COURSE TECHNOLOGY
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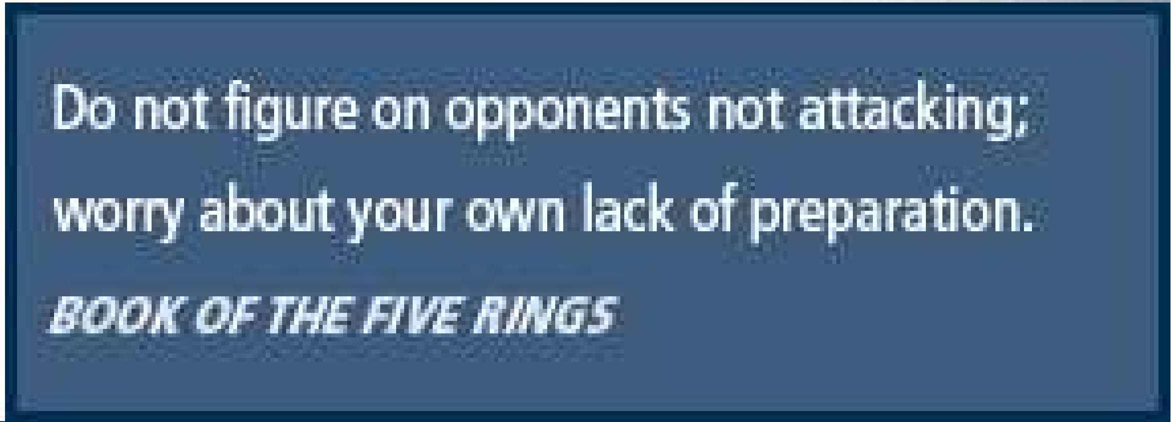
Principles of Information Security, Fifth Edition

Chapter 1
Introduction to Information Security



Do not figure on opponents not attacking; worry about your own lack of preparation.

BOOK OF THE FIVE RINGS

Learning Objectives

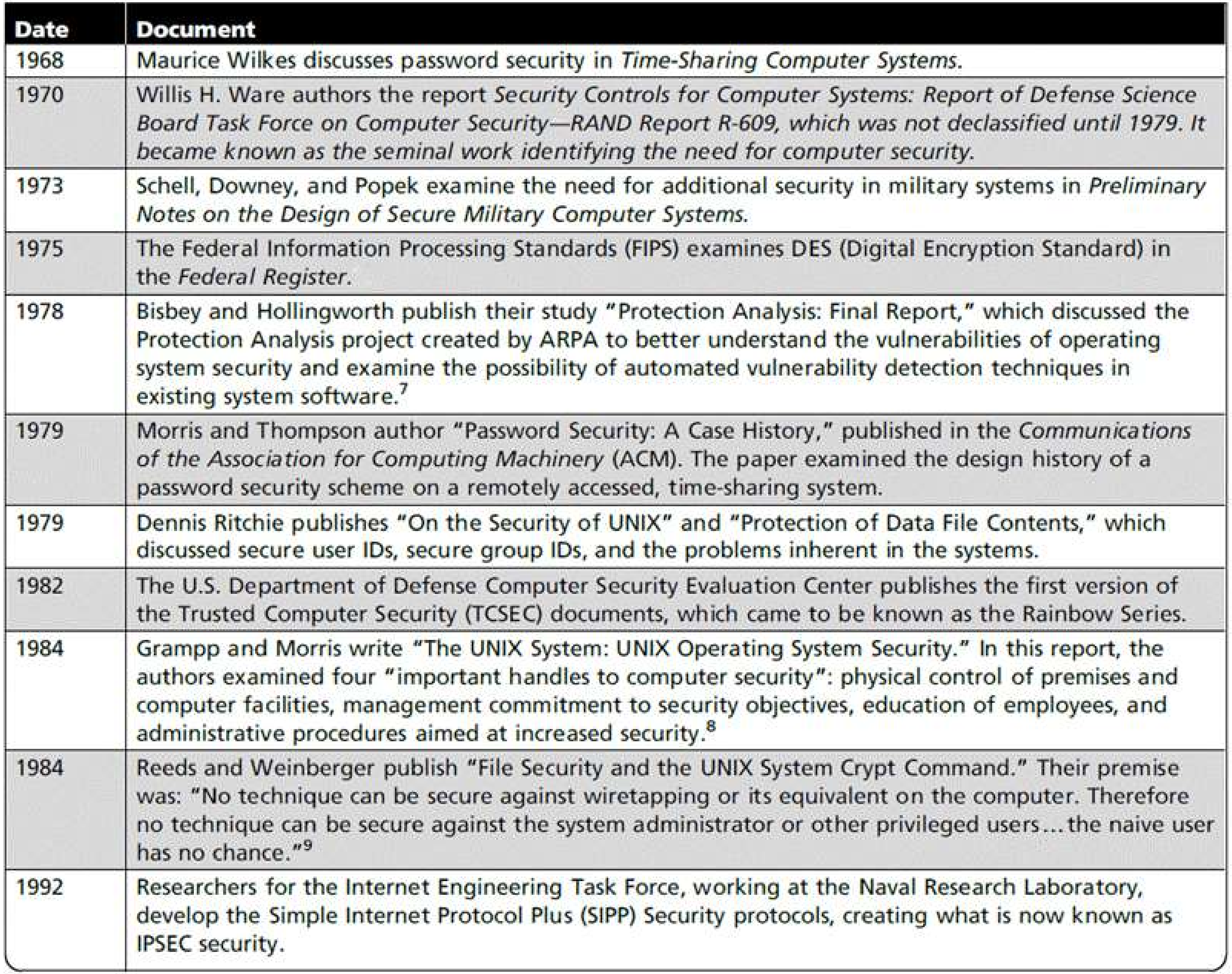
- Upon completion of this material, you should be able to:
  - Define information security
  - Recount the history of computer security and how it evolved into information security
  - Define key terms and critical concepts of information security
  - List the phases of the security systems development life cycle
  - Describe the information security roles of professionals within an organization

Introduction

- Information security: a “well-informed sense of assurance that the information risks and controls are in balance.”—Jim Anderson, Emagined Security, Inc.
- Security professionals must review the origins of this field to understand its impact on our understanding of information security today.

The History of Information Security

- Computer security began immediately after the first mainframes were developed.
  - Groups developing code-breaking computations during World War II created the first modern computers.
  - Multiple levels of security were implemented.
- Physical controls limiting access to sensitive military locations to authorized personnel
- Rudimentary in defending against physical theft, espionage, and sabotage



Date	Document
1968	Maurice Wilkes discusses password security in *Time-Sharing Computer Systems.*
1970	Willis H. Ware authors the report *Security Controls for Computer Systems: Report of Defense Science Board Task Force on Computer Security—RAND Report R-609, which was not declassified until 1979. It became known as the seminal work identifying the need for computer security.*
1973	Schell, Downey, and Popek examine the need for additional security in military systems in *Preliminary Notes on the Design of Secure Military Computer Systems.*
1975	The Federal Information Processing Standards (FIPS) examines DES (Digital Encryption Standard) in the *Federal Register.*
1978	Bisbey and Hollingworth publish their study "Protection Analysis: Final Report," which discussed the Protection Analysis project created by ARPA to better understand the vulnerabilities of operating system security and examine the possibility of automated vulnerability detection techniques in existing system software.[7]
1979	Morris and Thompson author "Password Security: A Case History," published in the *Communications of the Association for Computing Machinery* (ACM). The paper examined the design history of a password security scheme on a remotely accessed, time-sharing system.
1979	Dennis Ritchie publishes "On the Security of UNIX" and "Protection of Data File Contents," which discussed secure user IDs, secure group IDs, and the problems inherent in the systems.
1982	The U.S. Department of Defense Computer Security Evaluation Center publishes the first version of the Trusted Computer Security (TCSEC) documents, which came to be known as the Rainbow Series.
1984	Grampp and Morris write "The UNIX System: UNIX Operating System Security." In this report, the authors examined four "important handles to computer security": physical control of premises and computer facilities, management commitment to security objectives, education of employees, and administrative procedures aimed at increased security.[8]
1984	Reeds and Weinberger publish "File Security and the UNIX System Crypt Command." Their premise was: "No technique can be secure against wiretapping or its equivalent on the computer. Therefore no technique can be secure against the system administrator or other privileged users...the naive user has no chance."[9]
1992	Researchers for the Internet Engineering Task Force, working at the Naval Research Laboratory, develop the Simple Internet Protocol Plus (SIPP) Security protocols, creating what is now known as IPSEC security.

Table 1-1 Key Dates in Information Security

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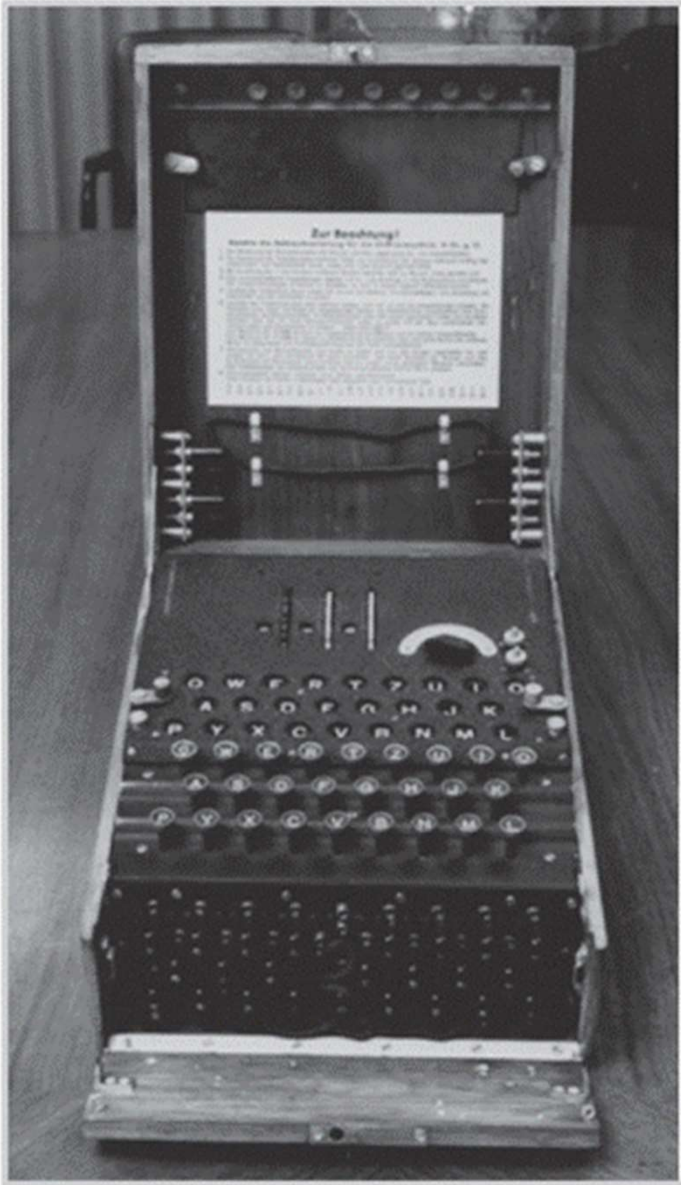


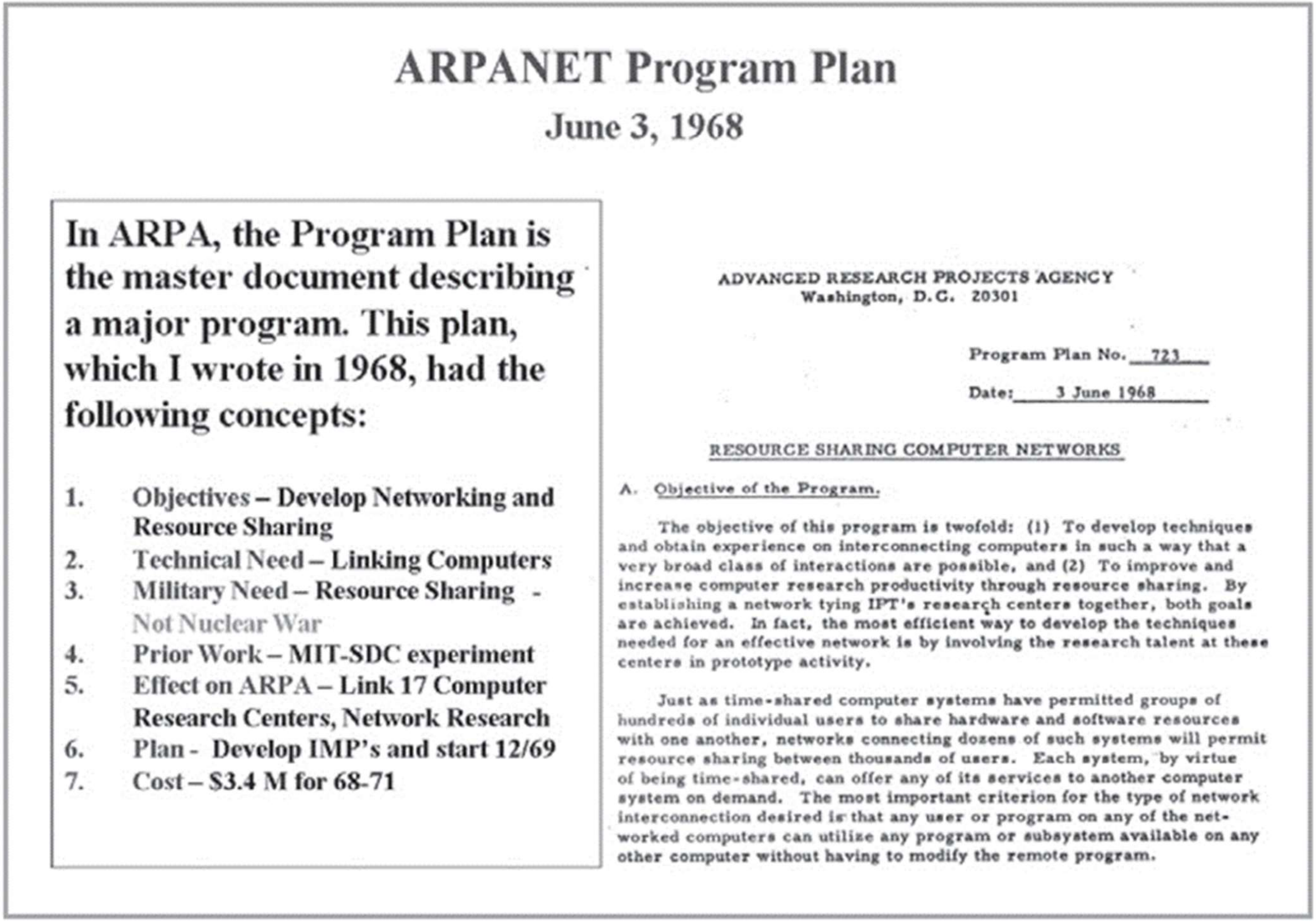
Earlier versions of the German code machine Enigma were first broken by the Poles in the 1930s. The British and Americans managed to break later, more complex versions during World War II. The increasingly complex versions of the Enigma, especially the submarine or *Unterseeboot* version of the Enigma, caused considerable anguish to Allied forces before finally being cracked. The information gained from decrypted transmissions was used to anticipate the actions of German armed forces. "Some ask why, if we were reading the Enigma, we did not win the war earlier. One might ask, instead, when, if ever, we would have won the war if we hadn't read it."

Figure 1-1 The Enigma[1]

Source: National Security Agency. Used with permission.[2]

The 1960s

- Advanced Research Project Agency (ARPA) began to examine the feasibility of redundant networked communications.
- Larry Roberts developed the ARPANET from its inception.



ARPANET Program Plan

June 3, 1968

In ARPA, the Program Plan is the master document describing a major program. This plan, which I wrote in 1968, had the following concepts:

1. Objectives – Develop Networking and Resource Sharing
2. Technical Need – Linking Computers
3. Military Need – Resource Sharing - Not Nuclear War
4. Prior Work – MIT-SDC experiment
5. Effect on ARPA – Link 17 Computer Research Centers, Network Research
6. Plan - Develop IMP's and start 12/69
7. Cost – $3.4 M for 68-71

ADVANCED RESEARCH PROJECTS AGENCY
Washington, D.C. 20301

Program Plan No. 723

Date: 3 June 1968

RESOURCE SHARING COMPUTER NETWORKS

A. Objective of the Program.

The objective of this program is twofold: (1) To develop techniques and obtain experience on interconnecting computers in such a way that a very broad class of interactions are possible, and (2) To improve and increase computer research productivity through resource sharing. By establishing a network tying IPT's research centers together, both goals are achieved. In fact, the most efficient way to develop the techniques needed for an effective network is by involving the research talent at these centers in prototype activity.

Just as time-shared computer systems have permitted groups of hundreds of individual users to share hardware and software resources with one another, networks connecting dozens of such systems will permit resource sharing between thousands of users. Each system, by virtue of being time-shared, can offer any of its services to another computer system on demand. The most important criterion for the type of network interconnection desired is that any user or program on any of the networked computers can utilize any program or subsystem available on any other computer without having to modify the remote program.

Figure 1-2 Development of the ARPANET

Source: Courtesy of Dr. Lawrence Roberts. Used with permission.[4]

The 1970s and 80s

- ARPANET grew in popularity, as did its potential for misuse.
- Fundamental problems with ARPANET security were identified.
  - No safety procedures for dial-up connections to ARPANET
  - Nonexistent user identification and authorization to system

The 1970s and 80s (cont'd)

- Information security began with Rand Report R-609 (paper that started the study of computer security and identified the role of management and policy issues in it).
- The scope of computer security grew from physical security to include:
  - Securing the data
  - Limiting random and unauthorized access to data
  - Involving personnel from multiple levels of the organization in information security

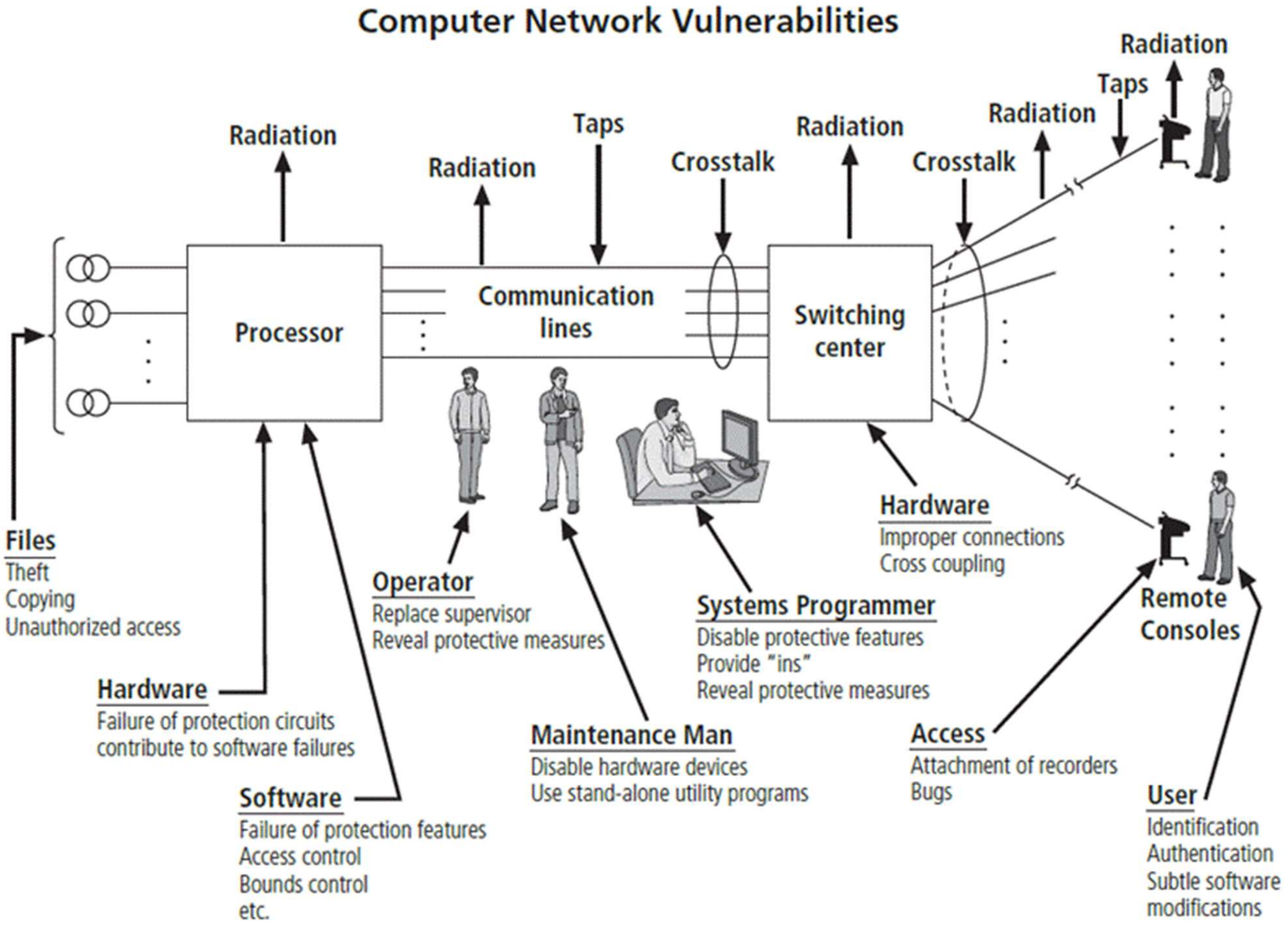


Figure 1-4 Illustration of computer network vulnerabilities from Rand Report R-609

Source: Rand Report R-609. Used with permission.[10]

MULTICS

- Early focus of computer security research centered on a system called Multiplexed Information and Computing Service (MULTICS).
- First operating system was created with security integrated into core functions.
- Mainframe, time-sharing OS was developed in the mid-1960s by General Electric (GE), Bell Labs, and Massachusetts Institute of Technology (MIT).
- Several MULTICS key players created UNIX.
  - Primary purpose of UNIX was text processing.
- Late 1970s: The microprocessor expanded computing capabilities and security threats.

The 1990s

- Networks of computers became more common, as did the need to connect them to each other.
- Internet became the first global network of networks.
- Initially, network connections were based on de facto standards.
- In early Internet deployments, security was treated as a low priority.
- In 1993, DEFCON conference was established for those interested in information security.

2000 to Present

- The Internet brings millions of unsecured computer networks into continuous communication with each other.
- The ability to secure a computer's data was influenced by the security of every computer to which it is connected.
- Growing threat of cyber attacks has increased the awareness of need for improved security.
  - Nation-states engaging in information warfare

What Is Security?

- “A state of being secure and free from danger or harm; the actions taken to make someone or something secure.”
- A successful organization should have multiple layers of security in place to protect:
  - Operations
  - Physical infrastructure
  - People
  - Functions
  - Communications
  - Information

What Is Security? (cont'd)

- The protection of information and its critical elements, including systems and hardware that use, store, and transmit that information
- Includes information security management, data security, and network security
- C.I.A. triangle
  - Is a standard based on confidentiality, integrity, and availability, now viewed as inadequate.
  - Expanded model consists of a list of critical characteristics of information.

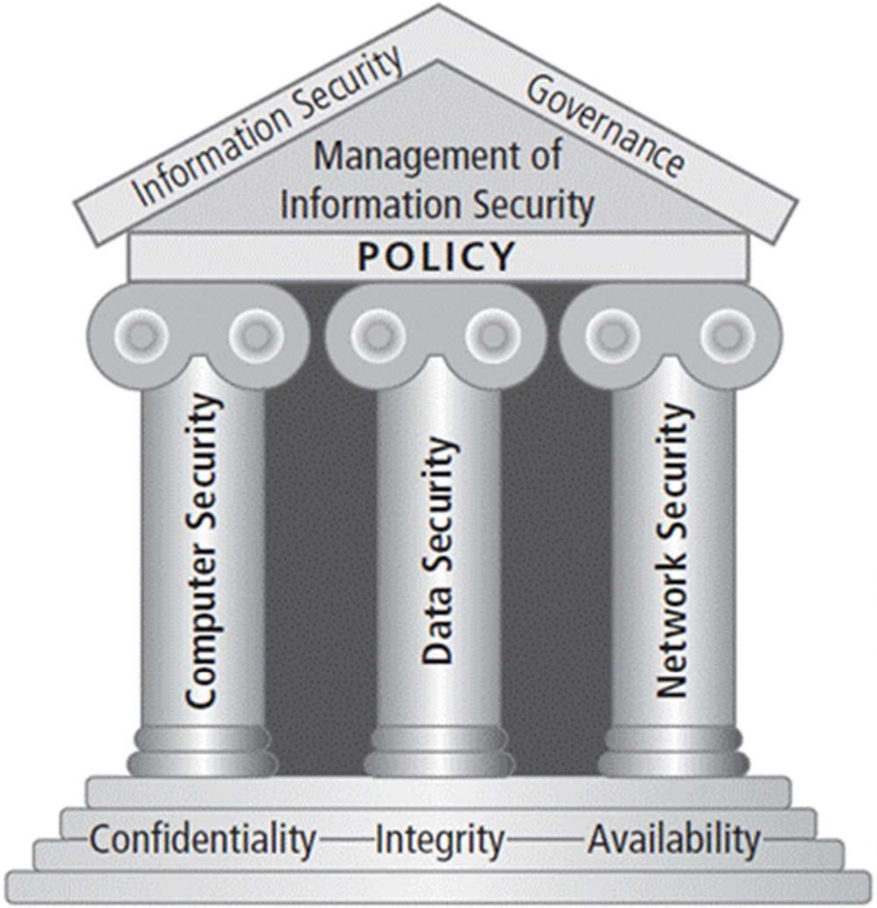


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Figure 1-5 Components of information security

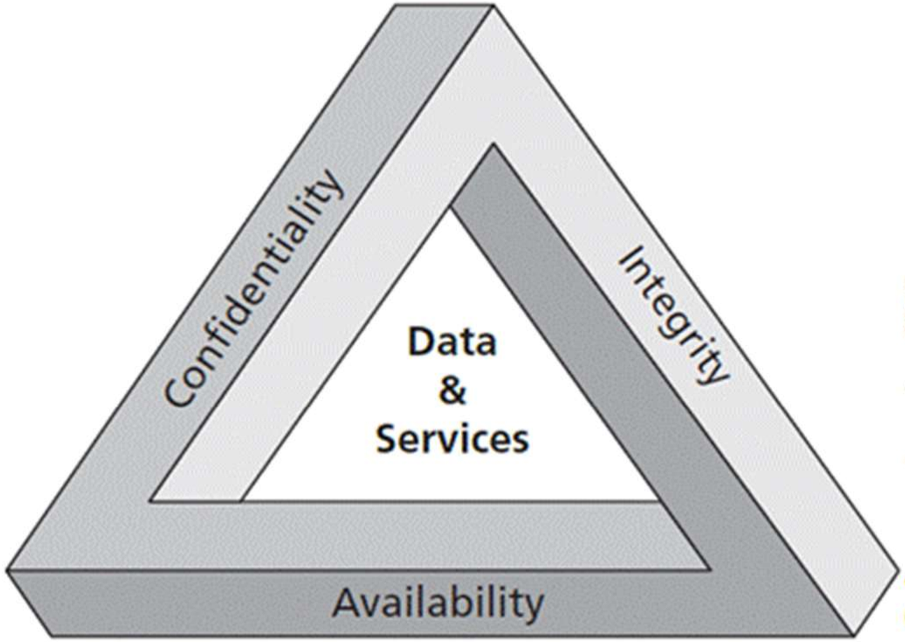

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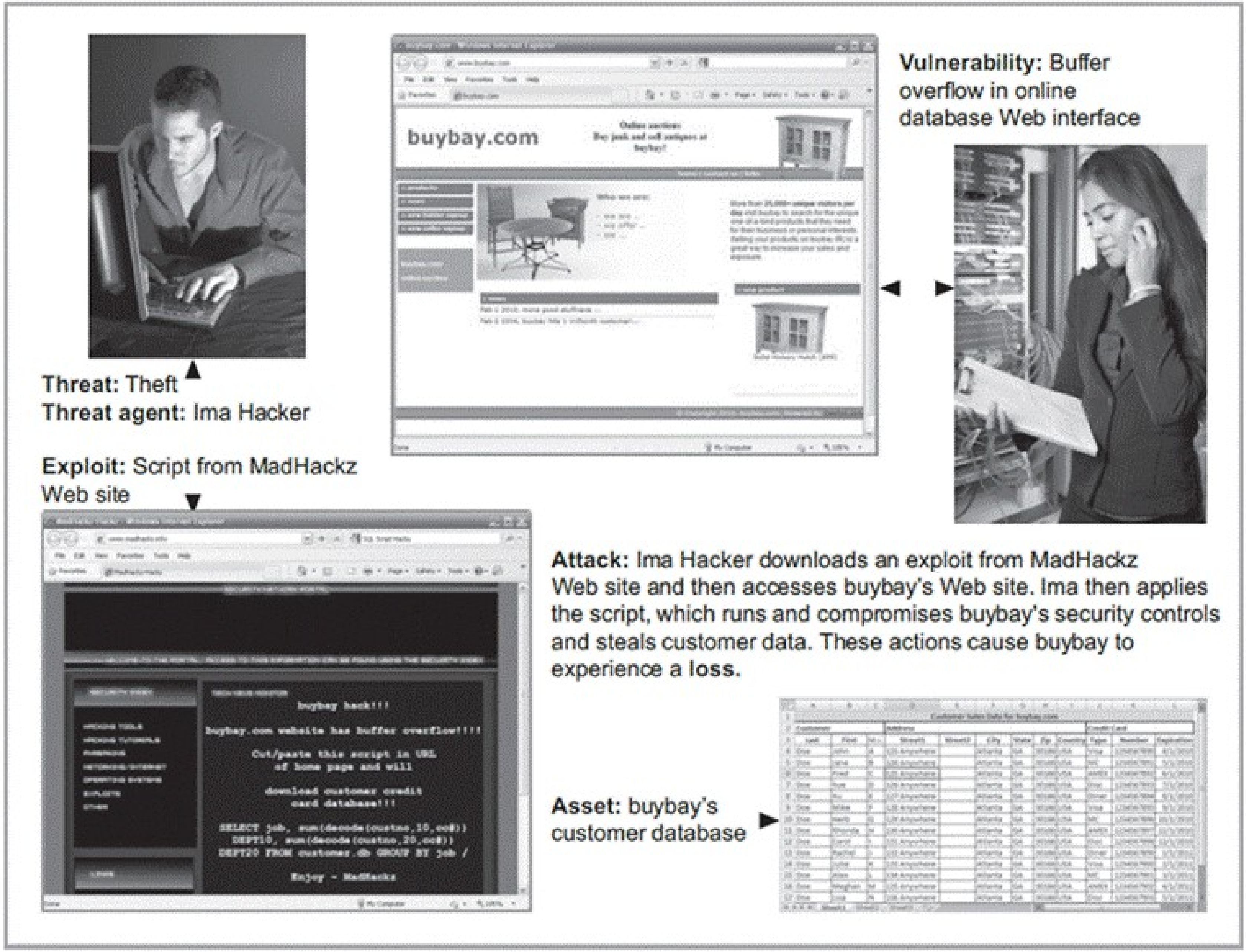
Figure 1-6 The C.I.A. triangle

Key Information Security Concepts

- Access
- Asset
- Attack
- Control, safeguard, or countermeasure
- Exploit
- Exposure
- Loss
- Protection profile or security posture
- Risk
- Subjects and objects
- Threat
- Threat agent
- Vulnerability



Threat: Theft
Threat agent: Ima Hacker

Exploit: Script from MadHackz Web site

Vulnerability: Buffer overflow in online database Web interface

```
buybay hack!!!

buybay.com website has buffer overflow!!!!

Cut/paste this script in URL
of home page and will

download customer credit
card database!!!

SELECT job, sum(decode(custno,10,cc#))
DEPT10, sum(decode(custno,20,cc#))
DEPT20 FROM customer.db GROUP BY job /

Enjoy - MadHackz
```

Attack: Ima Hacker downloads an exploit from MadHackz Web site and then accesses buybay's Web site. Ima then applies the script, which runs and compromises buybay's security controls and steals customer data. These actions cause buybay to experience a **loss.**

Asset: buybay's customer database

Figure 1-7 Key concepts in information security

Sources (top left to bottom right): © iStockphoto/tadija, Internet Explorer, © iStockphoto/darrenwise, Internet Explorer, Microsoft Excel.

Key Information Security Concepts (cont’d)

- A computer can be the subject of an attack and/or the object of an attack.
  - When the subject of an attack, the computer is used as an active tool to conduct attack.
  - When the object of an attack, the computer is the entity being attacked.

Critical Characteristics of Information

- The value of information comes from the characteristics it possesses:
  - Availability
  - Accuracy
  - Authenticity
  - Confidentiality
  - Integrity
  - Utility
  - Possession

CNSS Security Model

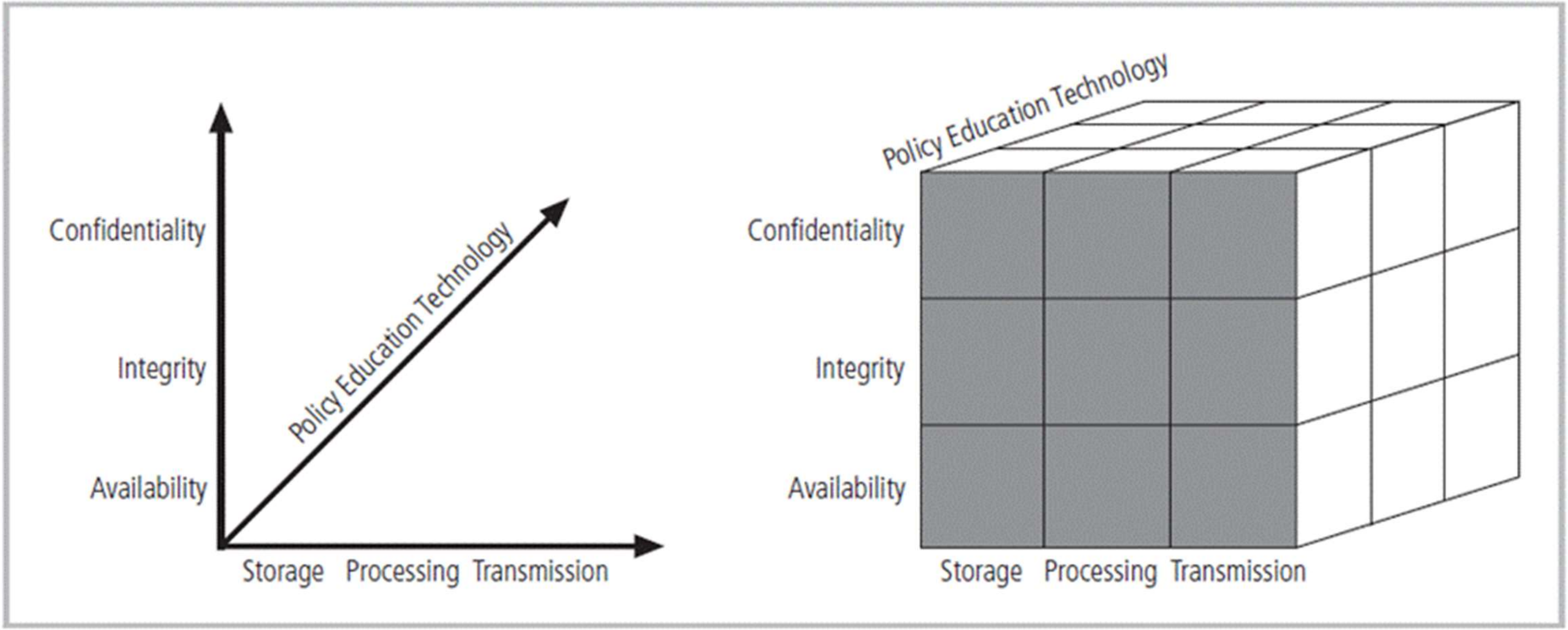


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Figure 1-9 The McCumber Cube[13]

Components of an Information System

- Information system (IS) is the entire set of people, procedures, and technology that enable business to use information.
  - Software
  - Hardware
  - Data
  - People
  - Procedures
  - Networks

Balancing Information Security and Access

- Impossible to obtain perfect information security—it is a process, not a goal.
- Security should be considered a balance between protection and availability.
- To achieve balance, the level of security must allow reasonable access, yet protect against threats.

Approaches to Information Security Implementation: Bottom-Up Approach

- Grassroots effort: Systems administrators attempt to improve security of their systems.
- Key advantage: technical expertise of individual administrators
- Seldom works, as it lacks a number of critical features:
  - Participant support
  - Organizational staying power

Approaches to Information Security Implementation: Top-Down Approach

- Initiated by upper management
  - Issue policy, procedures, and processes
  - Dictate goals and expected outcomes of project
  - Determine accountability for each required action
- The most successful type of top-down approach also involves a formal development strategy referred to as systems development life cycle.

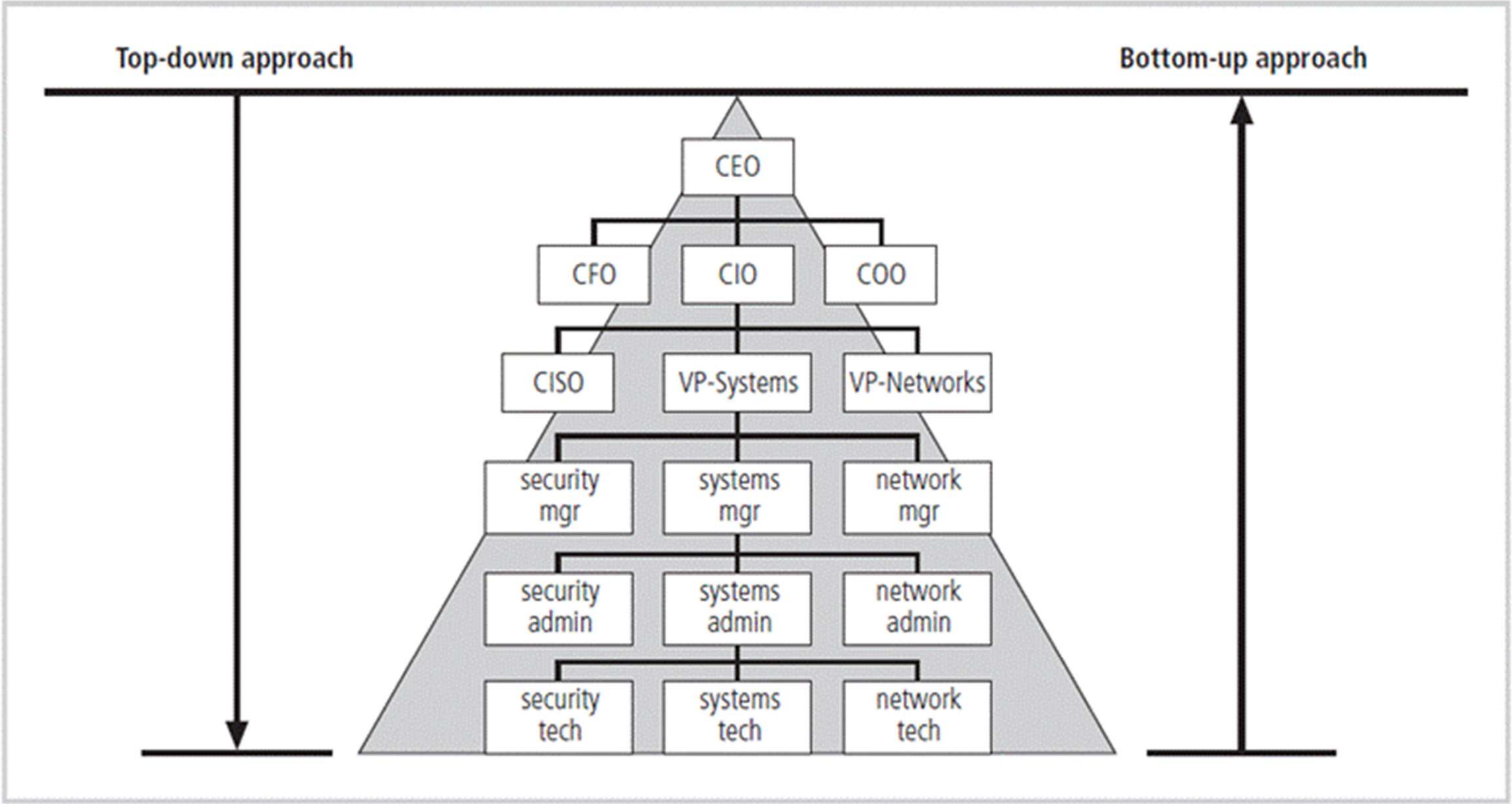

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Figure 1-12 Approaches to information security implementation

The Systems Development Life Cycle

- Systems development life cycle (SDLC): a methodology for the design and implementation of an information system
- Methodology: a formal approach to solving a problem based on a structured sequence of procedures
- Using a methodology:
  - Ensures a rigorous process with a clearly defined goal
  - Increases probability of success
- Traditional SDLC consists of six general phases.

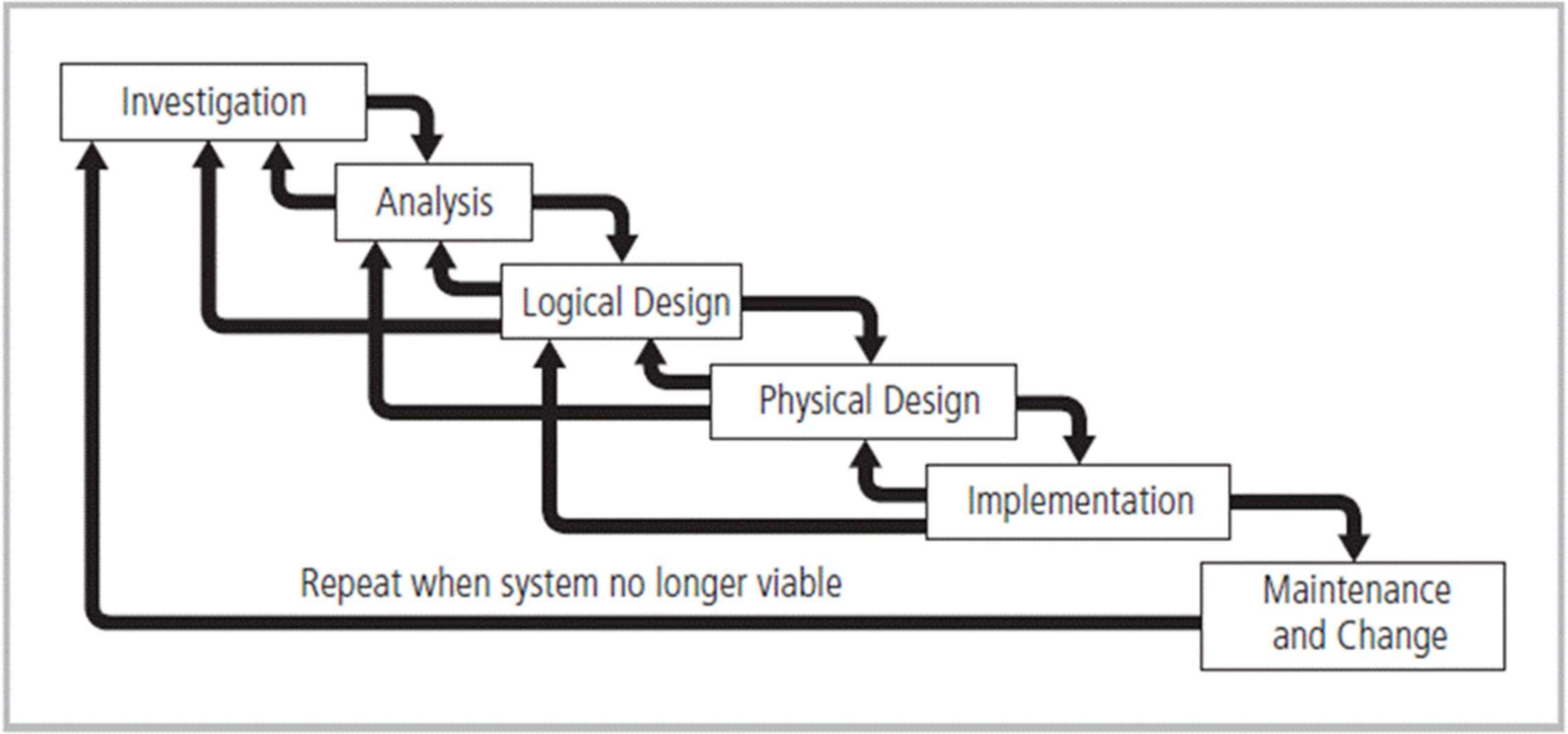

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Figure 1-13 SDLC waterfall methodology

Investigation

- What problem is the system being developed to solve?
- Objectives, constraints, and scope of project are specified.
- Preliminary cost-benefit analysis is developed.
- At the end of all phases, a process is undertaken to assess economic, technical, and behavioral feasibilities and ensure implementation is worth the time and effort.

Analysis

- Consists of assessments of:
  - The organization
  - Current systems
  - Capability to support proposed systems
- Analysts determine what new system is expected to do and how it will interact with existing systems.
- Analysis ends with documentation of findings and an update of feasibility.

Logical Design

- The first and driving factor is the business need.
  - Applications are selected to provide needed services.
- Data support and structures capable of providing the needed inputs are identified.
- Specific technologies are delineated to implement the physical solution.
- Analysts generate estimates of costs and benefits to allow comparison of available options.
- Feasibility analysis is performed at the end.

Physical Design

- Specific technologies are selected to support the alternatives identified and evaluated in the logical design.
- Selected components are evaluated on make-or-buy decision.
- Feasibility analysis is performed.
  - Entire solution is presented to organization's management for approval.

Implementation

- Needed software is created.
- Components are ordered, received, and tested.
- Users are trained and supporting documentation created.
- Feasibility analysis is prepared.
  - Sponsors are presented with the system for a performance review and acceptance test.

Maintenance and Change

- Longest and most expensive phase
- Consists of the tasks necessary to support and modify the system for the remainder of its useful life
- Life cycle continues until the team determines the process should begin again from the investigation phase.
- When current system can no longer support the organization’s mission, a new project is implemented.

The Security Systems Development Life Cycle (SecSDLC)

- The same phases used in traditional SDLC can be adapted to support implementation of an IS project.
- It involves identifying specific threats and creating specific controls to counter them.
- SecSDLC is a coherent program rather than a series of random, seemingly unconnected actions.

Investigation

- Identifies process, outcomes, goals, and constraints of the project
- Begins with an enterprise information security policy (EISP)
  - Outlines implementation of a security program within the organization
- Organizational feasibility analysis is performed.

Analysis

- Documents from investigation phase are studied.
- Preliminary analysis of existing security policies or programs, along with documented current threats and associated controls
- Includes analysis of relevant legal issues that could affect design of the security solution
- Risk management begins.

Logical Design

- Creates and develops blueprints for information security; examines and implements key policies
- Incident response actions planned:
  - Continuity planning
  - Incident response
  - Disaster recovery
- Feasibility analysis to determine whether project should be continued or outsourced

Physical Design

- Evaluates information security technology needed to support blueprint, as outlined in logical design
- Final physical design chosen.
- At end of phase, feasibility study determines readiness of organization for project.
  - Champion and sponsors presented with design for approval

Implementation

- Security solutions are acquired, tested, implemented, and tested again.
- Personnel issues are evaluated; specific training and education programs are conducted.
- Entire tested package is presented to upper management for final approval.

Maintenance and Change

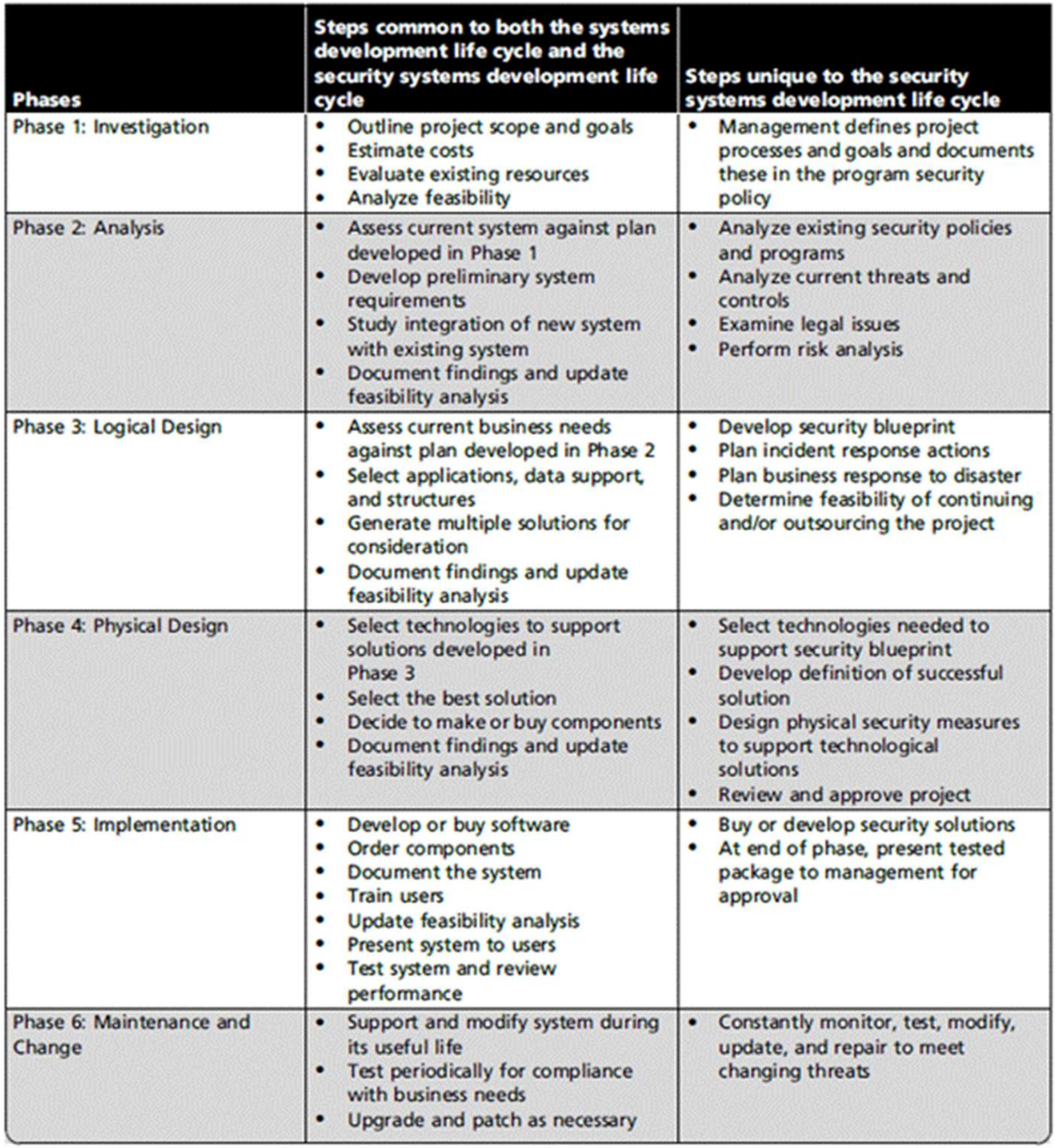
- Perhaps the most important phase, given the ever-changing threat environment.
- Often, repairing damage and restoring information is a constant effort against an unseen adversary.
- Information security profile of an organization requires constant adaptation as new threats emerge and old threats evolve.

Software Assurance—Security in the SDLC

- Many organizations recognize the need to include planning for security objectives in the SDLC used to create systems.
  - Established procedures to create software that is more capable of being deployed in a secure fashion
- This approach is known as software assurance (SA).
- Software Assurance Initiative resulted in the publication of Secure Software Assurance (SwA) Common Body of Knowledge (CBK).

Software Assurance—Security in the SDLC (cont’d)

- SwA CBK, which is a work in progress, contains the following sections:
  - Nature of Dangers
  - Fundamental Concepts and Principles
  - Ethics, Law, and Governance
  - Secure Software Requirements
  - Secure Software Design
  - Secure Software Construction
  - Secure Software Verification, Validation, and Evaluation
  - Secure Software Tools and Methods
  - Secure Software Processes
  - Secure Software Project Management
  - Acquisition of Secure Software
  - Secure Software Sustainment



Phases	Steps common to both the systems development life cycle and the security systems development life cycle	Steps unique to the security systems development life cycle
Phase 1: Investigation	• Outline project scope and goals • Estimate costs • Evaluate existing resources • Analyze feasibility	• Management defines project processes and goals and documents these in the program security policy
Phase 2: Analysis	• Assess current system against plan developed in Phase 1 • Develop preliminary system requirements • Study integration of new system with existing system • Document findings and update feasibility analysis	• Analyze existing security policies and programs • Analyze current threats and controls • Examine legal issues • Perform risk analysis
Phase 3: Logical Design	• Assess current business needs against plan developed in Phase 2 • Select applications, data support, and structures • Generate multiple solutions for consideration • Document findings and update feasibility analysis	• Develop security blueprint • Plan incident response actions • Plan business response to disaster • Determine feasibility of continuing and/or outsourcing the project
Phase 4: Physical Design	• Select technologies to support solutions developed in Phase 3 • Select the best solution • Decide to make or buy components • Document findings and update feasibility analysis	• Select technologies needed to support security blueprint • Develop definition of successful solution • Design physical security measures to support technological solutions • Review and approve project
Phase 5: Implementation	• Develop or buy software • Order components • Document the system • Train users • Update feasibility analysis • Present system to users • Test system and review performance	• Buy or develop security solutions • At end of phase, present tested package to management for approval
Phase 6: Maintenance and Change	• Support and modify system during its useful life • Test periodically for compliance with business needs • Upgrade and patch as necessary	• Constantly monitor, test, modify, update, and repair to meet changing threats

Table 1-2 SDLC and SecSDLC Phases Summary

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Software Design Principles

- Software development leaders J. H. Saltzer and M. D. Schroeder first identified security principles:
  - Economy of mechanism
  - Fail-safe defaults
  - Complete mediation
  - Open design
  - Separation of privilege
  - Least privilege
  - Least common mechanism
  - Psychological acceptability

The NIST Approach to Securing the SDLC

- NIST Special Publication 800-64 rev. 2 maintains that early integration of security in the SDLC enables agencies to maximize return on investment through:
  - Early identification and mitigation of security vulnerabilities and misconfigurations
  - Awareness of potential engineering challenges
  - Identification of shared security services and reuse of security strategies and tools
  - Facilitation of informed executive decision making

The NIST Approach: Initiation

- Security at this point is looked at in terms of business risks, with information security office providing input.
- Key security activities include:
  - Delineation of business requirements in terms of confidentiality, integrity, and availability
  - Determination of information categorization and identification of known special handling requirements to transmit, store, or create information
  - Determination of any privacy requirements

The NIST Approach: Development/Acquisition

- Key security activities include:
  - Conducting risk assessment and using results to supplement baseline security controls
  - Analyzing security requirements
  - Performing functional and security testing
  - Preparing initial documents for system certification and accreditation
  - Designing security architecture

The NIST Approach: Implementation/Assessment

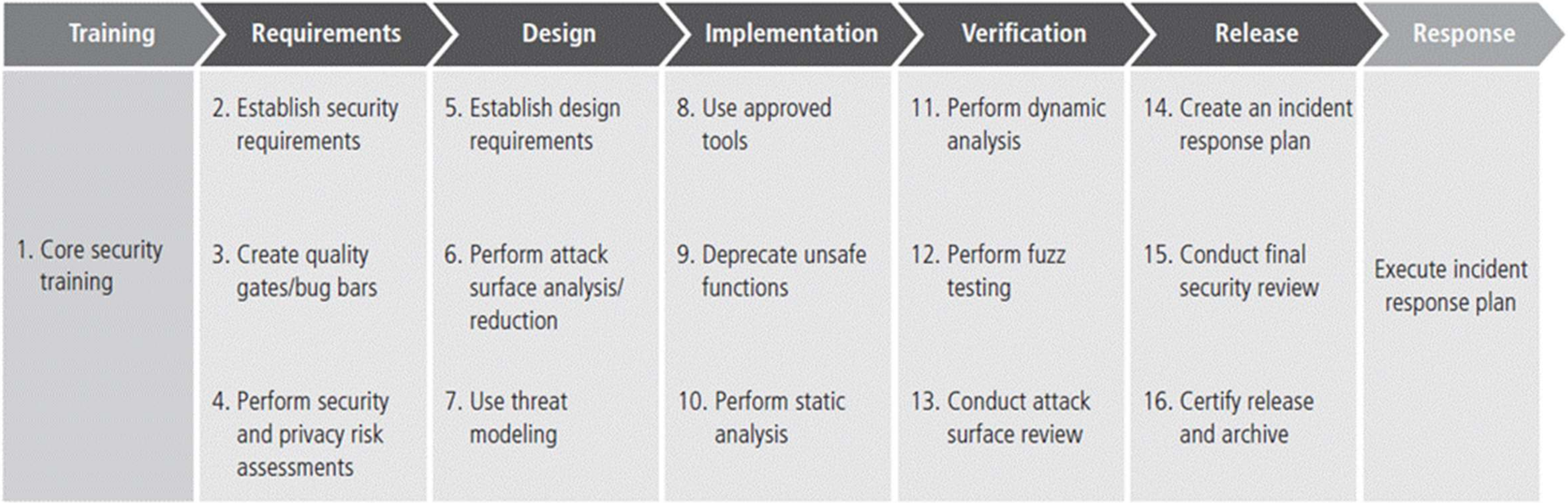
- System is installed and evaluated in operational environment.
- Key security activities include:
  - Integrating information system into its environment
  - Planning and conducting system certification activities in synchronization with testing of security controls
  - Completing system accreditation activities

The NIST Approach: Operations and Maintenance

- Systems are in place and operating, enhancements and/or modifications to the system are developed and tested, and hardware and/or software are added or replaced.
- Key security activities include:
  - Conducting operational readiness review
  - Managing configuration of system
  - Instituting process and procedure for assured operations and continuous monitoring of information system’s security controls
  - Performing reauthorization as required

The NIST Approach: Disposal

- Provides for disposal of system and closeout of any contracts in place
- Key security activities include:
  - Building and executing disposal/transition plan
  - Archival of critical information
  - Sanitization of media
  - Disposal of hardware and software



Training	Requirements	Design	Implementation	Verification	Release	Response
1. Core security training	2. Establish security requirements	5. Establish design requirements	8. Use approved tools	11. Perform dynamic analysis	14. Create an incident response plan	Execute incident response plan
	3. Create quality gates/bug bars	6. Perform attack surface analysis/ reduction	9. Deprecate unsafe functions	12. Perform fuzz testing	15. Conduct final security review	
	4. Perform security and privacy risk assessments	7. Use threat modeling	10. Perform static analysis	13. Conduct attack surface review	16. Certify release and archive	

Figure 1-14 Microsoft's SDL

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Security Professionals and the Organization

- Wide range of professionals are required to support a diverse information security program.
- Senior management is the key component.
- Additional administrative support and technical expertise are required to implement details of IS program.

Senior Management

- Chief information officer (CIO)
  - Senior technology officer
  - Primarily responsible for advising the senior executives on strategic planning
- Chief information security officer (CISO)
  - Has primary responsibility for assessment, management, and implementation of IS in the organization
  - Usually reports directly to the CIO

Information Security Project Team

- A small functional team of people who are experienced in one or multiple facets of required technical and nontechnical areas:
  - Champion
  - Team leader
  - Security policy developers
  - Risk assessment specialists
  - Security professionals
  - Systems administrators
  - End users

Data Responsibilities

- Data owners: senior management responsible for the security and use of a particular set of information
- Data custodian: responsible for information and systems that process, transmit, and store it
- Data users: individuals with an information security role

Communities of Interest

- Group of individuals united by similar interests/values within an organization
  - Information security management and professionals
  - Information technology management and professionals
  - Organizational management and professionals

Information Security: Is It an Art or a Science?

- Implementation of information security is often described as a combination of art and science.
- “Security artisan” idea: based on the way individuals perceive system technologists and their abilities

Security as Art

- No hard and fast rules nor many universally accepted complete solutions
- No manual for implementing security through entire system

Security as Science

- Dealing with technology designed for rigorous performance levels
- Specific conditions cause virtually all actions in computer systems.
- Almost every fault, security hole, and systems malfunction is a result of interaction of specific hardware and software.
- If developers had sufficient time, they could resolve and eliminate faults.

Security as a Social Science

- Social science examines the behavior of individuals interacting with systems.
- Security begins and ends with the people that interact with the system, intentionally or otherwise.
- Security administrators can greatly reduce the levels of risk caused by end users and create more acceptable and supportable security profiles.

Summary

- Information security is a “well-informed sense of assurance that the information risks and controls are in balance.”
- Computer security began immediately after the first mainframes were developed.
- Successful organizations have multiple layers of security in place: physical, personal, operations, communications, network, and information.

Summary (cont’d)

- Security should be considered a balance between protection and availability.
- Information security must be managed similar to any major system implemented in an organization using a methodology like SecSDLC.
- Implementation of information security is often described as a combination of art and science.