properly addressing these security issues.[77]

This chapter examines issues concerning the staffing of positions that interact with computer systems; the administration of users on a system, including considerations for terminating employee access; and special considerations that may arise when contractors or the public have access to systems. Personnel issues are closely linked to logical access controls, discussed in Chapter 17.

10.1 Staffing

The staffing process generally involves at least four steps and can apply equally to general users as well as to application managers, system management personnel, and security personnel. These four steps are: (1) defining the job, normally involving the development of a position description; (2) determining the sensitivity of the position; (3) filling the position, which involves screening applicants and selecting an individual; and (4) training.

10.1.1 Groundbreaking – Position Definition

Early in the process of defining a position, security issues should be identified and dealt with. Once a position has been broadly defined, the responsible supervisor should determine the type of computer access needed for the position. There are two general principles to apply when granting access: *separation of duties* and *least privilege*.

Separation of duties refers to dividing roles and responsibilities so that a single individual cannot subvert a critical process. For example, in financial systems, no single individual should normally be given authority to issue checks. Rather, one person initiates a request for a payment and another authorizes that same payment. In effect, checks and balances need to be designed into both the process as well as the specific, individual positions of personnel who will implement the process. Ensuring that such duties are well defined is the responsibility of management.

Least privilege refers to the security objective of granting users *only those accesses they need to*

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[77] A distinction is made between users and personnel, since some users (e.g., contractors and members of the public) may not be considered personnel (i.e., employees).

perform their official duties. Data entry clerks, for example, may not have any need to run analysis reports of their database. However, least privilege does not mean that all users will have extremely little functional access; some employees will have significant access if it is required for their position. However, applying this principle may limit the damage resulting from accidents, errors, or unauthorized use of system resources. It is important to make certain that the implementation of least privilege does not interfere with the ability to have personnel substitute for each other without undue delay. Without careful planning, access control can interfere with contingency plans.

10.1.2 Determining Position Sensitivity

Knowledge of the duties and access levels that a particular position will require is necessary for determining the sensitivity of the position. The responsible management official should correctly identify position sensitivity levels so that appropriate, cost-effective screening can be completed.

Various levels of sensitivity are assigned to positions in the federal government. Determining the appropriate level is based upon such factors as the type and degree of harm (e.g., disclosure of private information, interruption of critical processing, computer fraud) the individual can cause through misuse of the computer system as well as more traditional factors, such as access to classified information and fiduciary responsibilities. Specific agency guidance should be followed on this matter.

It is important to select the appropriate position sensitivity, since controls in excess of the sensitivity of the position wastes resources, while too little may cause unacceptable risks.

10.1.3 Filling the Position -- Screening and Selecting

Once a position's sensitivity has been determined, the position is ready to be staffed. In the federal government, this typically includes publishing a formal vacancy announcement and identifying which applicants meet the position requirements. More sensitive positions typically require *preemployment* background screening; screening after employment has commenced (post-entry-on-duty) may suffice for less sensitive positions.

> In general, it is more effective to use separation of duties and least privilege to limit the sensitivity of the position, rather than relying on screening to reduce the risk to the organization.

Background screening helps determine whether a particular individual is suitable for a given position. For example, in positions with high-level fiduciary responsibility, the screening process will attempt to ascertain the person's trustworthiness and appropriateness for a particular position. In the federal government, the screening process is formalized through a series of background checks conducted through a central investigative office within the

organization or through another organization (e.g., the Office of Personnel Management).

Within the Federal Government, the most basic screening technique involves a check for a criminal history, checking FBI fingerprint records, and other federal indices.[78] More extensive background checks examine other factors, such as a person's work and educational history, personal interview, history of possession or use of illegal substances, and interviews with current and former colleagues, neighbors, and friends. The exact type of screening that takes place depends upon the sensitivity of the position and applicable agency implementing regulations. Screening is not conducted by the prospective employee's manager; rather, agency security and personnel officers should be consulted for agency-specific guidance.

Outside of the Federal Government, employee screening is accomplished in many ways. Policies vary considerably among organizations due to the sensitivity of examining an individual's background and qualifications. Organizational policies and procedures normally try to balance fears of invasiveness and slander against the need to develop confidence in the integrity of employees. One technique may be to place the individual in a less sensitive position initially.

For both the Federal Government and private sector, finding something compromising in a person's background does not necessarily mean they are unsuitable for a particular job. A determination should be made based on the type of job, the type of finding or incident, and other relevant factors. In the federal government, this process is referred to as *adjudication.*

10.1.4 Employee Training and Awareness

Even after a candidate has been hired, the staffing process cannot yet be considered complete – employees still have to be trained to do their job, which includes computer security responsibilities and duties. As discussed in Chapter 13, such security training can be very cost-effective in promoting security.

Some computer security experts argue that employees must receive initial computer security training before they are granted any access to computer systems. Others argue that this must be a risk-based decision, perhaps granting only restricted access (or, perhaps, only access to their PC) until the required training is completed. Both approaches recognize that adequately trained employees are crucial to the effective functioning of computer systems and applications. Organizations may provide introductory training prior to granting any access with follow-up more extensive training. In addition, although training of new users is critical, it is important to recognize that security training and awareness activities should be ongoing during the time an

[78] In the federal government, separate and unique screening procedures are not established for each position. Rather, positions are categorized by general sensitivity and are assigned a corresponding level of background investigation or other checks.

individual is a system user. (See Chapter 13 for a more thorough discussion.)

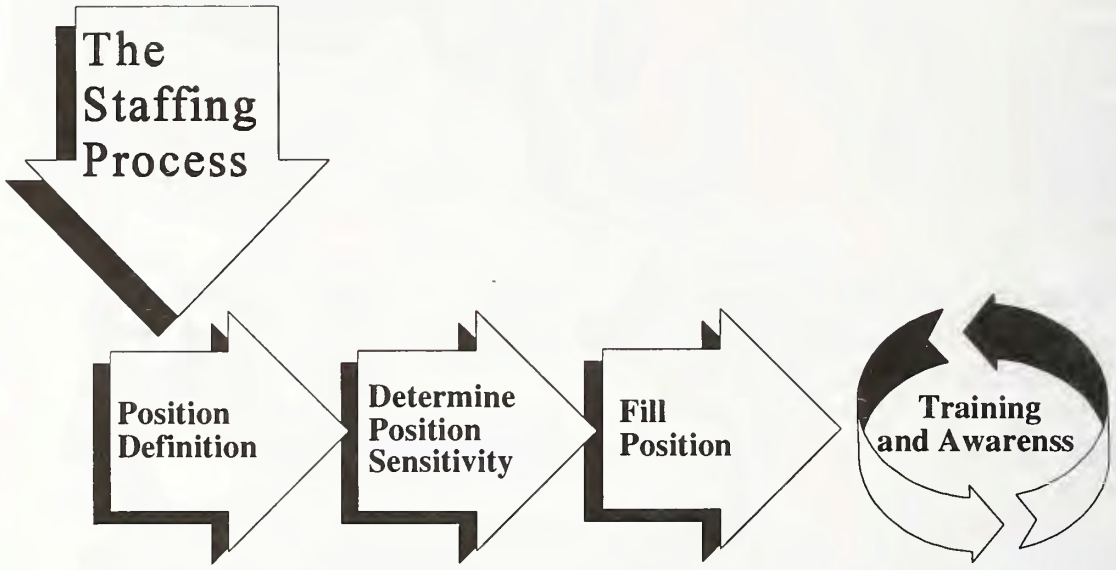

Figure 10.1

10.2 User Administration

Effective administration of users' computer access is essential to maintaining system security. *User account management* focuses on identification, authentication, and access authorizations. This is augmented by the process of *auditing* and otherwise periodically verifying the legitimacy of current accounts and access authorizations. Finally, there are considerations involved in the *timely modification or removal of access* and associated issues for employees who are reassigned, promoted, or terminated, or who retire.

10.2.1 User Account Management

User account management involves (1) the process of requesting, establishing, issuing, and closing user accounts; (2) tracking users and their respective access authorizations; and (3) managing these functions.

User account management typically begins with a request from the user's supervisor to the system manager for a system account. If a user is to have access to a particular application, this request may be sent through the application manager to the system manager. This will ensure that the systems office receives formal approval from the "application manager" for the employee to be given access. The request will normally state the level of access to be granted, perhaps by function or by specifying a particular user profile. (Often when more than one employee is doing the same job, a "profile" of permitted authorizations is created.)

Example of Access Levels Within an Application

Level	Function
1	Create Records
2	Edit *Group A* records
3	Edit *Group B* records
4	Edit *all* records

Systems operations staff will normally then use the account request to create an account for the new user. The access levels of the account will be consistent with those requested by the supervisor. This account will normally be assigned selected access authorizations. These are sometimes built directly into applications, and other times rely upon the operating system. "Add-on" access applications are also used. These access levels and authorizations are often tied to specific access levels within an application.

Next, employees will be given their account information, including the account identifier (e.g., user ID) and a means of authentication (e.g., password or smart card/PIN). One issue that may arise at this stage is whether the user ID is to be tied to the particular *position* an employee holds (e.g., ACC5 for an accountant) or the *individual employee* (e.g., BSMITH for Brenda Smith). Tying user IDs to positions may simplify administrative overhead in some cases; however, it may make auditing more difficult as one tries to trace the actions of a particular individual. It is normally more advantageous to tie the user ID to the individual employee. However, if the user ID is created and tied to a position, procedures will have to be established to change them if employees switch jobs or are otherwise reassigned.

When employees are given their account, it is often convenient to provide initial or refresher training and awareness on computer security issues. Users should be asked to review a set of rules and regulations for system access. To indicate their understanding of these rules, many organizations require employees to sign an "acknowledgment statement," which may also state causes for dismissal or prosecution under the Computer Fraud and Abuse Act and other

applicable state and local laws.[79]

When user accounts are no longer required, the supervisor should inform the application manager and system management office so accounts can be removed in a timely manner. One useful secondary check is to work with the local organization's personnel officer to establish a procedure for routine notification of employee departures to the systems office. Further issues are discussed in the "Termination" section of this chapter.

Sample User Account and Password Acknowledgment Form

I hereby acknowledge personal receipt of the system password(s) associated with the user Ids listed below. I understand that I am responsible for protecting the password(s), will comply with all applicable system security standards, and will not divulge my password(s) to any person. I further understand that I must report to the Information Systems Security Officer any problem I encounter in the use of the password(s) or when I have reason to believe that the private nature of my password(s) has been compromised.

It is essential to realize that *access and authorization administration is a continuing process*. New user accounts are added while others are deleted. Permissions change: sometimes permanently, sometimes temporarily. New applications are added, upgraded, and removed. Tracking this information to keep it up to date is not easy, but is necessary to allow users access to only those functions necessary to accomplish their assigned responsibilities – thereby helping to maintain the principle of *least privilege*. In managing these accounts, there is a need to balance timeliness of service and record keeping. While sound record keeping practices are necessary, delays in processing requests (e.g., change requests) may lead to requests for more access than is really necessary – just to avoid delays should such access ever be required.

Managing this process of user access is also one that, particularly for larger systems, is often decentralized. Regional offices may be granted the authority to create accounts and change user access authorizations or to submit forms requesting that the centralized access control function make the necessary changes. Approval of these changes is important – it may require the approval of the file owner and the supervisor of the employee whose access is being changed.

10.2.2 Audit and Management Reviews

From time to time, it is necessary to review user account management on a system. Within the area of user access issues, such reviews may examine the levels of access each individual has, conformity with the concept of least privilege, whether all accounts are still active, whether management authorizations are up-to-date, whether required training has been completed, and so forth.

[79] Whenever users are asked to sign a document, appropriate review by organizational legal counsel and, if applicable, by employee bargaining units should be accomplished.

These reviews can be conducted on *at least* two levels:[80] (1) on an application-by-application basis or (2) on a systemwide basis. Both kinds of reviews can be conducted by, among others, in-house systems personnel (a self-audit), the organization's internal audit staff, or external auditors. For example, a good practice is for application managers (and data owners, if different) to review all access levels of all application users every month – and sign a formal access approval list, which will provide a written record of the approvals. While it may initially appear that such reviews should be conducted by systems personnel, they usually are not fully effective. System personnel *can* verify that users only have those accesses that their managers have specified. However because access requirements may change over time, it is important to involve the application manager, who is often the only individual in a position to know current access requirements.

Outside audit organizations (e.g., the Inspector General [IG] or the General Accounting Office) may also conduct audits. For example, the IG may direct a more extensive review of permissions. This may involve discussing the need for particular access levels for specific individuals or the number of users with sensitive access. For example, how many employees should really have authorization to the check-printing function? (Auditors will also examine non-computer access by reviewing, for example, who should have physical access to the check printer or blank-check stock.)

10.2.3 Detecting Unauthorized/Illegal Activities

Several mechanisms are used besides auditing[81] and analysis of audit trails to detect unauthorized and illegal acts. (See Chapters 9 and 18.) For example, fraudulent activities may require the regular physical presence of the perpetrator(s). In such cases, the fraud may be detected during the employee's absence. Mandatory vacations for critical systems and applications personnel can help detect such activity (however, this is not a guarantee, for example, if problems are saved for the employees to handle upon their return). It is useful to avoid creating an excessive dependence upon any single individual, since the system will have to function during periods of absence. Particularly within the government, periodic rescreening of personnel is used to identify possible indications of illegal activity (e.g., living a lifestyle in excess of known income level).

10.2.4 Temporary Assignments and In-house Transfers

One significant aspect of managing a system involves keeping user access authorizations up to date. Access authorizations are typically changed under two types of circumstances: (1) change in job role, either temporarily (e.g., while covering for an employee on sick leave) or permanently

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[80] Note that this is not an either/or distinction.

[81] The term *auditing* is used here in a broad sense to refer to the review and analysis of past events.

(e.g., after an in-house transfer) and (2) termination discussed in the following section.

Users often are required to perform duties outside their normal scope during the absence of others. This requires additional access authorizations. Although necessary, such extra access authorizations should be granted sparingly and monitored carefully, consistent with the need to maintain separation of duties for internal control purposes. Also, they should be removed promptly when no longer required.

Permanent changes are usually necessary when employees change positions within an organization. In this case, the process of granting account authorizations (described in Section 10.2.1) will occur again. At this time, however, is it also important that access authorizations of the prior position be removed. Many instances of "authorization creep" have occurred with employees continuing to maintain access rights for previously held positions within an organization. This practice is inconsistent with the principle of least privilege.

10.2.5 Termination

Termination of a user's system access generally can be characterized as either "friendly" or "unfriendly." Friendly termination may occur when an employee is voluntarily transferred, resigns to accept a better position, or retires. Unfriendly termination may include situations when the user is being fired for cause, "RIFed,"[82] or involuntarily transferred. Fortunately, the former situation is more common, but security issues have to be addressed in both situations.

10.2.5.1 Friendly Termination

Friendly termination refers to the removal of an employee from the organization when there is no reason to believe that the termination is other than mutually acceptable. Since terminations can be expected regularly, this is usually accomplished by implementing a standard set of procedures for outgoing or transferring employees. These are part of the standard employee "out-processing," and are put in place, for example, to ensure that system accounts are removed in a timely manner. Out-processing often involves a sign-out form initialed by each functional manager with an interest in the separation. This normally includes the group(s) managing access controls, the control of keys, the briefing on the responsibilities for confidentiality and privacy, the library, the property clerk, and several other functions not necessarily related to information security.

In addition, other issues should be examined as well. The continued availability of data, for example, must often be assured. In both the manual and the electronic worlds, this may involve documenting procedures or filing schemes, such as how documents are stored on the hard disk, and how are they backed up. Employees should be instructed whether or not to "clean up" their

[82] *RIF* is a term used within the government as shorthand for "reduction in force."

PC before leaving. If cryptography is used to protect data, the availability of cryptographic keys to management personnel must be ensured. Authentication tokens must be collected.

Confidentiality of data can also be an issue. For example, do employees know what information they are allowed to share with their immediate organizational colleagues? Does this differ from the information they may share with the public? These and other organizational-specific issues should be addressed throughout an organization to ensure continued access to data and to provide continued confidentiality and integrity during personnel transitions. (Many of these issues should be addressed on an ongoing basis, not just during personnel transitions.) The training and awareness program normally should address such issues.

10.2.5.2 Unfriendly Termination

Unfriendly termination involves the removal of an employee under involuntary or adverse conditions. This may include termination for cause, RIF, involuntary transfer, resignation for "personality conflicts," and situations with pending grievances. The tension in such terminations may multiply and complicate security issues. Additionally, all of the issues involved in friendly terminations are still present, but addressing them may be considerably more difficult.

The greatest threat from unfriendly terminations is likely to come from those personnel who are capable of changing code or modifying the system or applications. For example, systems personnel are ideally positioned to wreak considerable havoc on systems operations. Without appropriate safeguards, personnel with such access can place logic bombs (e.g., a hidden program to erase a disk) in code that will not even execute until after the employee's departure. Backup copies can be destroyed. There are even examples where code has been "held hostage." But other employees, such as general users, can also cause damage. Errors can be input purposefully, documentation can be misfiled, and other "random" errors can be made. Correcting these situations can be extremely resource intensive.

Given the potential for adverse consequences, security specialists routinely recommend that system access be terminated as quickly as possible in such situations. If employees are to be fired, system access should be removed at the same time (or just before) the employees are notified of their dismissal. When an employee notifies an organization of a resignation and it can be reasonably expected that it is on unfriendly terms, system access should be immediately terminated. During the "notice" period, it may be necessary to assign the individual to a restricted area and function. This may be particularly true for employees capable of changing programs or modifying the system or applications. In other cases, physical removal from their offices (and, of course, logical removal, *when logical access controls exist*) may suffice.

10.3 Contractor Access Considerations

Many federal agencies as well as private organizations use contractors and consultants to assist with computer processing. Contractors are often used for shorter periods of time than regular employees. This factor may change the cost-effectiveness of conducting screening. The often higher turnover among contractor personnel generates additional costs for security programs in terms of user administration.

10.4 Public Access Considerations

Many federal agencies have begun to design, develop, and implement public access systems for electronic dissemination of information to the public. Some systems provide electronic interaction by allowing the public to send information to the government (e.g., electronic tax filing) as well as to receive it. When systems are made available for access by the public (or a large or significant subset thereof), additional security issues arise due to: (1) increased threats against public access systems and (2) the difficulty of security administration.

OMB Circular A-130, Appendix III "Security of Federal Automated Information" and NIST *CSL Bulletin* "Security Issues in Public Access Systems" both recommend segregating information made directly accessible to the public from official records.

While many computer systems have been victims of hacker attacks, public access systems are well known and have published phone numbers and network access IDs. In addition, a successful attack could result in a lot of publicity. For these reasons, public access systems are subject to a greater threat from hacker attacks on the confidentiality, availability, and integrity of information processed by a system. In general, it is safe to say that when a system is made available for public access, the risk to the system increases – and often the constraints on its use are tightened.

Besides increased risk of hackers, public access systems can be subject to insider malice. For example, an unscrupulous user, such as a disgruntled employee, may try to introduce errors into data files intended for distribution in order to embarrass or discredit the organization. Attacks on public access systems could have a substantial impact on the organization's reputation and the level of public confidence due to the high visibility of public access systems. Other security problems may arise from unintentional actions by untrained users.

In systems without public access, there are procedures for enrolling users that often involve some user training and frequently require the signing of forms acknowledging user responsibilities. In addition, user profiles can be created and sophisticated audit mechanisms can be developed to detect unusual activity by a user. In public access systems, users are often anonymous. This can complicate system security administration.

In most systems without public access, users are typically a mix of known employees or contractors. In this case, imperfectly implemented access control schemes may be tolerated. However, when opening up a system to public access, additional precautions may be necessary because of the increased threats.

10.5 Interdependencies

User issues are tied to topics throughout this handbook.

Training and Awareness discussed in Chapter 13 is a critical part of addressing the user issues of computer security.

Identification and Authentication and *Access Controls* in a computer system can only prevent people from doing what the computer is instructed they are not allowed to do, as stipulated by *Policy*. The recognition by computer security experts that much more harm comes from people doing what they are allowed to do, but should not do, points to the importance of considering user issues in the computer security picture, and the importance of *Auditing*.

Policy, particularly its compliance component, is closely linked to personnel issues. A deterrent effect arises among users when they are aware that their misconduct, intentional or unintentional, will be detected.

These controls also depend on manager's (1) selecting the right type and level of access for their employees and (2) informing system managers of which employees need accounts and what type and level of access they require, and (3) promptly informing system managers of changes to access requirements. Otherwise, accounts and accesses can be granted to or maintained for people who should not have them.

10.6 Cost Considerations

There are many security costs under the category of user issues. Among these are:

Screening -- Costs of initial background screening and periodic updates, as appropriate.[83]

Training and Awareness -- Costs of training needs assessments, training materials, course fees, and so forth, as discussed separately in Chapter 13.

User Administration -- Costs of managing identification and authentication which, particularly for

[83] When analyzing the costs of screening, it is important to realize that screening is often conducted to meet requirements wholly unrelated to computer security.

large distributed systems, may be rather significant.

Access Administration -- Particularly beyond the initial account set-up, are ongoing costs of maintaining user accesses currently and completely.

Auditing -- Although such costs can be reduced somewhat when using automated tools, consistent, resource-intensive human review is still often necessary to detect and resolve security anomalies.

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Chapter 11

PREPARING FOR CONTINGENCIES AND DISASTERS

A *computer security contingency* is an event with the potential to disrupt computer operations, thereby disrupting critical mission and business functions. Such an event could be a power outage, hardware failure, fire, or storm. If the event is very destructive, it is often called a disaster.[84]

To avert potential contingencies and disasters or minimize the damage they cause organizations can take steps early to control the event. Generally called *contingency planning*,[85] this activity is closely related to incident handling, which primarily addresses malicious technical threats such as hackers and viruses.[86]

> Contingency planning directly supports an organization's goal of continued operations. Organizations practice contingency planning because it makes good business sense.

Contingency planning involves more than planning for a move offsite after a disaster destroys a data center. It also addresses how to keep an organization's critical functions operating in the event of disruptions, both large and small. This broader perspective on contingency planning is based on the distribution of computer support throughout an organization.

This chapter presents the contingency planning process in six steps:[87]

1. *Identifying the mission- or business-critical functions.*
2. *Identifying the resources that support the critical functions.*
3. *Anticipating potential contingencies or disasters.*
4. *Selecting contingency planning strategies.*

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[84] There is no distinct dividing line between disasters and other contingencies.

[85] Other names include disaster recovery, business continuity, continuity of operations, or business resumption planning.

[86] Some organizations include incident handling as a subset of contingency planning. The relationship is further discussed in Chapter 12, Incident Handling.

[87] Some organizations and methodologies may use a different order, nomenclature, number, or combination of steps. The specific steps can be modified, as long as the basic functions are addressed.

5. *Implementing the contingency strategies.*

6. *Testing and revising the strategy.*

11.1 Step 1: Identifying the Mission- or Business-Critical Functions

Protecting the continuity of an organization's mission or business is very difficult if it is not clearly identified. Managers need to understand the organization from a point of view that usually extends beyond the area they control. The definition of an organization's critical mission or business functions is often called a *business plan*.

> This chapter refers to an organization as having critical *mission* or *business* functions. In government organizations, the focus is normally on performing a mission, such as providing citizen benefits. In private organizations, the focus is normally on conducting a business, such as manufacturing widgets.

Since the development of a business plan will be used to support contingency planning, it is necessary not only to identify critical missions and businesses, but also to *set priorities for* them. A fully redundant capability for each function is prohibitively expensive for most organizations. In the event of a disaster, certain functions will not be performed. If appropriate priorities have been set (and approved by senior management), it could mean the difference in the organization's ability to survive a disaster.

11.2 Step 2: Identifying the Resources That Support Critical Functions

After identifying critical missions and business functions, it is necessary to identify the supporting resources, the time frames in which each resource is used (e.g., is the resource needed constantly or only at the end of the month?), and the effect on the mission or business of the unavailability of the resource. In identifying resources, a traditional problem has been that different managers oversee different resources. They may not realize how resources interact to support the organization's mission or business. Many of these resources are *not* computer resources. Contingency planning should address all the resources needed to perform a function, regardless whether they directly relate to a computer.[88]

> In many cases, the longer an organization is without a resource, the more critical the situation becomes. For example, the longer a garbage collection strike lasts, the more critical the situation becomes.

[88] However, since this is a computer security handbook, the descriptions here focus on the computer-related resources. The logistics of coordinating contingency planning for computer-related and other resources is an important consideration.

The analysis of needed resources should be conducted by those who understand how the function is performed and the dependencies of various resources on other resources and other critical relationships. This will allow an organization to *assign priorities* to resources since not all elements of all resources are crucial to the critical functions.

11.2.1 Human Resources

Resources That Support Critical Functions

Human Resources
Processing Capability
Computer-Based Services
Data and Applications
Physical Infrastructure
Documents and Papers

People are perhaps an organization's most obvious resource. Some functions require the effort of specific individuals, some require specialized expertise, and some only require individuals who can be trained to perform a specific task. Within the information technology field, human resources include both operators (such as technicians or system programmers) and users (such as data entry clerks or information analysts).

11.2.2 Processing Capability

Traditionally contingency planning has focused on processing power (i.e., if the data center is down, how can applications dependent on it continue to be processed?). Although the need for data center backup remains vital, today's other processing alternatives are also important. Local area networks (LANs), minicomputers, workstations, and personal computers in all forms of centralized and distributed processing may be performing critical tasks.

Contingency Planning Teams

To understand what resources are needed from each of the six resource categories and to understand how the resources support critical functions, it is often necessary to establish a contingency planning team. A typical team contains representatives from various organizational elements, and is often headed by a contingency planning coordinator. It has representatives from the following three groups:

1. business-oriented groups , such as representatives from functional areas;
2. facilities management; and
3. technology management.

Various other groups are called on as needed including financial management, personnel, training, safety, computer security, physical security, and public affairs.

11.2.3 Automated Applications and Data

Computer systems run applications that process data. Without current electronic versions of both applications and data, computerized processing may not be possible. If the processing is being performed on alternate hardware, the applications must be compatible with the alternate hardware, operating systems and other software (including version and configuration), and numerous other technical factors. Because of

the complexity, it is normally necessary to periodically verify compatibility. (See Step 6, Testing and Revising.)

11.2.4 Computer-Based Services

An organization uses many different kinds of computer-based services to perform its functions. The two most important are normally communications services and information services. Communications can be further categorized as data and voice communications; however, in many organizations these are managed by the same service. Information services include any source of information outside of the organization. Many of these sources are becoming automated, including on-line government and private databases, news services, and bulletin boards.

11.2.5 Physical Infrastructure

For people to work effectively, they need a safe working environment and appropriate equipment and utilities. This can include office space, heating, cooling, venting, power, water, sewage, other utilities, desks, telephones, fax machines, personal computers, terminals, courier services, file cabinets, and many other items. In addition, computers also need space and utilities, such as electricity. Electronic and paper media used to store applications and data also have physical requirements.

11.2.6 Documents and Papers

Many functions rely on vital records and various documents, papers, or forms. These records could be important because of a legal need (such as being able to produce a signed copy of a loan) or because they are the only record of the information. Records can be maintained on paper, microfiche, microfilm, magnetic media, or optical disk.

11.3 Step 3: Anticipating Potential Contingencies or Disasters

Although it is impossible to think of *all* the things that can go wrong, the next step is to identify a likely range of problems. The development of scenarios will help an organization develop a plan to address the wide range of things that can go wrong.

Scenarios should include small and large contingencies. While some general classes of contingency scenarios are obvious, imagination and creativity, as well as research, can point to other possible, but less obvious, contingencies. The contingency scenarios should address each of the resources described above. The following are *examples* of some of the types of questions that contingency scenarios may address:

Human Resources: Can people get to work? Are key personnel willing to cross a picket line? Are there critical skills and knowledge possessed by one person? Can people easily get to an alternative site?

Processing Capability: Are the computers harmed? What happens if some of the computers are inoperable, but not all?

Automated Applications and Data: Has data integrity been affected? Is an application sabotaged? Can an application run on a different processing platform?

Computer-Based Services: Can the computers communicate? To where? Can people communicate? Are information services down? For how long?

Examples of Some Less Obvious Contingencies

1. A computer center in the basement of a building had a minor problem with rats. Exterminators killed the rats, but the bodies were not retrieved because they were hidden under the raised flooring and in the pipe conduits. Employees could only enter the data center with gas masks because of the decomposing rats.

2. After the World Trade Center explosion when people reentered the building, they turned on their computer systems to check for problems. Dust and smoke damaged many systems when they were turned on. If the systems had been cleaned *first*, there would not have been significant damage.

Infrastructure: Do people have a place to sit? Do they have equipment to do their jobs? Can they occupy the building?

Documents/Paper: Can needed records be found? Are they readable?

11.4 Step 4: Selecting Contingency Planning Strategies

The next step is to plan how to recover needed resources. In evaluating alternatives, it is necessary to consider what controls are in place to prevent and minimize contingencies. Since no set of controls can cost-effectively prevent all contingencies, it is necessary to coordinate prevention and recovery efforts.

A contingency planning strategy normally consists of three parts: emergency response, recovery, and resumption.[89] *Emergency response* encompasses the initial actions taken to protect lives and limit damage. *Recovery* refers to the steps that are taken to continue support for critical functions. *Resumption* is the return to normal operations. The relationship between recovery and resumption is important. The longer it takes to resume normal operations, the longer the

[89] Some organizations divide a contingency strategy into emergency response, backup operations, and recovery. The different terminology can be confusing (especially the use of conflicting definitions of *recovery*), although the basic functions performed are the same.

organization will have to operate in the recovery mode.

The selection of a strategy needs to be based on practical considerations, including feasibility and cost. The different categories of resources should each be considered. Risk assessment can be used to help estimate the cost of options to decide on an optimal strategy. For example, is it more expensive to purchase and maintain a generator or to move processing to an alternate site, considering the likelihood of losing electrical power for various lengths of time? Are the consequences of a loss of computer-related resources sufficiently high to warrant the cost of various recovery strategies? The risk assessment should focus on areas where it is not clear which strategy is the best.

In developing contingency planning strategies, there are many factors to consider in addressing each of the resources that support critical functions. Some examples are presented in the sidebars.

Example 1: If the system administrator for a LAN has to be out of the office for a long time (due to illness or an accident), arrangements are made for the system administrator of another LAN to perform the duties. Anticipating this, the absent administrator should have taken steps beforehand to keep documentation current. This strategy is inexpensive, but service will probably be significantly reduced on both LANs which may prompt the manager of the loaned administrator to partially renege on the agreement.

Example 2: An organization depends on an on-line information service provided by a commercial vendor. The organization is no longer able to obtain the information manually (e.g., from a reference book) within acceptable time limits and there are no other comparable services. In this case, the organization relies on the contingency plan of the service provider. The organization pays a premium to obtain priority service in case the service provider has to operate at reduced capacity.

Example #3: A large mainframe data center has a contract with a hot site vendor, has a contract with the telecommunications carrier to reroute communications to the hot site, has plans to move people, and stores up-to-date copies of data, applications and needed paper records off-site. The contingency plan is expensive, but management has decided that the expense is fully justified.

Example #4. An organization distributes its processing among two major sites, each of which includes small to medium processors (personal computers and minicomputers). If one site is lost, the other can carry the critical load until more equipment is purchased. Routing of data and voice communications can be performed transparently to redirect traffic. Backup copies are stored at the other site. This plan requires tight control over the architectures used and types of applications that are developed to ensure compatibility. In addition, personnel at both sites must be cross-trained to perform all functions.

11.4.1 Human Resources

To ensure an organization has access to workers with the right skills and knowledge, training and documentation of knowledge are needed. During a major contingency, people will be under significant stress and may panic. If the contingency is a regional disaster, their first concerns will probably be their family and property. In addition, many people will be either unwilling or unable to come to work. Additional hiring or temporary services can be used. The use of additional personnel may introduce security vulnerabilities.

Contingency planning, especially for emergency response, normally places the highest emphasis

on the protection of human life.

11.4.2 Processing Capability

Strategies for processing capability are normally grouped into five categories: hot site; cold site; redundancy; reciprocal agreements; and hybrids. These terms originated with recovery strategies for data centers but can be applied to other platforms.

1. *Hot site* – A building already equipped with processing capability and other services.

2. *Cold site* – A building for housing processors that can be easily adapted for use.

3. *Redundant site* – A site equipped and configured exactly like the primary site. (Some organizations plan on having reduced processing capability after a disaster and use partial redundancy. The stocking of spare personal computers or LAN servers also provides some redundancy.)

4. *Reciprocal agreement* – An agreement that allows two organizations to back each other up. (While this approach often sounds desirable, contingency planning experts note that this alternative has the greatest chance of failure due to problems keeping agreements and plans up-to-date as systems and personnel change.)

5. *Hybrids* – Any combinations of the above such as using having a hot site as a backup in case a redundant or reciprocal agreement site is damaged by a separate contingency.

Recovery may include several stages, perhaps marked by increasing availability of processing capability. Resumption planning may include contracts or the ability to place contracts to replace equipment.

11.4.3 Automated Applications and Data

Normally, the primary contingency strategy for applications and data is *regular backup* and secure *offsite storage*. Important decisions to be addressed include how often the backup is performed, how often it is stored off-site, and how it is transported (to storage, to an alternate processing site, or to support the resumption of normal operations).

> The need for computer security does not go away when an organization is processing in a contingency mode. In some cases, the need may increase due to sharing processing facilities, concentrating resources in fewer sites, or using additional contractors and consultants. Security should be an important consideration when selecting contingency strategies.

11.4.4 Computer-Based Services

Service providers may offer contingency services. Voice communications carriers often can reroute calls (transparently to the user) to a new location. Data communications carriers can also reroute traffic. Hot sites are usually capable of receiving data and voice communications. If one service provider is down, it may be possible to use another. However, the type of communications carrier lost, either local or long distance, is important. Local voice service may be carried on cellular. Local data communications, especially for large volumes, is normally more difficult. In addition, resuming normal operations may require another rerouting of communications services.

11.4.5 Physical Infrastructure

Hot sites and cold sites may also offer office space in addition to processing capability support. Other types of contractual arrangements can be made for office space, security services, furniture, and more in the event of a contingency. If the contingency plan calls for moving offsite, procedures need to be developed to ensure a smooth transition back to the primary operating facility or to a new facility. Protection of the physical infrastructure is normally an important part of the emergency response plan, such as use of fire extinguishers or protecting equipment from water damage.

11.4.6 Documents and Papers

The primary contingency strategy is usually backup onto magnetic, optical, microfiche, paper, or other medium and offsite storage. Paper documents are generally harder to backup than electronic ones. A supply of forms and other needed papers can be stored offsite.

11.5 Step 5: Implementing the Contingency Strategies

Once the contingency planning strategies have been selected, it is necessary to make appropriate preparations, document the strategies, and train employees. Many of these tasks are ongoing.

11.5.1 Implementation

Much preparation is needed to implement the strategies for protecting critical functions and their supporting resources. For example, one common preparation is to establish procedures for backing up files and applications. Another is to establish contracts and agreements, *if* the contingency strategy calls for them. Existing service contracts may need to be renegotiated to add contingency services. Another preparation may be to purchase equipment, especially to support a redundant capability.

It is important to keep preparations, including documentation, up-to-date. Computer systems change rapidly and so should backup services and redundant equipment. Contracts and agreements may also need to reflect the changes. If additional equipment is needed, it must be maintained and periodically replaced when it is no longer dependable or no longer fits the organization's architecture.

Backing up data files and applications is a critical part of virtually every contingency plan. Backups are used, for example, to restore files after a personal computer virus corrupts the files or after a hurricane destroys a data processing center.

Preparation should also include formally designating people who are responsible for various tasks in the event of a contingency. These people are often referred to as the contingency response team. This team is often composed of people who were a part of the contingency planning team.

There are many important implementation issues for an organization. Two of the most important are 1) how many plans should be developed? and 2) who prepares each plan? Both of these questions revolve around the organization's overall strategy for contingency planning. The answers should be documented in organization policy and procedures.

How Many Plans?

Some organizations have just one plan for the entire organization, and others have a plan for every distinct computer system, application, or other resource. Other approaches recommend a plan for each business or mission function, with separate plans, as needed, for critical resources.

Relationship Between Contingency Plans and Computer Security Plans

For small or less complex systems, the contingency plan may be a part of the computer security plan. For larger or more complex systems, the computer security plan could contain a brief synopsis of the contingency plan, which would be a separate document.

The answer to the question, therefore, depends upon the unique circumstances for each organization. But it is critical to coordinate between resource managers and functional managers who are responsible for the mission or business.

Who Prepares the Plan?

If an organization decides on a centralized approach to contingency planning, it may be best to name a *contingency planning coordinator.* The coordinator prepares the plans in cooperation with various functional and resource managers. Some organizations place responsibility directly with the functional and resource managers.

11.5.2 Documenting

The contingency plan needs to be written, kept up-to-date as the system and other factors change, and stored in a safe place. A written plan is critical during a contingency, especially if the person who developed the plan is unavailable. It should clearly state in simple language the sequence of tasks to be performed in the event of a contingency so that someone with minimal knowledge could immediately begin to execute the plan. It is generally helpful to store up-to-date copies of the contingency plan in several locations, including any off-site locations, such as alternate processing sites or backup data storage facilities.

11.5.3 Training

All personnel should be trained in their contingency-related duties. New personnel should be trained as they join the organization, refresher training may be needed, and personnel will need to practice their skills.

Training is particularly important for effective employee response during emergencies. There is no time to check a manual to determine correct procedures if there is a fire. Depending on the nature of the emergency, there may or may not be time to protect equipment and other assets. Practice is necessary in order to react correctly, especially when human safety is involved.

11.6 Step 6: Testing and Revising

Contingency plan maintenance can be incorporated into procedures for change management so that upgrades to hardware and software are reflected in the plan.

A contingency plan should be tested periodically because there will undoubtedly be flaws in the plan and in its implementation. The plan will become dated as time passes and as the resources used to support critical functions change. Responsibility for keeping the contingency plan current should be specifically assigned. The extent and frequency of testing will vary between organizations and among systems. There are several types of testing, including reviews, analyses, and simulations of disasters.

A *review* can be a simple test to check the accuracy of contingency plan documentation. For instance, a reviewer could check if individuals listed are still in the organization and still have the responsibilities that caused them to be included in the plan. This test can check home and work telephone numbers, organizational codes, and building and room numbers. The review can determine if files can be restored from backup tapes or if employees know emergency procedures.

An *analysis* may be performed on the entire plan or portions of it, such as emergency response procedures. It is beneficial if the analysis is performed by someone who did *not* help develop the contingency plan but has a good working knowledge of the critical function and supporting resources. The analyst(s) may mentally follow the strategies in the contingency plan, looking for flaws in the logic or process used by the plan's developers. The analyst may also interview functional managers, resource managers, and their staff to uncover missing or unworkable pieces of the plan.

> The results of a "test" often implies a grade assigned for a specific level of performance, or simply pass or fail. However, in the case of contingency planning, a test should be used to improve the plan. If organizations do not use this approach, flaws in the plan may remain hidden and uncorrected.

Organizations may also arrange *disaster simulations*. These tests provide valuable information about flaws in the contingency plan and provide practice for a real emergency. While they can be expensive, these tests can also provide critical information that can be used to ensure the continuity of important functions. In general, the more critical the functions and the resources addressed in the contingency plan, the more cost-beneficial it is to perform a disaster simulation.

11.7 Interdependencies

Since all controls help to prevent contingencies, there is an interdependency with all of the controls in the handbook.

Risk Management provides a tool for analyzing the security costs and benefits of various contingency planning options. In addition, a risk management effort can be used to help identify critical resources needed to support the organization and the likely threat to those resources. It is not necessary, however, to perform a risk assessment prior to contingency planning, since the identification of critical resources can be performed during the contingency planning process itself.

Physical and Environmental Controls help prevent contingencies. Although many of the other controls, such as logical access controls, also prevent contingencies, the major threats that a contingency plan addresses are physical and environmental threats, such as fires, loss of power, plumbing breaks, or natural disasters.

Incident Handling can be viewed as a subset of contingency planning. It is the emergency response capability for various technical threats. Incident handling can also help an organization prevent future incidents.

Support and Operations in most organizations includes the periodic backing up of files. It also

includes the prevention and recovery from more common contingencies, such as a disk failure or corrupted data files.

Policy is needed to create and document the organization's approach to contingency planning. The policy should explicitly assign responsibilities.

11.8 Cost Considerations

The cost of developing and implementing contingency planning strategies can be significant, especially if the strategy includes contracts for backup services or duplicate equipment. There are too many options to discuss cost considerations for each type.

One contingency cost that is often overlooked is the cost of testing a plan. Testing provides many benefits and should be performed, although some of the less expensive methods (such as a review) may be sufficient for less critical resources.

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Chapter 12

COMPUTER SECURITY INCIDENT HANDLING

Computer systems are subject to a wide range of mishaps – from corrupted data files, to viruses, to natural disasters. Some of these mishaps can be fixed through standard operating procedures. For example, frequently occurring events (e.g., a mistakenly deleted file) can usually be readily repaired (e.g., by restoration from the backup file). More severe mishaps, such as outages caused by natural disasters, are normally addressed in an organization's contingency plan. Other damaging events result from *deliberate malicious technical activity* (e.g., the creation of viruses or system hacking).

A computer security incident can result from a computer virus, other malicious code, or a system intruder, either an insider or an outsider. It is used in this chapter to broadly refer to those incidents resulting from deliberate malicious technical activity.[90] It can more generally refer to those incidents that, without technically expert response, could result in severe damage.[91] This definition of a computer security incident is somewhat flexible and may vary by organization and computing environment.

> Malicious code include viruses as well as Trojan horses and worms. A virus is a code segment that replicates by attaching copies of itself to existing executables. A Trojan horse is a program that performs a desired task, but also includes unexpected functions. A worm is a self-replicating program.

Although the threats that hackers and malicious code pose to systems and networks are well known, the occurrence of such harmful events remains unpredictable. Security incidents on larger networks (e.g., the Internet), such as break-ins and service disruptions, have harmed various organizations' computing capabilities. When initially confronted with such incidents, most organizations respond in an *ad hoc* manner. However recurrence of similar incidents often makes it cost-beneficial to develop a standing capability for quick discovery of and response to such events. This is especially true, since incidents can often "spread" when left unchecked thus increasing damage and seriously harming an organization.

Incident handling is closely related to contingency planning as well as support and operations. An incident handling capability may be viewed as a component of contingency planning, because it provides the ability to react quickly and efficiently to disruptions in normal processing. Broadly speaking, contingency planning addresses events with the potential to interrupt system operations. Incident handling can be considered that portion of contingency planning that responds to

[90] Organizations may wish to expand this to include, for example, incidents of theft.

[91] Indeed, damage may result, despite the best efforts to the contrary.

malicious technical threats.

This chapter describes how organizations can address computer security incidents (in the context of their larger computer security program) by developing a *computer security incident handling capability.*[92]

Many organizations handle incidents as part of their user support capability (discussed in Chapter 14) or as a part of general system support.

12.1 Benefits of an Incident Handling Capability

The primary benefits of an incident handling capability are *containing* and *repairing* damage from incidents, and *preventing* future damage. In addition, there are less obvious side benefits related to establishing an incident handling capability.

12.1.1 Containing and Repairing Damage From Incidents

When left unchecked, malicious software can significantly harm an organization's computing, depending on the technology and its connectivity. An incident handling capability provides a way for users to report incidents[93] and the appropriate response and assistance to be provided to aid in recovery. Technical capabilities (e.g., trained personnel and virus identification software) are prepositioned, ready to be used as necessary. Moreover, the organization will have already made important contacts with other supportive sources (e.g., legal, technical, and managerial) to aid in containment and recovery efforts.

Some organizations suffer repeated outbreaks of viruses because the viruses are never completely eradicated. For example suppose two LANs, Personnel and Budget, are connected, and a virus has spread within each. The administrators of each LAN detect the virus and decide to eliminate it on their LAN. The Personnel LAN administrator first eradicates the virus, but since the Budget LAN is not yet virus-free, the Personnel LAN is reinfected. Somewhat later, the Budget LAN administrator eradicates the virus. However, the virus reinfects the Budget LAN from the Personnel LAN. Both administrators may think all is well, but both are reinfected. An incident handling capability allows organizations to address recovery and containment of such incidents in a skilled, coordinated manner.

Without an incident handling capability, certain responses – although well intentioned – can actually make matters worse. In some cases, individuals have unknowingly infected anti-virus software with viruses and then spread them to

[92] See NIST Special Publication 800-3, *Establishing an Incident Response Capability*, November 1991.

[93] A good incident handling capability is closely linked to an organization's training and awareness program. It will have educated users about such incidents and what to do when they occur. This can increase the likelihood that incidents will be reported early, thus helping to minimize damage.

other systems. When viruses spread to local area networks (LANs), most or all of the connected computers can be infected within hours. Moreover, *uncoordinated* efforts to rid LANs of viruses can prevent their eradication.

Many organizations use large LANs internally and also connect to public networks, such as the Internet. By doing so, organizations increase their exposure to threats from intruder activity, especially if the organization has a high profile (e.g., perhaps it is involved in a controversial program). An incident handling capability can provide enormous benefits by responding quickly to suspicious activity and coordinating incident handling with responsible offices and individuals, as necessary. Intruder activity, whether hackers or malicious code, can often affect many systems located at many different network sites; thus, handling the incidents can be logistically complex and can require information from outside the organization. By planning ahead, such contacts can be preestablished and the speed of response improved, thereby containing and minimizing damage. Other organizations may have already dealt with similar situations and may have very useful guidance to offer in speeding recovery and minimizing damage.

12.1.2 Preventing Future Damage

An incident handling capability also assists an organization in preventing (or at least minimizing) damage from future incidents. Incidents can be studied internally to gain a better understanding of the organizations's threats and vulnerabilities so more effective safeguards can be implemented. Additionally, through outside contacts (established by the incident handling capability) early warnings of threats and vulnerabilities can be provided. Mechanisms will already be in place to warn users of these risks.

The incident handling capability allows an organization to learn from the incidents that it has experienced. Data about past incidents (and the corrective measures taken) can be collected. The data can be analyzed for patterns – for example, which viruses are most prevalent, which corrective actions are most successful, and which systems and information are being targeted by hackers. Vulnerabilities can also be identified in this process – for example, whether damage is occurring to systems when a new software package or patch is used. Knowledge about the types of threats that are occurring and the presence of vulnerabilities can aid in identifying security solutions. This information will also prove useful in creating a more effective training and awareness program, and thus help reduce the potential for losses. The incident handling capability assists the training and awareness program by providing information to users as to (1) measures that can help avoid incidents (e.g., virus scanning) and (2) what should be done in case an incident does occur.

Of course, the organization's attempts to prevent future losses does not occur in a vacuum. With a sound incident handling

> The sharing of incident data among organizations can help at both the national and the international levels to prevent and respond to breaches of security in a timely, coordinated manner.