Draft NIST Special Publication 800-171B

Protecting Controlled Unclassified Information in Nonfederal Systems and Organizations

Enhanced Security Requirements for Critical Programs and High Value Assets

This publication is to be used as a supplement to NIST Special Publication 800-171. The publication contains recommendations for enhanced security requirements to provide additional protection for Controlled Unclassified Information in nonfederal systems and organizations when such information is part of a critical program or a high value asset. The enhanced security requirements are designed to respond to the advanced persistent threat (APT) and supplement the basic and derived security requirements in NIST Special Publication 800-171 that provide the foundational protection for CUI.

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U.S. Department of Commerce

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Public comment period: June 19 through July 19, 2019

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Abstract

The protection of Controlled Unclassified Information (CUI) resident in nonfederal systems and organizations is of paramount importance to federal agencies and can directly impact the ability of the federal government to successfully conduct its essential missions and functions. This publication provides federal agencies with recommended enhanced security requirements for protecting the confidentiality of CUI: (1) when the information is resident in nonfederal systems and organizations; (2) when the nonfederal organization is not collecting or maintaining information on behalf of a federal agency or using or operating a system on behalf of an agency; and (3) where there are no specific safeguarding requirements for protecting the confidentiality of CUI prescribed by the authorizing law, regulation, or governmentwide policy for the CUI category listed in the CUI Registry. The enhanced requirements apply only to components of nonfederal systems that process, store, or transmit CUI, or that provide security protection for such components when the designated CUI is contained in a critical program or high value asset. The enhanced requirements supplement the basic and derived security requirements in NIST Special Publication 800-171 and are intended for use by federal agencies in contractual vehicles or other agreements established between those agencies and nonfederal organizations.

Keywords

Advanced Persistent Threat; Basic Security Requirement; Contractor Systems; Controlled Unclassified Information; CUI Registry; Derived Security Requirement; Enhanced Security Requirement; Executive Order 13556; FIPS Publication 199; FIPS Publication 200; FISMA; NIST Special Publication 800-53; Nonfederal Organizations; Nonfederal Systems; Security Assessment; Security Control; Security Requirement.

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Notes to Reviewers

This publication provides a set of enhanced security requirements to protect the confidentiality of Controlled Unclassified Information (CUI) in nonfederal systems and organizations from the advanced persistent threat (APT). The APT is an adversary that possesses sophisticated levels of expertise and significant resources that allow it to create opportunities to achieve its objectives by using multiple attack vectors including cyber, physical, and deception. The objectives include establishing and extending footholds within the infrastructure of the targeted organizations for purposes of exfiltrating information, undermining or impeding critical aspects of a mission, program, or organization; or positioning itself to carry out these objectives in the future. The APT pursues its objectives repeatedly over an extended period; adapts to defenders' efforts to resist it; and is determined to maintain the level of interaction needed to execute its objectives.

The APT is extremely dangerous to the national and economic security interests of the United States since we are totally dependent on computing systems of all types—including traditional Information Technology (IT) systems, Operational Technology (OT) systems, Internet of Things (IoT) systems, and Industrial IoT (IIoT) systems. The recent and rapid convergence of these types of systems has brought forth a new class of systems known as cyber-physical systems, many of which are in the critical infrastructure sectors including the energy, transportation, defense, manufacturing, and information and communications.

The enhanced security requirements provide the foundation for a new multidimensional, defense-in-depth protection strategy that includes three, mutually supportive and reinforcing components: (1) *penetration resistant architecture*; (2) *damage limiting operations*; and (3) designing for *cyber resiliency* and *survivability*. This strategy recognizes that despite the best protection measures implemented by organizations, the APT may find ways to breach those primary boundary defenses and deploy malicious code within a defender's system. When this situation occurs, organizations must have access to additional safeguards and countermeasures to confuse, deceive, mislead, and impede the adversary—that is, taking away the adversary's tactical advantage and protecting and preserving the organization's critical programs and high value assets.

The enhanced security requirements are not required for any particular category or article of CUI, rather are focused on designated high value assets or critical programs that contain CUI. These critical programs and high value assets are potential targets for the APT, and thus, require enhanced protection. The enhanced security requirements are to be implemented in addition to the basic and derived requirements in NIST Special Publication 800-171, since the basic and derived requirements are not designed to address the APT. The enhanced requirements apply only to the components of nonfederal systems that process, store, or transmit CUI or that provide protection for such components when the designated CUI is contained in a critical program or high value asset.

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CUI ENHANCED SECURITY REQUIREMENTS

Controlled Unclassified Information has the *same value*, whether such information is resident in a federal system that is part of a federal agency or a nonfederal system that is part of a nonfederal organization. Accordingly, the recommended security requirements contained in this publication are consistent with and are complementary to the standards and guidelines used by federal agencies to protect CUI. The enhanced security requirements are only *applicable* for a nonfederal system or organization when *mandated* by a federal agency in a contract, grant, or other agreement.

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FRAMEWORK FOR IMPROVING CRITICAL INFRASTRUCTURE CYBERSECURITY

Organizations that have implemented or plan to implement the NIST *Framework for Improving Critical Infrastructure Cybersecurity* [NIST CSF] can find in Appendix D, a direct mapping of the Controlled Unclassified Information (CUI) security requirements to the security controls in [SP 800-53]. These controls are also mapped to the Categories and Subcategories associated with Cybersecurity Framework Core Functions: *Identify*, *Protect*, *Detect*, *Respond*, and *Recover*. The security control mappings can be useful to organizations that wish to demonstrate compliance to the security requirements in the context of their established information security programs, when such programs have been built around the NIST security controls.

ADDITIONAL RESOURCES

Mapping security controls to the Cybersecurity Framework: https://www.nist.gov/file/372651.

Mapping CUI security requirements to the Cybersecurity Framework: https://csrc.nist.gov/publications/detail/sp/800-171/rev-1/final.

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Errata

This table contains changes that have been incorporated into Special Publication 800-171B. Errata updates can include corrections, clarifications, or other minor changes in the publication that are either *editorial* or *substantive* in nature.

DATE	TYPE	CHANGE	PAGE

CHAPTER ONE

INTRODUCTION

THE NEED TO PROTECT CONTROLLED UNCLASSIFIED INFORMATION

Today, more than at any time in history, the federal government is relying on external service providers to help carry out a wide range of federal missions and business functions using information systems.[1] Many federal contractors, for example, routinely process, store, and transmit sensitive federal information in their systems to support the delivery of essential products and services to federal agencies (e.g., financial services; providing Web and electronic mail services; processing security clearances or healthcare data; providing cloud services; and developing communications, satellite, and weapons systems). Federal information is frequently provided to or shared with entities such as State and local governments, colleges and universities, and independent research organizations. The protection of sensitive federal information while residing in *nonfederal systems*[2] and organizations is of paramount importance to federal agencies and can directly impact the ability of the federal government to carry out its designated missions and business operations.

The protection of unclassified federal information in nonfederal systems and organizations is dependent on the federal government providing a process for identifying the different types of information that are used by federal agencies. [EO 13556] established a governmentwide Controlled Unclassified Information (CUI)[3] Program to standardize the way the executive branch handles unclassified information that requires protection.[4] Only information that requires safeguarding or dissemination controls pursuant to federal law, regulation, or governmentwide policy may be designated as CUI. The CUI Program is designed to address several deficiencies in managing and protecting unclassified information to include inconsistent markings, inadequate safeguarding, and needless restrictions, both by standardizing procedures and by providing common definitions through a CUI Registry [NARA CUI]. The CUI Registry is the online repository for information, guidance, policy, and requirements on handling CUI, including issuances by the CUI Executive Agent. The CUI Registry identifies approved CUI categories, provides general descriptions for each, identifies the basis for controls, and sets out procedures for the use of CUI, including but not limited to marking, safeguarding, transporting, disseminating, reusing, and disposing of the information.

[1] An *information system* is a discrete set of information resources organized expressly for the collection, processing, maintenance, use, sharing, dissemination, or disposition of information. Information systems also include specialized systems for example, industrial/process control systems, cyber-physical systems, embedded systems, and devices. The term *system* is used throughout this publication to represent all types of computing platforms that can process, store, or transmit CUI.

[2] A *federal information system* is a system that is used or operated by an executive agency, by a contractor of an executive agency, or by another organization on behalf of an executive agency. A system that does not meet such criteria is a *nonfederal system*.

[3] *Controlled Unclassified Information* is any information that law, regulation, or governmentwide policy requires to have safeguarding or disseminating controls, excluding information that is classified under [EO 13526] or any predecessor or successor order, or [ATOM54], as amended.

[4] [EO 13526] designated the National Archives and Records Administration (NARA) as the Executive Agent to implement the CUI program.

[EO 13556] also required that the CUI Program emphasize openness, transparency, and uniformity of governmentwide practices, and that the implementation of the program take place in a manner consistent with applicable policies established by the Office of Management and Budget (OMB) and federal standards and guidelines issued by the National Institute of Standards and Technology (NIST). The federal CUI *regulation*,[5] developed by the CUI Executive Agent, provides guidance to federal agencies on the designation, safeguarding, dissemination, marking, decontrolling, and disposition of CUI, establishes self-inspection and oversight requirements, and delineates other facets of the program.

In certain situations, CUI may be contained in a critical program or a high value asset.[6] These critical programs and high value assets are potential targets for the advanced persistent threat (APT). The APT is an adversary that possesses sophisticated levels of expertise and significant resources that allow it to create opportunities to achieve its objectives by using multiple attack vectors including cyber, physical, and deception. The APT objectives include establishing and extending footholds within the infrastructure of the targeted organizations for purposes of exfiltrating information, undermining or impeding critical aspects of a mission, functions, program, or organization; or positioning itself to carry out these objectives in the future. The APT pursues its objectives repeatedly over an extended period; adapts to defenders' efforts to resist it; and is determined to maintain the level of interaction needed to execute its objectives.

The APT is extremely dangerous to the national and economic security interests of the United States since organizations are totally dependent on computing systems of all types—including traditional Information Technology (IT) systems, Operational Technology (OT) systems, Internet of Things (IoT) systems, and Industrial IoT (IIoT) systems. The rapid convergence of these types of systems has brought forth a new class of systems known as *cyber-physical* systems, many of which are in sectors of the U.S. critical infrastructure including energy, transportation, defense, manufacturing, and information and communications. Therefore, CUI that is processed, stored, or transmitted by any of the above systems related to a critical program or high value asset requires additional protection from the APT.

1.1 PURPOSE AND APPLICABILITY

The purpose of this publication is to provide federal agencies with recommended enhanced security requirements[7] for protecting the *confidentiality* of CUI: (1) when the CUI is resident in a nonfederal system and organization; (2) when the nonfederal organization is *not* collecting or

[5] [32 CFR 2002] was issued on September 14, 2016 and became effective on November 14, 2016.

[6] See [OMB M-19-03] and [OCIO HVA].

[7] The term *requirements* can be used in different contexts. In the context of federal information security and privacy policies, the term is generally used to refer to information security and privacy obligations imposed on organizations. For example, OMB Circular A-130 imposes a series of information security and privacy requirements with which federal agencies must comply when managing information resources. In addition to the use of the term requirements in the context of federal policy, the term requirements is used in this guideline in a broader sense to refer to an expression of the set of stakeholder protection needs for a particular system or organization. Stakeholder protection needs and corresponding security requirements may be derived from many sources (e.g., laws, executive orders, directives, regulations, policies, standards, mission and business needs, or risk assessments). The term requirements, as used in this guideline, includes both legal and policy requirements, as well as an expression of the broader set of stakeholder protection needs that may be derived from other sources. All of these requirements, when applied to a system, help determine the required characteristics of the system.

maintaining information on behalf of a federal agency or using or operating a system on behalf of an agency;[8] and (3) where there are no specific safeguarding requirements for protecting the confidentiality of CUI prescribed by the authorizing law, regulation, or governmentwide policy for the CUI category listed in the CUI Registry.[9]

The enhanced security requirements apply *only* to components[10] of nonfederal systems that process, store, or transmit CUI, or that provide security protection for such components when the designated CUI is contained in a critical program or high value asset. Additionally, the enhanced security requirements address protecting the integrity of CUI by promoting: (1) penetration resistant architecture; (2) damage limiting operations; and (3) designing for cyber resiliency and survivability. The enhanced security requirements are intended to supplement the basic and derived security requirements in [SP 800-171] and are for use by federal agencies in contractual vehicles or other agreements established between those agencies and nonfederal organizations.

1.2 TARGET AUDIENCE

This publication serves a diverse group of individuals and organizations in both the public and private sectors including, but not limited to individuals with:

- Acquisition or procurement responsibilities (e.g., contracting officers);
- System development life cycle responsibilities (e.g., program managers, mission/business owners, information owners/stewards, system designers and developers, system/security engineers, systems integrators);
- System, security, or risk management and oversight responsibilities (e.g., authorizing officials, chief information officers, chief information security officers, system owners, information security managers); and
- Security assessment and monitoring responsibilities (e.g., auditors, system evaluators, assessors, independent verifiers/validators, analysts).

The above roles and responsibilities can be viewed from two distinct perspectives: the *federal perspective* as the entity establishing and conveying the security requirements in contractual vehicles or other types of inter-organizational agreements; and the *nonfederal perspective* as the entity responding to and complying with the security requirements set forth in contracts or agreements.

[8] Nonfederal organizations that collect or maintain information *on behalf of* a federal agency or that use or operate a system *on behalf of* an agency, must comply with the requirements in FISMA, including the requirements in [FIPS 200] and the security controls in [SP 800-53] (See [44 USC 3554] (a)(1)(A)).

[9] The requirements in this publication can be used to comply with the FISMA requirement for senior agency officials to provide information security for the information that supports the operations and assets under their control, including CUI that is resident in nonfederal systems and organizations (See [44 USC 3554] (a)(1)(A) and (a)(2)).

[10] System *components* include mainframes, workstations, servers; input and output devices; cyber-physical components; network components; mobile devices; operating systems; virtual machines; and applications.

1.3 ORGANIZATION OF THIS SPECIAL PUBLICATION

The remainder of this special publication is organized as follows:

- **Chapter Two** describes the basic assumptions used to develop the enhanced requirements for protecting the confidentiality and integrity of CUI when it is part of a critical program or high value asset; and the structure and organization of the requirements.
- **Chapter Three** describes the fourteen families of enhanced security requirements for protecting the confidentiality and integrity of CUI in nonfederal systems and organizations.
- **Supporting appendices** provide additional information related to the protection of CUI in nonfederal systems and organizations including: general references; definitions and terms; acronyms; mapping tables relating the enhanced requirements to the security controls in [SP 800-53].

CHAPTER TWO

THE FUNDAMENTALS

ASSUMPTIONS FOR DEVELOPING ENHANCED SECURITY REQUIREMENTS

This chapter describes the assumptions used to develop the recommended enhanced security requirements to protect CUI in nonfederal systems and organizations when the CUI is part of a critical program or high value asset; and the structure and organization of the enhanced security requirements.

2.1 BASIC ASSUMPTIONS

The recommended security requirements described in this publication have been developed based on four fundamental assumptions:

- Statutory and regulatory requirements for the protection of CUI are *consistent*, whether such information resides in federal systems or nonfederal systems including the environments in which those systems operate;
- Safeguards implemented to protect CUI are *consistent* in both federal and nonfederal systems and organizations;
- The confidentiality impact value for CUI is no less than [FIPS 199] *moderate*;[11] [12] and
- Additional protections may be necessary to protect information related to critical programs or high value assets that are targeted by the APT.

The assumptions reinforce the concept that CUI has the same *value* and potential *adverse impact* if compromised—whether such information is located in a federal or a nonfederal organization. However, additional protections are required to protect CUI in critical programs and high value assets targeted by the APT. Protecting the confidentiality and integrity of CUI is critical to the mission and business success of federal agencies and the economic and national security interests of the nation. Additional assumptions that also impact the development of the security requirements and the expectation of federal agencies in working with nonfederal organizations include:

- Nonfederal organizations have specific safeguarding measures in place to protect their information which may also be sufficient to satisfy the basic and derived CUI security requirements in [SP 800-171].
- The basic and derived requirements may not be sufficient to address the APT, and thus, some modification, development, or acquisition may be necessary to meet a set of enhanced requirements;

[11] The moderate impact *value* defined in [FIPS 199] may become part of a moderate impact *system* in [FIPS 200], which requires the use of the moderate baseline in [SP 800-53] as the starting point for tailoring actions.

[12] In accordance with [32 CFR 2002], CUI is categorized at no less than the moderate confidentiality impact value. However, when federal law, regulation, or governmentwide policy establishing the control of the CUI specifies controls that differ from those of the moderate confidentiality baseline, then these will be followed.

- Nonfederal organizations may not have the necessary organizational structure or resources to satisfy every security requirement and may implement alternative, but equally effective, security measures to compensate for the inability to satisfy a requirement; and
- Nonfederal organizations can implement a variety of potential security solutions directly or using external service providers (e.g., managed services), to satisfy security requirements.

2.2 ORGANIZATION OF ENHANCED SECURITY REQUIREMENTS

In addition to the basic and derived security requirements described in [SP 800-171], a set of enhanced security requirements is provided in Chapter Three. The enhanced requirements are to be applied to nonfederal systems and organizations processing, storing, or transmitting CUI, when such information is contained in a critical program or designated high value asset. The enhanced security requirements have been designed to address the advanced persistent threat (APT). The structure of an enhanced requirement is similar to the basic and derived security requirements in [SP 800-171]. Similar to the basic and derived requirements, the enhanced requirements are mapped to the security controls in [SP 800-53], the source from which the requirements were derived.

A *discussion section* follows each CUI security requirement providing additional information to facilitate the implementation and assessment of the requirements. This information is derived primarily from the security controls discussion sections in [SP 800-53] and is provided to give organizations a better understanding of the mechanisms and procedures used to implement the controls used to protect CUI. The discussion section is not intended to extend the scope of the requirements. Figure 1 illustrates enhanced security requirement 3.2.2e with its supporting discussion section and informative references.

3.2.2e **Include practical exercises in awareness training that are aligned with current threat scenarios and provide feedback to individuals involved in the training and their supervisors.**

DISCUSSION

Awareness training is most effective when it is complemented by practical exercises tailored to the tactics, techniques, and procedures (TTP) of the threat. Examples of practical exercises include no-notice social engineering attempts to gain unauthorized access, collect information, or simulate the adverse impact of opening malicious email attachments or invoking, via spear phishing attacks, malicious web links. Rapid feedback is essential to reinforce desired user behavior. Training results, especially failures of personnel in critical roles, can be indicative of a potential serious problem. It is important that senior management are made aware of such situations so that they can take appropriate remediating actions.

[SP 800-181] provides guidance on role-based information security training in the workplace.

FIGURE 1: ENHANCED SECURITY REQUIREMENT EXAMPLE

The enhanced security requirements are organized into fourteen *families* consistent with the families for basic and derived requirements described in [SP 800-171]. Each family contains the requirements related to the general security topic of the family. The families are closely aligned with the minimum-security requirements for federal information and information systems contained in [FIPS 200]. The *contingency planning*, *system and services acquisition*, and *planning* requirements are not included within the scope of this publication due to the tailoring criteria in [SP 800-171]. Table 1 lists the security requirement families addressed in this publication.[13]

TABLE 1: SECURITY REQUIREMENT FAMILIES

FAMILY	FAMILY
Access Control	Media Protection
Awareness and Training	Personnel Security
Audit and Accountability	Physical Protection
Configuration Management	Risk Assessment
Identification and Authentication	Security Assessment
Incident Response	System and Communications Protection
Maintenance	System and Information Integrity

[13] Some families do not contain enhanced security requirements.

CHAPTER THREE

THE REQUIREMENTS

ENHANCED SECURITY REQUIREMENTS TO ADDRESS THE ADVANCED PERSISTENT THREAT

This chapter describes enhanced security requirements to protect the confidentiality[14] of CUI in nonfederal systems and organizations from the advanced persistent threat (APT).[15] The enhanced protections are not required for any particular category or article of CUI. If, however, an agency determines and designates information (which may include categories of CUI) or a system as a critical program or a high value asset,[16] such information or system is a potential target for the APT, and therefore, requires enhanced protection.[17] The enhanced requirements are implemented in addition to the basic and derived requirements contained in [SP 800-171], since the basic and derived requirements are not designed to address advanced threats including the APT.[18] The enhanced requirements apply *only* to the components of nonfederal systems that process, store, or transmit CUI contained in a critical program or high value asset or that provide protection for such components.[19]

The enhanced requirements in Sections 3.1 through 3.14 are derived from the security controls in [SP 800-53]. The requirements have been influenced by several studies on the most effective methods for protecting the confidentiality and integrity of information (and CUI in particular) against cyber-attacks from advanced cyber threats and for ensuring the cyber resiliency of systems and organizations while under attack. The enhanced security requirements focus on several key elements that are essential to addressing the APT:

- Applying a threat-centric approach to security requirements specification;
- Employing alternative system and security architectures that support logical and physical isolation using system and network segmentation techniques, virtual machines, and containers;[20]
- Implementing dual authorization controls for the most critical or sensitive operations;
- Limiting persistent storage to isolated enclaves or domains;

[14] The security objectives of confidentiality and integrity are closely related since many of the underlying security mechanisms at the system level support both objectives. Therefore, the enhanced security requirements in this appendix provide protection from unauthorized disclosure and unauthorized modification of CUI.

[15] [SP 800-39] defines the APT as an adversary that possesses sophisticated levels of expertise and significant resources which allow it to create opportunities to achieve its objectives by using multiple attack vectors including cyber, physical, and deception.

[16] See [OMB M-19-03].

[17] Organizations are cautioned against applying the enhanced security requirements in this appendix to protect all CUI. The application of the requirements is restricted to *critical programs* and *high value assets* containing CUI that are likely to be targeted by the APT.

[18] The enhanced security requirements have been designed to address the threats described in [NTCTF].

[19] System *components* include mainframes, workstations, servers; input and output devices; network components; operating systems; virtual machines; applications; cyber-physical components such as programmable logic controllers (PLC) or medical devices; and mobile devices such as smartphones and tablets.

[20] [SP 800-160-1] provides guidance on the development of system and security architectures.

- Implementing a comply-to-connect approach for systems and networks;
- Extending configuration management requirements by establishing authoritative sources for addressing changes to systems and system components;
- Periodically refreshing or upgrading organizational systems and system components to a known state or developing new systems or components;
- Employing a security operations center with advanced analytics to support continuous monitoring and protection of organizational systems; and
- Using deception to confuse and mislead adversaries regarding the information they use for decision making, the value and authenticity of the information they attempt to exfiltrate, or the environment in which they are operating.

Following each enhanced requirement, a discussion section provides additional information to facilitate the implementation and assessment of the requirement. Tables D-1 through D-14 in Appendix D provide a mapping of the enhanced security requirements to the security controls in [SP 800-53].[21]

Certain enhanced requirements may be too difficult or cost prohibitive for organizations to meet through in-house provisioning. In these situations, the use of external service providers[22] can be leveraged to satisfy the requirements. The services include, but are not limited to:

- IT infrastructure, platform, and software services;
- Threat intelligence;[23]
- Threat and adversary hunting;
- Threat, vulnerability, and risk assessments;
- Cyber resiliency;[24]

[21] The security controls in mapping tables D-1 through D-14 are taken from NIST Special Publication 800-53, Revision 5. Any changes in the designated controls due to future updates to [SP 800-53], will be reflected in this publication either as errata or during the next official update cycle.

[22] These services can be provided by a parent or supervisory organization (e.g., a prime contractor providing services to a subcontractor), or a third party (e.g., a cloud service provider).

[23] [SP 800-150] makes a distinction between threat information and threat intelligence. Threat information is any information related to a threat that might help an organization protect itself against that threat or detect the activities of a threat actor. Examples of threat information include indicators, TTPs, security alerts, threat intelligence reports, and tool configurations. Threat intelligence is threat information that has been aggregated, transformed, analyzed, interpreted, or enriched to provide the necessary context for risk-based decision-making processes. Threat information sharing is an activity that organizations can perform or participate in. Threat intelligence can be a service offering. Threat intelligence sources include commercial and government organizations with experience gathering and analyzing threat intelligence, parent or supervisory organizations (e.g., a prime contractor providing relevant threat intelligence to a subcontractor), Information Sharing and Analysis Organizations (ISAO), and Information Sharing and Analysis Centers (ISAC).

[24] [SP 800-160-2] provides guidance on cyber-resilient systems. The cyber resiliency measures described in this appendix represent a subset of the measures. For example, due to the focus of this publication, cyber resiliency measures to preclude the destruction of critical cyber resources by the APT are not included.

- System monitoring and security management;[25] and
- Response and recovery.[26]

The enhanced requirements provide the foundation for a multidimensional, defense-in-depth protection strategy that includes three, mutually supportive and reinforcing components: (1) *penetration resistant architecture*; (2) *damage limiting operations*; and (3) designing for *cyber resiliency* and *survivability*. This strategy recognizes that despite the best protection measures implemented by organizations, the APT may find ways to breach or compromise those primary boundary defenses and deploy malicious code within a defender's system. When this situation occurs, organizations must have access to safeguards and countermeasures to confuse, deceive, mislead, and impede the adversary—that is, taking away the adversary's tactical advantage and protecting the organization's critical programs or high value assets. Figure 2 illustrates the complementary nature of the enhanced security requirements when implemented as part of a multidimensional asset protection strategy.

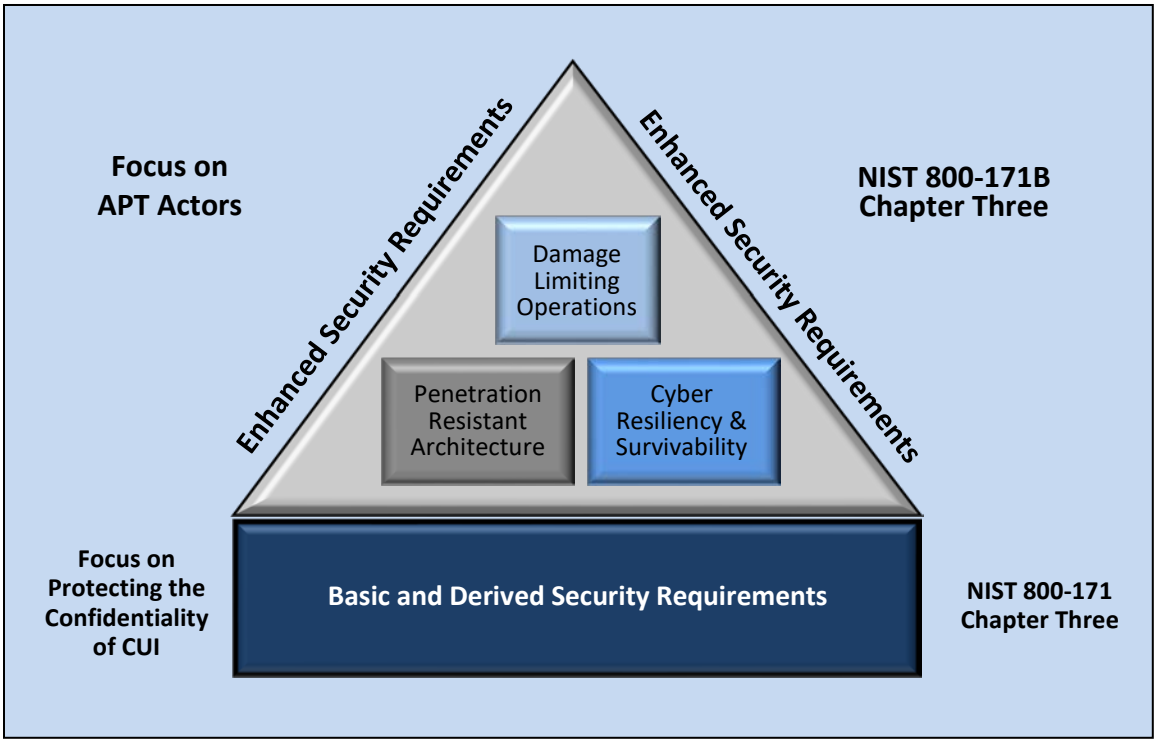

FIGURE 2: MULTIDIMENSIONAL (DEFENSE-IN-DEPTH) PROTECTION STRATEGY

[25] A managed security services provider (MSSP) can provide an off-site security operations center (SOC) in which analysts monitor security-relevant data flows on behalf of multiple customer or subordinate organizations. The best services go beyond monitoring perimeter defenses and additionally monitor system components, devices, and endpoint data from deep within organizational systems and networks.

[26] In some cases, MSSP organizations provide integrated security-related management and incident response services, similar to a managed detection and response (MDR) services provider. Alternatively, response and recovery services may be obtained separately.

While the enhanced security requirements are intended to be implemented comprehensively, federal agencies may, as part of their overarching risk management strategy and consistent with their organizational risk tolerance, request the implementation of selected enhanced security requirements or alternatively, exempt certain enhanced requirements. The requirements are intended for use by federal agencies in appropriate contractual vehicles or other agreements established between those agencies and nonfederal organizations. Nonfederal organizations may elect to specify and implement requirements in this appendix (or elements thereof) based on mission or business needs, criticality analyses, and risk assessments.

LIMITING THE SCOPE OF THE ENHANCED SECURITY REQUIREMENTS

The *enhanced* security requirements in this chapter are only applicable for a nonfederal system or organization when mandated by a federal agency in a contract, grant, or other agreement. The requirements apply *only* to the components of nonfederal systems that process, store, or transmit CUI contained in a critical program or high value asset or that provide protection for such components. The nature of critical programs and high value assets is such that they are likely to attract attention from the Advanced Persistent Threat (APT), and therefore, warrant the additional protection and cost that are associated with the enhanced security requirements.

3.1 ACCESS CONTROL

Enhanced Security Requirements

3.1.1e Employ dual authorization to execute critical or sensitive system and organizational operations.

DISCUSSION

Dual authorization, also known as two-person control, reduces risk related to insider threat. Dual authorization requires the approval of two authorized individuals to execute certain commands, actions, or functions. For example, organizations employ dual authorization to help ensure that changes to selected system components (i.e., hardware, software, and firmware) or information cannot occur unless two qualified individuals approve and implement such changes. The two individuals possess the skills and expertise to determine if the proposed changes are correct implementations of the approved changes. The individuals are also accountable for the changes. Organizations also employ dual authorization for the execution of privileged commands. To reduce the risk of collusion, organizations consider rotating dual authorization duties to other individuals.

3.1.2e Restrict access to systems and system components to only those information resources that are owned, provisioned, or issued by the organization.

DISCUSSION

Non-organizationally owned information resources include systems or system components owned by other organizations and personally owned devices. Non-organizational devices and software present a significant risk to the organization and complicate the organization's ability to employ a "comply-to-connect" policy or implement device attestation techniques to ensure the integrity of the organizational system.

3.1.3e Employ secure information transfer solutions to control information flows between security domains on connected systems.

DISCUSSION

Organizations employ information flow control policies and enforcement mechanisms to control the flow of information between designated sources and destinations within systems and between connected systems. Flow control is based on the characteristics of the information and/or the information path. Enforcement occurs, for example, in boundary protection devices that employ rule sets or establish configuration settings that restrict system services; provide a packet-filtering capability based on header information; or provide message-filtering capability based on message content. Organizations also consider the trustworthiness of filtering/inspection mechanisms (i.e., hardware, firmware, and software components) that are critical to information flow enforcement.

Transferring information between systems in different security domains with different security policies introduces risk that the transfers violate one or more domain security policies. In such situations, information owners or stewards provide guidance at designated policy enforcement points between connected systems. Organizations mandate specific architectural solutions when required to enforce logical or physical separation between systems in different security domains. Enforcement includes prohibiting information transfers between connected systems; employing hardware mechanisms to enforce one-way information flows; verifying write permissions before accepting information from another security domain or connected system; and implementing trustworthy regrading mechanisms to reassign security attributes and security labels.

Secure information transfer solutions often include one or more of the following properties: use of cross domain solutions when crossing security domains; mutual authentication (via hardware-based cryptography) of the sender and recipient; encryption of data in transit and at rest; isolation

from other domains; logging of information transfers (e.g., title of file, file size, cryptographic hash of file, sender, recipient, transfer time and IP address, receipt time and IP address). There are cross domain solutions approved by the United Cross Domain Services Management Office [UCDSMO] and secure information transfer solutions that have similar properties but are without formal UCDSMO approval.

Basic and derived security requirements for access control are contained in [SP 800-171].

3.2 AWARENESS AND TRAINING

Enhanced Security Requirements

3.2.1e **Provide awareness training focused on recognizing and responding to threats from social engineering, advanced persistent threat actors, breaches, and suspicious behaviors; update the training at least annually or when there are significant changes to the threat.**

DISCUSSION

One of the most effective ways to detect APT activities and to reduce the effectiveness of those activities is to provide specific awareness training for individuals. A well-trained and security aware workforce provides another organizational safeguard that can be employed as part of a defense-in-depth strategy to protect organizations against malicious code injections via email or the web applications. Threat awareness training includes educating individuals on the various ways APTs can infiltrate into organizations including through websites, emails, advertisement pop-ups, articles, and social engineering. Training can include techniques for recognizing suspicious emails, the use of removable systems in non-secure settings, and the potential targeting of individuals by adversaries outside the workplace. Awareness training is assessed and updated periodically to ensure that the training is relevant and effective, particularly with respect to the threat since it is constantly, and often rapidly, evolving.

[SP 800-50] provides guidance on security awareness and training programs.

3.2.2e **Include practical exercises in awareness training that are aligned with current threat scenarios and provide feedback to individuals involved in the training and their supervisors.**

DISCUSSION

Awareness training is most effective when it is complemented by practical exercises tailored to the tactics, techniques, and procedures (TTP) of the threat. Examples of practical exercises include no-notice social engineering attempts to gain unauthorized access, collect information, or simulate the adverse impact of opening malicious email attachments or invoking, via spear phishing attacks, malicious web links. Rapid feedback is essential to reinforce desired user behavior. Training results, especially failures of personnel in critical roles, can be indicative of a potential serious problem. It is important that senior management are made aware of such situations so that they can take appropriate remediating actions.

[SP 800-181] provides guidance on role-based information security training in the workplace.

Basic and derived requirements for awareness and training are contained in [SP 800-171].

3.3 AUDIT AND ACCOUNTABILITY

Enhanced Security Requirements

There are no enhanced security requirements for audit and accountability at this time.

Basic and derived requirements for audit and accountability are contained in [SP 800-171].

3.4 CONFIGURATION MANAGEMENT

Enhanced Security Requirements

3.4.1e **Establish and maintain an authoritative source and repository to provide a trusted source and accountability for approved and implemented system components.**

DISCUSSION

The establishment and maintenance of an authoritative source and repository includes a system component inventory of approved hardware, software and firmware; approved system baseline configurations and configuration changes; and verified system software and firmware, as well as images and/or scripts. See 3.4.1 and 3.4.3 related to system component inventories, baseline configurations, and configuration change control. The information in the repository is used to demonstrate adherence to or identify deviation from the established configuration baselines and to restore system components from a trusted source. From an automated assessment perspective, the system description provided by the authoritative source is referred to as the desired state. Using automated tools, the desired state is compared to the actual state to check for compliance or deviations.

[SP 800-128] provides guidance on security-focused configuration management including security configuration settings and configuration change control. [IR 8011] provides guidance on using automation support to assess system and system component configurations.

3.4.2e **Employ automated mechanisms to detect the presence of misconfigured or unauthorized system components and remove the components or place the components in a quarantine or remediation network that allows for patching, re-configuration, or other mitigations.**

DISCUSSION

System components used to process, store, transmit, or protect CUI are monitored and checked against the authoritative source (i.e., hardware and software inventory and associated baseline configurations). From an automated assessment perspective, the system description provided by the authoritative source is referred to as the desired state. Using automated tools, the desired state is compared to the actual state to check for compliance or deviations. System components that are unknown or that deviate from the approved configuration are removed from the system and rebuilt from the trusted configuration baseline established by the authoritative source. Automated security responses can include halting system functions, halting system processing, or issuing alerts or notifications to personnel when there is an unauthorized modification of an organization-defined configuration item.

[IR 8011] provides guidance on using automation support to assess system and system component configurations.

3.4.3e **Employ automated discovery and management tools to maintain an up-to-date, complete, accurate, and readily available inventory of system components.**

DISCUSSION

The system component inventory includes system-specific information required for component accountability and to provide support to identify, control, monitor, and verify configuration items in accordance with the authoritative source. Information necessary for effective accountability of system components includes system name; hardware component owners; hardware inventory specifications; software license information; software component owners; version numbers; and for networked components, the machine names and network addresses. Inventory specifications include manufacturer; supplier information; component type; date of receipt; cost; model; serial number; and physical location. Organizations also use automated mechanisms to implement and

maintain authoritative (i.e., up-to-date, complete, accurate, and available) baseline configurations for systems that include hardware and software inventory tools, configuration management tools, and network management tools. Tools can be used to track version numbers on operating systems, applications, types of software installed, and current patch levels.

Basic and derived requirements for configuration management are contained in [SP 800-171].

3.5 IDENTIFICATION AND AUTHENTICATION

Enhanced Security Requirements

3.5.1e **Identify and authenticate systems and system components before establishing a network connection using bidirectional authentication that is cryptographically-based and replay resistant.**

DISCUSSION

Cryptographically-based and replay resistant authentication between systems, components, and devices addresses the risk of unauthorized access from spoofing (i.e., claiming a false identity). The requirement applies to client-server authentication, server-server authentication, and device authentication (including mobile devices). The cryptographic key for authentication transactions is stored in suitably secure storage available to the authenticator application (e.g., keychain storage, Trusted Platform Module (TPM), Trusted Execution Environment (TEE), or secure element). For some architectures (e.g., service-oriented architectures), mandating authentication requirements at every connection point may not be practical and therefore, the authentication requirements may only be applied periodically or at the initial point of network connection.

[SP 800-63-3] provides guidance on identity and authenticator management.

3.5.2e **Employ password managers for the generation, rotation, and management of passwords for systems and system components that do not support multifactor authentication or complex account management.**

DISCUSSION

In situations where static passwords or personal identification numbers (PIN) are used (e.g., certain system components do not support multifactor authentication or complex account management such as separate system accounts for each user and logging), enterprise password managers can automatically generate, rotate, manage, and store strong and different passwords for users and device accounts. For example, a router might have one administrator account, but an enterprise typically has multiple network administrators. Thus, access management and accountability are problematic. An enterprise password manager uses techniques such as automated password rotation (in this example, for the router password) to allow a specific user to temporarily gain access to a device by checking out a temporary password and then checking the password back in to end the access. The enterprise password manager simultaneously logs these actions. Personnel turnover subsequently would not require generating and distributing a new password to remaining personnel. One of the risks in using password managers is an adversary targeting the collection of passwords that it generates. Therefore, it is important that the collection of passwords is secured. Methods of protecting passwords include the use of multifactor authentication to the password manager, encryption, and/or the use of secured hardware (e.g., a hardware security module).

[SP 800-63-3] provides guidance on password generation and management.

3.5.3e **Employ automated mechanisms to prohibit system components from connecting to organizational systems unless the components are known, authenticated, in a properly configured state, or in a trust profile.**

DISCUSSION

Identification and authentication of system components and component configurations can be determined, for example, via a cryptographic hash of the component. This is also known as device attestation and known operating state or trust profile. A trust profile based on factors such as the user, authentication method, device type, and physical location is used to make dynamic decisions on authorizations to data of varying types. If device attestation is the means of identification and

authentication, then it is important that patches and updates to the device are handled via a configuration management process such that the patches and updates are done securely and do not disrupt the identification and authentication to other devices. System components that are either unknown or in an unapproved state are placed in a quarantine or remediation network that allows for patching, configuration, or other appropriate mitigations.

[IR 8011] provides guidance on using automation support to assess system configurations.

Basic and derived requirements for identification and authentication are contained in [SP 800-171].

3.6 INCIDENT RESPONSE

Enhanced Security Requirements

3.6.1e **Establish and maintain a full-time security operations center capability.**

DISCUSSION

A security operations center (SOC) is the focal point for security operations and computer network defense for an organization. The purpose of the SOC is to defend and monitor an organization's systems and networks (i.e., cyber infrastructure) on an ongoing basis. The SOC is also responsible for detecting, analyzing, and responding to cybersecurity incidents in a timely manner. The SOC is staffed with skilled technical and operational personnel (e.g., security analysts, incident response personnel, systems security engineers); operates 24 hours per day, seven days per week; and implements technical, management, and operational controls (including monitoring, scanning, and forensics tools) to monitor, fuse, correlate, analyze, and respond to threat and security-relevant event data from multiple sources. Sources include perimeter defenses, network devices (e.g., gateways, routers, switches) and endpoint agent data feeds. The SOC provides a holistic situational awareness capability to help organizations determine the security posture of the system and organization. A SOC capability can be obtained in a variety of ways. Larger organizations may implement a dedicated SOC while smaller organizations may employ third-party organizations to provide such capability.

[SP 800-61] provides guidance on incident handling. [SP 800-86] and [SP 800-101] provide guidance on integrating forensic techniques into incident response. [SP 800-150] provides guidance on cyber threat information sharing. [SP 800-184] provides guidance on cybersecurity event recovery.

3.6.2e **Establish and maintain a cyber incident response team that can be deployed to any location identified by the organization within 24 hours.**

DISCUSSION

A cyber incident response team (CIRT) is a team of experts that assesses, documents, and responds to cyber incidents so that organizational systems can recover quickly and implement the necessary controls to avoid future incidents. CIRT personnel typically include forensic analysts, malicious code analysts, systems security engineers, and real-time operations personnel. The incident handling capability includes performing rapid forensic preservation of evidence and analysis of and response to intrusions. The team members may or may not be full-time but need to be available to respond in the time period required. The size and specialties of the team are based on known and anticipated threats. The team is typically pre-equipped with the software and hardware (e.g., forensic tools) necessary for rapid identification, quarantine, mitigation, and recovery, and is familiar with how to preserve evidence and maintain chain of custody for law enforcement or counterintelligence uses. For some organizations the CIRT can be implemented as a cross organizational entity or as part of the Security Operations Center (SOC).

[SP 800-61] provides guidance on incident handling. [SP 800-86] and [SP 800-101] provide guidance on integrating forensic techniques into incident response. [SP 800-150] provides guidance on cyber threat information sharing. [SP 800-184] provides guidance on cybersecurity event recovery.

Basic and derived requirements for incident response are contained in [SP 800-171].

3.7 MAINTENANCE

Enhanced Security Requirements

There are no enhanced security requirements for maintenance at this time.

Basic and derived requirements for maintenance are contained in [SP 800-171].

3.8 MEDIA PROTECTION

Enhanced Security Requirements

There are no enhanced security requirements for media protection at this time.

Basic and derived requirements for media protection are contained in [SP 800-171].

3.9 PERSONNEL SECURITY

Enhanced Security Requirements

3.9.1e **Conduct enhanced personnel screening (vetting) for individual trustworthiness and reassess individual trustworthiness on an ongoing basis.**

DISCUSSION

Personnel security is the discipline that provides a trusted workforce based on an evaluation or assessment of conduct, integrity, judgment, loyalty, reliability and stability (e.g., trustworthiness). The extent of the vetting is commensurate with the level of risk that individuals could bring about by their position and access. For individuals accessing federal government facilities and systems, the federal government employs resources, information, and technology in its vetting processes, to ensure a trusted workforce. These vetting processes may be extended all or in part to persons accessing federal information including CUI resident in nonfederal systems and organizations through contractual vehicles or other agreements established between federal agencies and nonfederal organizations.

Examples of enhanced personnel screening for security purposes include additional background checks. Personnel reassessment activities reflect applicable laws, Executive Orders, directives, policies, regulations, and specific criteria established for the level of access required for assigned positions.

3.9.2e **Ensure that organizational systems are protected whenever adverse information develops regarding the trustworthiness of individuals with access to CUI.**

DISCUSSION

When adverse information develops which questions an individual's trustworthiness for continued access to systems containing CUI, actions are taken to protect the CUI while the information is resolved, or the individual is terminated or transferred to other duties that do not involve access to CUI.

Basic and derived requirements for personnel security are contained in [SP 800-171].

3.10 PHYSICAL PROTECTION

Enhanced Security Requirements

There are no enhanced security requirements for physical protection at this time.

Basic and derived requirements for physical protection are contained in [SP 800-171].

3.11 RISK ASSESSMENT

Enhanced Security Requirements

3.11.1e Employ threat intelligence to inform the development of the system and security architectures, selection of security solutions, monitoring, threat hunting, and response and recovery activities.

DISCUSSION

The constantly changing and increased sophistication of adversaries, especially the advanced persistent threat (APT), makes it more likely that adversaries can successfully compromise or breach organizational systems. Accordingly, threat intelligence can be integrated into and inform each step of the risk management process throughout the system development life cycle. This includes defining system security requirements, developing system and security architectures, selecting security solutions, monitoring (including threat hunting) and remediation efforts.

[SP 800-30] provides guidance on risk assessments. [SP 800-39] provides guidance on the risk management process. [SP 800-160-1] provides guidance on security architectures and systems security engineering. [SP 800-150] provides guidance on cyber threat information sharing.

3.11.2e Establish and maintain a cyber threat hunting capability to search for indicators of compromise in organizational systems and detect, track, and disrupt threats that evade existing controls.

DISCUSSION

Threat hunting is an active means of cyber defense in contrast to the traditional protection measures such as firewalls, intrusion detection and prevention systems, quarantining malicious code in sandboxes, and Security Information and Event Management (SIEM) technologies and systems. Cyber threat hunting involves proactively searching organizational systems, networks, and infrastructure for advanced threats. The objective is to track and disrupt cyber adversaries as early as possible in the attack sequence and to measurably improve the speed and accuracy of organizational responses. Indicators of compromise are forensic artifacts from intrusions that are identified on organizational systems at the host or network level, and can include unusual network traffic, unusual file changes, and the presence of malicious code. Threat hunting teams use existing threat intelligence and may create new threat information, which may be shared with peer organizations, Information Sharing and Analysis Organizations (ISAO), Information Sharing and Analysis Centers (ISAC), and relevant government departments and agencies. Threat indicators, signatures, tactics, techniques, and procedures, and other indicators of compromise may be available via government and non-government cooperatives including Forum of Incident Response and Security Teams, United States Computer Emergency Readiness Team, Defense Industrial Base Cybersecurity Information Sharing Program, and CERT Coordination Center.

[SP 800-30] provides guidance on threat and risk assessments, risk analyses, and risk modeling. [SP 800-160-2] provides guidance on systems security engineering and cyber resiliency. [SP 800-150] provides guidance on cyber threat information sharing.

3.11.3e Employ advanced automation and analytics capabilities to predict and identify risks to organizations, systems, or system components.

DISCUSSION

A properly resourced Security Operations Center (SOC) or Computer Incident Response Team (CIRT) may be overwhelmed by the volume of information generated by the proliferation of security tools and appliances unless it employs advanced automation and analytics to analyze the data. Advanced automation and predictive analytics capabilities are typically supported by artificial intelligence concepts and machine learning. Examples include Automated Workflow Operations,

Automated Threat Discovery and Response (which includes broad-based collection, context-based analysis, and adaptive response capabilities), and Machine Assisted Decision tools. Note, however, that sophisticated adversaries may be able to extract information related to analytic parameters and retrain the machine learning to classify malicious activity as benign. Accordingly, machine learning is augmented by human monitoring to help ensure sophisticated adversaries are not able to conceal their activity.

[SP 800-30] provides guidance on risk assessments and risk analyses.

3.11.4e Document or reference in the system security plan the risk basis for security solution selection and identify the system and security architecture, system components, boundary isolation or protection mechanisms, and dependencies on external service providers.

DISCUSSION

System security plans relate security requirements to a set of security controls and solutions. The plans describe how the controls and solutions meet the security requirements, and, when the APT is a concern, includes traceability between threat and risk assessments and selection of a security solution, including discussion of any relevant analyses of alternatives and rationale for key security-relevant architectural and design decisions. This level of detail is important as the threat changes, requiring reassessment of the risk and the basis for previous security decisions.

When incorporating external service providers into the system security plan, organizations state the type of service provided (e.g., software as a service, platform as a service), the point and type of connections (including ports and protocols), the nature and type of the information flows to and from the service provider, and the security controls implemented by the service provider. For safety critical systems, organizations document situations for which safety is the primary reason for not implementing a security solution (i.e., the solution is appropriate to address the threat but causes a safety concern).

[SP 800-18] provides guidance on the development of system security plans.

3.11.5e Assess the effectiveness of security solutions at least annually to address anticipated risk to the system and the organization based on current and accumulated threat intelligence.

DISCUSSION

Since sophisticated threats such as the APT are constantly changing, the threat awareness and risk assessment of the organization is dynamic, continuous and informs the actual system operations, the security requirements for the system, and the security solutions employed to meet those requirements. Threat intelligence (i.e., threat information that has been aggregated, transformed, analyzed, interpreted, or enriched to provide the necessary context for decision-making processes) is infused into risk assessment processes and information security operations of the organization to identify any changes required to address the dynamic threat environment.

[SP 800-30] provides guidance on risk assessments, threat assessments, and risk analyses.

3.11.6e Assess, respond to, and monitor supply chain risks associated with organizational systems.

DISCUSSION

Supply chain events include disruption, use of defective components, insertion of counterfeits, theft, malicious development practices, improper delivery practices, and insertion of malicious code. These events can have a significant impact on a system and its information and therefore, can also adversely impact organizational operations (i.e., mission, functions, image, or reputation), organizational assets, individuals, other organizations, and the Nation. The supply chain-related events may be unintentional or malicious and can occur at any point during the system life cycle.

An analysis of supply chain risk can help an organization identify systems or components for which additional supply chain risk mitigations are required.

[SP 800-30] provides guidance on risk assessments, threat assessments, and risk analyses. [SP 800-161] provides guidance on supply chain risk management.

3.11.7e Develop and update as required, a plan for managing supply chain risks associated with organizational systems.

DISCUSSION

The growing dependence on products, systems, and services from external providers, along with the nature of the relationships with those providers, present an increasing level of risk to an organization. Threat actions that may increase risk include the insertion or use of counterfeits, unauthorized production, tampering, theft, insertion of malicious software and hardware, as well as poor manufacturing and development practices in the supply chain. Supply chain risks can be endemic or systemic within a system element or component, a system, an organization, a sector, or the Nation. Managing supply chain risk is a complex, multifaceted undertaking requiring a coordinated effort across an organization building trust relationships and communicating with both internal and external stakeholders. Supply chain risk management (SCRM) activities involve identifying and assessing risks, determining appropriate mitigating actions, developing SCRM plans to document selected mitigating actions, and monitoring performance against plans. SCRM plans address requirements for developing trustworthy secure and resilient system components and systems, including the application of the security design principles implemented as part of life cycle-based systems security engineering processes.

[SP 800-161] provides guidance on supply chain risk management.

Basic and derived security requirements for risk assessment are contained in [SP 800-171].

3.12 SECURITY ASSESSMENT

Enhanced Security Requirements

3.12.1e Conduct penetration testing at least annually, leveraging automated scanning tools and ad hoc tests using human experts.

DISCUSSION

Penetration testing is a specialized type of assessment conducted on systems or individual system components to identify vulnerabilities that could be exploited by adversaries. Penetration testing goes beyond automated vulnerability scanning and is conducted by penetration testing agents and teams with demonstrable skills and experience that include technical expertise in network, operating system, and/or application level security. Penetration testing can be used to validate vulnerabilities or determine the degree of penetration resistance of systems to adversaries within specified constraints. Such constraints include time, resources, and skills. Organizations may also supplement penetration testing with red team exercises. Red teams attempt to duplicate the actions of adversaries in carrying out attacks against organizations and provide an in-depth analysis of security-related weaknesses or deficiencies.

Organizations can use the results of vulnerability analyses to support penetration testing activities. Penetration testing can be conducted internally or externally on the hardware, software, or firmware components of a system and can exercise both physical and technical controls. A standard method for penetration testing includes pretest analysis based on full knowledge of the system; pretest identification of potential vulnerabilities based on pretest analysis; and testing designed to determine exploitability of vulnerabilities. All parties agree to the rules of engagement before commencement of penetration testing scenarios. Organizations correlate the rules of engagement for penetration tests and red teaming exercises (if used) with the tools, techniques, and procedures that are anticipated to be employed by adversaries. The penetration testing team may be organization-based or external to the organization. In either case, it is important that the team possesses the necessary skills and resources to do the job and is objective in its assessment.

[SP 800-53A] provides guidance on conducting security assessments.

Basic and derived requirements for security assessment are contained in [SP 800-171].

3.13 SYSTEM AND COMMUNICATIONS PROTECTION

Enhanced Security Requirements

3.13.1e Employ diverse system components to reduce the extent of malicious code propagation.

DISCUSSION

Organizations often use homogenous information technology environments to reduce costs and to simplify administration and use. But a homogenous environment can also facilitate the work of the APT, as it allows for common mode failures and the propagation of malicious code across identical system components (i.e., hardware, software, and firmware). In these environments, adversary tactics, techniques, and procedures (TTP) that work on one instantiation of a system component will work equally well on other identical instantiations of the component regardless of how many times such components are replicated or how far away they may be placed in the architecture. Increasing diversity within organizational systems reduces the impact of potential exploitations or compromises of specific technologies. Such diversity protects against common mode failures, including those failures induced by supply chain attacks. Diversity also reduces the likelihood that the TTP adversaries use to compromise one system component will be effective against other system components, thus increasing the adversary's work factor to successfully complete the planned attacks. A heterogeneous or diverse information technology environment makes the task of propagating malicious code more difficult, as the adversary needs to develop and deploy different TTP for the diverse components.

Satisfying this requirement does not mean that organizations need to acquire and manage multiple versions of operating systems, applications, tools, and communication protocols. But the use of diversity in certain critical, organizationally determined, system components can be an effective countermeasure against the APT. In addition, organizations may already be practicing diversity, although not to counter the APT. For example, it is common for organizations to employ diverse anti-virus products at different parts of the infrastructure simply because each vendor may issue updates to new malicious code patterns at different times and frequency. Similarly, some organizations employ products from one vendor at the server level, and products from another vendor at the end-user level. Another example of diversity occurs in products that provide address space layout randomization (ASLR). Such products introduce a form of synthetic diversity by transforming the implementations of common software to produce a variety of instances. And finally, organizations may choose to use multiple virtual private network (VPN) vendors, tunneling one vendor's VPN within another vendor's VPN.

[SP 800-160-1] provides guidance on security engineering practices and security design concepts. [SP 800-160-2] provides guidance on developing cyber resilient systems and system components. [SP 800-161] provides guidance on supply chain risk management.

3.13.2e Disrupt the attack surface of organizational systems and system components through unpredictability, moving target defense, or non-persistence.

DISCUSSION

Cyber-attacks by adversaries are predicated on the assumption of a certain degree of predictability and consistency regarding the attack surface. The attack surface is the set of points on the boundary of a system, a system element, or an environment where an attacker can try to enter, cause an effect on, or extract data from, the system, system element, or environment. Changes to the attack surface reduce the predictability of the environment, making it difficult for adversaries to plan and carry out attacks and thus can cause the adversaries to make miscalculations that can either impact the overall effectiveness of the attacks or increase the observability of the attackers. Unpredictability can be achieved by making changes in seemingly random times or circumstances (e.g., by randomly shortening the time when the credentials are valid). Randomness introduces

increased levels of uncertainty for adversaries regarding the actions organizations take in defending their systems against attacks. Such actions may impede the ability of adversaries to correctly target system components supporting critical or essential missions or business functions. Uncertainty may also cause adversaries to hesitate before initiating attacks or continuing attacks. Misdirection techniques involving randomness include performing certain routine actions at different times of day, employing different information technologies, using different suppliers, and rotating roles and responsibilities of organizational personnel.

Changing processing and storage locations (also referred to as moving target defense) addresses the advanced persistent threat using techniques such as virtualization, distributed processing, and replication. This enables organizations to relocate the system components (i.e., processing and/or storage) supporting critical missions and business functions. Changing the locations of processing activities and/or storage sites introduces a degree of uncertainty into the targeting activities by adversaries. Targeting uncertainty increases the work factor of adversaries making compromises or breaches to organizational systems more difficult and time-consuming. It also increases the chances that adversaries may inadvertently disclose aspects of tradecraft while attempting to locate critical organizational resources. Other options for employing moving target defense include changing IP addresses, DNS names, or network topologies. Moving target defense can also increase the work factor for defenders who have a constantly-changing system to defend. Accordingly, organizations update their management and security tools and train personnel to adapt to the additional work factor.

Non-persistence can be achieved by refreshing system components by periodically re-imaging the components or by using a variety of common virtualization techniques. Non-persistent services can be implemented by using virtualization techniques as part of virtual machines or as new instances of processes on physical machines (either persistent or non-persistent). The benefit of periodic refreshes of system components and services is that it does not require organizations to first determine whether compromises of components or services have occurred (something that may often be difficult to determine). The refresh of selected system components and services occurs with sufficient frequency to prevent the spread or intended impact of attacks, but not with such frequency that it makes the system unstable. Refreshes of critical components and services may be done periodically to hinder the ability of adversaries to maintain persistence and to exploit optimum windows of vulnerabilities.

[SP 800-160-1] provides guidance on developing trustworthy secure systems using systems security engineering practices and security design concepts. [SP 800-160-2] provides guidance on developing cyber resilient systems and system components.

3.13.3e Employ technical and procedural means to confuse and mislead adversaries through a combination of misdirection, tainting, or disinformation.

DISCUSSION

Deception is used to confuse and mislead adversaries regarding the information the adversaries use for decision making; the value and authenticity of the information the adversaries attempt to exfiltrate; or the environment in which the adversaries desire to operate. Such actions can impede the adversary's ability to conduct meaningful reconnaissance of the targeted organization; delay or degrade an adversary's ability to move laterally through a system or from one system to another system; divert the adversary away from systems or system components containing CUI; and increase observability of the adversary to the defender, revealing the presence of the adversary along with its TTPs. Misdirection can be achieved through deception environments (e.g., deception nets) which provide virtual sandboxes into which malicious code can be diverted and adversary TTP can be safely examined. Tainting involves embedding data or information in an organizational system or system component which the organization desires adversaries to exfiltrate. Tainting allows organizations to determine that information has been exfiltrated or improperly removed

from the organization and potentially provides the organization information regarding the nature of exfiltration or adversary locations. Disinformation can be achieved by making false information intentionally available to adversaries regarding the state of the system or type of organizational defenses.

[SP 800-160-2] provides guidance on developing cyber resilient systems and system components.

3.13.4e Employ physical and logical isolation techniques in the system and security architecture.

DISCUSSION

Physical and logical isolation techniques applied at the architectural level of the system can limit the unauthorized flow of CUI; reduce the system attack surface; constrain the number of system components that must be highly secure; and impede the movement of an adversary. Physical and logical isolation techniques when implemented with managed interfaces, can isolate CUI into separate security domains where additional protections can be applied. Any communications across the managed interfaces (i.e., across security domains), constitutes remote access, even if the communications stay within the organization. Separating system components with boundary protection mechanisms provides the capability for increased protection of individual components and to more effectively control information flows between those components. This type of enhanced protection limits the potential harm from and susceptibility to hostile cyber-attacks and errors. The degree of isolation varies depending upon the boundary protection mechanisms selected. Boundary protection mechanisms include routers, gateways, and firewalls separating system components into physically separate networks or subnetworks; virtualization and micro-virtualization techniques; encrypting information flows among system components using distinct encryption keys; cross-domain devices separating subnetworks; and complete physical separation (i.e., air gaps).

Architectural strategies include logical isolation, partial physical and logical isolation, or complete physical isolation between subsystems and at system boundaries between resources that store, process, transmit, or protect CUI and other resources. Examples include:

Logical isolation: data tagging, digital rights management (DRM), and data loss prevention (DLP) that tags, monitors, and restricts the flow of CUI; virtual machines or containers that separate CUI and other information on hosts; and virtual local area networks (VLAN) that keep CUI and other information separate on networks.

Partial physical and logical isolation: physically or cryptographically isolated networks; dedicated hardware in data centers; and secure clients that: (a) may not directly access resources outside of the domain (i.e., all networked applications execute as remote virtual applications hosted in a DMZ or internal and protected enclave); (b) access via remote virtualized applications or virtual desktop with no file transfer capability other than with dual authorization; or (c) employ dedicated client hardware (e.g., a zero or thin client) or hardware approved for multi-level secure (MLS) usage.

Complete physical isolation: dedicated (not shared) client and server hardware; physically isolated, stand-alone enclaves for clients and servers; and (a) logically separate network traffic (e.g., using a VLAN) with end-to-end encryption using PKI-based cryptography, or (b) physically isolate it from other traffic.

Isolation techniques are selected based on a risk management perspective that balances the threat, the information being protected, and the cost of the options for protection. Architectural and design decisions are guided and informed by the security requirements and selected solutions.

[SP 800-160-1] provides guidance on developing trustworthy secure systems using systems security engineering practices and security design concepts.

1016 **Basic and derived requirements for system and communications protection are contained in [SP 800-**
1017 **171].**

3.14 SYSTEM AND INFORMATION INTEGRITY

Enhanced Security Requirements

3.14.1e Employ roots of trust, formal verification, or cryptographic signatures to verify the integrity and correctness of security critical or essential software.

DISCUSSION

Verifying the integrity of the organization's security critical or essential software is an important capability as corrupted software is the primary attack vector used by adversaries to undermine or disrupt the proper functioning of organizational systems. There are many ways to verify software integrity and correctness throughout the system development life cycle. Root of trust mechanisms such as secure boot and trusted platform modules verify that only trusted code is executed during boot processes. This capability helps system components protect the integrity of boot firmware in organizational systems by verifying the integrity and authenticity of updates to the firmware prior to applying changes to the system component and preventing unauthorized processes from modifying boot firmware. Formal verification involves proving that a software program satisfies some formal property or set of properties. The nature of such formal verification is generally time consuming and not employed for most commercial operating systems and applications. Therefore, it would likely only be applied to some very limited uses such as verifying cryptographic protocols. However, in cases where software exists with formal verification of its security properties, such software provides more assurance and trustworthiness and is preferred over similar software that has not been formally verified. The use of cryptographic signatures ensures the integrity and authenticity of critical and essential software that stores, processes, transmits, or protects CUI. Cryptographic signatures include digital signatures and the computation and application of signed hashes using asymmetric cryptography; protecting the confidentiality of the key used to generate the hash; and using the public key to verify the hash information.

[FIPS 140-2] provides security requirements for cryptographic modules. [FIPS 180-4] and [FIPS 202] provide secure hash standards. [FIPS 186-4] provides a digital signature standard. [SP 800-147] provides BIOS protection guidance. [NIST TRUST] provide guidance on the roots of trust project.

3.14.2e Monitor individuals and system components on an ongoing basis for anomalous or suspicious behavior.

DISCUSSION

Monitoring is used to identify unusual or unauthorized activities or conditions related to individual users and system components, for example, unusual internal systems communications traffic; unauthorized exporting of information; signaling to external systems; large file transfers; long-time persistent connections; attempts to access information from unexpected locations; unusual protocols and ports in use; and attempted communications with suspected malicious external addresses.

The correlation of physical audit record information and the audit records from systems may assist organizations in identifying examples of anomalous behavior. For example, the correlation of an individual's identity for logical access to certain systems with the additional information that the individual was not present at the facility when the logical access occurred, is indicative of anomalous behavior. Indications of increased risk from individuals can be obtained from many sources including human resource records, intelligence agencies, law enforcement organizations, and other sources. The monitoring of specific individuals is closely coordinated with management, legal, security, privacy, and human resource officials in organizations conducting such monitoring, and in certain circumstances requires the prior authorization by a specified senior organizational official.

[SP 800-61] provides guidance on incident handling. [SP 800-83] provides guidance for malicious code incident prevention and handling. [SP 800-92] provides guidance on computer security log management. [SP 800-94] provides guidance on intrusion detection and prevention. [SP 800-137] provides guidance on continuous monitoring of systems.

3.14.3e Ensure that Internet of Things (IoT), Operational Technology (OT), and Industrial Internet of Things (IIoT) systems, components, and devices are compliant with the security requirements imposed on organizational systems or are isolated in purpose-specific networks.

DISCUSSION

Operational Technology (OT) is the hardware, software, and firmware components of a system used to detect or cause changes in physical processes through the direct control and monitoring of physical devices. Examples include distributed control systems (DCS), supervisory control and data acquisition (SCADA) systems, and programmable logic controllers (PLC). The term operational technology is used to highlight the differences between industrial control systems (ICS) that are typically found in manufacturing and power plants and the information technology (IT) systems that typically support traditional data processing applications. The term Internet of Things (IoT) is used to describe the network of devices (e.g., vehicles, medical devices, wearables, and home appliances) that contain the hardware, software, firmware, and actuators which allow the devices to connect, interact, and freely exchange data and information. IoT extends Internet connectivity beyond workstations, notebook computers, smartphones and tablets to physical devices that have not historically had such connectivity. IoT devices can communicate and interact over the Internet, and they can be remotely monitored and controlled. Finally, the term Industrial Internet of Things (IIoT) is used to describe the sensors, instruments, machines, and other devices that are networked together and use Internet connectivity to enhance industrial and manufacturing business processes and applications.

The recent convergence of IT and OT increases the attack surface of organizations significantly and provides attack vectors that are challenging to address. Compromised IoT, OT, and IIoT devices can serve as a launching point for attacks on organizational IT systems that handle CUI. Some IoT, OT, and IIoT system components can also handle CUI (e.g., specifications or parameters for objects manufactured in support of critical programs). Unfortunately, most of the current generation of IoT, OT and IIoT devices are not designed with security as a foundational property. Connections to and from such devices are generally not encrypted, do not provide the necessary authentication, are not monitored, and are not logged. As a result, these devices pose a significant cyber threat. Gaps in IoT, OT, and IIoT security capabilities may be addressed by employing intermediary devices that can provide encryption, authentication, security scanning, and logging capabilities, and preclude the devices from being accessible from the Internet. But such mitigating options are not always available or practicable. The situation is further complicated because some of the IoT, OT, and IIoT devices may be needed for essential missions and functions. In those instances, it is necessary that such devices are isolated from the Internet to reduce the susceptibility to hostile cyber-attacks.

[SP 800-160-1] provides guidance on security engineering practices and security design concepts.

3.14.4e Refresh organizational systems and system components from a known, trusted state at least twice annually.

DISCUSSION

This requirement mitigates risk from the APT by reducing the targeting capability of adversaries (i.e., the window of opportunity for the attack). By implementing the concept of non-persistence for selected system components, organizations can provide a known state computing resource for a specific time-period that does not give adversaries sufficient time on target to exploit vulnerabilities in organizational systems and the environments in which those systems operate.

Since the APT is a high-end, sophisticated threat regarding capability, intent, and targeting, organizations assume that over an extended period, a percentage of attacks will be successful. Non-persistent system components and system services are activated as required using protected information and are terminated periodically or at the end of sessions. Non-persistence increases the work factor of adversaries in attempting to compromise or breach systems.

Non-persistence can be achieved by refreshing system components, for example, by periodically re-imaging components or by using a variety of common virtualization techniques. Non-persistent services can be implemented using virtualization techniques as part of virtual machines or as new instances of processes on physical machines (persistent or non-persistent). Periodic refreshes of system components and services do not require organizations to determine whether compromises of components or services have occurred (something that may often be difficult to determine). The refresh of selected system components and services occurs with sufficient frequency to prevent the spread or intended impact of attacks, but not with such frequency that it makes the system unstable. Refreshes may be done periodically to hinder the ability of adversaries to exploit optimum windows of vulnerabilities.

The reimaging of system components includes the reinstallation of firmware, operating systems, and applications from a known, trusted source. Reimaging also includes the installation of patches, re-application of configuration settings, and refresh of system or application data from a known, trusted source. The source implements integrity controls to log changes or attempts to change software, configurations, or data in the repository. Additionally, changes to the repository are subject to change management procedures and require authentication of the user requesting the change. In certain situations, organizations may also require dual authorization for such changes. Software changes are routinely checked for integrity and authenticity to ensure that the changes are legitimate both when updating the repository and when refreshing a system from the known, trusted source.

3.14.5e Conduct periodic reviews of persistent organizational storage locations and purge CUI that is no longer needed consistent with federal records retention policies and disposition schedules.

DISCUSSION

As programs, projects, and contracts evolve, some CUI may no longer be needed. Periodic and event-related (e.g., at project completion) reviews are conducted to ensure that CUI that is no longer required is securely removed from persistent storage. Retaining information for longer than it is needed makes the information a potential target for advanced adversaries searching for critical program or high value asset information to exfiltrate. For system-related information, unnecessary retention of such information provides advanced adversaries information that can assist in their reconnaissance and lateral movement through organizational systems. Alternatively, information which must be retained but is not required for current activities is removed from online storage and stored off-line in a secure location to eliminate the possibility of individuals gaining unauthorized access to the information through a network. The purging of CUI renders the information unreadable, indecipherable, and unrecoverable.

[SP 800-88] provides guidance on media sanitization.

3.14.6e Use threat indicator information relevant to the information and systems being protected and effective mitigations obtained from external organizations to inform intrusion detection and threat hunting.

DISCUSSION

The constantly changing and increasing sophistication of adversaries, especially the advanced persistent threat (APT), make it essential that threat information relating to specific threat events (e.g., TTP, targets) that organizations have experienced, mitigations that organizations have found

are effective against certain types of threats, and threat intelligence (i.e., indications and warnings about threats that can occur) be sourced from and shared with trusted organizations. This information can be used by organizational Security Operations Centers (SOC) and incorporated into monitoring capabilities. Threat information sharing includes threat indicators, signatures, and adversary TTP from organizations participating in various threat-sharing consortia, government-commercial cooperatives, and government-government cooperatives (e.g., CERTCC, US-CERT, FIRST, ISAO, DIB CS Program). Unclassified indicators, based on classified information but which can be readily incorporated into organizational intrusion detection systems, are available to qualified nonfederal organizations from government sources.

Basic and derived requirements for system and information integrity are contained in [SP 800-171].

1169 APPENDIX A

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APPENDIX B

GLOSSARY

COMMON TERMS AND DEFINITIONS

Appendix B provides definitions for security terminology used within Special Publication 800-171. Unless specifically defined in this glossary, all terms used in this publication are consistent with the definitions contained in [CNSSI 4009] *National Information Assurance Glossary*.

agency [OMB A-130]	Any executive agency or department, military department, Federal Government corporation, Federal Government-controlled corporation, or other establishment in the Executive Branch of the Federal Government, or any independent regulatory agency.
assessment	See *security control assessment*.
assessor	See *security control assessor*.
attack surface [GAO 19-128]	The set of points on the boundary of a system, a system element, or an environment where an attacker can try to enter, cause an effect on, or extract data from, that system, system element, or environment.
audit record	An individual entry in an audit log related to an audited event.
authentication [FIPS 200, Adapted]	Verifying the identity of a user, process, or device, often as a prerequisite to allowing access to resources in a system.
availability [44 USC 3552]	Ensuring timely and reliable access to and use of information.
advanced persistent threat [SP 800-39]	An adversary that possesses sophisticated levels of expertise and significant resources which allow it to create opportunities to achieve its objectives by using multiple attack vectors including, for example, cyber, physical, and deception. These objectives typically include establishing and extending footholds within the IT infrastructure of the targeted organizations for purposes of exfiltrating information, undermining or impeding critical aspects of a mission, program, or organization; or positioning itself to carry out these objectives in the future. The advanced persistent threat pursues its objectives repeatedly over an extended period; adapts to defenders' efforts to resist it; and is determined to maintain the level of interaction needed to execute its objectives.
baseline configuration	A documented set of specifications for a system, or a configuration item within a system, that has been formally reviewed and agreed on at a given point in time, and which can be changed only through change control procedures.

bidirectional authentication	Two parties authenticating each other at the same time. Also known as mutual authentication or two-way authentication.
confidentiality [44 USC 3552]	Preserving authorized restrictions on information access and disclosure, including means for protecting personal privacy and proprietary information.
configuration management	A collection of activities focused on establishing and maintaining the integrity of information technology products and systems, through control of processes for initializing, changing, and monitoring the configurations of those products and systems throughout the system development life cycle.
configuration settings	The set of parameters that can be changed in hardware, software, or firmware that affect the security posture and/or functionality of the system.
controlled unclassified information [EO 13556]	Information that law, regulation, or governmentwide policy requires to have safeguarding or disseminating controls, excluding information that is classified under Executive Order 13526, *Classified National Security Information*, December 29, 2009, or any predecessor or successor order, or the Atomic Energy Act of 1954, as amended.
CUI categories [32 CFR 2002]	Those types of information for which laws, regulations, or governmentwide policies require or permit agencies to exercise safeguarding or dissemination controls, and which the CUI Executive Agent has approved and listed in the CUI Registry.
CUI Executive Agent [32 CFR 2002]	The National Archives and Records Administration (NARA), which implements the executive branch-wide CUI Program and oversees federal agency actions to comply with Executive Order 13556. NARA has delegated this authority to the Director of the Information Security Oversight Office (ISOO).
CUI program [32 CFR 2002]	The executive branch-wide program to standardize CUI handling by all federal agencies. The program includes the rules, organization, and procedures for CUI, established by Executive Order 13556, 32 CFR Part 2002, and the CUI Registry.
cyber-physical systems	Interacting digital, analog, physical, and human components engineered for function through integrated physics and logic.
cyber resiliency [SP 800-160-2]	The ability to anticipate, withstand, recover from, and adapt to adverse conditions, stresses, attacks, or compromises on systems that use or are enabled by cyber resources.
discussion	Statements used to provide additional explanatory information for security controls or security control enhancements.

disinformation	The process of providing deliberately misleading information to adversaries to mislead or confuse them regarding the security posture of the system or organization or the state of cyber preparedness.
dual authorization [CNSSI 4009, Adapted]	The system of storage and handling designed to prohibit individual access to certain resources by requiring the presence and actions of at least two authorized persons, each capable of detecting incorrect or unauthorized security procedures with respect to the task being performed.
executive agency [OMB A-130]	An executive department specified in 5 U.S.C. Sec. 101; a military department specified in 5 U.S.C. Sec. 102; an independent establishment as defined in 5 U.S.C. Sec. 104(1); and a wholly owned Government corporation fully subject to the provisions of 31 U.S.C. Chapter 91.
external system (or component)	A system or component of a system that is outside of the authorization boundary established by the organization and for which the organization typically has no direct control over the application of required security controls or the assessment of security control effectiveness.
external network	A network not controlled by the organization.
federal agency	See *executive agency*.
federal information system [40 USC 11331]	An information system used or operated by an executive agency, by a contractor of an executive agency, or by another organization on behalf of an executive agency.
firmware [CNSSI 4009]	Computer programs and data stored in hardware—typically in read-only memory (ROM) or programmable read-only memory (PROM)—such that programs and data cannot be dynamically written or modified during execution of the programs. See *hardware* and *software*.
formal verification	A systematic process that uses mathematical reasoning and mathematical proofs (i.e., formal methods in mathematics) to verify that the system satisfies its desired properties, behavior, or specification (i.e., the system implementation is a faithful representation of the design).
hardware [CNSSI 4009]	The material physical components of a system. See *software* and *firmware*.
impact	With respect to security, the effect on organizational operations, organizational assets, individuals, other organizations, or the Nation (including the national security interests of the United States) of a loss of confidentiality, integrity, or availability of information or a system. With respect to privacy, the adverse effects that individuals could experience when an information system processes their PII.

impact value [FIPS 199]	The assessed worst-case potential impact that could result from a compromise of the confidentiality, integrity, or availability of information expressed as a value of low, moderate or high.
incident [44 USC 3552]	An occurrence that actually or imminently jeopardizes, without lawful authority, the confidentiality, integrity, or availability of information or an information system; or constitutes a violation or imminent threat of violation of law, security policies, security procedures, or acceptable use policies.
industrial internet of things	The sensors, instruments, machines, and other devices that are networked together and use Internet connectivity to enhance industrial and manufacturing business processes and applications.
information [OMB A-130]	Any communication or representation of knowledge such as facts, data, or opinions in any medium or form, including textual, numerical, graphic, cartographic, narrative, electronic, or audiovisual forms.
information flow control	Procedure to ensure that information transfers within a system are not made in violation of the security policy.
information resources [44 USC 3502]	Information and related resources, such as personnel, equipment, funds, and information technology.
information security [44 USC 3552]	The protection of information and systems from unauthorized access, use, disclosure, disruption, modification, or destruction in order to provide confidentiality, integrity, and availability.
information system [44 USC 3502]	A discrete set of information resources organized for the collection, processing, maintenance, use, sharing, dissemination, or disposition of information.
information technology [OMB A-130]	Any services, equipment, or interconnected system(s) or subsystem(s) of equipment, that are used in the automatic acquisition, storage, analysis, evaluation, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of data or information by the agency. For purposes of this definition, such services or equipment if used by the agency directly or is used by a contractor under a contract with the agency that requires its use; or to a significant extent, its use in the performance of a service or the furnishing of a product. Information technology includes computers, ancillary equipment (including imaging peripherals, input, output, and storage devices necessary for security and surveillance), peripheral equipment designed to be controlled by the central processing unit of a computer, software, firmware and similar procedures, services (including cloud computing and help-desk services or other professional services which support any point of the life cycle of the equipment or service), and related resources. Information

	technology does not include any equipment that is acquired by a contractor incidental to a contract which does not require its use.
insider threat	The threat that an insider will use her/his authorized access, wittingly or unwittingly, to do harm to the security of the United States. This threat can include damage to the United States through espionage, terrorism, unauthorized disclosure, or through the loss or degradation of departmental resources or capabilities.
integrity [44 USC 3552]	Guarding against improper information modification or destruction, and includes ensuring information non-repudiation and authenticity.
internal network	A network where establishment, maintenance, and provisioning of security controls are under the direct control of organizational employees or contractors; or the cryptographic encapsulation or similar security technology implemented between organization-controlled endpoints, provides the same effect (with regard to confidentiality and integrity). An internal network is typically organization-owned, yet may be organization-controlled while not being organization-owned.
internet of things (IoT)	The network of devices that contain the hardware, software, firmware, and actuators which allow the devices to connect, interact, and freely exchange data and information.
malicious code	Software or firmware intended to perform an unauthorized process that will have adverse impact on the confidentiality, integrity, or availability of a system. A virus, worm, Trojan horse, or other code-based entity that infects a host. Spyware and some forms of adware are also examples of malicious code.
media [FIPS 200]	Physical devices or writing surfaces including, but not limited to, magnetic tapes, optical disks, magnetic disks, Large-Scale Integration (LSI) memory chips, and printouts (but not including display media) onto which information is recorded, stored, or printed within a system.
misdirection	The process of maintaining and employing deception resources or environments and directing adversary activities to those resources/environments.

mobile device	A portable computing device that has a small form factor such that it can easily be carried by a single individual; is designed to operate without a physical connection (e.g., wirelessly transmit or receive information); possesses local, non-removable/removable data storage; and includes a self-contained power source. Mobile devices may also include voice communication capabilities, on-board sensors that allow the devices to capture information, or built-in features that synchronize local data with remote locations. Examples include smartphones, tablets, and E-readers.
moving target defense	The concept of controlling change across multiple system dimensions in order to increase uncertainty and apparent complexity for attackers, reduce their window of opportunity, and increase the costs of their probing and attack efforts.
multifactor authentication	Authentication using two or more different factors to achieve authentication. Factors include something you know (e.g., PIN, password); something you have (e.g., cryptographic identification device, token); or something you are (e.g., biometric). See *authenticator*.
mutual authentication [CNSSI 4009]	The process of both entities involved in a transaction verifying each other. See *bidirectional authentication*.
nonfederal organization	An entity that owns, operates, or maintains a nonfederal system.
nonfederal system	A system that does not meet the criteria for a federal system.
network	A system implemented with a collection of interconnected components. Such components may include routers, hubs, cabling, telecommunications controllers, key distribution centers, and technical control devices.
network access	Access to a system by a user (or a process acting on behalf of a user) communicating through a network (e.g., local area network, wide area network, Internet).
on behalf of (an agency) [32 CFR 2002]	A situation that occurs when: (i) a non-executive branch entity uses or operates an information system or maintains or collects information for the purpose of processing, storing, or transmitting Federal information; and (ii) those activities are not incidental to providing a service or product to the government.
operational technology	The hardware, software, and firmware components of a system used to detect or cause changes in physical processes through the direct control and monitoring of physical devices.
organization [FIPS 200, Adapted]	An entity of any size, complexity, or positioning within an organizational structure.

personnel security [SP 800-53]	The discipline of assessing the conduct, integrity, judgment, loyalty, reliability, and stability of individuals for duties and responsibilities requiring trustworthiness.
potential impact [FIPS 199]	The loss of confidentiality, integrity, or availability could be expected to have: (i) a *limited* adverse effect (FIPS Publication 199 low); (ii) a *serious* adverse effect (FIPS Publication 199 moderate); or (iii) a *severe* or *catastrophic* adverse effect (FIPS Publication 199 high) on organizational operations, organizational assets, or individuals.
privileged account	A system account with authorizations of a privileged user.
privileged user	A user that is authorized (and therefore, trusted) to perform security-relevant functions that ordinary users are not authorized to perform.
records	The recordings (automated and/or manual) of evidence of activities performed or results achieved (e.g., forms, reports, test results), which serve as a basis for verifying that the organization and the system are performing as intended. Also used to refer to units of related data fields (i.e., groups of data fields that can be accessed by a program and that contain the complete set of information on particular items).
remote access	Access to an organizational system by a user (or a process acting on behalf of a user) communicating through an external network (e.g., the Internet).
replay resistance	Protection against the capture of transmitted authentication or access control information and its subsequent retransmission with the intent of producing an unauthorized effect or gaining unauthorized access.
risk [OMB A-130]	A measure of the extent to which an entity is threatened by a potential circumstance or event, and typically is a function of: (i) the adverse impact, or magnitude of harm, that would arise if the circumstance or event occurs; and (ii) the likelihood of occurrence.
risk assessment [SP 800-30]	The process of identifying risks to organizational operations (including mission, functions, image, reputation), organizational assets, individuals, other organizations, and the Nation, resulting from the operation of a system.
roots of trust [NIST TRUST]	Highly reliable hardware, firmware, and software components that perform specific, critical security functions. Because roots of trust are inherently trusted, they must be secure by design. Roots of trust provide a firm foundation from which to build security and trust.

sanitization	Actions taken to render data written on media unrecoverable by both ordinary and, for some forms of sanitization, extraordinary means. Process to remove information from media such that data recovery is not possible. It includes removing all classified labels, markings, and activity logs.
security [CNSSI 4009]	A condition that results from the establishment and maintenance of protective measures that enable an organization to perform its mission or critical functions despite risks posed by threats to its use of systems. Protective measures may involve a combination of deterrence, avoidance, prevention, detection, recovery, and correction that should form part of the organization's risk management approach.
security assessment	See *security control assessment*.
security control [OMB A-130]	The safeguards or countermeasures prescribed for an information system or an organization to protect the confidentiality, integrity, and availability of the system and its information.
security control assessment [OMB A-130]	The testing or evaluation of security controls to determine the extent to which the controls are implemented correctly, operating as intended, and producing the desired outcome with respect to meeting the security requirements for an information system or organization.
security domain [CNSSI 4009, Adapted]	A domain that implements a security policy and is administered by a single authority.
security functionality	The security-related features, functions, mechanisms, services, procedures, and architectures implemented within organizational systems or the environments in which those systems operate.
security functions	The hardware, software, or firmware of the system responsible for enforcing the system security policy and supporting the isolation of code and data on which the protection is based.
system	See *information system*.
system component [SP 800-128]	A discrete identifiable information technology asset that represents a building block of a system and may include hardware, software, and firmware.
system security plan	A document that describes how an organization meets the security requirements for a system or how an organization plans to meet the requirements. In particular, the system security plan describes the system boundary; the environment in which the system operates; how security requirements are implemented; and the relationships with or connections to other systems.

system service	A capability provided by a system that facilitates information processing, storage, or transmission.
tactics, techniques, and procedures (TTP) [SP 800-150]	The behavior of an actor. A tactic is the highest-level description of the behavior; techniques provide a more detailed description of the behavior in the context of a tactic; and procedures provide a lower-level, highly detailed description of the behavior in the context of a technique.
tainting	The process of embedding covert capabilities in information, systems, or system components to allow organizations to be alerted to the exfiltration of information.
threat [SP 800-30]	Any circumstance or event with the potential to adversely impact organizational operations, organizational assets, individuals, other organizations, or the Nation through a system via unauthorized access, destruction, disclosure, modification of information, and/or denial of service.
threat information [SP 800-150]	Any information related to a threat that might help an organization protect itself against the threat or detect the activities of an actor. Major types of threat information include indicators, TTPs, security alerts, threat intelligence reports, and tool configurations.
threat intelligence [SP 800-150]	Threat information that has been aggregated, transformed, analyzed, interpreted, or enriched to provide the necessary context for decision-making processes.

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1181 **APPENDIX C**

1182 # ACRONYMS

1183 COMMON ABBREVIATIONS

APT	Advanced Persistent Threat
CERT	Computer Emergency Readiness Team
CERTCC	CERT Coordination Center
CFR	Code of Federal Regulations
CIRT	Cyber Incident Response Team
CNSS	Committee on National Security Systems
CUI	Controlled Unclassified Information
DIB	Defense Industrial Base
DIB CS	Defense Industrial Base Cybersecurity Sharing
DMZ	Demilitarized Zone
DNS	Domain Name Server
FIPS	Federal Information Processing Standards
FIRST	Forum of Incident Response and Security Teams
FISMA	Federal Information Security Modernization Act
IIoT	Industrial Internet of Things
IoT	Internet of Things
IP	Internet Protocol
ISAC	Information Sharing and Analysis Centers
ISAO	Information Sharing and Analysis Organizations
ISOO	Information Security Oversight Office
IT	Information Technology
ITL	Information Technology Laboratory
MDR	Managed Detection and Response
MSSP	Managed Security Services Provider
NARA	National Archives and Records Administration
NIST	National Institute of Standards and Technology
OMB	Office of Management and Budget
OT	Operational Technology
PKI	Public Key Infrastructure

SOC	Security Operations Center
SP	Special Publication
TTP	Tactics, Techniques, and Procedures
UCDSMO	United Cross Domain Services Management Office
US-CERT	United States Computer Emergency Readiness Team

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APPENDIX D

MAPPING TABLES

MAPPING ENHANCED SECURITY REQUIREMENTS TO SECURITY CONTROLS

Tables D-1 through D-14 provide a mapping of the enhanced security requirements to the security controls in [SP 800-53].[28] The mapping tables are included for informational purposes and do not impart additional security requirements beyond those requirements defined in Chapter Three. In some cases, the security controls include additional expectations beyond those required to protect CUI. Only the portion of the security control relevant to the security requirement is applicable. Satisfaction of an enhanced requirement does *not* imply the corresponding NIST security control or control enhancement has also been satisfied.

Organizations that have implemented or plan to implement the [NIST CSF] can use the mapping tables to locate the equivalent controls in the categories and subcategories associated with the core functions of the Cybersecurity Framework: Identify, Protect, Detect, Respond, and Recover. The mapping information can be useful to organizations that wish to demonstrate compliance to the security requirements as part of their established information security programs, when such programs have been built around the NIST security controls.

[28] The security controls in Tables D-1 through D-14 are taken from Draft NIST Special Publication 800-53, Revision 5. These tables will be updated upon final publication.

1201 **TABLE D-1: MAPPING ACCESS CONTROL REQUIREMENTS TO CONTROLS**

SECURITY REQUIREMENTS	NIST SP 800-53 *Relevant Security Controls*	
3.1.1e Employ dual authorization to execute critical or sensitive system and organizational operations.	AC-3(2)	Access Enforcement *Dual Authorization*
	AU-9(5)	Protection of Audit Information *Dual Authorization*
	CM-5(4)	Access Restrictions for Change *Dual Authorization*
	CP-9(7)	System Backup *Dual Authorization*
	MP-6(7)	Media Sanitization *Dual Authorization*
3.1.2e Restrict access to systems and system components to only those information resources that are owned, provisioned, or issued by the organization.	AC-20(3)	Use of External Systems *Non-Organizationally Owned Systems—Restricted Use*
3.1.3e Employ secure information transfer solutions to control information flows between security domains on connected systems.	AC-4	Information Flow Enforcement
	AC-4(1)	Information Flow Enforcement *Object Security Attributes*
	AC-4(6)	Information Flow Enforcement *Metadata*
	AC-4(8)	Information Flow Enforcement *Security Policy Filters*
	AC-4(12)	Information Flow Enforcement *Data Type Identifiers*
	AC-4(13)	Information Flow Enforcement *Decomposition into Policy-Relevant Subcomponents*
	AC-4(15)	Information Flow Enforcement *Detection of Unsanctioned Information*
	AC-4(20)	Information Flow Enforcement *Approved Solutions*
	SC-46	Cross Domain Policy Enforcement

1202

1203 **TABLE D-2: MAPPING AWARENESS AND TRAINING REQUIREMENTS TO CONTROLS**

SECURITY REQUIREMENTS	NIST SP 800-53 *Relevant Security Controls*	
3.2.1e Provide awareness training focused on recognizing and responding to threats from social engineering, advanced persistent threat actors, breaches, and suspicious behaviors; update the training at least annually or when there are significant changes to the threat.	AT-2	Awareness Training
	AT-2(3)	Awareness Training *Social Engineering and Mining*
	AT-2(4)	Awareness Training *Suspicious Communications and Anomalous System Behavior*
	AT-2(6)	Awareness Training *Advanced Persistent Threat*
	AT-2(7)	Awareness Training *Cyber Threat Environment*
3.2.2e Include practical exercises in awareness training that are aligned with current threat scenarios and provide feedback to individuals involved in the training and their supervisors.	AT-2(1)	Awareness Training *Practical Exercises*
	AT-2(8)	Awareness Training *Training Feedback*

1204

1205 **TABLE D-3: MAPPING AUDIT AND ACCOUNTABILITY REQUIREMENTS TO CONTROLS**

SECURITY REQUIREMENTS	NIST SP 800-53 *Relevant Security Controls*
There are no enhanced security requirements for audit and accountability at this time.	

1206

1207 **TABLE D-4: MAPPING CONFIGURATION MANAGEMENT REQUIREMENTS TO CONTROLS**

SECURITY REQUIREMENTS	NIST SP 800-53 *Relevant Security Controls*	
3.4.1e Establish and maintain an authoritative source and repository to provide a trusted source and accountability for approved and implemented system components.	CM-2	Baseline Configuration
	CM-3	Configuration Change Control
	CM-8	System Component Inventory
	SI-14(1)	Non-Persistence *Refresh from Trusted Sources*
3.4.2e Employ automated mechanisms to detect the presence of misconfigured or unauthorized system components and remove the components or place the components in a quarantine or remediation network that allows for patching, re-configuration, or other mitigations.	CM-2	Baseline Configuration
	CM-3	Configuration Change Control
	CM-3(5)	Configuration Change Control *Automated Security Response*
	CM-3(8)	Configuration Change Control *Prevent or Restrict Configuration Changes*
3.4.3e Employ automated discovery and management tools to maintain an up-to-date, complete, accurate, and readily available inventory of system components.	CM-2(2)	Baseline Configuration *Automation Support for Accuracy and Currency*
	CM-8(2)	System Component Inventory *Automated Maintenance*

1208

1209 **TABLE D-5: MAPPING IDENTIFICATION AND AUTHENTICATION REQUIREMENTS TO CONTROLS**

SECURITY REQUIREMENTS	NIST SP 800-53 *Relevant Security Controls*	
3.5.1e Identify and authenticate systems and system components before establishing a network connection using bidirectional authentication that is cryptographically-based and replay resistant.	IA-3	Device Identification and Authentication
	IA-3(1)	Device Identification and Authentication *Cryptographic Bidirectional Authentication*
	IA-2(8)	Identification and Authentication (Organizational Users) *Access to Accounts —Replay Resistant*
3.5.2e Employ password managers for the generation, rotation, and management of passwords for systems and system components that do not support multifactor authentication or complex account management.	IA-5(18)	Authenticator Management *Password Managers*
3.5.3e Employ automated mechanisms to prohibit system components from connecting to organizational systems unless the components are known, authenticated, in a properly configured state, or in a trust profile.	CM-8(3)	System Component Inventory *Automated Unauthorized Component Detection*
	IA-3(4)	Device Authentication and Authentication *Device Attestation*
	SI-4(22)	System Monitoring *Unauthorized Network Services*

1210

1211 **TABLE D-6: MAPPING INCIDENT RESPONSE REQUIREMENTS TO CONTROLS**

SECURITY REQUIREMENTS	NIST SP 800-53 *Relevant Security Controls*	
3.6.1e Establish and maintain a full-time security operations center capability.	IR-4(14)	Incident Handling *Security Operations Center*
3.6.2e Establish and maintain a cyber incident response team that can be deployed to any location identified by the organization within 24 hours.	IR-4(11)	Incident Handling *Cyber Incident Response Team*
	IR-7	Incident Response Assistance

1212

1213 **TABLE D-7: MAPPING MAINTENANCE REQUIREMENTS TO CONTROLS**

SECURITY REQUIREMENTS	NIST SP 800-53 *Relevant Security Controls*
There are no enhanced security requirements for maintenance at this time.	

1214

1215 **TABLE D-8: MAPPING MEDIA PROTECTION REQUIREMENTS TO CONTROLS**

SECURITY REQUIREMENTS	NIST SP 800-53 *Relevant Security Controls*
There are no enhanced security requirements for media protection at this time.	

1216

1217 **TABLE D-9: MAPPING PERSONNEL SECURITY REQUIREMENTS TO CONTROLS**

SECURITY REQUIREMENTS	NIST SP 800-53 *Relevant Security Controls*	
3.9.1e Conduct enhanced personnel screening (vetting) for individual trustworthiness and reassess individual trustworthiness on an ongoing basis.	PS-3	Personnel Screening
	SA-21	Developer Screening
3.9.2e Ensure that organizational systems are protected whenever adverse information develops regarding the trustworthiness of individuals with access to CUI.	PS-3	Personnel Screening
	SA-21	Developer Screening

1218

1219 **TABLE D-10: MAPPING PHYSICAL PROTECTION REQUIREMENTS TO CONTROLS**

SECURITY REQUIREMENTS	NIST SP 800-53 *Relevant Security Controls*
There are no enhanced security requirements for physical protection at this time.	

1220

1221 **TABLE D-11: MAPPING RISK ASSESSMENT REQUIREMENTS TO CONTROLS**

SECURITY REQUIREMENTS		NIST SP 800-53 *Relevant Security Controls*	
3.11.1e	Employ threat intelligence to inform the development of the system and security architectures, selection of security controls, monitoring, threat hunting, and response and recovery activities.	PM-16	Threat Awareness Program
		PM-16(1)	Threat Awareness Program *Automated Means for Sharing Threat Intelligence*
		RA-3(3)	Risk Assessment *Dynamic Threat Analysis*
3.11.2e	Establish and maintain a cyber threat hunting capability to search for indicators of compromise in organizational systems and detect, track, and disrupt threats that evade existing controls.	RA-10	Threat Hunting
		SI-4(24)	System Monitoring *Indicators of Compromise*
3.11.3e	Employ advanced automation and analytics capabilities to predict and identify risks to organizations, systems, or system components.	RA-3(4)	Risk Assessment *Predictive Cyber Analytics*
		SI-4(24)	System Monitoring *Indicators of Compromise*
3.11.4e	Document in the system security plan the risk basis for security solution selection and identify the system and security architecture, system components, boundary isolation or protection mechanisms, and dependencies on external service providers.	PL-2	System Security and Privacy Plans
3.11.5e	Assess the effectiveness of security solutions at least annually to address anticipated risk to the system and the organization based on current and accumulated threat intelligence.	RA-3	Risk Assessment
		RA-3(3)	Risk Assessment *Dynamic Threat Awareness*
3.11.6e	Assess, respond to, and monitor supply chain risks associated with organizational systems.	RA-3	Risk Assessment
		RA-3(1)	Risk Assessment *Supply Chain Risk Assessment*

SECURITY REQUIREMENTS		NIST SP 800-53 *Relevant Security Controls*	
3.11.7e	Develop and update as required, a plan for managing supply chain risks associated with the research, development, design, manufacturing, acquisition, delivery, integration, operations, and disposal of organizational systems.	SR-2	Supply Chain Risk Management Plan

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1223 **TABLE D-12: MAPPING SECURITY ASSESSMENT REQUIREMENTS TO CONTROLS**

SECURITY REQUIREMENTS		NIST SP 800-53 *Relevant Security Controls*	
3.12.1e	Conduct penetration testing at least annually, leveraging automated scanning tools and ad hoc tests using human experts.	CA-8	Penetration Testing
		SR-6(1)	Supplier Reviews *Penetration Testing and Analysis*

1224

1225 **TABLE D-13: MAPPING SYSTEM AND COMMUNICATIONS PROTECTION REQUIREMENTS TO CONTROLS**

SECURITY REQUIREMENTS		NIST SP 800-53 *Relevant Security Controls*	
3.13.1e	Employ diverse system components to reduce the extent of malicious code propagation.	PL-8	Security and Privacy Architectures
		SA-17(9)	Developer Security Architecture and Design *Design Diversity*
		SC-27	Platform-Independent Applications
		SC-29	Heterogeneity
		SC-29(1)	Heterogeneity *Virtualization Techniques*
		SC-47	Communications Path Diversity
3.13.2e	Disrupt the attack surface of organizational systems and system components through unpredictability, moving target defense, or non-persistence.	SC-30(2)	Concealment and Misdirection *Randomness*
		SC-30(3)	Concealment and Misdirection *Change Processing and Storage Locations*
		SI-14	Non-Persistence
3.13.3e	Employ technical and procedural means through a combination of misdirection, tainting, or disinformation to confuse and mislead adversaries.	SC-8(4)	Transmission Confidentiality and Integrity *Conceal or Randomize Communications*
		SC-26	Decoys
		SC-30	Concealment and Misdirection
		SC-30(2)	Concealment and Misdirection *Randomness*
		SI-20	Tainting
3.13.4e	Employ physical and logical isolation techniques in the system and security architecture.	SC-7	Boundary Protection
		SC-7(13)	Boundary Protection *Isolation of Security Tools, Mechanisms, and Support Components*
		SC-7(21)	Boundary Protection *Isolation of System Components*
		SC-7(22)	Boundary Protection *Separate Subnets for Connecting to Different Security Domains*
		SC-25	Thin Nodes

1226

1227 **TABLE D-14: MAPPING SYSTEM AND INFORMATION INTEGRITY REQUIREMENTS TO CONTROLS**

SECURITY REQUIREMENTS		NIST SP 800-53 *Relevant Security Controls*	
3.14.1e	Employ roots of trust, formal verification, or cryptographic signatures to verify the integrity and correctness of mission critical or essential software.	SI-7(6)	Software, Firmware, and Information Integrity *Cryptographic Protection*
		SI-7(9)	Software, Firmware, and Information Integrity *Verify Boot Process*
		SI-7(10)	Software, Firmware, and Information Integrity *Protection of Boot Firmware*
		SI-7(10)	Software, Firmware, and Information Integrity *Integrity Verification*
		SA-17	Developer Security Architecture and Design
3.14.2e	Monitor individuals and system components on an ongoing basis for anomalous or suspicious behavior.	AU-6(6)	Audit Record Review, Analysis, and Reporting *Correlation with Physical Monitoring*
		SI-4(4)	System Monitoring *Inbound and Outbound Communications Traffic*
		SI-4(7)	System Monitoring *Automated Response to Suspicious Events*
		SI-4(11)	System Monitoring *Analyze Communications Traffic Anomalies*
		SI-4(13)	System Monitoring *Analyze Traffic and Event Patterns*
		SI-4(18)	System Monitoring *Analyze Traffic and Covert Exfiltration*
		SI-4(19)	System Monitoring *Risk for individuals*
		SI-4(20)	System Monitoring *Privileged Users*
3.14.3e	Ensure that Internet of Things (IoT), Operational Technology (OT), and Industrial Internet of Things (IIoT) systems, components, and devices are compliant with the security requirements imposed on organizational systems or are isolated in purpose-specific networks.	AC-3	Access Enforcement
		AC-4	Information Flow Enforcement
		SA-8	Security and Privacy Engineering Principles
		SC-2	Separation of System and User Functionality
		SC-3	Security Function Isolation
		SC-49	Hardware-Enforced Separation and Policy Enforcement
3.14.4e	Refresh organizational systems and system components from a known, trusted state at least twice annually.	SI-14	Non-Persistence
		SI-14(1)	Non-Persistence *Refresh from Trusted Sources*
		SI-14(2)	Non-Persistence *Non-Persistent Information*
		SI-14(3)	Non-Persistence *Non-Persistent Connectivity*
3.14.5e	Conduct periodic reviews of persistent organizational storage locations and purge CUI that is no longer needed consistent with federal records retention policies and disposition schedules.	SC-28(2)	Protection of Information at Rest *Off-Line Storage*
		SI-14(2)	Non-Persistence *Non-Persistent Information*

SECURITY REQUIREMENTS	NIST SP 800-53 *Relevant Security Controls*	
3.14.6e Use threat indicator information relevant to the information and systems being protected and effective mitigations obtained from external organizations to inform intrusion detection and threat hunting.	PM-16(1)	Threat Awareness Program *Automated Means for Sharing Threat Intelligence*
	SI-4(24)	System Monitoring *Automated Means for Sharing Threat Intelligence*
	SI-5	Security Alerts, Advisories, and Directives

1228